

[DOCUMENT NAME] SPECIFICATION

[TITLE] AIR-CONDITIONING MANAGEMENT DEVICE, AIR-CONDITIONING MANAGEMENT METHOD, AND PROGRAM

[FIELD OF THE INVENTION]

[0001]

The present invention relates to an air-conditioning management device and the like each of which manages an operation of an air conditioner.

[DESCRIPTION OF THE RELATED ART]

[0002]

As only limited operations of nuclear power stations are allowed these years, various measures have been taken such that a total purchased power does not exceed an upper limit of a commercial power consumption. For example, a contracted power is set between a power company and a power customer, and, if a purchased power exceeds the contracted power, the power company charges an excess fee to the power customer, which encourages the power customer to save power.

[0003]

Another measure is that a nighttime electric power rate (for example, from 23:00 to 7:00 next morning) is set lower than a daytime electric power rate, to thereby level off power consumption. One of known techniques of leveling off the power consumption is a heat storage system in which: cold heat is generated by a refrigerator and is stored in a cooling tower in nighttime; and the cold heat in the cooling tower is supplied to a load side in daytime.

[0004]

For example, Patent Document 1 discloses a control device of a heat source system that includes an estimated load correcting means for, when a difference between an estimated air conditioning load value within a target time and an actual air conditioning load value exceeds a prescribed value, correcting the estimated air

conditioning load value after the target time.

[RELATED ART DOCUMENT]

[PATENT DOCUMENT]

[0005]

Patent Document 1: Japanese Laid-Open Patent Application, Publication No.
2008-82641

[SUMMARY OF THE INVENTION]

[PROBLEMS TO BE SOLVED BY THE INVENTION]

[0006]

Sometimes a temperature or a humidity on one day actually becomes higher than that forecast on a previous day (that is, an actual air conditioning load value becomes higher). For example, let us assume that, in a technique described in Patent Document 1, an actual air conditioning load value from 12:00 to 13:00 in daytime (during a target time) has far exceeded an estimated air conditioning load value. In this case, an estimated load correcting means corrects an estimated air conditioning load value after 13:00 (after the target time), based on a difference between the estimated air conditioning load value and the actual air conditioning load value between 12:00 to 13:00.

[0007]

That is, in the technique described in Patent Document 1, an immediate control of reducing a power consumption between 12:00 and 13:00 within the target time cannot be performed. Instead, such a control is performed after 13:00. As a result, a power consumption of a building in which the air conditioner is installed is likely to temporarily exceed a contracted power. There is thus a possibility that power consumption is not appropriately leveled off.

[0008]

In light of the problems described above, the present invention has been made

in an attempt to provide an air-conditioning management device and the like each of which can appropriately level off power consumption.

[MEANS FOR SOLVING THE PROBLEM]

[0009]

In order to solve the problem described above, an air-conditioning management device of the present invention: generates an instruction signal indicating that a start time of the heat release operation is to be advanced, if, before a scheduled start time of the heat release operation in the operation schedule, the power consumption calculated by the power consumption calculation unit becomes larger than a prescribed threshold value, the prescribed threshold value being a reference value for determining whether or not the heat release operation is to be performed; and generates an instruction signal indicating that the start time of the heat release operation is to be delayed, if, after the scheduled start time of the heat release operation in the operation schedule, the power consumption calculated by the power consumption calculation unit becomes equal to or smaller than the prescribed threshold value.

Details are described in embodiments for carrying out the invention.

[ADVANTAGEOUS EFFECTS OF THE INVENTION]

[0010]

The present invention can provide an air-conditioning management device and the like each of which appropriately levels off power consumption.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0011]

[FIG. 1] A diagram illustrating a structure of an air-conditioning system including an air-conditioning management server according to a first embodiment of the present invention.

[FIG. 2] A diagram illustrating a configuration of the air-conditioning

management server according to the first embodiment.

[FIG. 3] A flowchart illustrating steps of a processing performed by the air-conditioning management server.

[FIG. 4] A continued flowchart illustrating steps of the processing performed by the air-conditioning management server.

[FIG. 5] FIG. 5(a) is an explanatory diagram illustrating a change in a heat load of an air conditioner. FIG. 5(b) is an explanatory diagram illustrating a change in a power consumption in a case where: a temperature and a humidity has changed just as forecast; and the air conditioner A is operated consistent with an operation schedule. FIG. 5(c) is an explanatory diagram illustrating a change in a power consumption in a case where a start time of a heat release operation is advanced from a scheduled start time. FIG. 5(d) is an explanatory diagram illustrating a change in a power consumption in a case where the start time of the heat release operation is delayed than scheduled.

[FIG. 6] A continued flowchart illustrating steps of the processing performed by the air-conditioning management server.

[FIG. 7] A continued flowchart illustrating steps of the processing performed by the air-conditioning management server.

[FIG. 8] A continued flowchart illustrating steps of the processing performed by the air-conditioning management server.

[FIG. 9] A diagram illustrating a structure of an air-conditioning system including an air-conditioning management server according to a second embodiment of the present invention.

[FIG. 10] A diagram illustrating a configuration of the air-conditioning management server according to the second embodiment.

[FIG. 11] A flowchart illustrating steps of a processing performed by the air-conditioning management server.

[FIG. 12] A continued flowchart illustrating steps of the processing performed by the air-conditioning management server.

[EMBODIMENTS FOR CARRYING OUT THE INVENTION]

[0012]

«First Embodiment»

<Configuration of Air-Conditioning System>

FIG. 1 is a diagram illustrating a structure of an air-conditioning system including an air-conditioning management server according to this embodiment. In FIG. 1, a solid arrow represents a direction in which cold water or the like flows in a pipe, and a dashed arrow represents a signal line.

An air-conditioning system S includes an air conditioner A, a temperature and humidity sensor 30, a controller 40, a weather forecast server 50, and an air-conditioning management server 60.

[0013]

The air conditioner A: stores cold water cooled by the refrigerator 11 in the heat storage tank 14; and then circulates the cold water from at least one of the refrigerator 11 and the heat storage tank 14 via an indoor machine 22. The air conditioner A includes: a primary air conditioner 10 which generates and stores therein cold heat; and a secondary air conditioner 20 which consumes the cold heat.

[0014]

(Primary Air Conditioner)

The primary air conditioner 10 includes: the refrigerator 11, a cooling tower 12, a cooling water pump 13, the heat storage tank 14, and a primary cooling water pump 15.

The refrigerator 11 is, for example, a turbo refrigerator and serves as a cold source for cooling cold water flowing therein via a pipe q2.

[0015]

The cooling tower 12 cools the cooling water which has absorbed heat at a condenser (not shown) of the refrigerator 11 and has a blower 12a which takes in outside air and blows the outside air to the cooling water.

A pipe p1 illustrated in FIG. 1 has an upstream end connected to the refrigerator 11 and a downstream end connected to an upper portion of the cooling tower 12. A pipe p2 has an upstream end connected to a lower portion of the cooling tower 12 and a downstream end connected to the refrigerator 11.

[0016]

The cooling water pump 13: pumps the cooling water from which heat has been released and which has been thus cooled at the cooling tower 12, toward the refrigerator 11; and is disposed on the pipe p2.

The heat storage tank 14 is, for example, a thermal stratification heat storage tank and is used for storing cold heat by reserving cold water cooled by an evaporator (not shown) of the refrigerator 11. Note that the lower the cold water reserved is positioned in the heat storage tank 14, the lower a temperature of the cold water becomes, because cold water at a lower temperature has a larger density and is easier to go down.

[0017]

A pipe q1 has an upstream end connected to the refrigerator 11 and a downstream end facing a lower portion of the heat storage tank 14. A pipe q2 has an upstream end facing an upper portion of the heat storage tank 14 and a downstream end connected to the refrigerator 11.

The primary cooling water pump 15 pumps cold water from the heat storage tank 14 toward the refrigerator 11 and is disposed on the pipe q2.

[0018]

(Secondary Air Conditioner)

The secondary air conditioner 20 includes a secondary cooling water pump 21

and the indoor machine 22.

The secondary cooling water pump 21 pumps cold water from the heat storage tank 14 toward an indoor heat exchanger 22a and is disposed on a pipe q3. The pipe q3 has an upstream end facing the lower portion of the heat storage tank 14 and a downstream end connected to an upstream end of a heat exchanger tube r of the indoor heat exchanger 22a. A pipe q4 has an upstream end connected to a downstream end of the heat exchanger tube r and a downstream end facing the upper portion of the heat storage tank 14.

[0019]

The indoor machine 22 (FCU: Fan Coil Unit) is installed in a room of a facility K and cools air in the room by exchanging heat with the cold water. The indoor machine 22 includes the indoor heat exchanger 22a and an indoor fan 22b. More specifically, heat is exchanged in the indoor heat exchanger 22a between a low-temperature cold water flowing in the heat exchanger tube r and a high-temperature air blown from the indoor fan 22b, to thereby cool the air in the room.

[0020]

Each of the refrigerator 11, the blower 12a of the cooling tower 12, the cooling water pump 13, the primary cooling water pump 15, the secondary cooling water pump 21, and the indoor fan 22b is driven by power supplied from an electric system (not shown) and is operated under control of the controller 40.

[0021]

A plurality of instruments including a lighting device R1 and a business computer R2 are disposed in the room of the facility K. The lighting device R1 or the like is actuated or stopped independently of fluctuations in weather conditions. Power consumption thereof thus fluctuates in substantially constant patterns depending on a date, a day of the week, an hour of the day, and the like. Note that the power consumption patterns of the lighting device R1 or the like is stored in a power

consumption pattern DB 61a (see FIG. 2) of the air-conditioning management server 60 to be described later.

In the explanation below, instruments which is included in the air conditioner A (the refrigerator 11 and the like) and instruments which is not included in the air conditioner A (the lighting device R1 and the like) are collectively referred to as a “loading device”.

[0022]

(Temperature and Humidity Sensor)

The temperature and humidity sensor 30 is a sensor which measures a temperature and a humidity of outside air and is disposed near the facility K. The temperature and humidity sensor 30 outputs the measured temperature and humidity to the controller 40.

[0023]

(Controller)

The controller 40 (which may also be referred to as a management terminal): controls each of the instruments of the air conditioner A; and includes electronic circuits such as a CPU (Central Processing Unit), a ROM (Read Only Memory), a RAM (Random Access Memory), and various interfaces.

As illustrated in FIG. 1, the controller 40 is connected to the air-conditioning management server 60 via a network N. The controller 40 transmits the temperature and humidity near the facility K measured by the temperature and humidity sensor 30, to the air-conditioning management server 60 via the network N.

[0024]

The air-conditioning management server 60 transmits information containing an operation schedule of the air conditioner A, to the controller 40 via the network N. The controller 40 switches an operation mode of the air conditioner A in accordance with the information received from the air-conditioning management server 60.

Alternatively, the controller 40 may make a display device (not shown) display the information containing the operation schedule. When an administrator looks at the displayed information, the administrator may operate the controller 40 such that the operation mode of the air conditioner A is switched.

[0025]

The operation mode described above includes a heat storage operation, a follow-up operation, and a heat release operation.

The “heat storage operation” is an operation mode in which the refrigerator 11 cools cold water and stores the cooled cold water in the heat storage tank 14.

The “follow-up operation” is an operation mode in which the cold water cooled by the refrigerator 11 is supplied to the indoor machine 22 as it is.

The “heat release operation” is an operation mode in which the low-temperature cold water stored in the heat storage tank 14 is made to circulate to pass through the indoor machine 22. Note that the refrigerator 11 and the cooling tower 12 are stopped during the heat release operation, a power consumption of the air conditioner A thus becomes much smaller than that during any of the other operation modes.

[0026]

FIG. 1 illustrates just one unit of each of the air conditioner A, the temperature and humidity sensor 30, and the controller 40 for explanation. Actually, however, a plurality of each of the air conditioners A and the like are disposed at respective appropriate sites. A cloud computing system is also used in which the controller 40 at the each site exchanges information with the air-conditioning management server 60 via the network N.

[0027]

(Weather Forecast Server)

The weather forecast server 50 is a server which distributes a weather forecast

and is connected to the air-conditioning management server 60 via the network N. The weather forecast includes a forecast temperature and a forecast humidity. The weather forecast server 50 forecasts, for example, hourly temperatures and humidities for 24 hours and distributes the results as weather forecasts at regular intervals (for example, every six hours), to the air-conditioning management server 60.

[0028]

(Air-Conditioning Management Server)

The air-conditioning management server 60 (which may also be referred to as an air-conditioning management device) is a server which: creates an operation schedule of the air conditioner A, based on the weather forecast received from the weather forecast server 50; and creates an instruction signal on whether or not a heat release operation is started in accordance with the actually measured values of the temperature and humidity received from the controller 40. The air-conditioning management server 60 consolidates all operation schedules and the like of the air conditioners A disposed at the respective sites.

[0029]

<Configuration of Air-Conditioning Management Server>

FIG. 2 is a diagram illustrating a configuration of the air-conditioning management server 60 according to this embodiment. Note that the network N (see FIG. 1) is not illustrated in FIG. 2 for simplification.

The air-conditioning management server 60 includes: a storage part 61 that stores therein information on a setting of an operation schedule; and a computation processing part 62 that performs various arithmetic processings.

[0030]

The storage part 61 includes a power consumption pattern DB (Data Base) 61a and a power consumption threshold DB 61b.

The power consumption pattern DB 61a stores therein a power consumption

pattern of the lighting device R1 or the like which is not included in the air conditioner A of the “loading device” described above. That is, the power consumption pattern DB 61a stores therein an estimated value of a power consumption of the lighting device R1 or the like, in association with a date, a day of the week, an hour of the day, and the like.

[0031]

The power consumption threshold DB 61b stores therein information on a threshold value P_M (which may also be referred to as a prescribed threshold value) of a power consumption of the loading device described above. The threshold value P_M serves as a reference value for determining whether or not a heat release operation is to be performed, and is preset for each of the air conditioners A at the respective sites. Note that the threshold value P_M is set at a value smaller than a contracted power demand P_C which is an upper limit threshold of a purchased power (see FIG. 5(b)).

[0032]

As illustrated in FIG. 2, the computation processing part 62 includes a weather forecast acquisition unit 62a, a heat load estimation unit 62b, an energy consumption estimation unit 62c, a power consumption estimation unit 62d, a schedule setting unit 62e, an actual measured value acquisition unit 62f, a heat load calculation unit 62g, an energy consumption calculation unit 62h, a power consumption calculation unit 62i, an instruction signal generation unit 62j, and an instruction signal transmission unit 62k.

[0033]

The weather forecast acquisition unit 62a periodically acquires a weather forecast in an area in which the facility K is situated, from the weather forecast server 50.

The heat load estimation unit 62b estimates a heat load inside the facility K, based on the weather forecast acquired by the weather forecast acquisition unit 62a. The heat load used herein is an air conditioning load (a cooling load) for keeping the

inside of the facility K at a prescribed temperature. The heat load estimation unit 62b calculates the heat load inside the facility K, based on the weather forecast described above, a set temperature inside the facility K, a structure of a skeleton constituting the facility K, or the like.

[0034]

The energy consumption estimation unit 62c estimates an energy consumption of the air conditioner A when the refrigerator 11 supplies the facility K with cold heat (when the facility K is cooled using a follow-up operation), based on the heat load estimated by the heat load estimation unit 62b.

More specifically, the energy consumption estimation unit 62c calculates the energy consumption of the air conditioner A, based on, in addition to the heat load described above, an estimated value of an outside-air wet-bulb temperature of a following day, information on a specification of the air conditioner A, or the like. Note that the outside-air wet-bulb temperature described above is calculated based on the temperature and humidity estimated value acquired by the weather forecast acquisition unit 62a.

[0035]

The power consumption estimation unit 62d estimates a power consumption of the loading device including the air conditioner A, based on the energy consumption estimated by the energy consumption estimation unit 62c. The power consumption described above corresponds to a power consumption when the inside of the facility K is cooled in a follow-up operation (that is, no heat release operation is performed).

[0036]

The schedule setting unit 62e sets an operation schedule of the air conditioner A, based on the power consumption estimated by the power consumption estimation unit 62d. The schedule setting unit 62e then transmits the set operation schedule to the controller 40 via the network N (see FIG. 1).

Details of a processing performed herein by the schedule setting unit 62e will be described hereinafter.

[0037]

The actual measured value acquisition unit 62f acquires actual measured values including a current temperature and a current humidity near the facility K from the controller 40 via the network N (see FIG. 1) at regular intervals (for example, every five minutes or the like). Note that the term “current” used herein includes several or several tens of minutes before the actual measured value acquisition unit 62f acquires the actual measured values of the temperature and the humidity.

[0038]

The heat load calculation unit 62g calculates a current heat load inside the facility K, based on the actual measured values of the temperature and the humidity acquired by the actual measured value acquisition unit 62f.

The energy consumption calculation unit 62h calculates an energy consumption of the air conditioner A when the refrigerator 11 supplies the facility K with cold heat (when the facility K is cooled in a follow-up operation), based on the heat load calculated by the heat load calculation unit 62g.

[0039]

The power consumption calculation unit 62i calculates a power consumption of the loading device including the air conditioner A, based on the energy consumption calculated by the energy consumption calculation unit 62h. The power consumption described above corresponds to a power consumption when assuming that the inside of the facility K is cooled in a follow-up operation (that is, no heat release operation is performed).

[0040]

The instruction signal generation unit 62j has a function of generating an instruction signal on whether or not a heat release operation is to be performed. As

illustrated in FIG. 2, the instruction signal generation unit 62j includes a heat load comparison unit 621j, a power consumption comparison unit 622j, and a heat release start time change unit 623j.

The heat load comparison unit 621j: compares the heat load estimated by the heat load estimation unit 62b with the heat load (an actual heat load) calculated by the heat load calculation unit 62g; and determines which is larger or smaller. The heat load comparison unit 621j outputs a result from the comparison to the heat release start time change unit 623j.

The power consumption comparison unit 622j: compares the power consumption calculated by the power consumption calculation unit 62i with the threshold value P_M stored in the power consumption threshold DB 61b; and determines which is larger or smaller. The power consumption comparison unit 622j outputs a result from the comparison to the heat release start time change unit 623j.

[0041]

The heat release start time change unit 623j changes a start time of the heat release operation set by the schedule setting unit 62e, based on the comparison result by the heat load comparison unit 621j and the comparison result by the power consumption comparison unit 622j. That is, the heat release start time change unit 623j has a function of advancing or delaying a start time of a heat release operation from a scheduled start time of an operation schedule. Details of a processing performed herein by the heat release start time change unit 623j will be described later.

The instruction signal transmission unit 62k transmits the instruction signal generated by the instruction signal generation unit 62j, to the controller 40 via the network N (see FIG. 1).

[0042]

<Operations of Air-Conditioning Management Server>

FIG. 3 is a flowchart illustrating steps of a processing performed by the

air-conditioning management server.

In step S101, the air-conditioning management server 60 determines whether or not a weather forecast distribution time has come.

In step S102, the weather forecast acquisition unit 62a of the air-conditioning management server 60 acquires a weather forecast from the weather forecast server 50 (a weather forecast acquisition step). The “weather forecast” used herein includes, as described above, respective forecast temperatures and humidities each for 24 hours (every one hour).

[0043]

In step S103, the air-conditioning management server 60 estimates a heat load q_f inside the facility K for each prescribed period of time obtained by dividing the 24 hours described above by more than one (for example, every one hour) (a heat load estimation step). Such a heat load is preferably estimated by using a heat load simulator, based on a forecast temperature, a forecast humidity, a set temperature inside the facility K, or the like.

[0044]

In step S104, the energy consumption estimation unit 62c of the air-conditioning management server 60 estimates an energy consumption of the air conditioner A for the each period of time, based on the heat load q_f estimated in step S103 (an energy consumption estimation step). The energy consumption of the air conditioner A is preferably estimated by using a heat source simulator based on the heat load q_f , specification information on the air conditioner A, or the like.

[0045]

In step S105, the power consumption estimation unit 62d of the air-conditioning management server 60 estimates a power consumption $P1_f$ of the air conditioner A for the each period of time, based on the energy consumption estimated in step S104. The power consumption $P1_f$ corresponds to a power consumption when the inside of

the facility K is cooled in a follow-up operation as described above.

In step S106, the air-conditioning management server 60: references the power consumption pattern DB 61a (see FIG. 2); and thereby estimates a power consumption $P2_f$ of each of the instruments (the lighting device R1 and the like) other than the air conditioner A for the each period of time.

[0046]

In step S107, the air-conditioning management server 60: adds the power consumption $P1_f$ of the air conditioner A and the power consumption $P2_f$ of the instruments other than the air conditioner A; and thereby estimates a power consumption $P3_f$ of the loading device described above for the each period of time (a power consumption estimation step).

[0047]

In step S108 illustrated in FIG. 4, the air-conditioning management server 60 sets such that a value $n=1$ and also sets an initial value of a required heat storage capacity Q_v at zero. In accordance with the value n , a period of time represented by a time from $(t1+(n-1)\Delta t)$ to a time $(t1+n\Delta t)$ is determined. A time $t1$ is, for example, 7:00 a.m. when a heat storage operation is terminated and a follow-up operation is started. A prescribed period of time Δt is, for example, one hour.

The required heat storage capacity Q_v is a quantity of cold heat required for compensating a power by which the power consumption $P3_f$ of the loading device exceeds the threshold value P_M (a shaded area in FIG. 5(b)).

[0048]

In step S109, the air-conditioning management server 60 determines whether or not the power consumption $P3_f$ of the loading device is larger than the threshold value P_M in the period of time determined using the value n in step S108. If the power consumption $P3_f$ is larger than the threshold value P_M (S109→Yes), the processing performed by the air-conditioning management server 60 advances to step S110. In

the meantime, if the power consumption P_{3f} is equal to or smaller than the threshold value P_M (S109→No), the processing performed by the air-conditioning management server 60 advances to step S113.

[0049]

In step S110, the air-conditioning management server 60 calculates an excess power ΔP by subtracting the threshold value P_M from the power consumption P_{3f} .

In step S111, the air-conditioning management server 60 calculates a heat storage capacity ΔQ corresponding to the excess power ΔP calculated in step S110. That is, the air-conditioning management server 60 calculates the heat storage capacity ΔQ which is required for compensating a power calculated by a formula of “excess power $\Delta P \times$ prescribed period of time Δt ”. The heat storage capacity ΔQ is calculated based on specification information on the instruments included in the air conditioner A, an estimated value of an outside-air wet-bulb temperature, or the like.

[0050]

In step S112, the air-conditioning management server 60 updates the required heat storage capacity Q_v by adding the heat storage capacity ΔQ calculated in step S111 to the current required heat storage capacity Q_v . Note that if $n=1$, the air-conditioning management server 60 updates the required heat storage capacity Q_v by adding the heat storage capacity ΔQ to zero which is the initial value of the required heat storage capacity Q_v (S108).

[0051]

In step S113, the air-conditioning management server 60 determines whether or not $n=N$, wherein N is a natural number. N corresponds to an ending time of a period of time for which the required heat storage capacity Q_v is estimated (for example, 0:00 midnight of the day after next).

If $n < N$ (S113→No), the processing performed by the air-conditioning management server 60 advances to step S114. In step S114, the air-conditioning

management server 60 increments the value n , and the processing advances to step S109. If, for example, $n=2$, the air-conditioning management server 60: calculates the heat storage capacity ΔQ during the period of time from $(t1+\Delta t)$ to $(t1+2\Delta t)$ on a next day (S111); and adds the calculated heat storage capacity ΔQ to the required heat storage capacity Q_v up to a previous time (S112).

In the meantime, if $n=N$ (S113→Yes), the processing performed by the air-conditioning management server 60 advances to step S115.

[0052]

In step S115, the air-conditioning management server 60 sets a period of time during which a heat storage operation is performed, and a corresponding heat storage capacity (a load factor or the like of the refrigerator 11), such that the required heat storage capacity Q_v lastly updated in step S112 is satisfied. Note that the period of time for the heat storage operation is preferably set such that the heat storage operation is performed in nighttime when a power charge is low.

In step S116, the air-conditioning management server 60 sets a period of time during which a heat release operation is performed, and a corresponding amount of heat release (a flow rate of cold water or the like). The air-conditioning management server 60 sets, for example, an operation schedule such that the heat release operation is performed in a period of time in which the power consumption P_{3f} of the loading device is larger than the threshold value P_M (see FIG. 5(b)). This makes it possible to keep a power consumption of the loading device to not more than the threshold value P_M , when a temperature and a humidity near the facility K have changed just as forecast.

[0053]

In step S117, the schedule setting unit 62e of the air-conditioning management server 60 sets an operation schedule which is made up of the schedule of the heat storage operation set in step S115, the schedule of the heat release operation set in

step S116, and a schedule of a follow-up operation or the like (a schedule setting step). The operation schedule contains: a type of the operation mode (such as a heat storage operation, a follow-up operation, and a heat release operation); and a period of time during which each of the operations is performed (a start time and an ending time).

The air-conditioning management server 60 then transmits the set operation schedule to the controller 40 via the network N.

[0054]

Next are briefly described operations of the air conditioner A consistent with an operation schedule, with reference to FIG. 5.

FIG. 5(a) is an explanatory diagram illustrating a change in a heat load of the air conditioner A. FIG. 5(a) illustrates a heat load during a period of time during which a follow-up operation or a heat release operation is performed (from 7:00 to 22:00). As illustrated in an “estimated heat load” (G1 by solid line) in FIG. 5(a), the heat load of the air conditioner A is estimated to rise from about 9:00 and reach a peak at about 15:00.

[0055]

FIG. 5(b) is a diagram illustrating a change in a power consumption in a case where: a temperature and a humidity have changed just as forecast; and the air conditioner A is operated consistent with an operation schedule based on the forecast. The schedule setting unit 62e sets an operation schedule of the air conditioner A, based on a result of the estimated heat load (see the solid line G1 in FIG. 5(a)). In the case illustrated in FIG. 5(b), a heat storage operation is scheduled from 2:00 to 7:00; a follow-up operation, from 7:00 to 13:00; a heat release operation from 13:00 to 18:00; and another follow-up operation from 18:00 to 22:00.

[0056]

As illustrated as a shaded area in FIG. 5(b), if the follow-up operation is

continued without performing a heat release operation, a power consumption of the loading device from 13:00 to 18:00 disadvantageously exceeds the threshold value P_M . Thus, in order to prevent the power consumption from exceeding the threshold value P_M , the operation schedule is set such that a heat release operation is performed from 13:00 to 18:00.

[0057]

Sometimes a temperature becomes higher than that forecast at relatively early or late in a day. An actual heat load inside the facility K then hits a peak in a period of time different from that estimated based on a weather forecast (see a dashed line G2 and a chain line G3 of FIG. 5(a)). In that case, if a heat release operation is performed as the originally prepared operation schedule, there is a possibility that a power consumption of the loading device exceeds the contracted power demand P_C .

Thus, in this embodiment, the air-conditioning management server 60 is configured to adjust a period of time for the heat release operation in real time, based on an actual measured value by the temperature and humidity sensor 30. FIG. 5(c) and FIG. 5(d) will be described hereinafter.

[0058]

FIG. 6 is a continued flowchart illustrating steps of a processing performed by the air-conditioning management server 60. Before starting step S118, it is assumed that: the heat storage tank 14 stores therein cold heat (a heat storage operation has already been completed); and the controller 40 is performing a follow-up operation or a heat release operation consistent with the operation schedule set in step S117 of FIG. 4.

[0059]

In step S118, the actual measured value acquisition unit 62f of the air-conditioning management server 60 acquires actual measured values of a temperature and a humidity near the facility K, from the controller 40 (an actual

measured value acquisition step). The temperature and humidity described above are values detected by the temperature and humidity sensor 30 immediately before step S118. Alternatively, the actual measured values of the temperature and the humidity may be acquired every five minutes, for example, and respective averages thereof for an hour immediately before a time when step S118 is started may be calculated.

[0060]

In step S119, the heat load calculation unit 62g of the air-conditioning management server 60 calculates a current heat load q_r of the air conditioner A, based on the actual measured values of the temperature and the humidity acquired in step S118 (a heat load calculation step).

In step S120, the energy consumption calculation unit 62h of the air-conditioning management server 60 calculates a current energy consumption of the air conditioner A based on the heat load q_r calculated in step S119 (an energy consumption calculation step).

[0061]

In step S121, the power consumption calculation unit 62i of the air-conditioning management server 60 calculates a power consumption $P1_r$ of the air conditioner A, based on the energy consumption calculated in step S120 (a power consumption calculation step). The power consumption $P1_r$ corresponds to a power consumption assuming that the air conditioner A continues a follow-up operation without performing a heat release operation (see respective portions in broken lines in FIG. 5(c) and FIG. 5(d)).

In step S122, the air-conditioning management server 60: references the power consumption pattern DB 61a (see FIG. 2); and reads therefrom a power consumption $P2_r$ of the instruments other than the air conditioner A (the lighting device R1 and the like).

[0062]

In step S123, the air-conditioning management server 60 adds up the power consumption $P1_r$ of the air conditioner A and the power consumption $P2_r$ of the instruments other than the air conditioner A, to thereby calculate a power consumption $P3_r$ of the loading device.

[0063]

In step S124 of FIG. 7, the air-conditioning management server 60 determines whether or not the current heat load q_r calculated in step S119 (see FIG. 6) is equal to or larger than the heat load q_f estimated in step S103 (see FIG. 3).

If the current heat load q_r is equal to or larger than the estimated heat load q_f (S124→Yes), the processing performed by the air-conditioning management server 60 advances to step S125. For example, a temperature measured by the temperature and humidity sensor 30 is higher than an estimated value distributed by the weather forecast server 50, it is more likely that $q_r \geq q_f$.

[0064]

In step S125, the air-conditioning management server 60 determines whether or not the period of time for a heat release operation set in step S116 (see FIG. 4) contains a current time. If the period of time for the heat release operation does not contain the current time (S125→No), the processing performed by the air-conditioning management server 60 advances to step S126. For example, if the period of time for the heat release operation in the operation schedule is from 13:00 to 18:00 (see FIG. 5(b)) and the current time is 11:00, the processing performed by the air-conditioning management server 60 advances to step S126.

[0065]

In step S126, the air-conditioning management server 60 determines whether or not the power consumption $P3_r$ of the loading device calculated in step S123 (see FIG. 6) is larger than the threshold value P_M . If the power consumption $P3_r$ is larger than the threshold value P_M (S126→Yes), the processing performed by the

air-conditioning management server 60 advances to step S127.

[0066]

FIG. 5(c) is an explanatory diagram illustrating a change in a power consumption in a case where: a heat load changes as indicated by the dashed line G2 in FIG. 5(a); and a start time of a heat release operation is advanced from a scheduled one. In an example illustrated in FIG. 5(a), the heat load q_r (the dashed line G2) based on the actual measured values is larger than the heat load q_f (the solid line G1) based on the weather forecast during the period of time from 7:00 to 14:00.

In this case, if the follow-up operation is continued, as indicated by the broken line of FIG. 5(c), the power consumption P_{3r} of the loading device exceeds the threshold value P_M at 11:00. That is, if the heat release operation is started at 13:00 consistent with the operation schedule illustrated in FIG. 5(b), there is a possibility that the power consumption of the loading device temporarily exceeds the contracted power demand P_C from 11:00 to 13:00.

[0067]

Referring back to FIG. 7, explanation of the flowchart is continued.

In step S127, the air-conditioning management server 60 determines whether or not the heat storage tank 14 has stored therein cold heat. The air-conditioning management server 60 performs the determination in step S127 by, for example: subtracting an amount of cold heat consumed by the secondary air conditioner 20 during a heat release operation, from an amount of cold heat generated by the primary air conditioner 10 during a heat storage operation; and determining whether or not the obtained difference is larger than zero.

[0068]

If the heat storage tank 14 has stored therein cold heat (S127→Yes), the processing performed by the air-conditioning management server 60 advances to step S128.

In step S128, the air-conditioning management server 60 generates an instruction signal indicating that a heat release operation is to be performed (started) (an instruction signal generation step). That is, the air-conditioning management server 60 advances a start time of the heat release operation from a scheduled start time, if the power consumption P_{3r} has exceeded the threshold value P_M before the scheduled start time of the heat release operation.

[0069]

In an example illustrated in FIG. 5(b), the scheduled start time of the heat release operation is at 13:00, which is, as illustrated in FIG. 5(c), changed to at 11:00 by the air-conditioning management server 60. As described above, advancement of the start time of the heat release operation makes it possible to reduce a power consumption of the air conditioner A and prevent the power consumption P_{3r} of the loading device from exceeding the contracted power demand P_C (>threshold value P_M).

[0070]

Meanwhile, in step S127, if the heat storage tank 14 has not stored therein cold heat (S127→No), the processing performed by the air-conditioning management server 60 advances to step S129. In step S129, the air-conditioning management server 60 determines that the heat release operation is not to be performed (continued).

Note that, though the heat storage tank 14 has stored therein cold heat when the heat release operation is started, if the period of time for the heat release operation is advanced as described above, there is a possibility that the heat storage tank 14 runs out of the cold heat at a later time before the period of time ends.

[0071]

In step S130, the air-conditioning management server 60 thus generates an instruction signal indicating that an operation other than the heat release operation is

to be performed. In order to keep a power consumption of the loading device not more than the threshold value P_M , the air-conditioning management server 60, for example, reduces a power consumption of the lighting device R1 or the like than normal, while continuing a follow-up operation.

In step S125, if the period of time for the release heat operation contains the current time (S125→Yes), the processing performed by the air-conditioning management server 60 advances to step S127 (for example, at 15:00 in FIG. 5(c)). Note that step S127 and subsequent steps of the processing are as described above. [0072]

In step S126, if the current power consumption P_{3r} is not more than the threshold value P_M (S126→No), the processing performed by the air-conditioning management server 60 advances to step S131. In step S131, the air-conditioning management server 60 generates an instruction signal indicating that a heat release operation is not yet to be performed (started).

In some cases, for example, though the heat load q_r based on actual measured values of a temperature and a humidity is larger than the heat load q_f based on a weather forecast, the power consumption P_r still does not exceed the threshold value P_M (for example, at 9:00 in FIG. 5(a) and FIG. 5(c)). In this case, it is not necessary to perform the heat release operation (S131).

[0073]

In step S124, if the current heat load q_r is smaller than the estimated heat load q_f (S124→No), the processing performed by the air-conditioning management server 60 advances to step S132.

In step S132, the air-conditioning management server 60 determines whether or not the period of time for heat release set in step S116 (see FIG. 4) contains the current time. If the scheduled period of time for heat release does not contain the current time (S132→No), the processing performed by the air-conditioning

management server 60 advances to step S133.

In step S133, the air-conditioning management server 60 determines that the heat release operation is not yet performed (started).

[0074]

In step S132, if the scheduled period of time for heat release contains the current time (S132→Yes), the processing performed by the air-conditioning management server 60 advances to step S134.

In step S134, the air-conditioning management server 60 determines whether or not the current power consumption P_{3r} calculated in step S123 has exceeded the threshold value P_M . If the current power consumption P_{3r} has exceeded the threshold value P_M (S134→Yes), the processing performed by the air-conditioning management server 60 advances to step S135.

[0075]

In step S135, the air-conditioning management server 60 determines whether or not the heat storage tank 14 has stored therein cold heat. If the heat storage tank 14 is determined to have stored therein cold heat (S135→Yes), the processing of the air-conditioning management server 60 advances to step S136.

In step S136, the air-conditioning management server 60 generates an instruction signal indicating that a heat release operation is to be performed (started). That is, though a heat load of the air conditioner A is still somewhat smaller than estimated, if the power consumption of the loading device has exceeded the threshold value P_M , the controller 40 performs the heat release operation (for example, at past 15:00 in FIG. 5(a) and FIG.(c)).

[0076]

Meanwhile, if the heat storage tank 14 has not stored therein cold heat (S135→No), the processing performed by the air-conditioning management server 60 advances to step S137. In step S137, the air-conditioning management server 60

determines that a heat release operation is not to be performed (continued).

In step S138, the air-conditioning management server 60 generates an instruction signal indicating that an operation other than the heat release operation (for example, a reduction of a power consumption of the lighting device R1 and the like) is to be performed.

[0077]

In step S134, if the current power consumption P_{3r} is not more than the threshold value P_M (S134→No), the air-conditioning management server 60 generates an instruction signal indicating that a heat release operation is not to yet be performed (started) in step S133. That is, the air-conditioning management server 60 delays a start time of the heat release operation, if the power consumption P_{3r} is not more than the threshold value P_M after a scheduled start time of the heat release operation.

[0078]

FIG. 5 (d) is an explanatory diagram illustrating a change in a power consumption in a case where: a heat load is changed as indicated by the chain line G3 in FIG. 5(a); and a start time of a heat release operation is thus delayed than scheduled. In the example illustrated in FIG. 5(a), the heat load q_r (the chain line G3) based on the actual measured values is smaller than the heat load q_f (the solid line G1) based on the weather forecast, from 7:00 to 17:00.

In this case, if a heat release operation is started at 13:00 consistent with the operation schedule illustrated in FIG. 5(b), the cold heat having been stored in the heat storage tank 14 will be wasted. This is because, even if the follow-up operation is continued until 14:00, the power consumption can be kept equal to or less than the threshold value P_M . As illustrated in FIG. 5 (d), delay in the start time of the heat release operation until 14:00 (S133: see FIG. 7) makes it possible to be readily prepared for a possible increase in the heat load q_f at a later time (for example, at

16:00 in FIG. 5 (d)).

[0079]

In step S139 of FIG. 8, the instruction signal transmission unit 62k of the air-conditioning management server 60 transmits the instruction signal generated in step S128 or the like to the controller 40 (an instruction signal transmission step).

In step S140, the air-conditioning management server 60 calculates a remaining heat storage capacity of the heat storage tank 14. More specifically, the air-conditioning management server 60 calculates the remaining heat storage capacity of the heat storage tank 14 based on an amount of cold heat supplied to the secondary air conditioner 20 during the heat release operation. The remaining heat storage capacity is used in steps S127 and S135 to be performed in a next cycle (the determination on whether or not heat has been stored: see FIG. 7).

[0080]

In step S141, the air-conditioning management server 60 determines whether or not a weather forecast distribution time has come. If the weather forecast distribution time has already come (S141→Yes), the processing performed by the air-conditioning management server 60 returns to step S102 of FIG. 3.

Meanwhile, if the weather forecast distribution time has not yet come (S141→No), the processing performed by the air-conditioning management server 60 returns to step S118 of FIG. 6. Note that a series of steps S118 to S141 are repeatedly performed at every time when a weather forecast is made (for example, every one hour). Steps S118 to S141 may be performed, for example, every few minutes or every few seconds.

[0081]

<Advantageous Effects>

In this embodiment, when the power consumption P_{3r} of the loading device has exceeded the threshold value P_M before the scheduled start time of the heat release

operation (S126→Yes), the air-conditioning management server 60 advances the start time of the heat release operation (S128). This makes it possible to appropriately level off power of the loading device, compared to a case where the air conditioner A is controlled consistent with an operation schedule.

In this embodiment, when the power consumption P_{3r} of the loading device does not exceed the threshold value P_M after the scheduled start time of the heat release operation (S134→No), the air-conditioning management server 60 delays the start time of the heat release operation (S133). This makes it possible to effectively use the cold heat stored in the heat storage tank 14 so as to be ready for a heat load possibly becoming larger than estimated at a later time.

[0082]

In this embodiment, the air-conditioning management server 60: checks whether or not a period of time for heat release in an operation schedule is appropriate on a real time basis, based on an actual measured temperature and humidity; and transmits an appropriate instruction signal to the controller 40 according to the check result. This makes it possible to control a power consumption of the loading device by, for example, immediately starting a heat release operation, when a weather forecast has been off and a heat load inside the facility K shows a rapid rise. It is thus possible to prevent the power consumption of the loading device from exceeding the contracted power demand P_C .

[0083]

In this embodiment, the air-conditioning system S is a system using cloud computing in which the air-conditioning management server 60 consolidates information on a plurality of the air conditioners A and provides a number of users with the information. Thus, what a user should prepare is only a minimum connection environment, which allows a drastic reduction in cost required for managing the air conditioners A.

In this embodiment, the processing performed by the air-conditioning management server 60 is automatically performed using a heat source simulator or the like. It is thus possible to level off a power consumption with high accuracy, compared to a case where an operator adjusts an operation schedule by trial and error.

[0084]

«Second Embodiment»

A second embodiment is similar to the first embodiment except that: an air-conditioning system S according to the second embodiment includes the air-conditioning system S according to the first embodiment with added thereto a power meter 70 (see FIG. 9) that measures a power consumption of each of the instruments; and an air-conditioning management server 60A (see FIG. 10) according to the second embodiment has a configuration different from that according to the first embodiment. Description in this embodiment is made focusing on those different from the first embodiment, and duplicate description will be omitted herefrom.

[0085]

FIG. 9 is a diagram illustrating a structure of an air-conditioning system including an air-conditioning management server according to this embodiment. The power meter 70 measures the power consumption $P3_r$ (a total value) of each of the refrigerator 11, the blower 12a, the cooling water pump 13, the primary cooling water pump 15, the secondary cooling water pump 21, the indoor fan 22b, and each of the other instruments in the facility K. The each value of the power consumption $P3_r$ measured by the power meter 70 is outputted to the controller 40. The controller 40 transmits the actual values measured by the temperature and humidity sensor 30 and the power meter 70, for example, every five minutes to the air-conditioning management server 60A via the network N.

[0086]

<Configuration of Air-Conditioning Management Server>

FIG. 10 is a diagram illustrating a configuration of the air-conditioning management server 60A according to this embodiment.

The air-conditioning management server 60A illustrated in FIG. 10 has a configuration similar to that of the first embodiment, except that the air-conditioning management server 60A: has no energy consumption calculation unit 62h (see FIG. 2) which is provided in the air-conditioning management server 60 (see FIG. 2) described in the first embodiment; and has a power consumption acquisition unit 62m in place of the power consumption calculation unit 62i (see FIG. 2).

The power consumption acquisition unit 62m acquires an actual measured value of the power meter 70 (that is, an actual power consumption of the loading device), from the controller 40 via the network N. The actual measured value of the power consumption acquired by the power consumption acquisition unit 62m is outputted to the power consumption comparison unit 622j.

Note that the power consumption comparison unit 622j determines which is larger, the actual measured value of the power consumption or the threshold value P_M .
[0087]

<Operations of Air-Conditioning Management Server>

FIG. 11 is a flowchart illustrating steps of a processing performed by the air-conditioning management server.

Note that the processing of setting an operation schedule of the air conditioner A (S101 to S117: see FIG. 3 and FIG. 4) is same as that of the first embodiment. Also note that when a processing illustrated in FIG. 11 is started, the air conditioner A is performing a follow-up operation or a heat release operation.

[0088]

In step S118, the actual measured value acquisition unit 62f of the air-conditioning management server 60A acquires an actual measured value of each

of a temperature and a humidity near the facility K from the controller 40.

In step S119, the heat load calculation unit 62g of the air-conditioning management server 60A calculates a current heat load q_r of the air conditioner A, based on the actual measured values of the temperature and humidity acquired in step S119. The heat load q_r is used in a processing for comparison with an estimated heat load q_f (S124: see FIG. 12).

Next, in step S201, the power consumption acquisition unit 62m of the air-conditioning management server 60A acquires a current power consumption P_s of the loading device from the controller 40 (a power consumption acquisition step). As described above, the power consumption P_s is a value actually measured by the power meter 70.

[0089]

After step S201, the processing performed by the air-conditioning management server 60A advances to step S124 illustrated in FIG. 12. Note that the steps illustrated in FIG. 12, except steps S202 and S203, are similar to those in the flowchart of FIG. 7 described in the first embodiment.

[0090]

If, for example, before the scheduled start time of the heat release operation (S125→No), the measured power consumption P_s has exceeded the threshold value P_M (S202→Yes), the air-conditioning management server 60A advances the start time of the heat release operation than scheduled (S128).

If, after the scheduled start time of the heat release operation (S132→Yes), the measured power consumption P_s does not exceed the threshold value P_M (S203→No), the air-conditioning management server 60A delays the start time of the heat release operation than scheduled (S133).

Note that steps S139 to S141 are same as those explained in the first embodiment illustrated in FIG. 8, description of which is thus omitted herefrom.

[0091]

<Advantageous Effects>

In this embodiment, similarly to the first embodiment, an operation schedule can be flexibly changed in accordance with actually measured temperature and humidity.

In the first embodiment, the power consumption $P1_r$ of the air conditioner A is calculated based on a value actually measured by the temperature and humidity sensor 30 (S121: see FIG. 6); the power consumption $P2_r$ of the instruments other than the air conditioner A is read from the power consumption pattern DB 61a (S122); and the former and the latter are added up, to thereby obtain the power consumption $P3_r$ of the loading device (S123).

Meanwhile, in this embodiment, the power meter 70 directly measures a power consumption of the loading device. This makes it possible to determine whether or not the power consumption of the loading device has actually exceeded the threshold value P_M with high accuracy. An operation schedule can be thus adjusted more accurately than the first embodiment.

[0092]

«Variations»

The air-conditioning management servers 60, 60A of the present invention are described above according to the respective embodiments. The present invention is not, however, limited to those explanations, and various modifications can be made to the present invention.

For example, in each of the embodiments, description is made assuming that the air-conditioning management server 60 (or 60A) sets and adjusts all operation schedules of a plurality of the air conditioners A in a centralized manner. Alternatively, the processing can be distributed to a plurality of servers.

[0093]

In each of the embodiments, description is made assuming that whether or not the current heat load q_r is equal to or larger than the estimated heat load q_f is determined (S124: see FIG. 7). The present invention is not, however, limited to this. Alternatively, regardless of which of the heat loads q_r , q_f is larger or smaller, a processing in which a heat release operation is continued for a prescribed period of time can be repeatedly performed, only when a power consumption measured by the power meter 70 has exceeded the threshold value P_M . Also in this variation, the power consumption of the loading device can be prevented from exceeding the contracted power demand P_C .

[0094]

In each of the embodiments, description is made assuming that what is acquired by the weather forecast acquisition unit 62a as a weather forecast is a forecast temperature and a forecast humidity near the facility K. The present invention is not, however, limited to this. For example, in addition to the above-described values, the weather forecast can contain an estimated value of an amount of solar radiation.

In each of the embodiments, description is made assuming that a minimum cold heat which is required for compensating a power by which the power consumption P_{3f} exceeds the threshold value P_M is stored in the heat storage tank 14. The present invention is not, however, limited to this. For example, the heat storage tank 14 can be kept full by performing a heat storage operation, regardless of what is acquired as a weather forecast.

[0095]

In each of the embodiments, description is made assuming that the air-conditioning management server 60 which is a computer is made to execute a series of steps (FIG. 3, FIG. 4 to FIG. 8 and the like) using an appropriate program. The present invention is not, however, limited to this. Alternatively, the above-described program can be provided via a communications line or can be

distributed after being written to a recording medium such as a CD-ROM.

Part or all of the configurations, functions, processing parts, processing units, or the like described above can be embodied by hardware by means of, for example, designing of integrated circuits. In the description, only structures and configurations which are deemed necessary for explanation are illustrated, and not all of them which are otherwise necessary as a final product are illustrated.

[DESCRIPTION OF REFERENCE CHARACTERS]

[0096]

- S air-conditioning system
- K facility
- A air conditioner (loading device)
- 11 refrigerator
- 14 cooling tower
- 30 temperature and humidity sensor
- 40 controller (management terminal)
- 50 weather forecast server
- 60, 60A air-conditioning management server (air-conditioning management device)
- 62a weather forecast acquisition unit
- 62b heat load estimation unit
- 62c energy consumption estimation unit
- 62d power consumption estimation unit
- 62e schedule setting unit
- 62f actual measured value acquisition unit
- 62g heat load calculation unit
- 62h energy consumption calculation unit

- 62i power consumption calculation unit
- 62j instruction signal generation unit
- 62k instruction signal transmission unit
- 62m power consumption acquisition unit
- 70 power meter

[DOCUMENT NAME] CLAIMS

[Claim 1]

An air-conditioning management device, comprising:

a weather forecast acquisition unit that is configured to acquire a weather forecast containing a forecast temperature and a forecast humidity;

a heat load estimation unit that is configured to estimate a heat load inside a facility which is air-conditioned by an air conditioner, the air conditioner including a refrigerator and a cooling tower which stores therein cold heat generated by the refrigerator, based on the weather forecast acquired by the weather forecast acquisition unit;

an energy consumption estimation unit that is configured to estimate an energy consumption of the air conditioner in a case where the refrigerator supplies the facility with cold heat, based on the heat load estimated by the heat load estimation unit;

a power consumption estimation unit that is configured to estimate a power consumption of a loading device which includes the air conditioner, based on the energy consumption estimated by the energy consumption estimation unit;

a schedule setting unit that is configured to set an operation schedule of the air conditioner, based on the power consumption estimated by the power consumption estimation unit;

an actual measured value acquisition unit that is configured to acquire actual measured values including a temperature and a humidity near the facility;

a heat load calculation unit that is configured to calculate a heat load inside the facility, based on the actual measured values acquired by the actual measured value acquisition unit;

an energy consumption calculation unit that is configured to calculate an energy consumption of the air conditioner in the case where the refrigerator supplies

the facility with cold heat, based on the heat load calculated by the heat load calculation unit;

a power consumption calculation unit that is configured to calculate a power consumption of the loading device, based on the energy consumption calculated by the energy consumption calculation unit;

an instruction signal generation unit that is configured to generate an instruction signal on whether or not a heat release operation is to be performed, the heat release operation being an operation of supplying the inside of the facility with the cold heat stored in the cooling tower; and

an instruction signal transmission unit that is configured to transmit the instruction signal generated by the instruction signal generation unit, to a management terminal of the air conditioner,

wherein the instruction signal generation unit

generates an instruction signal indicating that a start time of the heat release operation is to be advanced, if, before a scheduled start time of the heat release operation in the operation schedule, the power consumption calculated by the power consumption calculation unit becomes larger than a prescribed threshold value, the prescribed threshold value being a reference value for determining whether or not the heat release operation is to be performed, and

generates an instruction signal indicating that the start time of the heat release operation is to be delayed, if, after the scheduled start time of the heat release operation in the operation schedule, the power consumption calculated by the power consumption calculation unit becomes equal to or smaller than the prescribed threshold value.

[Claim 2]

An air-conditioning management device, comprising:

a weather forecast acquisition unit that is configured to acquire a weather

forecast containing a forecast temperature and a forecast humidity;

a heat load estimation unit that is configured to estimate a heat load inside a facility which is air-conditioned by an air conditioner, the air conditioner including a refrigerator and a cooling tower which stores therein cold heat generated by the refrigerator, based on the weather forecast acquired by the weather forecast acquisition unit;

an energy consumption estimation unit that is configured to estimate an energy consumption of the air conditioner in a case where the refrigerator supplies the facility with cold heat, based on the heat load estimated by the heat load estimation unit;

a power consumption estimation unit that is configured to estimate a power consumption of a loading device which includes the air conditioner, based on the energy consumption estimated by the energy consumption estimation unit;

a schedule setting unit that is configured to set an operation schedule of the air conditioner, based on the power consumption estimated by the power consumption estimation unit;

a power consumption acquisition unit that is configured to acquire an actual measured value of a power consumption of the loading device;

an instruction signal generation unit that is configured to generate an instruction signal on whether or not a heat release operation is to be performed, the heat release operation being an operation of supplying an inside of the facility with the cold heat stored in the cooling tower; and

an instruction signal transmission unit that is configured to transmit the instruction signal generated by the instruction signal generation unit, to a management terminal of the air conditioner;

wherein the instruction signal generation unit

generates an instruction signal indicating that a start time of the heat

release operation is to be advanced, if, before a scheduled start time of the heat release operation in the operation schedule, the power consumption calculated by the power consumption calculation unit becomes larger than a prescribed threshold value, the prescribed threshold value being a reference value for determining whether or not the heat release operation is to be performed, and

generates an instruction signal indicating that the start time of the heat release operation is to be delayed, if, after the scheduled start time of the heat release operation in the operation schedule, the power consumption calculated by the power consumption calculation unit becomes equal to or smaller than the prescribed threshold value.

[Claim 3]

An air-conditioning management method, comprising:

a weather forecast acquisition step of acquiring a weather forecast containing a forecast temperature and a forecast humidity;

a heat load estimation step of estimating a heat load inside a facility which is air-conditioned by an air conditioner, the air conditioner including a refrigerator and a cooling tower which stores therein cold heat generated by the refrigerator, based on the weather forecast acquired in the weather forecast acquisition step;

an energy consumption estimation step of estimating an energy consumption of the air conditioner in a case where the refrigerator supplies the facility with cold heat, based on the heat load estimated in the heat load estimation step;

a power consumption estimation step of estimating a power consumption of a loading device which includes the air conditioner, based on the energy consumption estimated in the energy consumption estimation step;

a schedule setting step of setting an operation schedule of the air conditioner, based on the power consumption estimated in the power consumption estimation step;

an actual measured value acquisition step of acquiring actual measured values including a temperature and a humidity near the facility;

a heat load calculation step of calculating a heat load inside the facility, based on the actual measured values acquired in the actual measured value acquisition step;

an energy consumption calculation step of calculating an energy consumption of the air conditioner in the case where the refrigerator supplies the facility with cold heat, based on the heat load calculated in the heat load calculation step;

a power consumption calculation step of calculating a power consumption of the loading device, based on the energy consumption calculated in the energy consumption calculation step;

an instruction signal generation step of generating an instruction signal on whether or not a heat release operation is to be performed, the heat release operation being an operation of supplying the inside of the facility with the cold heat stored in the cooling tower; and

an instruction signal transmission step of transmitting the instruction signal generated in the instruction signal generation step, to a management terminal of the air conditioner,

wherein, in the instruction signal generation step,

an instruction signal is generated indicating that a start time of the heat release operation is to be advanced, if, before a scheduled start time of the heat release operation in the operation schedule, the power consumption calculated in the power consumption calculation step becomes larger than a prescribed threshold value, the prescribed threshold value being a reference value for determining whether or not the heat release operation is to be performed, and

an instruction signal is generated indicating that the start time of the heat release operation is to be delayed, if, after the scheduled start time of the heat

release operation in the operation schedule, the power consumption calculated in the power consumption calculation step becomes equal to or smaller than the prescribed threshold value.

[Claim 4]

An air-conditioning management method, comprising:

a weather forecast acquisition step of acquiring a weather forecast containing a forecast temperature and a forecast humidity;

a heat load estimation step of estimating a heat load inside a facility which is air-conditioned by an air conditioner, the air conditioner including a refrigerator and a cooling tower which stores therein cold heat generated by the refrigerator, based on the weather forecast acquired in the weather forecast acquisition step;

an energy consumption estimation step of estimating an energy consumption of the air conditioner in a case where the refrigerator supplies the facility with cold heat, based on the heat load estimated by the heat load estimation unit;

a power consumption estimation step of estimating a power consumption of a loading device which includes the air conditioner, based on the energy consumption estimated in the energy consumption estimation step;

a schedule setting step of setting an operation schedule of the air conditioner, based on the power consumption estimated in the power consumption estimation step;

a power consumption acquisition step of acquiring an actual measured value of a power consumption of the loading device;

an instruction signal generation step of generating an instruction signal on whether or not a heat release operation is to be performed, the heat release operation being an operation of supplying an inside of the facility with the cold heat stored in the cooling tower; and

an instruction signal transmission step of transmitting the instruction signal

generated in the instruction signal generation step, to a management terminal of the air conditioner,

wherein, in the instruction signal generation step,

an instruction signal is generated indicating that a start time of the heat release operation is to be advanced, if, before a scheduled start time of the heat release operation in the operation schedule, the power consumption calculated in the power consumption calculation step becomes larger than a prescribed threshold value, the prescribed threshold value being a reference value for determining whether or not the heat release operation is to be performed, and

an instruction signal is generated indicating that the start time of the heat release operation is to be delayed, if, after the scheduled start time of the heat release operation in the operation schedule, the power consumption calculated in the power consumption calculation step becomes equal to or smaller than the prescribed threshold value.

[Claim 5]

A program for causing a computer to perform the air-conditioning management method according to claim 3 or 4.