

Description

Title of Invention: CONTROL SYSTEM, GEOTHERMAL HEAT
UTILIZATION SYSTEM, CONTROL METHOD, AND PROGRAM

5 Technical Field

[0001]

The present disclosure relates to a control system, a geothermal heat utilization system, a control method, and a program.

The present application claims priority to Japanese Patent Application
10 No. 2023-136261 filed in Japan on August 24, 2023, the content of which is incorporated herein by reference.

Background Art

[0002]

15 In recent years, geothermal heat utilization systems that use groundwater as a hot heat source or a cold energy source have been proposed.

[0003]

For example, Patent Document 1 discloses a geothermal heat utilization system including a heat source well facility having a hot water well, a cold
20 water well, a well-side pipe, and a pump provided in the well-side pipe, a heat source device having a refrigeration cycle, a primary refrigerant circuit capable of exchanging heat between the heat source device and the well-side pipe, and a secondary refrigerant circuit capable of exchanging heat between the heat source device and a load. In this system, the heat source device includes a
25 condenser and an evaporator. This geothermal heat utilization system is configured such that a mode can be switched between a cold energy storage operation mode and a cold energy discharge operation mode in accordance with the season. In the cold energy storage operation mode, heat is exchanged between the evaporator of the heat source device and the well-side pipe, and
30 heat is also exchanged between the condenser of the heat source device and the load. In the cold energy discharge operation mode, heat is exchanged between the condenser of the heat source device and the well-side pipe, and heat is also exchanged between the evaporator of the heat source device and the load.

35 Citation List

Patent Literature

[0004]

Patent Document 1: JP 6857883 B

5 In the geothermal heat utilization system disclosed in Patent Document 1, in preparation for discharging cold energy in the cold energy discharge operation mode, the cold energy storage operation mode is performed in summer, night, winter, and the like, thereby maintaining the balance of a heat storage amount. However, when an operation is performed in the cold energy discharge operation mode, the amount of cold energy stored in the cold energy storage operation mode may be insufficient or excessive with respect to the amount of heat required in a peak period. For this reason, there is a problem that it is difficult to balance a heat storage amount of an aquifer.

15 The present disclosure has been made to solve the above-described problem, and an object thereof is to provide a control system, a geothermal heat utilization system, a control method, and a program which make it possible to easily balance a heat storage amount of an aquifer.

In order to solve the above problem, a control system according to the present disclosure is a control system that controls a geothermal heat utilization system including a heat source well facility including a hot water well and a cold water well, and an auxiliary heat storage facility including a cooling tower and a heat source device, the control system including: an operation control unit configured to switch a mode of the geothermal heat utilization system between a first cold energy storage mode in which hot heat stored in the hot water well is supplied to the cooling tower without going through the heat source device, and cold energy obtained from the cooling tower is stored in the cold water well without going through the heat source device, a second cold energy storage mode in which the hot heat stored in the hot water well is supplied to the cooling tower via the heat source device, and the cold energy obtained from the cooling tower is stored in the cold water well via the heat source device, a first cold energy discharge mode in which the cold energy stored in the cold water well is supplied to a device without going through the heat source device, and a second cold energy discharge mode in which the cold energy stored in the cold water well is supplied to the device via the heat

source device; a calculation unit configured to calculate a cumulative cold energy storage amount that is a cold energy storage amount stored in the cold water well; a prediction unit configured to predict a required cold energy storage amount that is a cold energy storage amount required for cooling the device; and a mode determination unit configured to determine whether to perform control in the first cold energy storage mode or in the second cold energy storage mode, based on the cumulative cold energy storage amount and the required cold energy storage amount.

[0008]

A geothermal heat utilization system according to the present disclosure includes the above-described control system, the heat source well facility, and the auxiliary heat storage facility.

[0009]

A control method according to the present disclosure includes calculating a cumulative cold energy storage amount which is a cold energy storage amount stored in a cold water well of a geothermal heat utilization system which includes a heat source well facility including a hot water well and the cold water well, and an auxiliary heat storage facility including a cooling tower and a heat source device, the geothermal heat utilization system having a mode switchable between a first cold energy storage mode in which hot heat stored in the hot water well is supplied to the cooling tower without going through the heat source device, and cold energy obtained from the cooling tower is stored in the cold water well without going through the heat source device, a second cold energy storage mode in which the hot heat stored in the hot water well is supplied to the cooling tower via the heat source device, and the cold energy obtained from the cooling tower is stored in the cold water well via the heat source device, a first cold energy discharge mode in which the cold energy stored in the cold water well is supplied to a device without going through the heat source device, and a second cold energy discharge mode in which the cold energy stored in the cold water well is supplied to the device via the heat source device; predicting a required cold energy storage amount that is a cold energy storage amount required for cooling the device; and determining whether to perform control in the first cold energy storage mode or in the second cold energy storage mode, based on the cumulative cold energy storage amount and the required cold energy storage amount.

[0010]

A program according to the present disclosure includes processing executable by a computer of a geothermal heat utilization system which

includes a heat source well facility including a hot water well and a cold water well, and an auxiliary heat storage facility including a cooling tower and a heat source device, the geothermal heat utilization system having a mode switchable between a first cold energy storage mode in which hot heat stored in the hot water well is supplied to the cooling tower without going through the heat source device, and cold energy obtained from the cooling tower is stored in the cold water well without going through the heat source device, a second cold energy storage mode in which the hot heat stored in the hot water well is supplied to the cooling tower via the heat source device, and the cold energy obtained from the cooling tower is stored in the cold water well via the heat source device, a first cold energy discharge mode in which the cold energy stored in the cold water well is supplied to a device without going through the heat source device, and a second cold energy discharge mode in which the cold energy stored in the cold water well is supplied to the device via the heat source device, the program causing the computer to execute the processing including calculating a cumulative cold energy storage amount which is a cold energy storage amount stored in the cold water well; predicting a required cold energy storage amount that is a cold energy storage amount required for cooling the device; and determining whether to perform control in the first cold energy storage mode or in the second cold energy storage mode, based on the cumulative cold energy storage amount and the required cold energy storage amount.

Advantageous Effects of Invention

[0011]

According to a control system, a geothermal heat utilization system, a control method, and a program of the present disclosure, it is possible to easily balance a heat storage amount of an aquifer.

Brief Description of Drawings

[0012]

FIG. 1 is a system diagram illustrating a schematic configuration of a geothermal heat utilization system according to an embodiment of the present disclosure.

FIG. 2 is a diagram illustrating flows of groundwater and a medium when an operation is performed in a first cold energy storage mode in the geothermal heat utilization system according to the embodiment of the present disclosure.

FIG. 3 is a diagram illustrating flows of groundwater and a medium when an operation is performed in a second cold energy storage mode in the geothermal heat utilization system according to the embodiment of the present disclosure.

FIG. 4 is a diagram illustrating flows of groundwater and a medium when an operation is performed in a first cold energy discharge mode in the geothermal heat utilization system according to the embodiment of the present disclosure.

FIG. 5 is a diagram illustrating flows of groundwater and a medium when an operation is performed in a second cold energy discharge mode in the geothermal heat utilization system according to the embodiment of the present disclosure.

FIG. 6 is a block diagram illustrating a functional configuration of a control system according to the embodiment of the present disclosure.

FIG. 7 is a flowchart showing a flow of a control method according to
15 the embodiment of the present disclosure.

FIG. 8 is a diagram illustrating an example of a hardware configuration of a computer included in each of a computation device and a control system according to the embodiment of the present disclosure.

20 Description of Embodiments

[0013]

An embodiment of a geothermal heat utilization system according to the present disclosure will be described below with reference to FIGS. 1 to 8.

Configuration of Geothermal heat Utilization System

As illustrated in FIG. 1, a geothermal heat utilization system 1 mainly includes a heat source well facility 10, an auxiliary heat storage facility 100, a heat exchanger 4, and a control system 300 (see FIG. 6).

[0014]

Configuration of Heat Source Well Facility

As illustrated in FIG. 1, the heat source well facility 10 mainly includes a hot water well 21, a cold water well 22, a well-side pipe 3, and pumps 31.

[0015]

Each of the hot water well 21 and the cold water well 22 extends from the ground into an aquifer.

Each of the hot water well 21 and the cold water well 22 is configured to take in groundwater in the aquifer and return the groundwater from the inside of each of the hot water well 21 and the cold water well 22 to the aquifer.

[0016]

The heat source well facility 10 pumps the groundwater from one of the hot water well 21 and the cold water well 22, performs heat exchange at the heat exchanger 4, and then injects the heat-exchanged groundwater into the other of the hot water well 21 and the cold water well 22. In other words, the heat source well facility 10 may pump up groundwater from the hot water well 21 and inject it into the cold water well 22, or may pump up groundwater from the cold water well 22 and inject it into the hot water well 21.

[0017]

The well-side pipe 3 connects the hot water well 21 and the cold water well 22.

Both ends of the well-side pipe 3 extend to the insides of the hot water well 21 and the cold water well 22.

For example, both ends of the well-side pipe 3 may be individually immersed in the groundwater of the hot water well 21 and the groundwater of the cold water well 22 to connect the hot water well 21 and the cold water well 22.

[0018]

The well-side pipe 3 is provided with the pumps 31.

Each of both end portions of the well-side pipe 3 is provided with a corresponding one of the pumps 31.

The pumps 31 pump up the water from the hot water well 21 and the cold water well 22 to the well-side pipe 3.

For example, the pumps 31 may be provided at both ends of the well-side pipe 3 and immersed in the groundwater of the hot water well 21 and the groundwater of the cold water well 22.

For example, the output of the pump 31 may be changeable through inverter control.

[0019]

The heat exchanger 4 exchanges heat between the groundwater in the well-side pipe 3 and the medium in a refrigerant circuit 101 (to be described later) on the auxiliary heat storage facility 100 side.

In the present embodiment, the heat exchanger 4 includes a first heat exchanger 41 and a second heat exchanger 42.

The first heat exchanger 41 and the second heat exchanger 42 are disposed in series with respect to the well-side pipe 3.

The first heat exchanger 41 and the second heat exchanger 42 are individually connected to the well-side pipe 3.

One side of the first heat exchanger 41 and one side of the second heat exchanger 42 are connected to the middle of the well-side pipe 3.

The other side of the first heat exchanger 41 and the other side of the second heat exchanger 42 are connected to the refrigerant circuit 101 to be described later.

By opening and closing an on-off valve (not shown) provided between the well-side pipe 3 and each of the first heat exchanger 41 and the second heat exchanger 42, groundwater in the well-side pipe 3 flows into any one of the first heat exchanger 41 and the second heat exchanger 42, and heat exchange is performed.

[0020]

Each of the first heat exchanger 41 and the second heat exchanger 42 performs heat exchange between groundwater pumped up from the hot water well 21 and flowing through the well-side pipe 3 and a medium on the auxiliary heat storage facility 100 side. After the heat exchange is performed, the groundwater flows from each of the first heat exchanger 41 and the second heat exchanger 42 through the well-side pipe 3 and is injected into the cold water well 22.

Each of the first heat exchanger 41 and the second heat exchanger 42 performs heat exchange between groundwater pumped up from the cold water well 22 and flowing through the well-side pipe 3 and the medium on the auxiliary heat storage facility 100 side. After the heat exchange is performed, the groundwater flows from each of the first heat exchanger 41 and the second heat exchanger 42 through the well-side pipe 3 and is injected into the hot water well 21.

For example, the first heat exchanger 41 and the second heat exchanger 42 may be provided on the ground and in the middle of the well-side pipe 3.

[0021]

When hot water is sent as groundwater from the hot water well 21 to each of the first heat exchanger 41 and the second heat exchanger 42, each of the first heat exchanger 41 and the second heat exchanger 42 cools the hot water to cold water by heat exchange with the medium on the auxiliary heat storage facility 100 side. This cold water is sent into the cold water well 22. In this case, hot heat discharge for discharging hot heat is performed in the hot water well 21, and cold energy storage for storing cold energy is performed in the cold water well 22.

When cold water is sent as groundwater from the cold water well 22 to each of the first heat exchanger 41 and the second heat exchanger 42, the cold water is heated to become hot water by heat exchange with the medium on the auxiliary heat storage facility 100 side in each of the first heat exchanger 41 and the second heat exchanger 42. This hot water is sent into the hot water well

21. In this case, cold energy discharge for discharging cold energy is performed in the cold water well 22, and hot heat storage for storing hot heat is performed in the hot water well 21.

Here, "hot water" refers to water at a temperature higher than the initial
 5 geothermal temperature of the groundwater in the aquifer or water at a temperature similar to the initial geothermal temperature of the groundwater in the aquifer, and "cold water" refers to water at a temperature lower than the initial geothermal temperature of the groundwater in the aquifer.

For example, the initial geothermal temperature of the groundwater in
 10 the aquifer is 18°C.

[0022]

Configuration of Auxiliary Heat Storage Facility

The auxiliary heat storage facility 100 uses a medium that has undergone heat exchange with groundwater in the well-side pipe 3 in the first heat
 15 exchanger 41 and the second heat exchanger 42.

In the present embodiment, the auxiliary heat storage facility 100 includes, for example, a heat source device 110, a cooling tower 130, and a refrigerant circuit 101.

[0023]

20 For example, the heat source device 110 may be a heat pump including a condenser, an evaporator, a compressor, and the like.

The heat source device 110 supplies a medium (cold water) to a device 120.

The device 120 is, for example, an air conditioning device that performs air conditioning of a space in which the device 120 is installed by exchanging
 25 heat with a medium (cold water) supplied from the heat source device 110.

In the present embodiment, the device 120 performs air conditioning of a space in which a plurality of computers (servers) and the like are accommodated, for example, in a data center or the like.

The use of the space in which air conditioning is performed by the
 30 device 120 is not limited to the data center, and may be another use.

Thus, a system including the geothermal heat utilization system 1 and the device 120 functions as an air conditioning system.

[0024]

The cooling tower 130 cools cooling water by vaporization heat
 35 generated when the cooling water is vaporized by being brought into contact with the atmosphere.

The cooling tower 130 circulates the cooling water between the heat source device 110 and the second heat exchanger 42.

In a certain mode, the cooling tower 130 can select either the heat source device 110 or the second heat exchanger 42 and circulate the cooling water.

In another mode, the cooling tower 130 can circulate the cooling water between the heat source device 110 and the second heat exchanger 42.

5 That is, a unit including the heat source device 110 and the cooling tower 130 functions as a refrigeration unit.

[0025]

10 The refrigerant circuit 101 forms a flow path for a medium between the first and second heat exchangers 41 and 42, the heat source device 110, and the device 120.

The refrigerant circuit 101 includes a device-side circuit portion 102 that connects the heat source device 110 and the device 120, and a cooling tower-side circuit portion 103 that connects the heat source device 110 and the cooling tower 130.

15 A medium flowing through the device-side circuit portion 102 and a medium flowing through the cooling tower-side circuit portion 103 exchange heat in the heat source device 110.

[0026]

20 The device-side circuit portion 102 includes a supply line 102a for supplying a medium from the heat source device 110 to the device 120, and a return line 102b for returning a medium from the device 120 to the heat source device 110.

25 The cooling tower-side circuit portion 103 includes a supply line 103a for supplying a medium from the cooling tower 130 to the heat source device 110, and a return line 103b for returning a medium from the heat source device 110 to the cooling tower 130.

[0027]

30 The refrigerant circuit 101 further includes a first heat exchanger-side circuit 104 that connects the device-side circuit portion 102 and the other side of the first heat exchanger 41, and a second heat exchanger-side circuit 105 that connects the cooling tower-side circuit portion 103 and the other side of the second heat exchanger 42.

35 The first heat exchanger-side circuit 104 includes a cold water line 104a through which cold water flows and a hot water line 104b through which hot water flows.

The second heat exchanger-side circuit 105 includes a cold water line 105a through which cold water flows and a hot water line 105b through which hot water flows.

[0028]

The refrigerant circuit 101 is appropriately provided with pumps, on-off valves, and the like (not shown), and is configured to circulate a medium along a predetermined route between the first heat exchanger 41, the heat source device 110, and the device 120, and between the second heat exchanger 42, the heat source device 110, and the cooling tower 130, depending on an operation mode.

For example, the auxiliary heat storage facility 100 is configured to be able to switch operation modes among a first cold energy storage mode M1, a second cold energy storage mode M2, a first cold energy discharge mode M3, and a second cold energy discharge mode M4 shown below by switching a medium circulation route in the refrigerant circuit 101.

[0029]

Configuration of First Cold energy Storage Mode

As illustrated in FIG. 2, in the first cold energy storage mode M1, the geothermal heat utilization system 1 supplies hot heat stored in the hot water well 21 to the cooling tower 130 without going through the heat source device 110, and stores the cold energy obtained from the cooling tower 130 in the cold water well 22 without going through the heat source device 110.

In FIG. 2, among media flowing through the well-side pipe 3, the device-side circuit portion 102, the cooling tower-side circuit portion 103, and the second heat exchanger-side circuit 105, a warm medium is indicated by a dotted line, and a cold medium is indicated by a thick line.

[0030]

Specifically, in the first cold energy storage mode M1, the geothermal heat utilization system 1 pumps up hot water by the pump 31 of the hot water well 21 and sends the hot water to the second heat exchanger 42.

On the other hand, in the cooling tower-side circuit portion 103 on the auxiliary heat storage facility 100 side, the geothermal heat utilization system 1 exchanges heat between the medium (cold water) cooled by the cooling tower 130 and the medium flowing through the device-side circuit portion 102 by the heat source device 110. Thereby, the device-side circuit portion 102 cools the medium circulating between the device 120 and the heat source device 110 and sends the medium to the device 120. In the heat source device 110, the medium (hot water) whose temperature has been increased by heat exchange with the medium flowing through the device-side circuit portion 102 is returned to the cooling tower 130.

[0031]

A part of the medium (cold water) cooled by the cooling tower 130 is sent to the second heat exchanger 42 via the second heat exchanger-side circuit 105, and exchanges heat with the hot water on the heat source well facility 10 side which is sent from the hot water well 21. Thereby, the hot water on the heat source well facility 10 side is cooled and sent to the cold water well 22 through the well-side pipe 3. For this reason, cold energy is stored in the cold water well 22. The medium whose temperature has been increased by heat exchange with the hot water on the heat source well facility 10 side returns to the cooling tower 130.

[0032]

The first cold energy storage mode M1 is particularly effective when the outside air temperature is low, such as at night or in winter, and a sufficient medium cooling effect can be obtained only by the cooling tower 130.

In the first cold energy storage mode M1, the heat source device 110 is not used to cool the hot water on the heat source well facility 10 side, and thus power consumption in the heat source device 110 is curbed.

[0033]

Configuration of Second Cold energy Storage Mode

As illustrated in FIG. 3, in the second cold energy storage mode M2, the geothermal heat utilization system 1 supplies hot heat stored in the hot water well 21 to the cooling tower 130 via the heat source device 110, and stores cold energy obtained from the cooling tower 130 in the cold water well 22 via the heat source device 110.

In FIG. 3, among media flowing through the well-side pipe 3, the device-side circuit portion 102, the cooling tower-side circuit portion 103, and the first heat exchanger-side circuit 104, a warm medium is indicated by a dotted line, and a cold medium is indicated by a thick line.

[0034]

Specifically, in the second cold energy storage mode M2, the geothermal heat utilization system 1 pumps up hot water by the pump 31 of the hot water well 21 and sends the hot water to the first heat exchanger 41.

On the other hand, in the cooling tower-side circuit portion 103 on the auxiliary heat storage facility 100 side, the geothermal heat utilization system 1 exchanges heat between a medium (cold water) cooled by the cooling tower 130 and a medium flowing through the device-side circuit portion 102 by the heat source device 110.

For example, when cooling of the device 120 is also required, the device-side circuit portion 102 may cool the medium circulating between the

device 120 and the heat source device 110 and send the medium to the device 120. In the heat source device 110, the medium (hot water) whose temperature has been increased by heat exchange with the medium flowing through the device-side circuit portion 102 is returned to the cooling tower 130.

5 [0035]

In addition, all or a part of the medium (cold water) cooled by the heat source device 110 is sent from the device-side circuit portion 102 to the first heat exchanger 41 via the first heat exchanger-side circuit 104, and exchanges heat with the hot water on the heat source well facility 10 side. Thereby, the hot water
10 on the heat source well facility 10 side is cooled and sent to the cold water well 22 through the well-side pipe 3. For this reason, cold energy is stored in the cold water well 22. The medium whose temperature has been increased by heat exchange with the hot water on the heat source well facility 10 side returns to the heat source device 110 via the first heat exchanger-side circuit 104.

15 [0036]

The performance of the heat source device 110 is improved when a difference in temperature between the medium on the device-side circuit portion 102 side and the medium on the cooling tower-side circuit portion 103 side is small. For this reason, the second cold energy storage mode M2 is
20 particularly effective when the outside air temperature is low, such as at night or in winter, and a difference in temperature between the medium on the device-side circuit portion 102 side and the medium on the cooling tower-side circuit portion 103 side is small in the heat source device 110.

In the second cold energy storage mode M2, the heat source device 110
25 is effectively used when the performance thereof is improved, and thus cold energy storage can be efficiently performed.

[0037]

Configuration of First Cold Energy Discharge Mode

As illustrated in FIG. 4, in the first cold energy discharge mode M3, the
30 geothermal heat utilization system 1 supplies cold energy stored in the cold water well 22 to the device 120 without going through the heat source device 110.

In FIG. 4, among media flowing through the well-side pipe 3, the device-side circuit portion 102, and the first heat exchanger-side circuit 104, a warm medium is indicated by a dotted line, and a cold medium is indicated by a thick line.

35 [0038]

Specifically, in the first cold energy discharge mode M3, the geothermal heat utilization system 1 pumps up cold water by the pump 31 of the cold water well 22 and sends the cold water to the first heat exchangers 41.

In the first heat exchanger 41, the geothermal heat utilization system 1 exchanges heat between the cold water on the heat source well facility 10 side and the medium flowing through the device-side circuit portion 102. Thereby, the device-side circuit portion 102 cools the medium circulating between the device 120 and the first heat exchanger 41 and sends the medium to the device 120.

[0039]

On the other hand, the cold water on the heat source well facility 10 side increases in temperature to become hot water by heat exchange in the first heat exchanger 41, and is sent to the hot water well 21 through the well-side pipe 3. Thereby, cold energy is discharged in the cold water well 22.

[0040]

In this manner, in the first cold energy discharge mode M3, cold energy can be directly supplied to the device 120 by using cold water stored in the cold water well 22 without using the heat source device 110.

[0041]

Configuration of Second Cold energy Discharge Mode

As illustrated in FIG. 5, in the second cold energy discharge mode M4, the geothermal heat utilization system 1 supplies cold energy stored in the cold water well 22 to the device 120 via the heat source device 110.

In FIG. 5, among media flowing through the well-side pipe 3, the device-side circuit portion 102, the cooling tower-side circuit portion 103, and the second heat exchanger-side circuit 105, a warm medium is indicated by a dotted line, and a cold medium is indicated by a thick line.

[0042]

Specifically, in the second cold energy discharge mode M4, the geothermal heat utilization system 1 pumps up cold water by the pump 31 of the cold water well 22 and sends the cold water to the second heat exchanger 42.

In the second heat exchanger 42, the geothermal heat utilization system 1 exchanges heat between the cold water on the heat source well facility 10 side and the medium flowing through the cooling tower-side circuit portion 103. Thereby, the cooling tower-side circuit portion 103 cools the medium circulating between the heat source device 110 and the second heat exchanger 42 and sends the medium to the heat source device 110.

In the heat source device 110, the geothermal heat utilization system 1 exchanges heat between the medium on the cooled cooling tower-side circuit portion 103 side and the medium flowing through the device-side circuit portion 102. Thereby, the device-side circuit portion 102 cools the medium

circulating between the device 120 and the heat source device 110 and sends the medium to the device 120.

[0043]

On the other hand, the cold water on the heat source well facility 10 side
 5 increases in temperature by the heat exchange in the second heat exchanger 42 to become hot water, and the hot water is sent to the hot water well 21 through the well-side pipe 3. Thereby, cold energy is discharged in the cold water well 22.

[0044]

In this manner, in the second cold energy discharge mode M4, the cold
 10 water stored in the cold water well 22 is cooled using the heat source device 110, and the cold energy is supplied to the device 120. Thereby, when the amount of cold energy required on the device 120 side is larger than the cold energy stored in the cold water well 22, the amount of cold energy to be supplied to the device 120 side can be secured by using the heat source device 110.

15 [0045]

Configuration of Control system

The control system 300 controls the operation of the geothermal heat utilization system 1.

The control system 300 controls the operation of each part of the
 20 geothermal heat utilization system 1 in each of the first cold energy storage mode M1, the second cold energy storage mode M2, the first cold energy discharge mode M3, and the second cold energy discharge mode M4.

[0046]

As illustrated in FIG. 6, the control system 300 includes an operation
 25 control unit 310, a calculation unit 320, a prediction unit 330, an outside air temperature acquisition unit 340, a cold water temperature acquisition unit 350, and a mode determination unit 360.

[0047]

The operation control unit 310 can switch an operation mode among the
 30 first cold energy storage mode M1, the second cold energy storage mode M2, the first cold energy discharge mode M3, and the second cold energy discharge mode M4. The operation control unit 310 controls the operation of each part of the geothermal heat utilization system 1 in accordance with the switched operation mode among the first cold energy storage mode M1, the second cold energy storage mode M2, the first cold energy discharge mode M3, and the
 35 second cold energy discharge mode M4.

[0048]

The operation control unit 310 may reduce a cold energy storage amount in the cold water well 22 when a cumulative cold energy storage amount is larger than a required cold energy storage amount (to be described later) predicted by the prediction unit 330 at the time of executing at least one mode out of the first cold energy storage mode M1 and the second cold energy storage mode M2.

The operation control unit 310 may store cold energy in the cold water well 22 according to a difference between a required cold energy storage amount (to be described later) predicted by the prediction unit 330 and a predicted value of an amount of power to be peak-cut (to be described later) predicted by the prediction unit 330 at the time of executing at least one mode out of the first cold energy storage mode M1 and the second cold energy storage mode M2.

The operation control unit 310 may reduce a cold energy storage amount in the cold water well 22 when a cumulative cold energy storage amount is larger than a predicted value of the amount of power to be peak-cut at the time of executing at least one mode out of the first cold energy storage mode M1 and the second cold energy storage mode M2.

[0049]

The operation control unit 310 may constantly supply cold energy to the device 120 at the time of executing at least one mode out of the first cold energy discharge mode M3 and the second cold energy discharge mode M4. That is, the operation control unit 310 may perform a cooling operation of constantly supplying cold energy to the device 120 throughout the day and night over the year without performing a heating operation of supplying hot heat.

[0050]

The calculation unit 320 calculates a cumulative cold energy storage amount which is a cold energy storage amount stored in the cold water well 22. Here, the "cumulative cold energy storage amount" is a value obtained by subtracting an integrated value of the amount of heat discharged from the cold water well 22 by pumping up water from the cold water well 22, from an integrated value of the amount of heat stored in the cold water well 22 by injecting water into the cold water well 22, from the state in which the groundwater in the aquifer of the cold water well 22 is at the initial geothermal temperature up to the time of calculation.

[0051]

The prediction unit 330 predicts a required cold energy storage amount that is a cold energy storage amount required for cooling the device 120. Here,

the "required cold energy storage amount" is a cold energy storage amount required in a predetermined period in the near future. The "predetermined period in the near future" is, for example, the daytime of the next day or the next nearest summer.

5 The prediction unit 330 further predicts the amount of power equal to or greater than a preset threshold value as a predicted value of the amount of power to be peak-cut.

 The prediction unit 330 may accumulate information such as the past cold energy usage amount, the usage time, the temperature, a calorific value of
10 a computer or the like disposed in a space where air conditioning is planned in the device 120, and the number of computers, and may predict, based on the accumulated information, a required cold energy storage amount and a predicted value of the amount of power to be peak-cut, based on the prediction time, the temperature, a usage plan of the computer or the like, and the like.

15 The prediction unit 330 may perform deep learning of accumulated information by using artificial intelligence or the like for the prediction of the required cold energy storage amount and the prediction of the predicted value of the amount of power to be peak-cut.

[0052]

20 The outside air temperature acquisition unit 340 acquires an outside air temperature.

 The outside air temperature acquisition unit 340 may acquire, as the outside air temperature, the measured value of the outside air temperature by, for example, a thermometer or the like at a location where the geothermal heat
25 utilization system 1 is provided.

 The outside air temperature acquisition unit 340 may acquire a numerical value of the outside air temperature input by, for example, an operator.

 The outside air temperature acquisition unit 340 may also acquire data of the outside air temperature via an external network.

30 [0053]

 The cold water temperature acquisition unit 350 acquires a pumped water temperature of the cold water well 22.

 The cold water temperature acquisition unit 350 may acquire the pumped water temperature of the cold water well 22 which is detected by a
35 cold water temperature sensor (not shown) installed in the cold water well 22.

[0054]

 The mode determination unit 360 determines which mode the operation control unit 310 switches to among the first cold energy storage mode M1, the

second cold energy storage mode M2, the first cold energy discharge mode M3, and the second cold energy discharge mode M4.

The mode determination unit 360 selects the mode, based on at least one of the cumulative cold energy storage amount and the required cold energy
5 storage amount.

When cold energy is stored in the cold water wells 22, the mode determination unit 360 determines whether to perform control in the first cold energy storage mode M1 or the second cold energy storage mode M2, based on the cumulative cold energy storage amount and the required cold energy
10 storage amount.

When cold energy is stored in the cold water wells 22, the mode determination unit 360 may determine whether to perform control in the first cold energy storage mode M1 or the second cold energy storage mode M2 based on the outside air temperature.

15 When cold energy is stored in the cold water well 22, the mode determination unit 360 may determine whether to perform the first cold energy storage mode M1 or the second cold energy storage mode M2, based on the cumulative cold energy storage amount and the pumped water temperature of the cold water wells 22.

20 When the cold energy stored in the cold water well 22 is supplied to the device 120, the mode determination unit 360 may determine whether to perform control in the first cold energy discharge mode M3 or the second cold energy discharge mode M4, based on the pumped water temperature of the cold water well 22.

25 [0055]

An operation of the control system 300 of the present embodiment will be described below.

The operation of the control system 300 is equivalent to an embodiment of the control method.

30 The control system 300 performs each step illustrated in FIG. 7.

[0056]

First, the control system 300 confirms whether a cooling operation is in an ON state in the device 120 (step S11).

35 When the cooling operation is in an ON state in step S11 (step S11: Yes), the operation proceeds to step S12 and the subsequent steps. When the cooling operation is in an OFF state in step S11 (step S11: No), the operation proceeds to step S21 to be described later and the subsequent steps.

[0057]

In step S12, the control system 300 confirms whether suppression of a demand (demand cut) is required. Here, the "demand" is an amount of power required for an air conditioning facility including the geothermal heat utilization system 1 and the device 120. For example, in step S12, the control system 300 confirms whether it is necessary to suppress a demand using a heat storage amount of the heat source well facility 10 so that the demand does not exceed a predetermined upper limit for lowering a basic electricity fee.

In step S12, when a demand cut is required (step S12: Yes), a target value of the demand cut (demand target value) is set (step S13).

Next, the control system 300 calculates a heat discharge amount of the cold water well 22 (step S14).

[0058]

Next, a pumped water temperature of the cold water well 22 at that time is acquired by the cold water temperature acquisition unit 350. The control system 300 confirms whether the acquired pumped water temperature is higher than a preset reference temperature (step S15).

As a result, when the pumped water temperature is equal to or less than the reference temperature (step S15: No), the mode determination unit 360 selects the first cold energy discharge mode M3 (see FIG. 4) as an operation mode (step S16). The operation control unit 310 controls the operation of each part of the geothermal heat utilization system 1 so that the geothermal heat utilization system 1 operates in the first cold energy discharge mode M3 selected by the mode determination unit 360.

On the other hand, when the pumped water temperature is higher than the reference temperature (step S15: Yes), the mode determination unit 360 selects the second cold energy discharge mode M4 (see FIG. 5) as an operation mode (step S17). In this case, the operation control unit 310 controls the operation of each part of the geothermal heat utilization system 1 so that the geothermal heat utilization system 1 operates in the second cold energy discharge mode M4 selected by the mode determination unit 360.

In step S12 described above, when a demand cut is not required (step S12: No), the mode determination unit 360 selects the second cold energy discharge mode M4 (refer to FIG. 5) as an operation mode (step S17).

[0059]

In step S11 described above, when a cooling operation is in an OFF state on the device 120 side (step S11: No), the calculation unit 320 first calculates, in step S21, a cumulative cold energy storage amount which is a cold energy storage amount stored in the cold water well 22. In step S21, the outside air

temperature acquisition unit 340 acquires an outside air temperature at that time. In step S21, the cold water temperature acquisition unit 350 acquires a pumped water temperature of the cold water well 22.

[0060]

5 Next, in step S22, the mode determination unit 360 confirms whether the cumulative cold energy storage amount calculated in step S21 is less than a preset target value. In step S22, the mode determination unit 360 confirms whether the pumped water temperature of the cold water well 22 acquired in step S21 is higher than a preset target temperature. In step S22, when the conditions
10 that the cumulative cold energy storage amount is less than the target value and the pumped water temperature is higher than the target temperature are satisfied (step S22: Yes), the mode determination unit 360 proceeds to step S23. In step S22, when the conditions that the cumulative cold energy storage amount is less than the target value and the pumped water temperature is higher than the target
15 temperature cannot be satisfied (step S22: No), the mode determination unit 360 ends the processing for selecting an operation mode.

[0061]

20 In step S23, the prediction unit 330 predicts a required cold energy storage amount that is a cold energy storage amount required for cooling the device 120.

 Next, in step S24, the mode determination unit 360 determines which of the first cold energy storage mode M1 and the second cold energy storage mode M2 is to be selected based on the outside air temperature acquired in step S21.

25 In step S24, the mode determination unit 360 may perform a simulation based on the outside air temperature using, for example, a technique described in JP 7136965 B, and select either the first cold energy storage mode M1 or the second cold energy storage mode M2 based on the simulation result.

[0062]

30 Next, in step S25, the operation control unit 310 sets detailed operation conditions in the first cold energy storage mode M1 or the second cold energy storage mode M2 selected in step S24.

 For this, the operation control unit 310 sets a cold energy storage amount, a heat storage temperature, a flow amount, a time, and the like of the cold water stored in the cold water well 22 in the selected first cold energy storage mode
35 M1 or second cold energy storage mode M2, based on the past operation records of the geothermal heat utilization system 1 or a table input by a user.

 In the subsequent step S26, the operation control unit 310 controls the operation of each part of the geothermal heat utilization system 1 so that the

geothermal heat utilization system 1 operates under the operation condition set in step S25 in the first cold energy storage mode M1 or the second cold energy storage mode M2 selected in step S24.

[0063]

5 Operations and Effects

According to the present embodiment, the control system 300, the geothermal heat utilization system 1, and the control method can make it possible to store, in a cold water well, predicted cold energy required for cooling a device by determining whether to perform control in the first cold energy storage mode M1 or the second cold energy storage mode M2, based on a cumulative cold energy storage amount and a required cold energy storage amount.

For this reason, cold energy to be stored in the aquifer is less likely to be insufficient or excessive throughout the entire period.

Thus, the control system 300, the geothermal heat utilization system 1, and the control method can make it possible to easily balance a heat storage amount of the aquifer.

[0064]

According to an example of the present embodiment, it is possible to store cold energy in the cold water well 22 by determining whether to perform control in the first cold energy storage mode M1 or the second cold energy storage mode M2 based on an outside air temperature to select an appropriate cold energy storage mode according to the outside air temperature.

[0065]

According to an example of the present embodiment, when a pumped water temperature of the cold water well 22 is equal to or higher than a preset target temperature, cold energy can be stored in the cold water well 22 in an appropriate cold energy storage mode selected based on the cumulative cold energy storage amount and the pumped water temperature of the cold water well 22.

[0066]

According to an example of the present embodiment, it is possible to supply cold energy stored in the cold water well 22 to the device 120 by determining whether to perform control in the first cold energy discharge mode M3 or the second cold energy discharge mode M4 based on the pumped water temperature of the cold water well 22 to select an appropriate cold energy discharge mode according to the pumped water temperature of the cold water well 22.

[0067]

According to an example of the present embodiment, when a cumulative cold energy storage amount is larger than a required cold energy storage

amount at the time of executing the first cold energy storage mode M1 or the second cold energy storage mode M2, the cold energy storage amount in the cold water wells 22 is reduced, and thus it is possible to reduce the amount of power required for the operation of the cooling tower 130, the heat source device 110, various pumps, and the like, which is the amount of power required for storing heat in the cold water well 22.

[0068]

According to an example of the present embodiment, cold energy can be constantly supplied to the device 120 at the time of executing at least one mode out of the first cold energy discharge mode M3 and the second cold energy discharge mode M4. Thereby, a space in which a heat generation source such as a computer, which is always operating, is accommodated can be cooled throughout the day and night over the year.

[0069]

Modification Example

In the above-described embodiment, the heat exchanger 4 includes the first heat exchanger 41 and the second heat exchanger 42, but may be configured in any manner as long as heat exchange can be performed between the groundwater in the well-side pipe 3 and a medium in the refrigerant circuit 101 on the auxiliary heat storage facility 100 side.

As a modification example, the heat exchanger 4 may be configured as one system by devising each pipe. As a specific example thereof, the heat exchanger 4 may include only the first heat exchanger 41 out of the first heat exchanger 41 and the second heat exchanger 42. In this case, one side of the first heat exchanger 41 may be connected to the middle of the well-side pipe 3, and the other side of the first heat exchanger 41 may be connected to the first heat exchanger-side circuit 104 and the cooling tower-side circuit portion 103. In addition, the first heat exchanger-side circuit 104 and the cooling tower-side circuit portion 103 may be connected in parallel to the first heat exchanger 41 via an on-off valve or the like.

[0070]

In the above-described embodiment, in the second cold energy storage mode M2, the device-side circuit portion 102 cools a medium circulating between the device 120 and the heat source device 110 and sends the medium to the device 120, but the device-side circuit portion 102 may be configured in any manner as long as cold energy is stored in the cold water well 22.

As a modification example, in the second cold energy storage mode M2, the device-side circuit portion 102 need not send a medium cooled by the heat

source device 110 to the device 120. At this time, the medium cooled by the heat source device 110 is sent from the device-side circuit portion 102 to the first heat exchanger 41 via the first heat exchanger-side circuit 104.

[0071]

5 In the above-described embodiment, the mode determination unit 360 determines whether to perform control in the first cold energy storage mode M1 or in the second cold energy storage mode M2 based on an outside air temperature, but the mode determination unit 360 may be configured in any manner as long as it can determine whether to perform control in the first cold
10 energy storage mode M1 or in the second cold energy storage mode M2.

As a modification example, the mode determination unit 360 may determine whether to perform control in the first cold energy storage mode M1 or the second cold energy storage mode M2 based on an outdoor wet-bulb temperature.

15 [0072]

In the above-described embodiment, a program for achieving various functions of the control system 300 is recorded in a computer-readable recording medium, and various processes are performed by reading and executing the program recorded in the recording medium by a computer system
20 such as a microcomputer. Here, the procedure of the various processing of the CPU of the computer system is stored in the computer-readable recording medium in the form of a program, and the various processing is performed by reading and executing that program by the computer. The computer-readable recording medium refers to a magnetic disk, a magneto-optical disk, a CD-ROM, a DVD-ROM, a semiconductor memory, and the like. The computer
25 program may be distributed to a computer via a communication line, and the computer having received the distribution may execute the program.

[0073]

In the above-described embodiment, an example of a hardware
30 configuration of a computer 190 that executes the program for achieving various functions of the control system 300 is described.

[0074]

As illustrated in FIG. 8, the computer 190 included in the control system 300 includes a processor 195, a memory 196, a storage/reproduction device 197,
35 an input output interface (hereinafter referred to as the "IO I/F") 198, and a communication interface (hereinafter referred to as the "communication I/F") 199.

[0075]

For example, the processor 195 may be a CPU.

For example, the memory 196 may be a medium such as a random access memory (hereinafter referred to as the "RAM") for temporarily storing data and the like used in the program executed by the control system 300.

For example, the storage/reproduction device 197 may be a device for
5 storing data and the like in an external medium such as a CD-ROM, a DVD, and a flash memory, and/or reproducing data and the like of the external medium.

For example, the IO I/F 198 may be an interface for inputting and outputting information and the like between the control system 300 and another device.

10 For example, the communication I/F 199 may be an interface for performing communication between the control system 300 and another device through a communication line such as the Internet and a dedicated communication line.

[0076]

15 <Other Embodiments>

While the embodiments of the present disclosure are described above, the embodiments are examples, and are not intended to limit the scope of the present disclosure. The embodiments can be implemented in various other forms, and various omissions, substitutions, and modifications can be made
20 without departing from the gist of the present disclosure. The embodiments and variations thereof are included in the scope of the present disclosure and equivalents thereof as well as in the scope and gist of the present disclosure.

[0077]

<Supplementary Notes>

25 The control system 300, the geothermal heat utilization system 1, the control method, and the program according to the embodiment are understood as follows, for example.

[0078]

(1) A control system 300 according to a first aspect is the control system
30 300 that controls a geothermal heat utilization system 1 including a heat source well facility 10 including a hot water well 21 and a cold water well 22, and an auxiliary heat storage facility 100 including a cooling tower 130 and a heat source device 110, the control system including an operation control unit 310 configured to switch a mode of the geothermal heat utilization system 1
35 between a first cold energy storage mode M1 in which hot heat stored in the hot water well 21 is supplied to the cooling tower 130 without going through the heat source device 110, and cold energy obtained from the cooling tower 130 is stored in the cold water well 22 without going through the heat source device

110, a second cold energy storage mode M2 in which the hot heat stored in the hot water well 21 is supplied to the cooling tower 130 via the heat source device 110, and the cold energy obtained from the cooling tower 130 is stored in the cold water well 22 via the heat source device 110, a first cold energy
 5 discharge mode M3 in which the cold energy stored in the cold water well 22 is supplied to a device 120 without going through the heat source device 110, and a second cold energy discharge mode M4 in which the cold energy stored in the cold water well 22 is supplied to the device 120 via the heat source device 110; a calculation unit 320 configured to calculate a cumulative cold energy storage
 10 amount that is a cold energy storage amount stored in the cold water well 22; a prediction unit 330 configured to predict a required cold energy storage amount that is a cold energy storage amount required for cooling the device 120; and a mode determination unit 360 configured to determine whether to perform control in the first cold energy storage mode M1 or in the second cold energy
 15 storage mode M2, based on the cumulative cold energy storage amount and the required cold energy storage amount.

[0079]

The control system 300 can store, in the cold water well, predicted cold energy required for cooling the device by determining whether to perform
 20 control in the first cold energy storage mode M1 or in the second cold energy storage mode M2, based on the cumulative cold energy storage amount and the required cold energy storage amount.

For this reason, cold energy to be stored in the aquifer is less likely to be insufficient or excessive throughout the entire period.

25 Thus, the control system 300 can make it possible to easily balance a heat storage amount of an aquifer.

[0080]

(2) A control system 300 according to a second aspect is the control system 300 according to (1), further including an outside air temperature
 30 acquisition unit 340 configured to acquire an outside air temperature, in which the mode determination unit 360 determines, when the cold energy is stored in the cold water well 22, whether to perform control in the first cold energy storage mode M1 or in the second cold energy storage mode M2, based on the outside air temperature.

35 [0081]

Thereby, it is possible to store cold energy in the cold water well 22 by determining whether to perform control in the first cold energy storage mode M1 or the second cold energy storage mode M2 based on the outside air

temperature to select an appropriate cold energy storage mode according to the outside air temperature.

[0082]

(3) A control system 300 according to a third aspect is the control system 300 according to (1) or (2), further including a cold water temperature acquisition unit 350 configured to acquire a pumped water temperature of the cold water well 22, in which the mode determination unit 360 determines, when the cold energy is stored in the cold water well 22, whether to perform the first cold energy storage mode M1 or the second cold energy storage mode M2, based on the cumulative cold energy storage amount and the pumped water temperature of the cold water well 22.

[0083]

Thereby, when a pumped water temperature of the cold water well 22 is equal to or higher than a preset target temperature, cold energy can be stored in the cold water well 22 in an appropriate cold energy storage mode selected based on the cumulative cold energy storage amount and the pumped water temperature of the cold water well 22.

[0084]

(4) A control system 300 according to a fourth aspect is the control system 300 according to any one of (1) to (3), further including the cold water temperature acquisition unit 350 configured to acquire a pumped water temperature of the cold water well 22, in which the mode determination unit 360 determines, when the cold energy stored in the cold water well 22 is supplied to the device 120, whether to perform control in the first cold energy discharge mode M3 or in the second cold energy discharge mode M4, based on the pumped water temperature of the cold water well 22.

[0085]

Thereby, it is possible to supply cold energy stored in the cold water well 22 to the device 120 by determining whether to perform control in the first cold energy discharge mode M3 or the second cold energy discharge mode M4 based on the pumped water temperature of the cold water well 22 to select an appropriate cold energy discharge mode according to the pumped water temperature of the cold water well 22.

[0086]

(5) A control system 300 according to a fifth aspect is the control system 300 according to any one of (1) to (4), in which the operation control unit 310 reduces a cold energy storage amount in the cold water well 22 when the first cold energy storage mode M1 or the second cold energy storage mode M2 is

executed and the cumulative cold energy storage amount is larger than the required cold energy storage amount.

[0087]

5 Thereby, when the first cold energy storage mode M1 or the second cold energy storage mode M2 is executed, it is possible to reduce the amount of power which is required for the operation of the cooling tower 130, the heat source device 110, various pumps, and the like, which is the amount of power required for storing heat in the cold water wells 22.

[0088]

10 (6) A control system 300 according to a sixth aspect is the control system 300 according to any one of (1) to (5), in which the cold energy is constantly supplied to the device 120 when the first cold energy discharge mode M3 or the second cold energy discharge mode M4 is executed.

[0089]

15 Thereby, a space in which a heat generation source such as a computer, which is always operating, is accommodated can be cooled throughout the day and night over the year.

[0090]

20 (7) A geothermal heat utilization system 1 according to a seventh aspect includes the control system 300 according to any one of (1) to (6), the heat source well facility 10; and the auxiliary heat storage facility 100.

[0091]

25 The geothermal heat utilization system 1 can store, in a cold water well, predicted cold energy required for cooling a device by determining whether to perform control in the first cold energy storage mode M1 or the second cold energy storage mode M2, based on the cumulative cold energy storage amount and the required cold energy storage amount.

For this reason, cold energy to be stored in the aquifer is less likely to be insufficient or excessive throughout the entire period.

30 Thus, the geothermal heat utilization system 1 can make it possible to easily balance a heat storage amount of the aquifer.

[0092]

35 (8) A control method according to an eighth aspect includes a step of calculating a cumulative cold energy storage amount which is a cold energy storage amount stored in a cold water well 22 to a computer of a geothermal heat utilization system which includes a heat source well facility 10 including a hot water well 21 and the cold water well 22, and an auxiliary heat storage facility 100 including a cooling tower 130 and a heat source device 110, the

geothermal heat utilization system having a mode switchable between a first cold energy storage mode M1 in which hot heat stored in the hot water well 21 is supplied to the cooling tower 130 without going through the heat source device 110, and cold energy obtained from the cooling tower 130 is stored in the cold water well 22 without going through the heat source device 110, a second cold energy storage mode M2 in which the hot heat stored in the hot water well 21 is supplied to the cooling tower 130 via the heat source device 110, and the cold energy obtained from the cooling tower 130 is stored in the cold water well 22 via the heat source device 110, a first cold energy discharge mode M3 in which the cold energy stored in the cold water well 22 is supplied to a device 120 without going through the heat source device 110, and a second cold energy discharge mode M4 in which the cold energy stored in the cold water well 22 is supplied to the device 120 via the heat source device 110; a step of predicting a required cold energy storage amount that is a cold energy storage amount required for cooling the device 120; and a step of determining whether to perform control in the first cold energy storage mode M1 or in the second cold energy storage mode M2, based on the cumulative cold energy storage amount and the required cold energy storage amount.

[0093]

In the control method, it is possible to store, in a cold water well, predicted cold energy required for cooling a device by determining whether to perform control in the first cold energy storage mode M1 or the second cold energy storage mode M2, based on a cumulative cold energy storage amount and a required cold energy storage amount.

For this reason, cold energy to be stored in the aquifer is less likely to be insufficient or excessive throughout the entire period.

Thus, the control method can make it possible to easily balance a heat storage amount of the aquifer.

[0094]

(9) A program according to a ninth aspect causes a computer of a geothermal heat utilization system which includes a heat source well facility including a hot water well 21 and a cold water well 22, and an auxiliary heat storage facility 100 including a cooling tower 130 and a heat source device 110, the geothermal heat utilization system having a mode switchable between a first cold energy storage mode M1 in which hot heat stored in the hot water well 21 is supplied to the cooling tower 130 without going through the heat source device 110, and cold energy obtained from the cooling tower 130 is stored in the cold water well 22 without going through the heat source device

110, a second cold energy storage mode M2 in which the hot heat stored in the hot water well 21 is supplied to the cooling tower 130 via the heat source device 110, and the cold energy obtained from the cooling tower 130 is stored in the cold water well 22 via the heat source device 110, a first cold energy
 5 discharge mode M3 in which the cold energy stored in the cold water well 22 is supplied to a device 120 without going through the heat source device 110, and a second cold energy discharge mode M4 in which the cold energy stored in the cold water well 22 is supplied to the device 120 via the heat source device 110, to execute processing including a step of calculating a cumulative cold energy
 10 storage amount that is a cold energy storage amount stored in the cold water well 22; a step of predicting a required cold energy storage amount that is a cold energy storage amount required for cooling the device 120; and a step of determining whether to perform control in the first cold energy storage mode M1 or in the second cold energy storage mode M2, based on the cumulative
 15 cold energy storage amount and the required cold energy storage amount.
 [0095]

The program can make it possible to store, in a cold water well, predicted cold energy required for cooling a device by determining whether to perform control in the first cold energy storage mode M1 or the second cold
 20 energy storage mode M2, based on a cumulative cold energy storage amount and a required cold energy storage amount.

For this reason, cold energy to be stored in the aquifer is less likely to be insufficient or excessive throughout the entire period.

Thus, the program can make it possible to easily balance a heat storage
 25 amount of the aquifer.

Industrial Applicability

[0096]

According to the control system, the geothermal heat utilization system,
 30 the control method, and the program of the present disclosure, it is possible to easily balance a heat storage amount of an aquifer.

Reference Signs List

[0097]

- 35 1 Geothermal heat utilization system
- 3 Well-side Pipe
- 4 Heat exchanger
- 10 Heat source well facility

- 21 Hot water well
- 22 Cold water well
- 31 Pump
- 41 First heat exchanger
- 5 42 Second heat exchanger
- 100 Auxiliary heat storage facility
- 101 Refrigerant circuit
- 102 Device-side circuit portion
- 102a Supply line
- 10 102b Return line
- 103 Cooling tower-side circuit portion
- 103a Supply line
- 103b Return line
- 104 First heat exchanger-side circuit
- 15 104a Cold water line
- 104b Hot water line
- 105 Second heat exchanger-side circuit
- 105a Cold water line
- 105b Hot water line
- 20 110 Heat source device
- 120 Device
- 130 Cooling tower
- 190 Computer
- 195 Processor
- 25 196 Memory
- 197 Storage/reproduction device
- 198 IO I/F
- 199 Communication I/F
- 300 Control system
- 30 310 Operation control unit
- 320 Calculation unit
- 330 Prediction unit
- 340 Outside air temperature acquisition unit
- 350 Cold water temperature acquisition unit
- 35 360 Mode determination unit
- M1 First cold energy storage mode
- M2 Second cold energy storage mode
- M3 First cold energy discharge mode

M4 Second cold energy discharge mode

Claims

[Claim 1]

5 A control system configured to control a geothermal heat utilization system including a heat source well facility including a hot water well and a cold water well, and an auxiliary heat storage facility including a cooling tower and a heat source device, the control system comprising:

an operation control unit configured to switch a mode of the geothermal heat utilization system between

10 a first cold energy storage mode in which hot heat stored in the hot water well is supplied to the cooling tower without going through the heat source device, and cold energy obtained from the cooling tower is stored in the cold water well without going through the heat source device,

15 a second cold energy storage mode in which the hot heat stored in the hot water well is supplied to the cooling tower via the heat source device, and the cold energy obtained from the cooling tower is stored in the cold water well via the heat source device,

20 a first cold energy discharge mode in which the cold energy stored in the cold water well is supplied to a device without going through the heat source device, and

a second cold energy discharge mode in which the cold energy stored in the cold water well is supplied to the device via the heat source device;

a calculation unit configured to calculate a cumulative cold energy storage amount being a cold energy storage amount stored in the cold water well;

25 a prediction unit configured to predict a required cold energy storage amount being a cold energy storage amount required for cooling the device; and

30 a mode determination unit configured to determine whether to perform control in the first cold energy storage mode or in the second cold energy storage mode, based on the cumulative cold energy storage amount and the required cold energy storage amount.

[Claim 2]

The control system according to claim 1, further comprising an outside air temperature acquisition unit configured to acquire an outside air temperature,

35 wherein the mode determination unit determines, when the cold energy is stored in the cold water well, whether to perform control in the first cold energy storage mode or in the second cold energy storage mode, based on the outside air temperature.

[Claim 3]

The control system according to claim 1 or 2, further comprising a cold water temperature acquisition unit configured to acquire a pumped water temperature of the cold water well,

wherein the mode determination unit determines, when the cold energy is stored in the cold water well, whether to perform the first cold energy storage mode or the second cold energy storage mode, based on the cumulative cold energy storage amount and the pumped water temperature of the cold water well.

[Claim 4]

The control system according to claim 1 or 2, further comprising a cold water temperature acquisition unit configured to acquire a pumped water temperature of the cold water well,

wherein the mode determination unit determines, when the cold energy stored in the cold water well is supplied to the device, whether to perform control in the first cold energy discharge mode or in the second cold energy discharge mode, based on the pumped water temperature of the cold water well.

[Claim 5]

The control system according to claim 1 or 2, wherein the operation control unit reduces a cold energy storage amount in the cold water well when the first cold energy storage mode or the second cold energy storage mode is executed and the cumulative cold energy storage amount is larger than the required cold energy storage amount.

[Claim 6]

The control system according to claim 1 or 2, wherein the cold energy is constantly supplied to the device when the first cold energy discharge mode or the second cold energy discharge mode is executed.

[Claim 7]

A geothermal heat utilization system comprising:
the control system according to claim 1 or 2;
the heat source well facility; and
the auxiliary heat storage facility.

[Claim 8]

A control method comprising:

calculating a cumulative cold energy storage amount being a cold energy storage amount stored in a cold water well of a geothermal heat utilization system including a heat source well facility including a hot water well and the cold water well, and an auxiliary heat storage facility including a cooling tower and a heat source device, the geothermal heat utilization system having a mode switchable between a first cold energy storage mode in which hot heat stored in the hot water well is supplied to the cooling tower without going through the heat source device and cold energy obtained from the cooling tower is stored in the cold water well without going through the heat source device, a second cold energy storage mode in which the hot heat stored in the hot water well is supplied to the cooling tower via the heat source device and the cold energy obtained from the cooling tower is stored in the cold water well via the heat source device, a first cold energy discharge mode in which the cold energy stored in the cold water well is supplied to a device without going through the heat source device, and a second cold energy discharge mode in which the cold energy stored in the cold water well is supplied to the device via the heat source device;

predicting a required cold energy storage amount being a cold energy storage amount required for cooling the device; and

determining whether to perform control in the first cold energy storage mode or in the second cold energy storage mode, based on the cumulative cold energy storage amount and the required cold energy storage amount.

[Claim 9]

A program comprising processing executable by a computer of a geothermal heat utilization system including a heat source well facility including a hot water well and a cold water well, and an auxiliary heat storage facility including a cooling tower and a heat source device, the geothermal heat utilization system having a mode switchable between a first cold energy storage mode in which hot heat stored in the hot water well is supplied to the cooling tower without going through the heat source device and cold energy obtained from the cooling tower is stored in the cold water well without going through the heat source device, a second cold energy storage mode in which the hot heat stored in the hot water well is supplied to the cooling tower via the heat source device and the cold energy obtained from the cooling tower is stored in the cold water well via the heat source device, a first cold energy discharge mode in which the cold energy stored in the cold water well is supplied to a device

without going through the heat source device, and a second cold energy discharge mode in which the cold energy stored in the cold water well is supplied to the device via the heat source device, the program causing the computer to execute the processing comprising:

- 5 calculating a cumulative cold energy storage amount being a cold energy storage amount stored in the cold water well;
 predicting a required cold energy storage amount being a cold energy storage amount required for cooling the device; and
- 10 determining whether to perform control in the first cold energy storage mode or in the second cold energy storage mode, based on the cumulative cold energy storage amount and the required cold energy storage amount.