

**PEAK ELECTRIC POWER REDUCTION SIMULATION SYSTEM USING BACKUP
HEAT SOURCE AND SIMULATION METHOD USING THE SAME**

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Korean Patent Application No. 10-2020-0181375, filed on December 22, 2020, which is hereby incorporated by reference as if fully set forth herein.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present disclosure relates to a peak power reduction simulation system using a backup heat source and a simulation method using the same, and particularly to a peak power reduction simulation system using a backup heat source and a simulation method using the same for energy saving and presenting an accurate guideline for server expansion within the range that does not require additional power facilities by simulating an energy reduction state using the backup heat source.

Discussion of the Related Art

[0003] A data center consumes much energy for cooling of a server room and inputs energy for cooling for 24 hours. A data

center that is efficiently managed in a climate environment of Korea consumes 40 to 50 air conditioning power based on 100, which is IT power consumption.

[0004] Power consumption of a data center is proportional to power consumption of IT equipment, and power consumption in the afternoon time in summer generally consumes the most power.

[0005] In particular, when power consumption increases in the afternoon in summer, there is a problem in that an electricity rate increases rapidly due to application of an electricity rate variable rate system, and furthermore, when power consumption is large compared to supplied power, there is a problem in that a black out occurs.

[0006] To overcome this, Korean Patent No. 10-0911264 provides a technology for communicating with a load provided at a consumer (building, factory) directly from Korea Electric Power Corporation and directly controlling the load in a peak power section, thereby reducing power used by the load.

[0007] In addition, Korean Patent No. 10-1699563 also provides a control method for reducing power consumption in a peak power section in consideration of internal environmental information (temperature, humidity, etc.) of a consumer.

[0008] However, due to the characteristics of a data center, it is impossible to turn off an operation of a server to reduce a load of the server used by each company, and large-scale

cooling energy is required, and accordingly, when a cooling operation is insufficient, there is a serious problem that the server breaks down and that there is a limit in reducing peak power only by simple load control as in the prior art.

SUMMARY OF THE INVENTION

[0009] An object of the present disclosure is to perform air conditioning with assistance from a backup heat source in a peak time zone using a backup heat source with heat storage and to easily recognize a time zone in which assistance from the backup heat source is to be performed and a ratio at which power is saved in the time zone through simulation without direct driving of a system.

[0010] According to an aspect of the present disclosure, a peak power reduction simulation system using a backup heat source includes a database containing power usage data for each time zone of a specific building or a specific space, an inquirer configured to read power usage data for each time zone from the database, a power calculator configured to calculate maximum power consumption and minimum power consumption and peak power therebetween, which is reference power, based on the power usage data for each time, read from the inquirer, a backup heat source information recognizer configured to recognize total capacity of the backup heat source and supplied capacity of the backup

heat source, a simulation calculator configured to calculate a time zone in which the backup heat source is required, a supplied amount of the backup heat source for each time zone, to be introduced in each time zone in which the backup heat source is required, and a peak reduction rate by supply of the backup heat source based on remaining capacity of the backup heat source calculated by continuously calculating a difference between the total capacity of the backup heat source and the supplied capacity of the backup heat source, and a controller configured to control the database, the inquirer, the power calculator, the backup heat source information recognizer, and the simulation calculator.

[0011] When there is available capacity of the backup heat source, the simulation calculator may calculate, under control of the controller, a time zone in which the backup heat source is required and the supplied amount of the backup heat source for each time zone, to be introduced in each time zone in which the backup heat source is required, based on remaining capacity of the backup heat source calculated by continuously calculating a difference between the total capacity of the backup heat source and the supplied capacity of the backup heat source.

[0012] When there is no available capacity of the backup heat source, the simulation calculator may calculate the peak reduction rate under control of the controller, and the peak

reduction rate is a ratio calculated by dividing the supplied amount of the backup heat source in a time zone in which power consumption is highest by required power that is a difference value obtained by subtracting peak power as reference power from maximum power consumption in a time zone in which power consumption is highest.

[0013] The power usage data for each time zone may contain an item for each month, each day of a week, and each time zone, or an item for each season, each day of a week, and each time zone and may be provided.

[0014] The supplied amount of the backup heat source for each time zone, supplied by the backup heat source, may be calculated to make a slope of a graph of required common power due to supply of the backup heat source be smoother than a slope of a graph of common power when the backup heat source is not supplied.

[0015] According to another aspect of the present disclosure, a peak power reduction simulation method using a backup heat source includes inquiring into power usage data for each time zone, calculating or setting maximum power consumption and minimum power consumption and peak power therebetween based on the power usage data for each time, recognizing total capacity of the backup heat source and supplied capacity of the backup heat source, and calculating a time zone in which the backup heat source is required, a supplied amount of the backup heat

source for each time zone, to be introduced in each time zone in which the backup heat source is required, and a peak reduction rate by supply of the backup heat source based on remaining capacity of the backup heat source calculated by continuously calculating a difference between the total capacity of the backup heat source and the supplied capacity of the backup heat source.

[0016] The calculating the peak reduction rate may include calculating a time zone in which the backup heat source is required and the supplied amount of the backup heat source for each time zone, to be introduced in each time zone in which the backup heat source is required, based on remaining capacity of the backup heat source calculated by continuously calculating a difference between the total capacity of the backup heat source and the supplied capacity of the backup heat source.

[0017] When there is no available capacity of the backup heat source, a simulation calculator may calculate the peak reduction rate under control of a controller, and the peak reduction rate may be a ratio calculated by dividing the supplied amount of the backup heat source in a time zone in which power consumption is highest by required power that is a difference value obtained by subtracting peak power as reference power from maximum power consumption in a time zone in which power consumption is highest.

[0018] The power usage data for each time zone may contain an item for each month, each day of a week, and each time zone, or an item for each season, each day of a week, and each time zone and may be provided.

[0019] The supplied amount of the backup heat source for each time zone, supplied by the backup heat source, may be calculated to make a slope of a graph of required common power due to supply of the backup heat source be smoother than a slope of a graph of common power when the backup heat source is not supplied.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings:

[0021] FIG. 1 is a schematic view showing a plane of the configuration of a server room.

[0022] FIG. 2 is a schematic view showing a side of the configuration of a server room.

[0023] FIG. 3 is a schematic view showing the configuration of a simulation system according to the present disclosure.

[0024] FIG. 4 is a diagram showing flow of a refrigerant when a backup heat source radiates heat according to the present disclosure.

[0025] FIG. 5 is a diagram showing flow of a refrigerant when a backup heat source stores heat according to the present disclosure.

[0026] FIG. 6 is a schematic flowchart showing a simulation method according to the present disclosure.

[0027] FIG. 7 is a detailed flowchart of a simulation method according to the present disclosure.

[0028] FIG. 8(A) is a table showing classification of loads for respective seasons provided by Korea Electric Power Corporation.

[0029] FIG. 8(B) is a graph showing an energy usage pattern using heat storage.

[0030] FIG. 9 is a graph showing a simulation result value derived using a simulation method according to the present disclosure.

[0031] FIG. 10 is a table showing a simulation result value derived using a simulation method according to the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

[0032] As the present disclosure allows for various changes and numerous embodiments, particular embodiments will be illustrated in the drawings and described in detail in the written description.

[0033] However, this is not intended to limit the present disclosure to particular modes of practice, and it is to be appreciated that all changes, equivalents, and substitutes that do not depart from the spirit and technical scope of the present disclosure are encompassed in the present disclosure.

[0034] The terms such as "first" and "second" are used herein merely to describe a variety of constituent elements, but the constituent elements are not limited by the terms.

[0035] The terms are used only for the purpose of distinguishing one constituent element from another constituent element.

[0036] For example, a first element may be termed a second element and a second element may be termed a first element without departing from the teachings of the present disclosure.

[0037] As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0038] It will be understood that when an element, such as a layer, a region, or a substrate, is referred to as being "connected to" or "coupled to" another element, it may be

directly on, connected or coupled to the other element or intervening elements may be present.

[0039] In contrast, when an element is referred to as being "directly on," "directly connected to" or "directly coupled to" another element or layer, there are no intervening elements or layers present.

[0040] The terms used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure.

[0041] The singular forms are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0042] It will be further understood that the terms "comprises" or "comprising" when used in this specification, specify the presence of stated features, integers, steps, operations, elements, or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, or groups thereof.

[0043] Hereinafter, the present disclosure will be described in detail by explaining exemplary embodiments of the present disclosure with reference to the attached drawings. The same reference numerals in the drawings denote like elements, and a repeated explanation thereof will not be given.

[0044] FIG. 1 is a state diagram showing a server room of a data center or a building, and FIG. 2 is a schematic system

diagram of a control system of an air conditioning control system of a server room according to an embodiment of the present disclosure.

[0045] As shown in FIGS. 1 and 2, in a server room 1000, a plurality of server racks 100 may form one row, and a plurality of rows of the server racks 100 may be separately face each other.

[0046] In more detail, one row of the server racks 100 may include the plurality of server racks 100, and the plurality of server racks 100 may be arranged with sides adjacent to each other.

[0047] In addition, a plurality of rows of the server racks 100 may be spaced apart from each other in front and rear directions, and a cold aisle 200 or a hot aisle 300 may be formed in a space formed by spacing rows of the server racks 100 in front and rear directions.

[0048] Here, two rows of the server racks 100, which are arranged to face adjacent to each other, may be arranged with front sides facing each other or rear sides facing each other.

[0049] Since a server generates much heat due to the characteristics thereof, it may be important to constantly provide cooling air to prevent a server temperature from rising above a specific temperature in order to prevent a problem due to server overheating.

[0050] To this end, cooling air may be supplied between a specific row of the server racks 100 and an adjacent row of the server racks 100, and the cold aisle 200 may refer to a space to which the cooling air is supplied. In the cold aisle 200, the server racks 100 or rows of the server racks 100, which face each other, may be arranged in such a way that front surfaces from which cooling air is supplied face each other.

[0051] On the other hand, the hot aisle 300 may refer to a space in which cooling air supplied through front surfaces of the server racks 100 exchanges heat with a server and heated air (i.e., hot air) is discharged. In the hot aisle 300, the server racks 100 or the rows of the server racks 100 may be arranged in such a way that rear surfaces from which cooling air is discharged face each other.

[0052] In FIG. 1, a region indicated by ㊟ may be the cold aisle 200, and a region indicated by ㊦ may be the hot aisle 300 that exchanges heat with each server and hot air is discharged.

[0053] In FIG. 2, B-arrows may refer to cooling air for cooling a server, and R-arrows may refer to hot air, temperature of which rises after the server is cooled.

[0054] In order to increase cooling efficiency and concentration of cooling air, a closed room may be implemented to form a closed space in the cold aisle 200.

[0055] From a structural point of view, an air conditioning control system of the server room 1000 may include a closed room, a guidance space 400, an exhaust duct 500 and/or a double ceiling, a cooling air supply adjuster 600, an air conditioner (not shown), a sensor(not shown), and a controller (not shown).

[0056] The closed room may include the plurality of cold aisles 200, the plurality of hot aisles 300, and the plurality of server racks 100 that are arranged to be surrounded by the cold aisles 200 and the hot aisles 300 in front and rear directions.

[0057] The plurality of cold aisles 200 may be provided between two rows of the server racks 100 that face each other and may be configured to allow cooling air to be introduced to the server racks 100 to flow.

[0058] The plurality of hot aisles 300 may be provided opposite the cold aisle 200 to surround the server racks 100 with the cold aisle 200 and may be configured to allow hot air to be discharged after cooling the server racks 100 to flow.

[0059] The guidance space 400 may be provided below a support floor (not shown) by which the closed room is supported and may be configured to guide air to be introduced to the plurality of cold aisles 200.

[0060] The exhaust duct 500 and/or the double ceiling may be configured to recover hot air to the air conditioner by combining hot air discharged from the hot aisle 300.

[0061] The air conditioner may be provided outside the closed room and may be configured to appropriately adjust the temperature and humidity of air to be introduced to the guidance space 400 by exchanging heat between the hot air and a refrigerant.

[0062] Here, the air conditioner may perform an air conditioning function using power supplied from a common power source connected to a power grid of Korea Electric Power Corporation or may perform an air conditioning function using a backup heat source placed in a data center or a building.

[0063] Hereinafter, a heat source that provides cooling heat using a heat storage system is defined as a backup heat source, and a heat source that provides cooling heat using power supplied from a common power source is defined as a common heat source.

[0064] A plurality of sensors may be provided at the server racks 100, respectively, and may be configured to detect air conditioning state information such as humidity and temperature and/or state information of each of the server racks 100 including power consumption of each of the server racks 100.

[0065] Cooling air supplied from an air conditioner (e.g., a thermo-hygrostat) included in an air conditioning system

connected to a backup heat source or a common heat source may be supplied to the aforementioned guidance space 400 and may perform an air conditioning function of cooling servers of a server rack through the closed room 300 and then refluxing to the exhaust duct 500 to continuously cool the servers in the server room in a circulation pattern.

[0066] The controller of the air conditioning system may be configured to control the closed room 300, the guidance space 400, the cooling air supply adjuster 600, the air conditioner, and the sensor and may be configured to drive various control algorithms.

[0067] An air conditioning system 900 for supplying cooling air to the server room 1000 and taking hot air may receive heat from either a common heat source 2 or a backup heat source 1 or may receive heat from both the common heat source 2 and the backup heat source 1.

[0068] The backup heat source 1 may be an air conditioner for storing cold heat by operating a low-temperature freezer at night using inexpensive late-night electricity and then performing cooling using the stored cold heat even in the state in which an operation of the low-temperature freezer is stopped during the daytime and may be mainly installed and operated in large buildings.

[0069] This system may be configured to perform primary heat exchange by filling capsule, liquid, or water that easily absorbs heat inside a heat storage tank and passing high-temperature brine (ethylene glycol) through heat storage tank, to then perform secondary heat exchange by storing a heat source, transmitting the stored heat source to a heat exchanger configuring a loop through the brine, and exchanging heat with circulating cold water configuring another loop in the heat exchanger, and to perform tertiary heat exchange by re-transmitting the heat-exchanged circulating water to an air conditioning system including a radiator such as a fan coil unit, and, that is, may perform cooling.

[0070] An ice capsule (ice ball) may be generally used as a material inside the heat storage tank and may be formed by putting a solution in which water and a nucleating agent (a room temperature freezing material) are diluted in a spherical plastic container into a capsule and sealing the capsule.

[0071] FIGS. 4 and 5 are diagrams showing an example of a heat storage cooling system configuring the backup heat source 1, FIG. 4 is a system diagram in a cooling state, and FIG. 5 is a system diagram in an ice making state.

[0072] FIG. 4 is a system diagram in a cooling state, and as shown in the drawing, when a brine pump 20 on a first brine circulation path 10 is operated, low-temperature brine inside a

heat storage tank 30 may be discharged through a low temperature inlet and outlet pipe 31, and the discharged low-temperature brine may be supplied toward a low-temperature freezer 40 that stops being operated through the first brine circulation path 10.

[0073] The supplied low-temperature brine may be in the state in which heat is not exchanged with the low-temperature freezer 40 and may be introduced to the heat exchanger 50 through a brine inlet pipe 51 of a heat exchanger 50.

[0074] In this case, the low-temperature freezer 40 may configure a loop with a cooling tower 41 and a coolant pump 43.

[0075] The introduced low-temperature brine may be changed to a state of high temperature while exchanging heat with cold water circulating inside the heat exchanger 50 through a cold water inlet pipe 55 and a cold water outlet pipe 53 and may then be transmitted again toward the first brine circulation path 10 through a brine outlet pipe 57, and the transmitted high-temperature brine may be continuously circulated for cooling by being introduced into the heat storage tank 30 through a high and low temperature inlet and outlet pipe 33 of the heat storage tank 30.

[0076] In this case, a first on/off valve 11 on the first brine circulation path 10 may be opened and a second on/off valve 61 on a second brine circulation path 60 may be closed,

thereby preventing the low-temperature brine passing via the first brine circulation path 10 through the second brine circulation path 60 from being introduced to the low temperature inlet and outlet pipe 31 of the heat storage tank 30.

[0077] A first three way valve 70 may open a travel route of brine passing toward the low-temperature freezer 40 from the heat storage tank 30 and may close a travel route of brine passing toward the heat storage tank 30 from the first brine circulation path 10. A second three way valve 80 may be maintained in the state in which both a travel route of the first brine circulation path 10 and a travel route to the first brine circulation path 10 from the brine outlet pipe 57 of the heat exchanger 50 are opened.

[0078] This cooling operation is used during the daytime when an electricity rate is high and electricity demand is high.

[0079] FIG. 5 is a system diagram in an ice making state, and as shown in the drawing, when the brine pump 20 on the first brine circulation path 10 is operated, high-temperature brine inside the heat storage tank 30 may be discharged through the high and low temperature inlet and outlet pipe 33, and the discharged high-temperature brine may be supplied toward the low-temperature freezer 40 that is currently operated through the first brine circulation path 10.

[0080] The supplied high-temperature brine may be changed to a state of low temperature while exchanging heat with the low-temperature freezer 40, and the low-temperature brine may be continuously and repeatedly introduced again to the low temperature inlet and outlet pipe 31 and the heat storage tank 30 through the second brine circulation path 60, and thus de-icing of an ice capsule inside the heat storage tank 30 may be performed.

[0081] Here, a low-temperature freezer may be operated using inexpensive late-night electric power at night.

[0082] In this case, the first on/off valve 11 on the first brine circulation path 10 may be closed, the second on/off valve 61 on the second brine circulation path 60 may be opened, and the first three way valve 70 may close a travel route of bring passing toward the low-temperature freezer 40 from the heat storage tank 30 and may open a travel route of bring passing toward the heat storage tank 30 from the first brine circulation path 10.

[0083] The second three way valve 80 may close both the travel route of the first brine circulation path 10 and the travel route to the first brine circulation path 10 from the brine outlet pipe 57 of the heat exchanger 50.

[0084] As shown in FIG. 3, the common heat source 2 and the backup heat source 1, and the server room 1000 may be connected

to communicate with a peak power reduction simulation system (hereafter referred to as the "simulation system") 800 using a backup heat source according to the present disclosure and may provide various data to the simulation system 800.

[0085] The simulation system 800 may not actually control operations of a common heat source 1 or a backup heat source 2 or the air conditioning system 900 connected thereto and may be a system for simulating a method of inquiring into power usage data for each time zone of a specific building (e.g., a data center) or a specific space (e.g., a server room), checking maximum power consumption and minimum power consumption for each time zone, peak power based thereon (a power level at which a backup heat source needs to be used), capacity to be provided by the backup heat source, and capacity to be supplied for each time zone, and lowering a peak value of common power use.

[0086] To this end, the simulation system 800 may include a database 801, an inquirer 802, a power calculator 803, a backup heat source information recognizer 804, an inputter 805, an outputter 806, a simulation calculator 807, and a controller 808.

[0087] The database 801 may include an energy usage database of a building or a specific server room, a facility information database of air conditioning equipment, lighting equipment, etc. installed in a building, a facility information database

containing information such as the type and number of server racks or servers installed in a building or a specific server room, and the power consumption, installation year, and installation location of each of the server racks or the servers, and a weather information database containing weather information (seasonal and monthly temperature and humidity, etc.).

[0088] Power usage information, temperature information, humidity information, etc., which are stored in the database, may be collected and recorded by an EMS (Energy Management System) that manages energy of a building.

[0089] The inquirer 802 may inquire into power usage data / building facility information data / equipment information data / weather information data for each time zone of a specific building or a specific space listed in the database 801 above.

[0090] The power calculator 803 may calculate maximum power consumption and minimum power consumption, and a peak power as a reference for introducing a backup heat source, based on the power usage data for each time zone read from the inquirer.

[0091] The power usage data for each time zone may be changed for each season and month and may also be changed depending on weather state (rainy season with high humidity, etc.). Calculation of power may be changed depending on the characteristics of the season and the characteristics of the

weather and may be changed depending on information retrieved from the aforementioned database.

[0092] The backup heat source information recognizer 804 may receive, recognize, or set total capacity of the backup heat source and supplied capacity of the backup heat source. When the total capacity of the backup heat source is a concept of stock, the supplied capacity of the backup heat source may be classified based on a concept of flow. That is, the supplied capacity of the backup heat source may be considered as a concept of the amount supplied per unit time.

[0093] The inputter 805 may allow an operator to input various pieces of information. Through the inputter 805, an area or volume of a space or a server room, the number of racks in which IT equipment is installed, the number of servers installed in each rack, the maximum heating value of IT equipment, a heating value of a lighting per unit area, other loads, the number of ventilation, an outdoor condition, an indoor condition, and capacity, power factor, efficiency, etc. of other electrical devices other than an IT device may be input, and a more precise simulation in consideration of various environments may be achieved.

[0094] The outputter 806 may visually display the result of such as simulation operation. The result may be displayed as in FIG. 9 or 10 through the outputter 806.

[0095] The simulation calculator 807 may calculate a time zone in which the backup heat source is required, the supplied amount of the backup heat source for each time zone, to be introduced in each time zone in which the backup heat source is required, and a peak reduction rate by supply of the backup heat source total capacity of the backup heat source and the supplied capacity of the backup heat source, and the controller may control the above components.

[0096] As shown in FIG. 6, a basic algorithm for reducing a peak power load may largely and sequentially analyze predicted peak power and analyze a required amount of the backup heat source according to the analysis result.

[0097] In detail, It may be calculated and predicted when usage power reaches peak power based on power usage data acquired for each time in the past. The usage power for each time zone may be changed for each season, month, and day of the week, and thus may be predicted in consideration of these factors (S61).

[0098] Here, the peak power may not refer to the maximum value of power in dictionary meaning but may refer to power usage at a level at which it is insufficient to use power only with common power. That is, the peak power may refer to a kind of reference power at which only a common heat source is used and then a backup heat source needs to be additionally used.

[0099] Accordingly, the peak power may be defined as a specific reference value and may mean that the backup heat source needs to be supplied in a time zone in which power equal to or greater than the peak power is used.

[00100] According to the present disclosure, a backup required heat source in a time zone may be a difference between the peak power and power consumption to be actually consumed or predicted to be actually consumed, a time zone in which the required heat source is highest may be selected among corresponding time zones, and a supply heat source may be supplied.

[00101] The difference may be subtracted from the backup heat source, and subtraction may be performed until all available backup heat sources are deducted.

[00102] Performing of subtraction may be changed from time to time depending on the total amount of the backup heat source that is currently charged with the backup heat source 1, and the supplied amount of the heat source to be supplied from the backup heat source per hour. In addition, a setting temperature condition for air conditioning, the number and installation area of servers, etc. need to be input.

[00103] When the usage power does not reach the peak power, the backup heat source 1 may not be used, but whether the backup heat source 1 needs to be charged may be determined (S62).

[00104] The backup heat source 1 may be charged using power of the common power source. However, power of the common power source for charging the backup heat source 1 may be used during the late night time in which an hourly electricity rate is inexpensive (e.g., 23:00 the day before - 9:00 the next day) (S63).

[00105] A charging method of the backup heat source 1 has been described above with reference to FIG. 3 and a detailed description thereof.

[00106] When the power consumption is predicted to reach the peak power, whether there is available capacity of the backup heat source may be determined (S64), and in this case, the available capacity of the backup heat source 1 may be used (S65).

[00107] The reliability of simulation calculation and data establishment may be increased as a time for which data is collected is increased and the amount of data is increased. According to the present disclosure, the reliability of simulation calculation may be increased through big data establishment and machine learning.

[00108] A machine learning scheme may include genetic programming (GP), an artificial neural network (ANN), a support vector machine (SVM), and a random forest (RF) method.

[00109] Detailed methods are prior art, and a detailed description will be omitted.

[00110] The method shown in FIG. 6 is now described in more detail, and as shown in FIG. 7, power usage data and weather data for each time zone may be inquired from a database (S71), predicted maximum power and minimum power may be calculated, and peak power (reference power) may be calculated based thereon (S72).

[00111] Here, the peak power may be a value between the maximum power and the minimum power and may be calculated using a predetermined weight, or may be set to be calculated or input depending on an order of an ordering party or a situation of an electricity bill.

[00112] When such calculation is completed, the total capacity of the backup heat source may be received or read or the supplied amount of the heat source may be received or read. Here, the supplied amount of the heat source may refer to the supplied amount of the heat source per hour (per minute or second) (S73).

[00113] Whether reserve capacity of the backup heat source is equal to or greater than 0 may be checked. The reserve backup capacity may refer to the remaining heat source capacity except for emergency heat source capacity (e.g., capacity to be always reserved for a blackout) to be used for emergency use (S74).

[00114] When it is determined that the reserve backup heat source capacity is equal to or greater than 0, a time zone in which the reserve capacity of the backup heat source is to be

used may be selected. When the reserve capacity of the backup heat source is high, a significant part of a time zone in which the usage power is greater than the peak power may be covered, and when the reserve capacity of the backup heat source is low, capacity of the backup heat source may be inevitably used only in some time zones in which power consumption is maximized.

[00115] A time zone in which a heat source is to be supplied may be selected in consideration of the reserve capacity of the backup heat source and the supplied amount of the heat source (S75), and the heat source may be supplied in the corresponding time zone to drive an air conditioning system by the backup heat source with the common heat source (S76).

[00116] While the air conditioning system is driven, the reserve capacity of the backup heat source may be repeatedly calculated, and according to a result value, the above operation may be repeatedly performed until the reserve capacity of the backup heat source is 0 (S77).

[00117] When the reserve backup heat source is 0, the heat source may stop being supplied by the backup heat source, and a peak reduction rate may be calculated (S78).

[00118] The peak reduction rate may be a ratio calculated by dividing the supplied amount of the backup heat source in a time zone in which power consumption is highest by required power that is a difference value obtained by subtracting peak power

as reference power from the maximum power consumption in a time zone in which power consumption is highest, and through the peak reduction rate, how much common power is saved may be recognized through the backup heat source in the time zone (e.g., 14 o'clock time zone) in which the power consumption is highest.

[00119] It may be possible to examine how much a server is expanded as much as that without increase in common power usage using the backup heat source.

[00120] That is, in terms of the economic feasibility of a data center, when the peak of usage power is reduced by 5%, servers corresponding to 5% may be accommodated, and because additional profits are advantageously increased using existing infrastructure facilities without additional investment, the above peak reduction rate may be used as an indicator for additionally accommodating servers.

[00121] FIG. 8A is a table showing classification of loads for respective seasons (summer, spring/fall, and winter) provided by Korea Electric Power Corporation, and FIG. 8B is a graph showing an energy usage pattern using ice heat storage.

[00122] Generally, from 23:00 to 9:00 the day before, it may be a light load time zone and may be classified as a late-night power application time, and in this case, the aforementioned backup heat source may be charged with inexpensive electricity rates. This is indicated by ice heat storage.

[00123] During the daytime, an air conditioning function may be performed by operating a freezer using common power up to a predetermined level, and then above a predetermined level of reference power (peak power), the air conditioning function may be performed by simultaneously performing the common heat source and the backup heat source using ice heat storage charged during the late-night power application time, thereby an electricity bill could be reduced or an available load could be increased without additional use of utility power.

[00124] FIG. 9 is a graph showing a power peak simulation according to the present disclosure, and FIG. 10 is a table showing the power peak simulation.

[00125] For example, when peak power is defined as 10463.85 kWh, power in excess of the peak power may be defined as required power, and a backup heat source may be mainly used in a time zone in which the corresponding required power is needed.

[00126] However, when a heat source amount of the backup heat source is not capable of covering a heat source total amount corresponding to the required power, the backup heat source may be used partly in a time zone in which usage power is highest.

[00127] In the graph, a section indicated with a Y-line alone may be common power (AS IS total power) consumed when the backup heat source is not supplied, and a section indicated with a P-line may be common power (To Be total power) consumed when the

backup heat source is used. In addition, the corresponding section may be indicated by a box (indicated by an Backup heat source application section).

[00128] In addition, a region indicating the difference may be indicated by a shaded area.

[00129] When a result obtained by digitizing this is shown in FIG. 10, a time zone in which usage power is above the peak power is from 9 o'clock to 20 o'clock, and excess required power is indicated by number greater than 0(zero) in required power section in FIG. 10. The required power is 3289.28 kWh, but reserve power of the backup heat source is 150 kWh, and accordingly, to effectively distribute this, a time zone may be divided into a 14 o'clock time zone, a 15 o'clock time zone, and 16 o'clock time zone and may be provided, and the backup heat source may not be provided in the other time zones.

[00130] Supplied power to be supplied in each time zone may be determined in such a way that a slope of the graph of required common power due to supply of the backup heat source is smoother than a slope of the graph of common power when the backup heat source is not supplied.

[00131] That is, 63 kWh may be supplied in the 14 o'clock time zone, 56 kWh may be supplied in the 15 o'clock time zone, and 31 kwh may be supplied in the 16 o'clock time zone. In addition,

the backup heat source may be charged again in a late night power time zone.

[00132] Here, a time zone that is a target of calculation of a peak reduction rate may be the 14 o'clock time zone, and in this case, the peak reduction rate may be calculated as $63/469.1$ and may be 13.43% as a percentage.

[00133] According to the present disclosure, power of the reserve backup heat source, the peak power as a reference, required power for each time zone, a time zone in which the backup heat source is introduced, and power of the backup heat source allocated in each time zone may be set, and accordingly, it may be advantageous that a level of common power to be saved due to supply of the backup heat source may be recognized by calculating even the peak reduction rate and that a guide for expanding the server as much as power of the backup heat source without addition of a separate common power facility.

[00134] According to the present disclosure, it may be possible to recognize how much energy is saved due to an operation of the backup heat source through simulation without actually operating an air conditioning system, and how many servers are installed while maintaining the current facilities without addition of more power facilities to use additional common power may be exactly recognized.

[00135] When available capacity is used from backup heat source capacity, the available capacity may be optimized and allocated for each time zone, and thus the backup heat source capacity may not be concentrated only at a specific time and power cost may be reduced as much as possible, thereby improving economic efficiency.

[00136] While the present disclosure has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit.

[00137] Accordingly, the scope of the present disclosure as defined by the following claims.

WHAT IS CLAIMED IS:

1. A peak power reduction simulation system using a backup heat source, comprising:

a database containing power usage data for each time zone of a specific building or a specific space;

an inquirer configured to read power usage data for each time zone from the database;

a power calculator configured to calculate maximum power consumption and minimum power consumption and peak power therebetween, which is reference power, based on the power usage data for each time, read from the inquirer;

a backup heat source information recognizer configured to recognize total capacity of the backup heat source and supplied capacity of the backup heat source;

a simulation calculator configured to calculate a time zone in which the backup heat source is required, a supplied amount of the backup heat source for each time zone, to be introduced in each time zone in which the backup heat source is required, and a peak reduction rate by supply of the backup heat source based on remaining capacity of the backup heat source calculated by continuously calculating a difference between the total capacity of the backup heat source and the supplied capacity of the backup heat source; and

a controller configured to control the database, the inquirer, the power calculator, the backup heat source information recognizer, and the simulation calculator.

2. The peak power reduction simulation system using the backup heat source of claim 1, wherein, when there is available capacity of the backup heat source, the simulation calculator calculates, under control of the controller, a time zone in which the backup heat source is required and the supplied amount of the backup heat source for each time zone, to be introduced in each time zone in which the backup heat source is required, based on remaining capacity of the backup heat source calculated by continuously calculating a difference between the total capacity of the backup heat source and the supplied capacity of the backup heat source.

3. The peak power reduction simulation system using the backup heat source of claim 1, wherein, when there is no available capacity of the backup heat source, the simulation calculator calculates the peak reduction rate under control of the controller, and

wherein the peak reduction rate is a ratio calculated by dividing the supplied amount of the backup heat source in a time zone in which power consumption is highest by required power

that is a difference value obtained by subtracting peak power as reference power from maximum power consumption in a time zone in which power consumption is highest.

4. The peak power reduction simulation system using the backup heat source of claim 1, wherein the power usage data for each time zone contains an item for each month, each day of a week, and each time zone, or an item for each season, each day of a week, and each time zone and is provided.

5. The peak power reduction simulation system using the backup heat source of claim 1, wherein the supplied amount of the backup heat source for each time zone, supplied by the backup heat source, is calculated to make a slope of a graph of required common power due to supply of the backup heat source be smoother than a slope of a graph of common power when the backup heat source is not supplied.

6. A peak power reduction simulation method using a backup heat source, the method comprising:

inquiring into power usage data for each time zone;

calculating or setting maximum power consumption and minimum power consumption and peak power therebetween based on the power usage data for each time;

recognizing total capacity of the backup heat source and supplied capacity of the backup heat source; and

calculating a time zone in which the backup heat source is required, a supplied amount of the backup heat source for each time zone, to be introduced in each time zone in which the backup heat source is required, and a peak reduction rate by supply of the backup heat source based on remaining capacity of the backup heat source calculated by continuously calculating a difference between the total capacity of the backup heat source and the supplied capacity of the backup heat source.

7. The method of claim 6, wherein the calculating the peak reduction rate includes calculating a time zone in which the backup heat source is required and the supplied amount of the backup heat source for each time zone, to be introduced in each time zone in which the backup heat source is required, based on remaining capacity of the backup heat source calculated by continuously calculating a difference between the total capacity of the backup heat source and the supplied capacity of the backup heat source.

8. The method of claim 6, wherein, when there is no available capacity of the backup heat source, a simulation

calculator calculates the peak reduction rate under control of a controller, and

wherein the peak reduction rate is a ratio calculated by dividing the supplied amount of the backup heat source in a time zone in which power consumption is highest by required power that is a difference value obtained by subtracting peak power as reference power from maximum power consumption in a time zone in which power consumption is highest.

9. The method of claim 6, wherein the power usage data for each time zone contains an item for each month, each day of a week, and each time zone, or an item for each season, each day of a week, and each time zone and is provided.

10. The method of claim 6, wherein the supplied amount of the backup heat source for each time zone, supplied by the backup heat source, is calculated to make a slope of a graph of required common power due to supply of the backup heat source be smoother than a slope of a graph of common power when the backup heat source is not supplied.