

[Document Name] Specification

[Title of the Invention] **ENERGY CONSUMPTION CALCULATING SYSTEM**

[Technical Field]

[0001]

The present invention relates to an energy consumption calculating system, for example, an energy consumption calculating system that calculates an estimated value of energy consumed by a heating, ventilating, air conditioning (HVAC) unit provided with an automatic control function.

[Background Art]

[0002]

For an HVAC unit used in homes, company places of business, schools, hospitals, entertainment facilities, stores, and the like, output is generally controlled so that power consumption is kept to minimum based on indoor temperatures measured by temperature sensors installed in areas (indoor) to be cooled and heated.

[0003]

Furthermore, Patent Document 1 discloses an air conditioning equipment management system as technology relating to an HVAC unit energy conservation, where, in a system for managing air conditioning equipment connected to a communication company through a central server from an external environment, the central server, which incorporates an electric current value or information on power consumption, calculates electricity charges associated with the operation of the air conditioning equipment, and displays alerts for a plurality of times on a display device of communication terminal equipment when an approximate electricity charge based on an operation of the air conditioning equipment exceeds a plurality of predetermined percentages or predetermined values of a target electricity charge with respect to the target electricity charge that serves as a standard associated with the air conditioning equipment as set from the communication terminal based on the calculated electricity charge information before reaching the target electricity charge.

[Documents of the Prior Art]

[Patent Documents]

[0004]

[Patent Document 1] Japanese Patent No. 4274095

[Summary of the Invention]

[Problem to be Solved by the Invention]

[0005]

Meanwhile, decarbonization and energy reduction are currently being emphasized globally from the perspective of protecting the global environment. Energies used at companies, places

of business, and the like (offices, factories, hospitals, commercial facilities, restaurants, and the like) occupy a large percentage of global energy consumption, and energies consumed by HVAC units occupy a large percentage of that energy.

Furthermore, although, against the above background, various manufacturers sell systems that automatically control the output of HVAC units to reduce energy consumption, these systems consider how to adjust indoor temperature with respect to a set temperature in an energy-efficient manner, but there are no systems that variably adjust temperature to reduce energy consumption according to building structure and environmental conditions (indoor conditions (changes in the number of people present) and external environmental conditions such as outside air temperature, and the like) that change over time. There is also nothing to infer energy consumed according to environmental conditions that can serve as an indicator for such control.

[0006]

Furthermore, although company offices are used jointly by plural people and the appropriate temperature that should be controlled by an HVAC unit thus changes with the number of people, temperatures are typically not managed, and are thus kept the same even when energy consumption rises above what is required. Even when there is a condition where significant energy reduction can be expected by changing one degree in temperature in a certain environment, there is no indicator relating to reducing energy consumed where a system operator in such environments could use while making predictions.

Therefore, although it would be preferable if there were a system that enables an operator of a system that controls an HVAC unit to ascertain appropriate temperature for and infer energy consumed by an HVAC unit based on an environmental condition that changes over time, no such system exists.

Note that the system disclosed in Patent Document 1 above simply uses an electric current value or information on power consumption from the air conditioning equipment to calculate an electricity charge and provides an alert to prevent a target electricity charge from being exceeded, and it does not infer energy consumed by an HVAC unit according to environmental conditions that change over time.

[0007]

An object of the present invention is to resolve the problem described above by providing an energy consumption calculating system that calculates an estimated value of energy consumed with respect to a set temperature based on environmental conditions that change over time in an HVAC unit having an automatic control function.

[Means for Solving the Problem]

[0008]

In order to resolve the problem described above, the present invention is an energy consumption calculating system comprising: an information processor that calculates an estimated value of energy consumed by an HVAC unit provided with an automatic control function, the information processor comprising: a data acquisition unit for acquiring internal and external environmental information of a building in which the HVAC unit is installed; an energy consumption table in which a plurality of cells is formed into a matrix; an energy consumption calculator that calculates cell values for the energy consumption table; and an energy consumption approximating unit that approximates the cell values of the energy consumption table and calculates an estimated value of energy consumed by the HVAC unit over a predetermined period, wherein the data acquisition unit acquires at least an indoor temperature of an interior of a building in which the HVAC unit is installed, an outside air temperature outside the building in which the HVAC unit is installed, and a set temperature for the HVAC unit, as the environmental information for each predetermined time, each cell of the energy consumption table is stored with a value that is assigned according to a value of the environmental information and is a basis for calculating energy consumption, and the energy consumption approximating unit, by using the environmental information acquired at each predetermined time, calculates the cell values in the energy consumption table corresponding to the environmental information, and calculates an estimated value of energies consumed according to a change in an environment in which the HVAC unit is installed.

[0009]

According to the configuration described above, environmental information (outside air temperature, indoor temperature, and set temperature) inside and outside the building in which the HVAC unit is installed that can lead to an increase in energy consumed by the HVAC unit can be acquired for each predetermined time. Furthermore, the present invention provides an energy consumption table in which a plurality of cells is formed into a matrix where each cell of the energy consumption table is assigned according to a value of environmental information, and in which is stored a value that is the basis for calculating energy consumption.

Moreover, when, for example, the HVAC unit is set to cool and thus operates to lower the indoor temperature “from 30°C to 25°C,” the cooling acts as repulsive energy since an outside air temperature warms the building. That is, since environmental information becomes an indicator of repulsive energy with respect to the HVAC unit and an equilibrium as a relationship between energy consumed by the HVAC unit and a reaction, it becomes possible for the HVAC unit to calculate the energy that must be consumed to adjust the temperature by referencing the value that is the basis for calculating energy consumption which has been stored in the cell that matches the conditions of the acquired current environmental information. As a result, the present invention makes it possible to infer power consumption at each set

temperature in an individual space in advance, and to control a set temperature according to an HVAC unit environment using the present invention can make significant contributions to decarbonization and energy reduction.

Note that a temperature sensor may be provided in the vicinity of the building in which the HVAC unit is installed, and the data acquisition unit may acquire the outside air temperature from the temperature sensor, or a configuration where the data acquisition unit acquires the outside air temperature in the area near the building through the Internet may also be used. Additionally, the data acquisition unit may also acquire the indoor temperature and set temperature from the HVAC unit, or may acquire the indoor temperature from a temperature sensor installed in the room in which the HVAC unit is installed.

[0010]

Furthermore, it is preferable that the energy consumption table includes a column specified according to a value of a difference between the outside air temperature and the set temperature, and a row specified according to a value of a difference between the indoor temperature and the set temperature, and that power consumption, which is the value used in the energy consumption calculation, be stored in a cell where the column and the row intersect.

Note that power consumption is a numerical value indicating repulsive energy with respect to an output of the HVAC unit.

[0011]

Moreover, it is preferable each cell of the energy consumption table stores the HVAC unit power consumption, as measured by a power meter, when the HVAC unit is able to measure power consumption for each predetermined time using the power meter, and a predetermined equation in which a value determined by the HVAC unit is set and power consumption calculated by the acquired environmental information, when the HVAC unit is unable to measure the power consumption.

Since, power consumption that reflects the environmental conditions of the building in which the HVAC unit is installed is stored in each cell of the energy consumption table in this way in the present invention, an estimated value of energy consumed that matches changes in the HVAC unit environment can be calculated, or a power consumption amount that can be reduced if the set temperature is changed in the same environment can be calculated, by referencing the power consumption stored in the cell whose conditions match the acquired current environmental information.

[0012]

It is also preferable that the energy consumption calculator calculates, by using the predetermined equation in which a value determined by the HVAC unit is set as a pre-process for calculation of an estimated value of energy consumed by the energy consumption

approximating unit and the acquired environmental information, the HVAC unit power consumption, and stores the calculated power consumption in the cells of the energy consumption table assigned according to the environmental information used in the calculation.

[0013]

It is preferable that the data acquisition unit is able to acquire environmental factors that include indoor congestion condition, climate condition, and humidity as the environmental information, the environmental factors are set as an offset value in the predetermined formula, and the energy consumption calculator is able to calculate the power consumption using the predetermined equation in which the environmental factors are set as the offset value.

Using this configuration, it is possible, for example, in the case of a cooling setting, to create an energy consumption table in which power consumption that reflects environmental factors for warming the indoor temperature is stored. Therefore, even in a special case where, for example, the HVAC unit installation environment is one in which there are dramatic changes to numbers of people in a room, or the like, an estimated value of energy consumed can be calculated that reflects environmental factors.

[0014]

It is also preferable that the energy consumption calculator calculates power consumption for the cell referenced when a difference between the indoor temperature and the set temperature is 0 using a temperature maintaining energy calculating equation having a first graph shape as the equation, and calculates power consumption for the cell referenced when a difference between the outside air temperature and the set temperature is not 0 using a temperature changing energy calculating equation having a second graph shape as the equation.

[0015]

It is also preferable that the temperature maintaining energy equation having the first graph shape is a formula that adds a minimum power consumption value and offset of the HVAC unit, to a Gompertz formula that uses a maximum power consumption value for maintaining two different variables and a set temperature different in each environment, and the temperature changing energy calculating formula having the second graph shape is a formula formed by a solution for the maintaining energy equation, a maximum power consumption of the HVAC unit value and two other variables that are different from the previous two variables.

[0016]

Finally, it is preferable that there is a variable relationship calculator that specifies variables for the temperature maintaining energy calculating equation and the temperature changing energy calculating equation, wherein the variable relationship calculator, uses actual HVAC

unit power consumption acquired by the power meter and environmental information acquired by the data acquisition unit as teaching data, uses, to tie the power consumption to the environmental information, machine learning to narrow a relationship between the variables of the temperature maintaining energy calculating equation and the temperature changing energy calculating equation, and specifies variables for the temperature maintaining energy calculating equation and the temperature changing energy calculating equation, respectively.

[Effect of the Invention]

[0017]

According to the present invention, it is possible to provide an energy consumption calculating system that calculates an estimated value of energy consumed with respect to a set temperature based on environmental conditions that change over time in an HVAC unit having an automatic control function.

[Brief Description of the Drawings]

[0018]

[Figure 1] is a schematic diagram illustrating a configuration of an energy consumption calculating system for an HVAC unit of an embodiment according to the present invention.

[Figure 2] is a schematic diagram illustrating one example of a data structure for a data table provided in an energy consumption calculating system of an embodiment according to the present invention.

[Figure 3] is a schematic diagram illustrating one example of a data structure for an energy consumption table provided in an energy consumption calculating system of an embodiment according to the present invention.

[Figure 4] is a schematic diagram for describing a process for calculating power consumption stored in a cell of an energy consumption table by an energy consumption calculating system of an embodiment according to the present invention, where (a) is a table showing a data table in which environmental information measured at each predetermined time (y1, y2, and y3) is stored, (b) is a schematic diagram illustrating an equation for calculating energy consumption (power consumption), and (c) is a schematic diagram for describing the calculation processing parameters for the equation illustrated in (b).

[Figure 5] is a schematic diagram for describing a relationship between the power consumptions shown in the environmental information illustrated in FIG. 4 and cells of the energy consumption table.

[Figure 6] is a schematic diagram illustrating a graph of an equation for calculating energy consumed when an HVAC unit using an energy consumption calculating system of an embodiment according to the present invention is operated to maintain an indoor temperature at a set temperature.

[Figure 7] is a schematic diagram illustrating a graph of an equation for calculating energy consumed when an HVAC unit using an energy consumption calculating system of an embodiment according to the present invention is operated to change an indoor temperature to a set temperature.

[Figure 8] is a schematic diagram illustrating number of times a cell of an energy consumption calculating system corresponding to an environmental value measured at each fixed time is referenced by an energy consumption calculating system of an embodiment according to the present invention.

[Description of the Preferred Embodiments]

[0019]

Below is a description of an embodiment according to the present invention with reference to the drawings.

[0020]

First, FIGs. 1 through 3 will be used to describe a configuration of an energy consumption calculating system according to the present embodiment.

Here, FIG. 1 is a schematic diagram illustrating the configuration of the energy consumption calculating system according to the present embodiment. FIG. 2 is a schematic diagram illustrating one example of a data structure for a data table provided in the energy consumption calculating system according to the present embodiment. FIG. 3 is a schematic diagram illustrating one example of a data structure for an energy consumption table provided in the energy consumption calculating system according to the present embodiment.

[0021]

As illustrated in FIG. 1, the energy consumption calculating system according to the present embodiment includes an environmental information acquiring unit (an outside air temperature sensor 1, an indoor temperature sensor 2 (2a and 2b), a congestion detecting sensor 4 (4a and 4b), and a power meter (wattmeter) 5 (5a and 5b)) for acquiring environmental information of a building (an office building in the example illustrated in the figure) in which an HVAC unit 3 (3a and 3b) provided with an automatic control function is installed, and an information processor 100 that acquires “each value measured by the environmental information acquiring unit and set temperature of the HVAC unit 3,” and uses this acquired data (set temperature and environmental information) to calculate an estimated value of energy consumed over time in the HVAC unit 3.

[0022]

Note that although an example is a case that calculates an estimated value of energy consumed by the HVAC unit 3 installed in each office of an office building, this is nothing more than one example. The HVAC unit 3 of the energy consumption calculating system

according to the present embodiment, which includes an automatic control function, is also applicable when installed in a residential room such as a detached house, apartment, or the like. Furthermore, the present embodiment can also be used to calculate an estimated value of energy consumed over time according to the environmental conditions of the HVAC unit 3, which includes an automatic control function, installed in a hospital, a school, a restaurant, or the like. However, it may not be possible to use the HVAC unit for personal use such as a detached house, and the like, if the set temperature cannot be obtained by the present system.

[0023]

With the energy consumption calculating system described above, an estimated value of energy consumed by the HVAC unit 3 is calculated based on environmental conditions that change over time for each installed HVAC unit 3, and measuring instruments such as sensors, and the like, that configure an environmental information acquiring unit are installed in each area of a building in which the HVAC unit 3 (3a and 3b) is installed.

[0024]

Specifically, as illustrated in FIG. 1, the followings are provided in an “office A” in which the HVAC unit 3a (3) is installed; an indoor temperature sensor 2a (2) that measures an indoor temperature in the “office A,” a congestion detecting sensor 4a (4) that measures congestion conditions of people in the “office A,” and a power meter 5a (5) that measures power consumption of the HVAC unit 3a installed in the “office A.”

[0025]

Furthermore, the followings are provided in an “office n” in which the HVAC unit 3a (3) is installed; an indoor temperature sensor 2b (2) that measures an indoor temperature in the “office n,” a congestion detecting sensor 4b (4) that measures congestion conditions of people in the “office n,” and a power meter 5b (5) that measures power consumption of the HVAC unit 3a installed in the “office n.”

An outside air temperature sensor 1 that measures an outside air temperature is also provided outside in the vicinity of the building in which the offices A and n are located.

[0026]

Furthermore, all of the measuring instruments (the outside air temperature sensor 1, indoor temperature sensor 2 (2a and 2b), the congestion detecting sensor 4 (4a and 4b), and power meter 5 (5a and 5b)) forming the environmental information acquiring unit are capable of wired or wireless communication with the information processor 100, and each measuring instrument sends measured and acquired environmental information to the information processor 100 at each predetermined time.

[0027]

For example, the outside air temperature sensor 1 measures the outside air temperature outside in the vicinity of the building in which the offices A and n are located at each predetermined time, and sends the measured outside air temperature to the information processor 100. Additionally, the indoor temperature sensor 2a measures the indoor temperature of the office A at each predetermined time, and sends the measured outside air temperature to the information processor 100. The congestion detecting sensor 4a measures the congestion conditions in the office A at each predetermined time and sends the measured congestion conditions to the information processor 100. Moreover, the power meter 5a measures the power consumption of the HVAC unit 3a installed in the office A, and sends the measured power consumption to the information processor 100. However, the power meter 5a sometimes can be only able to measure power consumption for an entire interior that includes an air conditioner.

[0028]

Furthermore, the HVAC units 3a and 3b are configured to be capable of wired or wireless communication with the information processor 100 through a separately attached data acquisition device or through an IP interface of the HVAC unit 3. Additionally, the information processor 100 acquires a “set temperature” set in the HVAC unit 3 at each predetermined time.

Note that when the HVAC units 3a and 3b include built-in temperature sensors that measure indoor temperatures, the temperature sensors built into the HVAC units 3a and 3b may acquire the indoor temperature measured at each predetermined time without providing the indoor temperature sensor 2 in each office.

[0029]

Note that although FIG. 1 illustrates the outside air temperature sensor 1 (1a and 1b), indoor temperature sensor 2 (2a and 2b), congestion detecting sensor 4 (4a and 4b), and power meter 5 (5a and 5b) as the environmental information acquiring unit, this is only one example thereof. For example, a server that provides temperatures (outside air temperatures) for each region on the Internet may be used to acquire the outside air temperature instead of the outside air temperature sensor 1 (1a and 1b). In such cases, the information processor 100 accesses this server to acquire the outside air temperature in an applicable region at each predetermined time.

[0030]

Furthermore, the information processor 100 may, in addition to temperature, acquire weather information (fair, rainy, cloudy, etc.) and humidity that could affect the energy

consumed by the HVAC unit 3 from the above server, and may use the “weather information and humidity” in calculating an estimated value of energy consumed.

Additionally, since Building Management Systems (BMS) are installed in most office buildings, “environmental information and all HVAC units 3 set temperatures and power consumption” may be acquired using a Building Management System.

[0031]

A specific description of the information processor 100 is provided next.

The information processor 100 includes a data acquisition unit 110 that acquires a set temperature and environmental information (environmental values) of the HVAC unit 3, an energy consumption calculator 120 that calculates a cell value (power consumption) for an energy consumption table 200, an energy consumption approximating unit 130 that approximates energy consumption at fixed times and derives power consumption at each time, a variable relationship calculator 140 that calculates parameters (variables) of an equation (described later) for calculating power consumption stored in an energy consumption table 210, a display 150 that displays power consumption status, and a memory unit 160. The data table 200, the energy consumption table 210, and a calculation data table 220, in which environmental information from each predetermined time is stored, are stored in the memory unit 160.

[0032]

Furthermore, the above energy consumption table 210 includes a plurality of cells that forms a matrix, where each cell is assigned according to a value of environmental information, and a value (power consumption) that is the basis for calculating energy consumption is stored in each cell by the power meter 5 or the energy consumption calculator.

Additionally, the energy consumption approximating unit 130, by using the environmental information acquired by the data acquisition unit 110 at each predetermined time to approximate a cell value of the energy consumption table 210 corresponding to the environmental information, calculates an estimated value of energy consumed according to changes in the environment in which the HVAC unit 3 is installed.

[0033]

Furthermore, although the hardware configuration of the information processor 100 is not limited in any particular way, the information processor 100 is formed of a computer (one or a plurality of computers) equipped with a CPU, memory (a main memory device and an auxiliary memory device), an I/O interface, a communication interface, and the like. In such cases, a program (for convenience of description, a first program) that realizes the functions of “the data acquisition unit 110, the energy consumption calculator 120, and the energy consumption approximating unit 130,” and “an artificial intelligence program that realizes the

functions of the variable relationship calculator 140,” are stored in the auxiliary memory device).

[0034]

Additionally, the functions of the data acquisition unit 110, the energy consumption calculator 120, and the energy consumption approximating unit 130 are realized by the CPU reading and executing the first program in the main memory device. Moreover, the functions of the variable relationship calculator 140 are realized by the CPU reading and executing the artificial intelligence program in the main memory device.

In similar fashion, the display 150, by the CPU reading and executing a display program based on data on the memory unit and results from the first program, also enables a user to reference information through a browser, and the like.

Furthermore, the data table 200, the energy consumption table 210, and the calculation data table 220 are stored in predetermined areas in memory.

Constituent components of the information processor 100 and a data base (data table 200, energy consumption table 210, and calculation data table 220) configuration will be described next.

[0035]

The data acquisition unit 110 receives (acquires) environmental information (outside air temperature, indoor temperature, congestion conditions, and power consumption) sent from the measuring instruments (outside air temperature sensor 1, indoor temperature sensor 2, congestion detecting sensor 4, and power meter 5) corresponding to all HVAC units 3 at predetermined time intervals (for example, every 5 minutes). The data acquisition unit 110 also receives (acquires) set temperature of all HVAC units 3 at predetermined time intervals (for example, every 5 minutes).

[0036]

During each time slot (Hour : Minute to Hour : Minute), the data acquisition unit 110 also associates and stores “environmental information (outside air temperature, indoor temperature, congestion conditions, and set temperature), and power consumption” in the data table 200, which is provided with data bases provided for each HVAC unit 3.

Note that processing for calculating an estimated value of energy consumed (power consumption) is performed with respect to data registered in the data table 200, and power consumption to be stored in each cell of the energy consumption table 210 is calculated and used to calculate the parameters (variables) for the equation (described later) performed by the variable relationship calculator 140.

[0037]

A data configuration of the data table 200 will now be described with reference to FIG. 2.

A table-shaped data base is provided for each HVAC unit 3, and the data table 200 is able to associate and store “environmental information (outside air temperature, indoor temperature, congestion conditions, and set temperature) and power consumption” in the database of each HVAC unit 3 during each time slot (yn (Hour : Minute to Hour : Minute)). The example illustrated in the figures illustrates a data base for the “HVAC unit 3a” in which “outside air temperature (32.5°C), indoor temperature (28°C), set temperature (24°C), congestion conditions (60%), other (XX), and power consumption (1200W)” are registered in the “10:00 to 10:05 (y1)” time slot.

Note that the field for registering other (XX) is used when HVAC unit fan speed setting information can be obtained, or when there are special factors in the HVAC unit 3 installation area that could affect power consumption.

Furthermore, with respect to power consumption, when power consumption can be acquired for each HVAC unit 3 using building equipment of a BMS, or the like, or in a case where each HVAC unit operates independently, power consumption is placed in the data base of each HVAC unit, like with the data table 200, however, in a case where power consumption for a plurality of HVAC units is acquired, measured power consumption is stored in the calculation data table 220.

[0038]

Note that, with respect to “environmental information (outside air temperature, indoor temperature, congestion conditions, and set temperature) and power consumption” for each time slot (yn 00:00 to 00:05), the data acquisition unit 110 may associate acquired “environmental information (outside air temperature, indoor temperature, congestion conditions, and set temperature) and power consumption” with time slots that include the time the “environmental information (outside air temperature, indoor temperature, congestion conditions, and set temperature) and power consumption” were acquired, and then register the information in the data table 200.

Or, when operating so as to acquire “environmental information (outside air temperature, indoor temperature, congestion conditions, and set temperature) and power consumption” every 1 minute, the data acquisition unit 110 may calculate average values for the acquired “environmental information (outside air temperature, indoor temperature, congestion conditions, and set temperature) and power consumption,” associate the average values to each time slot, and then register the values in the data table 200.

[0039]

The calculation data table 220 is a data table for linking and storing various required information relating to the energy consumption calculating system according to the present

embodiment, such as storing basic information when the variable relationship calculator 140 performs artificial intelligence calculations, and the like.

[0040]

Configurations of the energy consumption calculator 120 and the energy consumption approximating unit 130 will be described next. The energy consumption calculator 120 uses environmental information (outside air temperature, indoor temperature, and set temperature) acquired by the data acquisition unit 110 at each predetermined time to calculate (calculation method described below) a value for a cell in the energy consumption table 210 that corresponds to the acquired environmental information, and stores calculated power consumption in a cell in the energy consumption table 210 assigned to the environmental information used in the calculation.

[0041]

Additionally, the energy consumption approximating unit 130 calculates an estimated value of energy consumed according to changes in the environment in which the HVAC unit 3 is installed by approximating corresponding energy consumption table power consumption at each predetermined time based on changes in environmental conditions at each predetermined time.

[0042]

A configuration of the energy consumption table 210 will now be described with reference to FIG. 3.

Note that FIG. 3 is a schematic diagram illustrating one example of a data structure for the energy consumption table 210 provided in the energy consumption calculating system according to the present embodiment.

[0043]

As illustrated in the figure, the energy consumption table 210 is a table shaped like a matrix having gradations “0 to 15” on a vertical axis upper part (upper part in the center of the figure), gradations “0 to -15” on a vertical axis lower part (lower part in the center of the figure), gradations “0 to 15” on a horizontal axis right side part (right side part facing the center of the figure), and gradations “0 to -15” on a horizontal axis left side part (left side part facing the center of the figure).

In the energy consumption table 210, the gradations on the vertical axis indicate temperature differences derived by subtracting set temperatures (set temperatures of the HVAC unit 3) from indoor temperatures, and the gradations on the horizontal axis indicate temperature differences derived by subtracting set temperatures (set temperatures of the HVAC unit 3) from outside air temperatures.

[0044]

Furthermore, the energy consumption table 210 has two display areas 210a and 210b arranged vertically. The upper display area 210a is used to calculate energy consumed during cooling operations and the lower display area 210b is used to calculate energy consumed during heating operations.

Moreover, since the HVAC unit 3 that is the subject of the present embodiment has an automatic control function, the unit does not heat or cool a room temperature above the set temperature or below the set temperature. Thus, in the energy consumption table 210 illustrated in the figure, a lower part is not provided below the upper display area 210a used during cooling operations and an upper part is not provided above the lower display area 210b used during heating operations.

[0045]

Note that, if for some reason, the indoor temperature rose above the set temperature or fell below the set temperature, the energy consumption calculating system according to the present embodiment can, because the system uses the “0” row, calculate energy consumed without difficulty even in such cases.

Furthermore, since, so long as there are no indoor heat sources, a difference between the outside air temperature and the indoor temperature is the upper and lower limit of a difference between the indoor temperature and the set temperature, the parts of the table not normally used are filled in (colored gray) in the figure. However, there is no problem with using the parts displayed in gray. Moreover, if the difference between the indoor temperature and the set temperature rose above 15°C, a numerical value of +/- 15°C can be prepared and used as the difference between the outside air temperature and the set temperature.

[0046]

An applicable cell is identified in the energy consumption table 210 according to the environmental information acquired from the sensors, etc., and the energy required to operate the HVAC unit 3 such as energy consumption, and the like, is stored in the identified cell. Note that, in essence, the numerical value in this cell is the value of the repulsive energy the HVAC unit 3 must resist in a given environment and can be displayed as power consumption or as an electricity charge.

[0047]

Every space in which the HVAC unit 3 is installed has a different specific heat energy. For example, assume that the room in which the HVAC unit 3a in FIG. 1 is installed has a large window located on the south side. And that, by contrast, the room in which the HVAC unit 3b in FIG. 1 has no window on the north side. In this case, the room in which the HVAC unit 3a is installed is susceptible to temperature increases caused by weather and outside air, and thus the repulsive energy against which the force of the HVAC unit tries to lower the temperature of

the room will be larger than that in the room in which the HVAC unit 3b is installed. In other words, even if the same HVAC unit is operated, even if under the same environment temperature conditions, an amount of power consumed will vary greatly. As was described in the example above, since repulsive energy against the HVAC unit 3 will vary by space, it is important to prepare the energy consumption table 210 to calculate energy consumption for each space and to insert a repulsive value corresponding to the environmental information in an applicable cell.

[0048]

The energy consumption table 210 is structured so that power consumption is stored based on the calculation results of the energy consumption calculator 120, however, since the acquired power consumption and calculated calculation results are the same value, when the power consumption of the HVAC unit 3 can be acquired for each predetermined time individually from the power meter 5, the power consumption acquired as a result is stored in the cell in the energy consumption table 210 that is assigned to the corresponding environmental information (outside air temperature, indoor temperature, and set temperature). This is because power consumption is a reaction to repulsive energy, and it is correct that the result calculated by the energy consumption calculator 120 is the same value as power consumption for each predetermined time measured by the power meter 5, that is the same value as the repulsive energy.

[0049]

A method for calculating energy consumption (power consumption) to be stored in a cell of the energy consumption table 210 will be described next with reference to FIGs. 4 and 5.

Here, FIG. 4 is schematic diagram for describing a process for calculating power consumption stored in a cell of an energy consumption table by an energy consumption calculating system of an embodiment according to the present invention, where (a) is a table showing the data table 200 in which environmental information measured at each predetermined time (y1, y2, and y3) is stored, (b) is a schematic diagram illustrating an equation for calculating energy consumption (power consumption), and (c) is a schematic diagram for describing the calculation processing parameters for the formula illustrated in (b).

Furthermore, FIG. 5 is a schematic diagram for describing a relationship between the power consumptions shown in the environmental information illustrated in FIG. 4 and the cells of the energy consumption table.

[0050]

FIG. 4(a) illustrates examples of environmental information measured at “10:00 to 10:05 (y1),” environmental information measured at “10:05 to 10:10 (y2),” and environmental information measured at “10:10 to 10:15 (y3).”

[0051]

For example, in the environmental information for “10:00 to 10:05 (y1)” illustrated in the figure, the “difference between the outside air temperature and set temperature” is “9°C (rounded to the nearest whole number)” and the difference between the indoor temperature and the set temperature” is “4°C.” Since the HVAC unit 3 is operating as a cooling function (cooling operation) in this case, the “1200 W” energy consumption (power consumption) of the environmental information for “y1” is stored in the cell, at the cells in the upper display area 210a in FIG. 5, where “outside air temperature - set temperature” is “9°C” and “indoor temperature - set temperature” is “4°C.”

[0052]

Furthermore, in the environmental information for “10:05 to 10:10 (y2),” the “difference between the outside air temperature and set temperature” is “9°C” and the difference between the indoor temperature and the set temperature” is “2°C.” Since the HVAC unit 3 is operating as a cooling and heating function (cooling operation) in this case as well, the “600 W” energy consumption (power consumption) of the environmental information for “y2” is stored in the cell, at the cells in the upper display area 210a in FIG. 5, where “outside air temperature - set temperature” is “9°C” and “indoor temperature - set temperature” is “2°C.”

[0053]

Moreover, in the environmental information for “10:10 to 10:15 (y3),” the “difference between the outside air temperature and set temperature” is “10°C (rounded to the nearest whole number)” and the difference between the indoor temperature and the set temperature” is “0°C.” Since the HVAC unit 3 is operating as a cooling and heating function (cooling operation) in this case as well, the “180 W” energy consumption (power consumption) of the environmental information for “y3” is stored in the cell, at the cells in the upper display area 210a in FIG. 5, where “outside air temperature - set temperature” is “10°C” and “indoor temperature - set temperature” is “0°C.”

[0054]

Note that as the difference between the outside air temperature and the set temperature is separated left or right from “0” on the horizontal axis in the center of the energy consumption table 210 due to the fact that the outside air temperature heats and cools the building, the energy repulsive force against temperature adjustments by the HVAC unit 3 and thus energy consumption increase more. Additionally, in the same way, as the difference between the indoor temperature and the set temperature is separated vertically from “0” on the vertical axis in the center of the energy consumption table 210, the HVAC unit 3 energy consumption increases more.

[0055]

In other words, the energy consumption table 210 indicates that the amount of energy consumed per given time varies based on the environmental conditions corresponding to each position of each cell, and, by approximating energy consumption value (power consumption) in positions of each cell with changes in the environmental conditions, it is able to calculate power consumption at a given time.

[0056]

The “process for calculating power consumption for each time slot to be assigned to, and stored in, each cell of the energy consumption table 210” performed by the energy consumption calculator 120 of the information processor 100 will be described next.

[0057]

The energy consumption calculator 120 of the information processor 100 uses (Equation 1) and (Equation 2) below and environmental information (values) to calculate energy consumption (power consumption).

Note that, as has already been mentioned above, the process for calculating the HVAC unit 3 power consumption performed by the energy consumption calculator 120 using (Equation 1) and (Equation 2) below produces the same numerical value as the power meter 5 in cases where the HVAC unit 3 is able to use the power meter 5 to measure power consumption for each predetermined time.

[0058]

The equations (Equation 1) and (Equation 2) used by the energy consumption calculator 120 are Gompertz equations to which specific constants have been added. Furthermore, (Equation 1) is the formula used to calculate the energy consumption values stored in “0 row” cells (the cells where the difference between the indoor temperature and the set temperature is 0) of the energy consumption table 210, and (Equation 2) is the formula used to calculate the energy consumption values stored in cells other than the above “0 row” cells of the energy consumption table 210.

[Number 1]

$$y = Kb^{e^{-cx}} + (A + \alpha) \cdot \cdot \cdot \quad (\text{Equation 1})$$

$$y = Kb^{e^{-cx}} + A \cdot \cdot \cdot \quad (\text{Equation 2})$$

[0059]

Note that although the energy consumption (power consumption) stored in a cell of the energy consumption table 210 is, in the end, the same value as the value acquired by the actual

power meter (wattmeter) 5, even if the values of some of the cells out of all the cells of the energy consumption table 210 could be measured by a power meter, that does not mean that the values of all cells could be measured under a real environment that changes from one minute to the next. Therefore, the fact that, in the present embodiment, the energy consumption calculator 120 of the information processor 100 uses acquired environmental information and the above (Equation 1) and (Equation 2) to calculate a value (power consumption) for each cell of the energy consumption table 210 has important significance.

[0060]

The equation of the above (Equation 1) will be described first.

In the above (Equation 1), the maximum power consumption the HVAC unit 3 uses to maintain the indoor temperature at the set temperature is substituted for “K.” That is, when described using the energy consumption table 210 in FIG. 3, this is the value at the left or right end of the “0 row” in the center of the vertical axis.

Furthermore, in the above (Equation 1), x represents the “difference between the outside air temperature and the set temperature (outside air temperature - set temperature). The maximum power consumption the HVAC unit 3 uses to maintain the indoor temperature at the set temperature is the power consumption when x becomes the maximum value in a corresponding environment. Calculation of the value “K” will be described later as part of the artificial intelligence calculation.

[0061]

The minimum power consumption (minimum power consumption value) of the HVAC unit 3 is substituted for the value of A in the above (Equation 1). The minimum power consumption of the HVAC unit 3 is generally described as a specification of the HVAC unit 3, and the value as so described may be used.

[0062]

Furthermore, the value of α in the above (Equation 1) is a variable used to offset elements other than temperature, such as when an HVAC unit fan speed is set manually, when there is a heat source that generates the temperature in a room, or when environmental temperature is raised by congestion caused by people, or the like.

For example, a dynamic heat source caused by changes in the number of people may be reflected by adding or subtracting the value of “ α ” in the equation of (Equation 1) described above based on a measurement value of the congestion detecting sensor 4.

However, since frequent significant changes in heat sources or people conditions in actual environments are rare in offices and because there are few offices where HVAC unit fan speeds are set manually, in this case, consumption energy is measured based on the corresponding environment (indoor environment such as indoor temperature and set

temperature, and the like) including a heat source without using an offset. Furthermore, no detailed content is defined with respect to the value of α in the present embodiment.

[0063]

When the indoor temperature varies from the set temperature, the HVAC unit 3 transitions from a maintenance mode to an operational mode (operations and names differ by model), and power consumption changes. The calculation method of the above (Equation 1) is a method for expressing changes in energy consumption used to maintain temperature in case where there is a difference between outside air temperature and indoor temperature. However, strictly speaking, when temperature changes are measured for sufficiently short time, actual temperature changes will be small.

However, since effective measurement intervals of 5 and 10 minutes, and the like, are assumed in the present embodiment, a description of “energy consumption for maintaining temperature (temperature maintaining energy)” will be provided.

[0064]

Furthermore, graphing the formula for calculating the temperature maintaining energy for the above (Equation 1) tends to create a shape like that illustrated in FIG. 6. The graph in FIG. 6 shows energy consumption (power consumption value) on the vertical axis (y-axis) and the difference between outside air temperature and set temperature on the horizontal axis (x-axis).

As is illustrated in FIG. 6, the greater the difference between outside air temperature and set temperature, the greater the amount of energy consumed. This is because the greater the difference with outside air temperature, the quicker the indoor temperature rises or drops, which lengthens the operational mode of the HVAC unit 3.

[0065]

Although depending on the model of the HVAC unit 3, the inclination of the graph in FIG. 6 tends to take on a graph shape that is relatively close to a linear function, and the graph shape is determined by the variables (parameters) for “ b and c ” in (Equation 1). Note that the appropriate range of variables for b and c is limited to a certain range.

[0066]

The equation of the above (Equation 2) will be described next.

The equation of the above (Equation 2) is a calculation method used to calculate the energy consumed when the HVAC unit 3 operates to change the indoor temperature to the set temperature.

The value of the solution from the calculation method for the above (Equation 1), that is, the solution from a temperature maintaining energy calculation is substituted for “ A ” in the above (Equation 2). However, since the value of “ A ” varies with each difference between the outside

air temperature and the set temperature, the calculation method for (Equation 2) will have a different value for “A” for each vertical column in the Energy consumption table 210.

[0067]

Furthermore, unlike the formula of the above (Equation 1), the maximum power consumption (maximum power consumption value) for the HVAC unit 3 is substituted for the value of “K” in the above (Equation 2). However, as was described above, since the above (Equation 1) is substituted for the value of “A” in the above (Equation 2) and then added, in reality, a value obtained by deleting the value of “K” in the above (Equation 1) from the maximum power consumption is substituted here. As with minimum power consumption, maximum power consumption is generally described as a specification of the HVAC unit 3, and thus the maximum power consumption described for the target HVAC unit 3 may be used. Furthermore, in the above (Equation 2), x represents the “difference between the indoor temperature and the set temperature (indoor temperature - set temperature).

[0068]

Furthermore, graphing the formula for calculating energy consumption (power consumption) for the above (Equation 2) creates a shape like that illustrated in FIG. 7. The graph in FIG. 7 shows energy consumption (power consumption value) on the vertical axis (y-axis) and the difference between indoor temperature and set temperature on the horizontal axis (x-axis).

In contrast to the graph in FIG. 6 described above, which expresses changes in energy consumption when the indoor temperature is maintained at the set temperature, the graph in FIG. 7 expresses changes in energy consumption when the indoor temperature is changed to the set temperature. The graph in FIG. 7 has a different curve inclination than the graph in FIG. 6, and typically illustrates a tendency for the graph inclination to soften when the difference between the indoor temperature and the set temperature is small, for the power consumption value to dramatically increase in response to certain temperature differences, and then for the graph inclination to soften again when a certain temperature difference is reached and exceeded.

[0069]

Although depending on the model of the HVAC unit 3, the inclination of the graph in FIG. 7 is determined by the variables (parameters) for “ b and c ” in (Equation 2). Furthermore, as with the above (Equation 1), the appropriate range of variables for b and c is limited to a certain range.

[0070]

(Equation 1) and (Equation 2) are used in the way described above in the present embodiment to calculate values for each cell in the energy consumption table 210. Furthermore,

the graphs illustrated in FIGs. 6 and 7 show the state of vertical and horizontal change in energy consumption value (power consumption). That is, according to the present embodiment, the value of each cell of the energy consumption table 210 can be calculated by substituting several fixed values and environmental information into (Equation 1) and (Equation 2) described above and then running calculations, making it possible to then calculate an estimated value (guess) of energy consumed by approximating a value for each cell.

[0071]

For example, the energy consumption calculator 120 of the information processor 100 uses environmental information acquired at each predetermined time in the office A in FIG. 1 and (Equation 1) and (Equation 2) described above to calculate power consumption at each predetermined time. Furthermore, the energy consumption calculator 120 stores calculated consumption energy in a corresponding cell of the energy consumption table 210.

After that, the energy consumption approximating unit 130 uses the energy consumption table 210 to calculate the energy consumption (referred to as “estimated energy consumption”) obtained by approximating a cell value for 1 day.

Furthermore, so long as an actual power consumption value (true energy consumption) can be acquired for 1 day for office A, the variable relationship calculator 140 can, by comparing an approximated “estimated energy consumption” and an acquired “true energy consumption,” back calculate the variables (b and c) of (Equation 1) and (Equation 2) described above, and specify a range of combination patterns of “ b and c ” for unfixed variables (for example, tentatively determined variables).

[0072]

Even if the actual power consumption amount (true energy consumption) for 1 day describe above cannot be acquired, values of the cells of the energy consumption table 210 can be calculated on a monthly basis and be deemed valid, even when “true energy consumption” cannot be acquired, so long as calculated “estimated energy consumption” and a power consumption value that can be calculated based on an electricity rate are compared (referenced). To improve the accuracy of calculated “estimated energy consumption,” more highly accurate values can be calculated for the cells in the energy consumption calculation table 210 by gradually narrowing the range of values for the variables (parameters) “ b and c ” by repeatedly referencing many times and thus gradually specifying the curves of the graphs illustrated in FIGs. 6 and 7.

[0073]

One example of the process for calculating energy consumption according to the present embodiment described above will be described next with reference to FIG. 4 described above.

[0074]

Measured values from the sensors are acquired every 5 minutes and registered in the data table 200 illustrated in FIG. 4(a). Note that the measurement interval does not necessarily have to be 5 minutes, and that shorter intervals are better in cases where environmental changes occur frequently. Note that although power consumption values are shown for every 5 minutes in FIG. 4(a), as is mentioned above, it is fine if values cannot actually be acquired in this manner.

[0075]

Since environmental information changes from one minute to the next, data of the data table 200 in FIG. 4(a) is referenced in each time unit, and the positions of reference cells of the energy consumption table 210 in FIG. 3 also change according to environmental conditions. Position changes for reference cells of the energy consumption table 210 in FIG. 3 at each time unit are expressed in FIG. 8 (during cooling and heating operations). Power consumption is initially stored in the cells of the energy consumption table 210, and FIG. 8 illustrates numerical values showing the number of times that cells corresponding to environmental values measured at each fixed time are referenced in a day. If power consumption is calculated each day by the energy consumption approximating unit 130, daily power consumption is calculated by approximating the solutions to the equations (calculation methods) shown in (Equation 1) and (Equation 2) described above the number of times as the numerical of the values of the cells in FIG. 8. Note that FIG. 4(b) is an image diagram indicating that $y_1 + y_2 + y_3$ are to be approximated by the energy consumption approximating unit 130, and FIG. 4(c) is an image diagram indicating that the variable relationship calculator 140 is comparing “estimated energy consumption” with acquired “true energy consumption.”

[0076]

Processing related to energy consumption table calculation artificial intelligence for specifying the parameters (variables) of the equations shown in (Equation 1) and (Equation 2) described above will be described next.

Note that processing of the energy consumption calculation artificial intelligence for specifying the parameters (variables) is performed by the variable relationship calculator 140 of the information processor 100.

Processing done by the variable relationship calculator 140 is realized by the CPU of the information processor 100 executing the artificial intelligence program.

Note that (Equation 1) and (Equation 2) described above are shown again for the convenience of description.

[Number 2]

$$y = Kb^{e^{-cx}} + (A + \alpha) \cdot \cdot \cdot \quad (\text{Equation 1})$$

$$y = Kb^{e^{-cx}} + A \quad \cdot \cdot \cdot \quad (\text{Equation 2})$$

[0077]

First, as a pre-process in performing the artificial intelligence calculation according to the present embodiment, the data acquisition unit 110 acquires the power consumption of the HVAC unit 3 that is the target of operation of the present system for a fixed time together with environmental information (values), and stores the time and information in the energy consumption table 210. Although it is preferable that around 2 weeks of data be stored, in the worst case, it will be possible if the values of any of the cells in the 0 row of the energy consumption table (row where the difference between the indoor temperature and the set temperature is 0) are specified.

[0078]

Furthermore, the initial values of the parameters (variables) of “*b* and *c*” are stored in the variable relationship calculator 140 in advance so that a graph shape of the above (Equation 1) is close a primary equation like the graph in FIG. 6. For example, a graph is illustrated in FIG. 6 where the value “0.08” has been inserted for the variable “*b*” and the value “0.2” has been inserted for the variable “*c*.” Since HVAC unit 3 operational parameters are similar depending on manufacturer and model, it is also effective that the initial values of “*b* and *c*” be automatically applied based on HVAC unit 3 model number data.

[0079]

Next, since, as was described above, the value of *A* is the value of the minimum power consumption shown in the specifications of the HVAC unit 3, the minimum power consumption value described in the specifications is stored in the calculation data table 220. (Since the α offset value in the equation of the above (Equation 1) is not used in the automatic calculations of the artificial intelligence calculation, no description thereof is provided here)

[0080]

By having the variable relationship calculator 140 calculate the above (Equation 1) in which the value of any cell specified by acquiring power consumption through the above pre-process and an initial value have been set, the value of “*K*” in the above (Equation 1) is in a state where the initial value has been derived.

The value of “*K*” can be tentatively determined more appropriately when the values of many cells in the energy consumption table 210 have been acquired in the pre-process. On the other

hand, in case where power consumption cannot be measured in the pre-process, it is permissible to estimate the value of “ K ” based on the specifications of the HVAC unit 3, and input the estimate as a temporary fixed value. Here, the accuracy of the value of “ K ” is not necessarily that import, but it is important to obtain a tentative initial value in the pre-process.

[0081]

Next, the variable relationship calculator 140 substitutes the solution of the equation of the above (Equation 1) that includes several initial values for “ A ” in the equation of the above (Equation 2), and substitutes a numerical value obtained by dividing the value of “ K ” in the above (Equation 1) from the maximum power consumption value shown in the specifications of the HVAC unit 3 for the value of “ K ” in the above (Equation 2). However, since the above substitutions and division are performed by automatic calculation on the system, the maximum power consumption value shown in the specifications of the HVAC unit 3 is actually input to the calculation data table 220.

[0082]

Based on the above, the variables, of the parameters (variables) of the above (Equation 1) and the above (Equation 2), that still have not been determined, are limited to the values of “ b and c ” of the above (Equation 2). Finally, determining initial values for the values of “ b and c ” of the above (Equation 2), as for the above (Equation 1), based on information such as the model of the HVAC unit 3 and storing the values in the calculation data table 220 completes the process that is the pre-process for performing the artificial intelligence calculation according to the present embodiment.

[0083]

Summarizing the above description, the data that actually must be input manually in the pre-process is the value of “ A ” in (Equation 1) and the value of “ K ” in (Equation 2), that is, the minimum power consumption and the maximum power consumption of the HVAC unit 3. If there is accumulated data relating to the HVAC unit 3, a mechanism may be incorporated where, by entering the manufacturer and model number of the HVAC unit 3, “ A ” and “ K ” are automatically input, and initial values are set for “ b and c ” (referred to as “key variables” for convenience of description) of (Equation 1) and (Equation 2).

[0084]

The method of the artificial intelligence calculation according to the present embodiment will be described next.

The artificial intelligence calculation in the present embodiment means that the variable relationship calculator 140 automatically narrows down the range of the above key variables by computer calculation. In the case of a large office in which a BMS has been implemented, the above key variables can be narrowed down in a relatively short time and the accuracy of

the values of the cell in the energy consumption table 210 can be raised in each environment by acquiring power consumption of each HVAC unit 3 from the BMS at each predetermined time.

On the other hand, in the worst case, in a situation where a plurality of HVAC units 3 is mixed and there is no BMS, the above key variables are narrowed down by artificial intelligence calculation based on the electricity rate. However, in such cases, long periods of time are required to raise the accuracy of the cell values of the energy consumption table 210.

[0085]

As was described above, the calculation element required for the artificial intelligence calculation of the present embodiment in all cases is the power consumption value obtained at a predetermined unit of time. If the power consumption value cannot be obtained, the value will be replaced with the electricity rate. Although electricity rates often include rates for OA equipment and lighting, the present invention does not limit the method for distinguishing power consumption of the HVAC unit 3 from electricity rates.

[0086]

Furthermore, a target value calculated by comparison with the power consumption value obtained at a predetermined unit of time becomes the total value of a cell of the energy consumption table 210 approximated at the same unit of time by the energy consumption approximating unit 130 with respect to the HVAC unit 3 (at times a plurality thereof) indicating that power consumption. The target value becomes the total value with respect to all HVAC units 3 when there is a plurality of HVAC units 3.

[0087]

For example, an example of a calculation method for an environment where two HVAC units 3 for which the power consumption amount is obtained each month operate within the same power consumption will be explained. In this case, it is assumed that outdoor units run within the same power cost, and that the power consumption amount has been specified for the HVAC units 3.

[0088]

First, it is presumed here that the energy consumption calculator 120 uses initial values to calculate values for all cells of the energy consumption table 210 through the pre-process describe above, and that cell values are tentatively specified.

Next, the power consumption and a power meter measurement period are input to the calculation data table 220 when the power consumption amount is obtained once a month. The energy consumption approximating unit 130 references the data tables 200 of the two target HVAC units 3 within the period corresponding to the input power consumption value, and, like the example in FIG. 5, approximates data for the cells in the energy consumption table 210 that

corresponds to the environmental conditions shown by the data, and totals approximation results for each HVAC unit 3.

Since the total result must match the power consumption value input to the calculation data table 220, the power consumption value is used as the solution for specifying the range of the above key variables in (Equation 2) and automatically adjusting the value within the range.

[0089]

An automatic adjustment method is specified based on the outside air temperature, indoor temperature, and set temperature during this period, and the flow of the method compares a transition of the corresponding cell of the energy consumption table 210 to transitions of the past month, adjusts the above key variables based on a bias of the corresponding cell and the magnitude of the energy consumption, and then adjusts the shape of the graph illustrated in FIG. 7.

For example, assume a case where the transition of the corresponding cell shown by the environmental information of the energy consumption table 210 for a certain month shows an upward bias from the previous month (the numerical bias illustrated in FIG. 8), and the power consumption consumed has increased by a total of 5%. In this case, when the value approximated by the energy consumption approximating unit 130 used in the comparison calculation of the variable relationship calculator 140 becomes a value smaller than the actual power consumption, the graph shape in FIG. 7 becomes more inclined.

[0090]

Furthermore, since, in the case of use in a normal office, the 0 row of the energy consumption table 210, that is, the state where the set temperature and the indoor temperature are in equilibrium (temperature maintenance energy consumption) will continue for a long time, there may be a case where the calculation of the variable relationship calculator 140 does not have a solution within the range of the above key variables of (Equation 2) that are narrowed down from the past. In such a case, the flow temporarily maintains the above key variables for (Equation 2) and adjusts the above key variables for (Equation 1).

[0091]

Although the example described above illustrated a description of an artificial intelligence calculation of the present embodiment using a comparatively special example of a case where power consumption is obtained only in units of months, in reality, most offices have BMSs implemented or allow the installation of power meters 5.

Even though, in the case where, unlike the previous example, environmental information can be acquired in a unit of 5 minutes and power consumption can also be acquired in a unit of 5 minutes, the comparison calculation method of the variable relationship calculator 140 is the same manual method, the cell values of the energy consumption table 210 are specified in

every 5 minutes, and the graph shapes in FIGs. 6 and 7 are naturally corrected by the variable relationship calculator 140 in every 5 minutes.

[0092]

As described above, the accuracy of each cell data of the energy consumption table 210 for predicting power consumption differs depending on the unit of power consumption measurement and the unit of the environmental information acquisition. Despite this, although the periods required to correct the above key variables are different, energy consumption can be predicted based on the environment in either case.

[0093]

Note that in a case where an environmental information acquisition cycle and a power consumption acquisition cycle differ, the value of each cell of the energy consumption table 210 can only be specified using the calculation method.

However, when the above cycles match, new values are often stored in the same cells. That is, it is possible to clearly acquire how much new measured values deviate from the previous data. In such cases, new environmental elements that contribute to increase or decrease in energy consumption may be found. In such cases, use of the α value in the above (Equation 1) can lead to more accurate predictions of power consumption.

[0094]

Furthermore, even in a case where there are many heat sources such as a refrigerator, or the like, in an office room, the artificial intelligence calculation according to the present embodiment provides repulsive energy against the HVAC unit 3 under this environment that includes the heat source, and thus, so as long as there is no dramatic change in the environment, such as the heat source being suddenly removed one day, or the like, the present embodiment will work effectively.

[0095]

Daily changes (outside air temperature, indoor temperature, and set temperature) in environmental conditions are stored in the data table 200. The relationship between any daily change in the environmental conditions and energy consumption can be shown by the change of corresponding cell of the energy table 210 as illustrated by the example in FIG. 8.

That is, so long as estimated values are calculated for all cells of the energy consumption table 210 using the method described above, it becomes possible to, for example, simulate how much power consumption could have been reduced if the set temperature had been set in a given way, or it also becomes possible to predict, in advance, how to set the set temperature to minimize power consumption with respect to expected environmental changes in the future. It also becomes possible to automate the operation of those temperature settings.

[0096]

The above is a description of the energy consumption calculating system according to the present embodiment, but accurately calculating the power consumption of a HVAC unit in a certain environment is not an object of the present invention. An object of the present invention is to ascertain environmentally-specific energy consumption tendencies using the energy consumption table 210 and the graphs in FIG. 6 and FIG. 7 as indicated by the energy table, and to show how effectively controlling an HVAC unit based on the environmental condition in reducing energy consumption. With the present invention, it is easy to use the cell values of the energy consumption table 210 to predict how to automatically control the temperature of the HVAC unit and how much this will reduce power consumption, and the invention also makes it possible to obtain an indicator for HVAC unit control.

[0097]

Note that the present invention is not limited to the embodiment describe above, and can be changed in various ways so long as those changes are within the scope of the gist thereof.

[0098]

For example, the energy consumption calculator 120 may be configured using a model (a taught power consumption calculating deep learning model) that has been taught as teaching data through machine learning; the teaching data being actual power consumption of the HVAC unit 3 measured by the power meter 5 and “environmental information (outside air temperature, indoor temperature, and set temperature) at the time power consumption was measured” acquired by the data acquisition unit 110.

[0099]

This machine learning uses teaching data to link environmental information and power consumption, and to narrow down and specify the relationship between the variables (a and b) of the “temperature maintaining energy calculating equation ((Equation 1) described above)” and the “temperature changing energy calculating equation ((Equation 2) described above).”

Note that the method for specifying the coefficients (K and A) other than the variables (a and b) of the temperature maintaining energy calculating equation and the temperature changing energy calculating equation is the same as that described in the embodiment.

[0100]

According to this configuration, as long as the environmental information (outside air temperature, indoor temperature, and set temperature) acquired by the data acquisition unit 110 is input to the energy consumption calculator 120, power consumption corresponding to the environmental information can be output (calculated) by the energy consumption calculator 120. The energy consumption calculator 120 may store outputted power consumption in the cells of the energy consumption table 210 assigned to the environmental information used in the calculation.

[Brief Description of the Reference Numerals]

[0101]

1...outside air temperature sensor

2, 2a, and 2b...indoor temperature sensors

3, 3a, and 3b...HVAC units

4, 4a, and 4b...congestion detecting sensors

5, 5a, and 5b...power meters

100...information processor

110...data acquisition unit

120...energy consumption calculator

130...energy consumption approximating unit

140...variable relationship calculator

150...display

160...memory unit

200...data table

210...energy consumption table

220...calculation data table

[Document Name] Scope of Patent Claims

[Claim 1]

An energy consumption calculating system comprising: an information processor that calculates an estimated value of energy consumed by an HVAC unit provided with an automatic control function,

the information processor comprising:

a data acquisition unit for acquiring internal and external environmental information of a building in which the HVAC unit is installed;

an energy consumption table in which a plurality of cells is formed into a matrix;

an energy consumption calculator that calculates cell values for the energy consumption table; and

an energy consumption approximating unit that approximates the cell values of the energy consumption table and calculates an estimated value of energy consumed by the HVAC unit over a predetermined period, wherein

the data acquisition unit acquires at least an indoor temperature of an interior of a building in which the HVAC unit is installed, an outside air temperature outside the building in which the HVAC unit is installed, and a set temperature for the HVAC unit, as the environmental information for each predetermined time,

each cell of the energy consumption table is stored with a value that is assigned according to a value of the environmental information and is a basis for calculating energy consumption, and

the energy consumption approximating unit, by using the environmental information acquired at each predetermined time, calculates the cell values in the energy consumption table corresponding to the environmental information, and calculates an estimated value of energies consumed according to a change in an environment in which the HVAC unit is installed.

[Claim 2]

The energy consumption calculating system according to claim 1, wherein the energy consumption table includes a column specified according to a value of a difference between an outside air temperature and a set temperature, and a row specified according to a value of a difference between an indoor temperature and a set temperature, and wherein power consumption, which is a value used in the energy consumption calculation, is stored in a cell where the column and the row intersect.

[Claim 3]

The energy consumption calculating system according to claim 2, wherein

each cell of the energy consumption table stores:

the HVAC unit power consumption, as measured by a power meter, when the HVAC unit is able to measure power consumption for each predetermined time using the power meter, and

a predetermined equation in which a value determined by the HVAC unit is set and power consumption calculated by the acquired environmental information, when the HVAC unit is unable to measure the power consumption.

[Claim 4]

The energy consumption calculating system according to claim 3, wherein the energy consumption calculator calculates, by using the predetermined equation in which a value determined by the HVAC unit is set as a pre-process for calculation of an estimated value of energy consumed by the energy consumption approximating unit and the acquired environmental information, the HVAC unit power consumption, and stores the calculated power consumption in the cells of the energy consumption table assigned according to the environmental information used in the calculation.

[Claim 5]

The energy consumption calculating system according to claim 4, wherein the data acquisition unit is able to acquire environmental factors that include indoor congestion condition, climate condition, and humidity as the environmental information,

the environmental factors are set as an offset value in the predetermined formula, and

the energy consumption calculator is able to calculate the power consumption using the predetermined equation in which the environmental factors are set as the offset value.

[Claim 6]

The energy consumption calculating system according to claim 4, wherein the energy consumption calculator,

calculates power consumption for the cell referenced when a difference between the indoor temperature and the set temperature is 0 using a temperature maintaining energy calculating equation having a first graph shape as the equation, and

calculates power consumption for the cell referenced when a difference between the outside air temperature and the set temperature is not 0 using a temperature changing energy calculating equation having a second graph shape as the equation.

[Claim 7]

The energy consumption calculating system according to claim 6, wherein the temperature maintaining energy equation having the first graph shape is a formula that adds a minimum power consumption value and offset of the HVAC unit, to a Gompertz formula that uses a maximum power consumption value for maintaining two different variables and a set temperature different in each environment, and

the temperature changing energy calculating formula having the second graph shape is a formula formed by a solution for the maintaining energy equation, a maximum power consumption of the HVAC unit value and two other variables that are different from the previous two variables.

[Claim 8]

The energy consumption calculating system according to claim 6 or 7, further comprising:
a variable relationship calculator that specifies variables for the temperature maintaining energy calculating equation and the temperature changing energy calculating equation,

wherein the variable relationship calculator,

uses actual HVAC unit power consumption acquired by the power meter and environmental information acquired by the data acquisition unit as teaching data, uses, to tie the power consumption to the environmental information, machine learning to narrow a relationship between the variables of the temperature maintaining energy calculating equation and the temperature changing energy calculating equation, and specifies variables for the temperature maintaining energy calculating equation and the temperature changing energy calculating equation, respectively.