

METHOD OF CALCULATING ENERGY SAVING EFFECT AND ENERGY SAVING
EFFECT CALCULATION APPARATUS

Background

The present disclosure relates to an energy saving control technique. More particularly, the present disclosure relates to a technique of calculating an energy saving effect when the energy saving is controlled in order to reduce an energy consumption amount and energy costs in facilities of an air conditioner and a heat source.

As a measure to reduce an energy consumption amount and energy costs in facilities such as an air conditioner and a heat source, for example, energy is saved by successively changing operation parameters of the facilities, not accompanied by a change of the facilities such that an old and inefficient refrigerator is changed to a newest refrigerator. In the present disclosure, an energy saving control technique refers that the operation parameters of the facilities are changed to save energy.

In the related art, for example, Japanese Patent Application Laid-open No. 2010-236786 suggests as such an energy saving control technique that the energy saving is achieved by changing (or alleviating) a water delivery temperature of a heat source device with a VWT control. Alternatively, Japanese Patent Application Laid-open No. 2013-029273 for example, suggests that the energy saving is achieved by changing (or alleviating) a setting temperature of the air conditioner.

Summary

To calculate the energy saving effect of such an energy saving control technique, according to a generally conceivable

approach, the energy consumption amounts before and after the energy saving control is applied are compared with each other.

However, an actual energy consumption amount is affected not only by validity or invalidity of the energy saving control, but also greatly by external conditions around the facilities such as an external temperature, a water temperature, and a building availability factor. Therefore, the effect of the energy saving control may not be calculated simply based on comparison between the energy consumption amounts of the valid and invalid energy saving controls.

For example, a certain energy saving control is not introduced at the preceding month and is introduced at this month. If this month is extremely hotter than the preceding month, irrespective of the effects of the energy saving control, the energy saving is not achieved, and the energy is increased in an opposite manner.

Japanese Patent Application Laid-open No. H11-328152 determines an approximate equation using actual performance data when the energy saving control is invalid and actual performance data when the energy saving control is valid, and virtually calculates the effects under the identical external conditions. Japanese Patent No. 3783929 applies an approximate equation, which is calculated based on the external conditions and the amount of power after the energy saving control is introduced, to the external conditions (external air information) before the introduction to compare the amount of power before and after the introduction, thereby virtually calculating the energy saving effect under the identical external conditions.

Actually, applicability/inapplicability (validity/invalidity) of the individual energy saving control

is often determined by an operator of air conditioning facilities. In this case, it is assumed that the operator has a motivation to achieve the energy saving, but has no detailed knowledge about the energy saving control and a calculation process of the effect.

Here, when the effect is virtually calculated by the correction and the approximation as in the related art, errors caused by the correction and the approximation may be generated. Accordingly, for the operator having no detailed knowledge, specifying and determining the presence or absence and the magnitude of the effect, while taking the effect of the errors into consideration per control, form a great burden on an actual operation. In addition, establishing a highly precise correction equation or approximate equation including errors as low as possible needs great efforts, and it is not realistic for a complicated subject.

On the other hand, comparison between the actual values not corrected and approximated contributes to alleviate the burden. However, as the actual values depend on the external conditions, it is also not realistic, either.

Embodiments of the present invention provide a technique of calculating more accurately an energy saving effect without requiring correction and approximation of the energy saving effect with an extremely low effect from external conditions.

According to a first aspect of the present invention, there is provided a method of calculating an energy saving effect used in an energy saving effect calculation apparatus for calculating an energy saving effect of an energy saving control based on an energy consumption amount consumed at facilities in a pre-specified effect calculation period, when the energy saving control in the facilities is valid/invalid,

including: switching validity/invalidity of the energy saving control in the facilities based on unit segments provided by dividing an effect calculation period by a time length, during which the energy saving effect is at least expressed, by an energy saving control switching unit; recording, as segment data showing a content of a control performed in each of the unit segments, an external condition variable value showing an external condition having an impact on the energy saving effect measured in the segment, validity/invalidity of the energy saving control in the segment, and an energy consumption amount in the facilities measured in the segment, on the storage unit for each of the unit segments by a segment data recording unit; selecting a pair of a valid segment and an invalid segment from the segment data, a difference between an external condition variable value of the valid segment and an external condition variable value of the invalid segment being within a criterion value, and calculating the energy saving effect during the effect calculation period based on the difference between the energy consumption amount of the valid segment and the energy consumption amount of the invalid segment per a pair by an energy saving effect calculation unit; predicting in advance, when a new segment is started during the effect calculation period, the external condition variable values in the new segment by an external condition prediction unit; and confirming a presence of an invalid segment (or a valid segment) in the segment data, where the energy saving control is invalid (or valid) with the proviso that a difference between the external condition variable value of the invalid segment (or the valid segment) and the external condition variable value of the new predicted segment is within the criterion value, and instructing

invalidity/invalidity of the energy saving control in the new segment to the energy saving control switching unit depending on a presence or absence of the invalid segment by a validity/invalidity judgement unit.

An embodiment of the method of calculating an energy saving effect according to the present invention, further includes: in calculating the energy saving effect, calculating a stratified energy saving effect during the effect calculation period by integrating the differences relating to the pairs, each of which includes a valid segment and an invalid segment whose external condition variable values are within the specified ranges, among all the pairs.

In an embodiment of the method of calculating an energy saving effect, the criterion value is an allowable range individually set per the external conditions variable values.

An embodiment of the method of calculating an energy saving effect according to the present invention, further includes: extending a range of the criterion value if the percentage or the number of the pairs of the valid segment and the invalid segment in the segment data is not more than the threshold value, where the difference between the external condition variable value of the valid segment and the external condition variable value of the invalid segment is within the criterion value, by an adjustment unit.

According to a second aspect of the present invention, there is provided a method of calculating an energy saving effect used in an energy saving effect calculation apparatus for calculating an energy saving effect of an energy saving control based on an energy consumption amount consumed at facilities in a pre-specified effect calculation period, when the energy saving control in the facilities is valid/invalid,

including: switching validity/invalidity of the energy saving control in the facilities based on unit segments provided by dividing an effect calculation period by a time length, during which the energy saving effect is at least expressed, by an energy saving control switching unit; recording, as segment data showing a content of a control performed in each of the unit segments, an external condition variable value showing an external condition having an impact on the energy saving effect measured in the segment, validity/invalidity of the energy saving control in the segment, and an energy consumption amount in the facilities measured in the segment, on the storage unit for each of the unit segments by a segment data recording unit; selecting a pair of a valid segment and an invalid segment from the segment data, a difference between an external condition variable value of the valid segment and an external condition variable value of the invalid segment being within a criterion value, and calculating the energy saving effect during the effect calculation period based on the difference between the energy consumption amount of the valid segment and the energy consumption amount of the invalid segment per a pair by an energy saving effect calculation unit; and shortening the time length of the segment if the percentage or the number of the pair of the valid segment and the invalid segment in the segment data is not more than the threshold value, where the difference between the external condition variable value of the valid segment and the external condition variable value of the invalid segment is within the criterion value, by an adjustment unit.

According to a third aspect of the present invention, there is provided an energy saving effect calculation apparatus for calculating an energy saving effect of an energy

saving control based on an energy consumption amount consumed at facilities in a pre-specified effect calculation period, when the energy saving control in the facilities is valid/invalid, including: an energy saving control switching unit for switching validity/invalidity of the energy saving control in the facilities based on unit segments provided by dividing an effect calculation period by a time length, during which the energy saving effect is at least expressed; a segment data recording unit for recording, as segment data showing a content of a control performed in each of the unit segments, an external condition variable value showing an external condition having an impact on the energy saving effect measured in the segment, validity/invalidity of the energy saving control in the segment, and an energy consumption amount in the facilities measured in the segment, on the storage unit for each of the unit segments; an energy saving effect calculation unit for selecting a pair of a valid segment and an invalid segment from the segment data, a difference between an external condition variable value of the valid segment and an external condition variable value of the invalid segment being within a criterion value, and calculating the energy saving effect during the effect calculation period based on the difference between the energy consumption amount of the valid segment and the energy consumption amount of the invalid segment per a pair; an external condition prediction unit for predicting in advance, when a new segment is started during the effect calculation period, the external condition variable values in the new segment; and a validity/invalidity judgement unit for confirming a presence of an invalid segment (or a valid segment) in the segment data, where the energy saving control

is invalid (or valid) with the proviso that a difference between the external condition variable value of the invalid segment (or the valid segment) and the external condition variable value of the new predicted segment is within the criterion value, and instructing invalidity/invalidity of the energy saving control in the new segment to the energy saving control switching unit depending on a presence or absence of the invalid segment.

According to a fourth aspect of the present invention, there is provided an energy saving effect calculation apparatus for calculating an energy saving effect of an energy saving control based on an energy consumption amount consumed at facilities in a pre-specified effect calculation period, when the energy saving control in the facilities is valid/invalid, including: an energy saving control switching unit for switching validity/invalidity of the energy saving control in the facilities based on unit segments provided by dividing an effect calculation period by a time length, during which the energy saving effect is at least expressed; a segment data recording unit for recording, as segment data showing a content of a control performed in each of the unit segments, an external condition variable value showing an external condition having an impact on the energy saving effect measured in the segment, validity/invalidity of the energy saving control in the segment, and an energy consumption amount in the facilities measured in the segment, on the storage unit for each of the unit segments; an energy saving effect calculation unit for selecting a pair of a valid segment and an invalid segment from the segment data, a difference between an external condition variable value of the valid segment and an external condition variable value of the

invalid segment being within a criterion value, and calculating the energy saving effect during the effect calculation period based on the difference between the energy consumption amount of the valid segment and the energy consumption amount of the invalid segment per a pair; and an adjustment unit for shortening the time length of the segment if the percentage or the number of the pair of the valid segment and the invalid segment in the segment data is not more than the threshold value, where the difference between the external condition variable value of the valid segment and the external condition variable value of the invalid segment is within the criterion value.

Effect of the Invention

According to embodiments of the present invention, the validity/invalidity of the energy saving control is switched for segments during the effect calculation period, and the energy saving effect is calculated during the effect calculation period based on a difference energy consumption amount per a pair of the valid segment and the invalid segment that can be seemed to have the identical external conditions among the segments.

Therefore, without requiring a correction and approximation of the energy saving effect and with an extremely less effect from the external conditions, a more accurate energy saving effect can be calculated.

Brief Description of Drawings

Fig. 1 is a block diagram showing an apparatus of calculating an energy saving effect according to an embodiment of the present disclosure;

Fig. 2 is a setting example of criterion values;
Fig. 3 is a configuration example of segment data;
Fig. 4 is a configuration example of comparison
data;

5 Fig. 5 is a flowchart showing judgment processing
of necessity of energy saving;

Fig. 6 is a flowchart showing comparison data
recording processing;

10 Fig. 7 is an operation example of an apparatus of
calculating an energy saving effect according to an
embodiment of the present disclosure;

Fig. 8 is an example (accumulation) of an energy
saving effect display screen; and

15 Fig. 9 is an example (stratified) of an energy
saving effect display screen.

Detailed Description of Embodiments

[Principle of Invention]

20 To calculate an energy saving effect of target
facilities, the following approach is conceivable: a
certain length of an effect calculation period, e.g.,
one year, is set in order to calculate the effect, and
an energy consumption amount for one year during which
an energy saving control is performed is compared with
25 an energy consumption amount for the preceding year
during which an energy saving control is not performed.
However, an average temperature may be changed

depending on the year, and there may be warm winter or extreme hot summer. It can be easily imagined that it is difficult to consider that both effect calculation periods have the identical external conditions for one
5 year. In addition, even if the effect calculation period is set as one month, and the energy consumption amount for this month during which the energy saving control is performed is compared with the energy consumption amount for the preceding month during which
10 the energy saving control is not performed, it is difficult to consider that both have the identical external conditions due to a seasonal transition.

Meanwhile, there is a conceivable approach that the energy saving effect under the identical external
15 conditions is virtually calculated based on correction or approximation. However, establishing a highly precise correction equation or approximate equation including errors, if present, as low as possible needs great efforts, and it is not realistic for a
20 complicated subject. For example, if a correction equation or an approximate equation is created using actual data in cold summer, and the energy saving effect in extreme hot summer is virtually calculated, it is conceivable that the errors caused by the
25 correction or the approximation become great.

Therefore, these approaches of calculating the energy saving effect have different external conditions

during the effect calculation periods to be compared.
It is found that this causes the errors upon the
calculation of the energy saving effect.

Here, in some cases, the external conditions of
5 the facilities upon the energy saving at one temporal
position in an effect calculation period may be
substantially identical to the external conditions at
another temporal position in the same effect
calculation period. For example, the external
10 conditions at the current time may be substantially
identical to the external conditions at the time 30
minutes before in the same day, or the external
conditions at a certain time of one day in one week may
be substantially identical to the similar time of
15 another day in the same week. The effect calculation
period is divided into a plurality of short and small
segments, each of which has the time length during
which at least the energy saving effect can be
expressed. The external conditions of an arbitrarily-
20 selected pair of segments often seem identical.

The present disclosure focuses on that a cause of
the errors generated upon the calculation of the energy
saving effect is the difference of the external
conditions during the effect calculation period to be
25 compared, and that the external conditions of an
arbitrarily-selected pair of segments out of all the
segments provided by dividing the effect calculation

period may seem identical. Based thereon, the external conditions of facilities of each next segment are successively predicted, necessity of the application of the energy saving control for the next segment is
5 determined based on the prediction result, and the energy consumption amounts provided at the segments having the identical external conditions in the segments are compared, thereby calculating the energy saving effect.

10 Next, an embodiment of the present disclosure will be described referring to the drawings.

[Energy saving Effect Calculation Apparatus]

 Firstly, referring to Fig. 1, an energy saving effect calculation apparatus 10 according to an
15 embodiment of the present disclosure will be described.

Fig. 1 is a block diagram showing a configuration of the energy saving effect calculation apparatus according to an embodiment of the present disclosure.

 The energy saving effect calculation apparatus 10
20 includes, as a whole, an information processing apparatus such as a server apparatus and a personal computer. In a pre-specified effect calculation period, when an energy saving control in target facilities 30 is valid/invalid, the apparatus 10 has a capability of
25 calculating an energy saving effect of the energy saving control based on the energy consumption amount consumed at the facilities.

A facilities control system 20 has a capability of controlling an operation of the facilities 30, a capability of switching validity/invalidity, i.e., applicability/inapplicability, of the energy saving control in the facilities 30 in response to an instruction from the energy saving effect calculation apparatus 10, and a capability of detecting external condition variable values showing external conditions having an impact on the energy saving effect of the facilities 30 and the energy consumption amount consumed by the facilities 30 and notifying the facilities control system 20 of them.

The facilities 30 are subjected to the energy saving control such as an air conditioner placed in a building or a factory. Hereinafter, by way of example, the facilities control system 20 applies the energy saving control (VWT control), for example, described in Japanese Patent Application Laid-open No. 2010-236786 described above, to the facilities 30 including a heat source system.

The energy saving effect calculation apparatus 10 mainly includes a communication I/F unit 11, an operation input unit 12, a screen display 13, a storage unit 14, and an arithmetic processing unit 15.

The communication I/F unit 11 has a capability of sending/receiving data to/from an external device such as the facilities control system 20 connected through a

communication line L.

The operation input unit 12 includes operation input devices such as a keyboard, a mouse, and a touch panel, and has a capability of detecting operations by an operator to output the detected information to the arithmetic processing unit 15.

The screen display 13 includes a screen display apparatus such as an LCD, and has a capability of displaying a variety of screen data outputted from the arithmetic processing unit 15 such as an operation menu, a setting screen, and an energy saving effect display screen.

The storage unit 14 includes a storage apparatus such as a hard disk and a semiconductor memory, and has a capability of storing a variety of processing data and a program 14P used for energy saving effect calculation processing by the arithmetic processing unit 15.

The program 14P is a program for operating a variety of processing units for the energy saving effect calculation processing executed by the arithmetic processing unit 15, is read out from an external device connected to the communication I/F unit 11 or a storage medium, and is stored in advance.

The processing data stored in the storage unit 14 mainly includes criterion values 14A, segment data 14B, and comparison data 14C.

Each criterion value 14A represents an acceptable range whether or not the external conditions are identical between different segments, and is set in advance, for example, by an operator's manipulation
5 input in the operation input unit 12 before calculating the energy saving effect. Fig. 2 is a setting example of criterion values. Here, as external condition variable values, a cooling water temperature [$^{\circ}\text{C}$] and a thermal load [kWh] are used, and an allowable range is
10 set in advance for determining the identical external conditions for each.

The external conditions have an effect on the energy saving effect of the energy saving control applied to the facilities 30. For example, in a heat
15 source system as the facilities 30, when a cooling water temperature used in a heat source device is low, heat source efficiency is increased; and when a cooling water temperature is high, heat source efficiency is decreased. Further, depending on the magnitude of the
20 thermal load covered by the facilities 30, heat source efficiency and the energy consumption amount are changed.

As described above, if the external conditions are different, the energy consumption amount required at
25 that time is different, even if the similar energy saving conditions are applied. Therefore, even if the energy consumption amounts acquired at different

external conditions are compared, an accurate energy saving effect cannot be calculated.

According to the present disclosure, the criterion values 14A as shown in Fig. 2 are set, and the energy consumption amounts in the segments that satisfy the criterion values 14A are compared, thereby calculating the accurate energy saving effect.

The segment data 14B is for recording the content of the control performed on each segment as an archive. Fig. 3 shows a configuration example of segment data. Here, per segment ID for identifying the segment, a starting time and date of the segment, the validity/invalidity (applicability/inapplicability) of the energy saving control in the segment, the cooling water temperature and the thermal load as the external condition variable values measured in the segment, and the energy consumption amount in the facilities measured in the segment are recorded in a pair.

The comparison data 14C is for recording pairs of a valid segment and an invalid segment where a difference between each external condition variable values is within each criterion value 14A. Fig. 4 shows a configuration example of comparison data. Here, the segment ID, the cooling water temperature, the thermal load, and the energy consumption amount are recorded per the valid segment and the invalid segment.

The arithmetic processing unit 15 includes a CPU

(central processing unit) and a peripheral circuit, and has a capability of operating a variety of processing units used in the calculation of the energy saving effect by executing the program 14P of the storage unit 14.

The arithmetic processing unit 15 mainly includes an energy saving control switching unit 15A, a segment data recording unit 15B, an external condition prediction unit 15C, a validity/invalidity judgement unit 15D, an energy saving effect calculation unit 15E, and an adjustment unit 15F.

The energy saving control switching unit 15A has a capability of switching the validity/invalidity of the energy saving control of the facilities 30 based on unit segments provided by dividing an effect calculation period by a time length, during which the energy saving effect is at least expressed, by instructing the facilities control system 20 through the communication I/F unit 11.

In the heat source system, although it depends on the sizes of the facilities, after a water delivery temperature setting of the heat source device is changed, the heat source device is operated for about 30 minutes at the water delivery temperature changed, thereby providing the energy saving effect. According to the embodiment of the present disclosure, the time length of the segment is set to 30 minutes. In

addition, in order to calculate the energy saving effect, the validity/invalidity of the energy saving control to the facilities 30 are switched. The effect calculation period is set to two weeks.

5 The segment data recording unit 15B has a capability of acquiring, for each segment, as the segment data 14B showing the content of the control performed in the unit segment, the cooling water temperature (segment average) and the thermal load
10 (segment integration) as the external condition variable values showing the external conditions measured in the segment, validity/invalidity of the energy saving control in the segment, and the energy consumption amount, e.g., the energy consumption amount
15 of a heat source device and a circulation pump of an air conditioner, from the communication I/F unit 11 and the facilities control system 20; and recording them on the storage unit 14.

 The external condition prediction unit 15C has a
20 capability of predicting in advance, when a new segment is started during the effect calculation period, a cooling water temperature (segment average) and a thermal load (segment integration) as the external condition variable values in the new segment.

25 As to the prediction of the external condition variable values, a general prediction model may be used.
 For example, if the prediction is made based on the

past variable values, an autoregression model that predicts the cooling water temperature and the thermal load for next 30 minutes as the next external condition variable values may be used.

5 Note that, as the prediction model, instead of the autoregression model, a physical model utilizing other explanatory variables acquired from the facilities 30, or a machine learning technique such as a neural network or a support vector regression may be used.
10 Weather forecast data and a building operation plan may be used as the explanatory variables. Also, a predicted distribution may be represented by a probability model.

 The validity/invalidity judgement unit 15D has a
15 capability of confirming the presence of the invalid segment (or the valid segment) from the segment data 14B, where the energy saving control is invalid (or valid) with the proviso that a difference between the external condition variable values in the invalid
20 segment (or the valid segment) and the external condition variable values in the new predicted segment is within the criterion value 14A, and that the invalid segment (or the valid segment) is considered as having the identical conditions as the new segment. Also, the
25 validity/invalidity judgement unit 15D has a capability of instructing the invalidity/invalidity of the energy saving control in the new segment to the energy saving

control switching unit 15A depending on the presence or absence of the invalid segment.

5 The energy saving effect calculation unit 15E has a capability of selecting a pair of the valid segment and the invalid segment where the difference between the respective external condition variable values is within the criterion value 14A from the segment data 14B and recording it to the comparison data 14C. Also, the energy saving effect calculation unit 15E has a
10 capability of calculating the energy saving effect (an energy saving effect amount and a reduction rate) during the effect calculation period by summing up the difference between the energy consumption amounts in each pair of the valid segment and the invalid segment
15 recorded in the comparison data 14C.

The adjustment unit 15F has a capability of extending the range of the criterion value 14A if the percentage or the number of the pair of the valid segment and the invalid segment is not more than the
20 threshold value, where the difference between the respective external condition variable values is within the criterion value 14A from the segment data 14B. Also, the adjustment unit 15F has a capability of shortening the time length of the segment if the
25 percentage or the number of the pair of the valid segment and the invalid segment is not more than the threshold value, where the difference between the

respective external condition variable values is within the criterion value 14A from the segment data 14B.

[Operations of Embodiment]

5 Next, referring to the figures, a variety of operations of the energy saving effect calculation apparatus 10 according to the embodiment of the present disclosure will be described.

[Judgment Processing of Necessity of Energy Saving]

10 Firstly, referring to Fig. 5, judgment processing of necessity of energy saving executed upon the start of a segment will be described. Fig. 5 is a flowchart showing judgment processing of necessity of energy saving.

15 The external condition prediction unit 15C predicts in advance, when a new segment is started during the effect calculation period, as the external condition variable values in the new segment, i.e., the cooling water temperature and the thermal load (step 100).

20 Next, the validity/invalidity judgement unit 15D searches segment data 14B for an invalid segment where the energy saving control is invalid and that is considered as having the identical conditions as the new segment based on the criterion value 14A (step 101).

25 Here, if an invalid segment is found (step 102: YES), the validity/invalidity judgement unit 15D instructs the energy saving control switching unit 15A

to be validity (applicability) of the energy saving control in the new segment (step 103).

On the other hand, if no invalid segment is found (step 102: NO), the validity/invalidity judgement unit
5 15D instructs the energy saving control switching unit 15A to be invalidity (inapplicability) of the energy saving control in the new segment (step 104).

In this way, after the validity/invalidity of the energy saving control in the new segment is judged, the
10 energy saving control switching unit 15A instructs switching of the validity/invalidity of the energy saving control in the new segment as necessary. Then, the segment is started.

After the new segment is started in this way, the
15 segment data recording unit 15B acquires the cooling water temperature, the thermal load, and the energy consumption amount from the communication I/F unit 11 and facilities control system 20 until the segment is ended, and successively records them to the segment
20 data 14B of the storage unit 14 (step 105). A series of the judgment processing of necessity of energy saving is ended.

In the flowchart shown in Fig. 5, an invalid segment is searched for in the step 101. Alternatively,
25 a valid segment may be searched for. If a valid segment is found, the stop of the energy saving control is instructed (step 104). If no valid segment is found,

the start of the energy saving control may be instructed (step 103).

[Comparison Data Recording Processing]

5 Next, referring to Fig. 6, comparison data recording processing executed upon the end of the segment will be described. Fig. 6 is a flowchart showing comparison data recording processing.

10 After the new segment is ended, if the segment is the valid segment to which the energy saving control is applied (Step 110: YES), the energy saving effect calculation unit 15E searches the segment data 14B for an invalid segment where a difference between the external condition variable values of the segments is within the criterion value 14A (Step 111).

15 If an invalid segment is found (Step 112: YES), a pair of the segment and the valid segment is recorded in the comparison data 14C (Step 113). A series of the comparison data recording processing is ended.

20 If no invalid segment is found (Step 112: NO), nothing is recorded in the comparison data 14C. A series of the comparison data recording processing is ended.

25 On the other hand, if the segment is an invalid segment where the energy saving control is invalid (Step 110: NO), the energy saving effect calculation unit 15E searches the segment data 14B for a valid segment where a difference between the external

condition variable values of the segment is within the criterion value 14A (Step 114).

If a valid segment is found (Step 115: YES), a pair of the segment and the invalid segment is recorded in the comparison data 14C (Step 116). A series of the comparison data recording processing is ended.

If no valid segment is found (Step 115: NO), nothing is recorded in the comparison data 14C. A series of the comparison data recording processing is ended.

Fig. 7 is an operation example of an energy saving effect according to the embodiment of the present disclosure.

Here, Fig. 7 shows an example that n (n is a positive integer) numbers of the segments $S1$ to S_n are provided in the effect calculation period. Each segment arrives in order of time beginning at the segment $S1$. Fig. 7 shows that, among the segments $S1$ to S_n , the energy saving control is not applied in the segments hatched in slant lines, and the energy saving control is applied in the blank segments.

As no invalid segments are present before the segments $S1$ and $S2$, the segments $S1$ and $S2$ are judged as the invalid segments. The invalid segment is such that differences between the predicted external condition variable values of each segment $S1$ or $S2$ and the external condition variable values of the invalid

segment are within the criterion values 14A. Further,
as differences between the predicted external condition
variable values of a segment S3 and the external
condition variable values of the segment S1, i.e., the
5 invalid segment, are within the criterion values 14A,
the segment S3 is judged as the valid segment.

Accordingly, at the end of the segment S3, an
invalid segment, where differences between the
actually-measured external condition variable values of
10 the segment S3 and external condition variable values
of the invalid segment are within the criterion values
14A, is searched for again, and the segment S1 is
selected again. As a result, these segments S1 and S3
are selected as a pair P1, which is recorded in the
15 comparison data 14C.

As differences between the predicted external
condition variable values of a segment S8 and the
external condition variable values of a segment S6,
i.e., the invalid segment, are within the criterion
20 values 14A, the segment S8 is judged as the valid
segment. However, at the end of the segment S8, if an
invalid segment, where differences between the
actually-measured external condition variable values of
the segment S8 and the external condition variable
25 values of the invalid segment are within the criterion
values 14A, is retrieved, a segment S5 is selected
instead of the segment S6. As a result, these segments

S5 and S8 are selected as a pair P2, which is recorded in the comparison data 14C.

If a pair of segments is selected by the validity/invalidity judgement unit 15D or the energy saving effect calculation unit 15E, it may be possible to prohibit the segment already selected as one pair from double selecting as another pair with another section. In this way, it is possible to avoid double use the energy consumption amount measured at the identical segment.

The energy saving effect calculation unit 15E sums up the energy consumption amounts of the valid segments in the pairs recorded in the comparison data 14C as described above, sums up the energy consumption amounts of the invalid segments therein, and thereby calculates the energy saving effect during the effect calculation period. The energy saving effect display screen is displayed on the screen display 13 to the operator.

Fig. 8 is an example (accumulation) of the energy saving effect display screen. Here, the integration value of the energy consumption amounts in the invalid segments and the integration value of the energy consumption amounts in the valid segments among the comparison data 14C are calculated by the energy saving effect calculation unit 15E, which are displayed in bar graphs. In addition, the difference between the integration values is represented by a bar graph as an

energy reduced amount and a reduction rate. In this way, the operator can extremely easily confirm the accumulated energy saving effect about all external conditions.

5 Fig. 9 is an example (stratified) of an energy saving effect display screen. Here, entry fields are provided for inputting a range of the cooling water temperature and a range of the thermal load as the external conditions, and the operator can specify
10 desirable stratification. In this way, the integration value of the energy consumption amounts in the invalid segments belonging to the stratification specified by the operator and the integration value of the energy consumption amounts in the valid segments belonging to
15 the stratification among the comparison data 14C are calculated by the energy saving effect calculation unit 15E, and displayed as the bar graphs. Also, the difference between the integration values is displayed in the bar graph as the energy reduced amount and the
20 reduction rate as the result of the energy saving control. In this way, the operator can extremely easily confirm the accumulated energy saving effect about the external conditions belonging to the stratification specified freely.

25 If the energy saving effect calculation apparatus 10 according to an embodiment of the present disclosure is used for evaluation of a new energy saving control,

for example, after two weeks of the effect calculation period, at the time of calculating the energy saving effect and confirming the desirable energy saving effect, it leads to an actual energy saving control.

5 At this time, in order to receive benefits of the actual energy saving control, it is desirable that the energy saving control is always valid in the actual energy saving control. Note that, if it is confirmed that the desirable energy saving control is not
10 acquired, the actual energy saving control is canceled, and the energy saving control may be adjusted.

For example, on the way or at the end of the effect calculation period, if the percentage or the number of the pairs of the valid segment and the
15 invalid segment in the segment data 14B is not more than the threshold value, where the differences between the external condition variable values of the valid segment and the external condition variable values of the invalid segment are within the criterion values 14A,
20 the adjustment unit 15F may extend the ranges of the criterion values 14A. Alternatively, the adjustment unit 15F may shorten the time length of each segment if the percentage or the number of the pairs of the valid segment and the invalid segment in the segment data 14B
25 is not more than the threshold value, where the differences between the external condition variable values of the valid segment and the external condition

variable values of the invalid segment are within the criterion values 14A. It should be noted that if the criterion values 14A or the time length of each segment are/is changed, a new effect calculation period is provided to calculate the energy saving effect.

Thus, if the number of the segments that can be seemed to have the identical external conditions is small, the ranges of the criterion values 14A are extended, or the time length of each segment is shortened. Therefore, the number of the pairs of the valid segment and the invalid segment is increased. As a result, a more accurate and reliable energy saving effect can be calculated.

[Advantages of the Embodiment]

According to the embodiment, the validity/invalidity of the energy saving control in the facilities is switched based on unit segments provided by dividing an effect calculation period by a time length, during which the energy saving effect is at least expressed, by the energy saving control switching unit 15A. As the segment data 14B showing the content of the control performed in the unit segments, the external condition variable values showing the external conditions having an impact on the energy saving effect measured in the segment, validity/invalidity of the energy saving control in the segment, and the energy consumption amount measured in the segment are recorded

by the segment data recording unit 15B on the storage unit 14 for each of the unit segments. A pair of the valid segment and the invalid segment where the difference between the respective external condition variable values is within the criterion value from the segment data 14B is selected, and the energy saving effect during the effect calculation period is calculated based on the difference between the energy consumption amount of the valid segment and the energy consumption amount of the invalid segment per a pair by the energy saving effect calculation unit 15E.

In this way, the validity/invalidity of the energy saving control is switched for segments during the effect calculation period. The energy saving effect during the effect calculation period is calculated based on a difference energy consumption amount per a pair of the valid segment and the invalid segment that can be seemed to have the identical external conditions among the segments.

Therefore, without requiring a correction and approximation of the energy saving effect and with an extremely less effect by the external conditions, a more accurate energy saving effect can be calculated.

In addition, according to the embodiment, when a new segment is started during the effect calculation period, the external condition variable values in the new segment may be predicted in advance by the external

condition prediction unit 15C. The presence of the
invalid segment from the segment data 14B, where the
energy saving control is invalid with the proviso that
a difference between the external condition variable
5 values in the invalid segment and the external
condition variable values in the new predicted segment
is within the criterion value may be confirmed by the
validity/invalidity judgement unit 15D. The
invalidity/invalidity of the energy saving control in
10 the new segment may be instructed to the energy saving
control switching unit 15A depending on the presence or
absence of the invalid segment.

In this way, depending on the presence or absence
of the invalid segment that can be seemed to have the
15 identical external conditions from the new segment, the
validity/invalidity of the energy saving control in the
new segment is determined automatically, whereby the
valid segment and the invalid segment that can be
seemed to have the identical external conditions can be
20 generated extremely efficiently. As a result, a more
accurate energy saving effect can be calculated.

Alternatively, according to the embodiment, the
differences relating to the pairs, each of which
includes a valid segment and an invalid segment whose
25 external condition variable values are within the
specified ranges, among all the pairs may be integrated
by the energy saving effect calculation unit 15E to

calculate the energy saving effect stratified during the effect calculation period.

In this way, the operator can extremely easily confirm the accumulated energy saving effect about the external conditions belonging to the stratification specified freely.

Further, according to the embodiment, the criterion value may be configured of the allowable range individually set per the external condition variable values. In this way, determination of identicalness of the external conditions between the segments can be set in detail. As a result, a more accurate energy saving effect can be calculated.

Moreover, according to the embodiment, the adjustment unit 15F may extend the range of the criterion value if the percentage or the number of the pair of the valid segment and the invalid segment is not more than the threshold value, where the difference between the respective external condition variable values is within the criterion value from the segment data 14B. Alternatively, the adjustment unit 15F may shorten the time length of the segment if the percentage or the number of the pair of the valid segment and the invalid segment is not more than the threshold value, where the difference between the respective external condition variable values is within the criterion value from the segment data 14B.

Thus, if the number of the segments that can be seemed to have the identical external conditions is small, the ranges of the criterion values 14A are extended, or the time length of each segment is shortened. Therefore, the number of the pairs of the valid segment and the invalid segment that are seemed to have the identical external conditions is increased. As a result, a more accurate and reliable energy saving effect can be calculated.

Furthermore, there is another object to be attained by the present disclosure. Specifically, when the method of controlling energy saving is introduced as an individual software application used by the facilities control system 20, an application provider considers as follows: the energy saving effect is confirmed by the user during a charge-free trial period, for example, and if the user feels the effect to some extent, the provider hopes that the user properly uses a paid software application.

In that case, confirming the effect of the application alone in a period as short as possible, not calculating the effect in a view point of a comprehensive energy consumption amount yearly or monthly, leads to the application provider's profit.

According to the present disclosure, an actual performance of the energy saving effect can be calculated in a relatively short period depending on

the individual energy saving control being different by
the user, whereby the user can confirm the effect in a
short period. Therefore, it is possible to lead the
user to continue to properly use the paid software
5 application.

[Extension of Embodiment]

Hereinabove, the present disclosure is described
referring to the embodiments, but the present
disclosure is not limited to the above-described
10 embodiments. Various changes that can be understood by
a person skilled in the art can be made on the
configuration and the details of the present disclosure
within the scope of the present disclosure.

Claims

1. A method of calculating an energy saving effect used in an energy saving effect calculation apparatus for calculating an energy saving effect of an energy saving control based on an energy consumption amount consumed at facilities in a pre-specified effect calculation period, when the energy saving control in the facilities is valid/invalid, comprising:

switching validity/invalidity of the energy saving control in the facilities based on unit segments provided by dividing an effect calculation period by a time length, during which the energy saving effect is at least expressed, by an energy saving control switching unit;

recording, as segment data showing a content of a control performed in each of the unit segments, an external condition variable value showing an external condition having an impact on the energy saving effect measured in the segment, validity/invalidity of the energy saving control in the segment, and an energy consumption amount in the facilities measured in the segment, on the storage unit for each of the unit segments by a segment data recording unit;

selecting a pair of a valid segment and an invalid segment from the segment data, a difference between an external condition variable value of the valid segment and an external condition variable value of the invalid segment being within a criterion value, and calculating the energy saving effect during the effect calculation period based on the difference between the energy consumption amount of the valid segment and the energy consumption amount of the invalid segment per a pair by an energy saving effect calculation unit;

predicting in advance, when a new segment is started during the effect calculation period, the external condition variable

values in the new segment by an external condition prediction unit; and

confirming a presence of an invalid segment (or a valid segment) in the segment data, where the energy saving control is invalid (or valid) with the proviso that a difference between the external condition variable value of the invalid segment (or the valid segment) and the external condition variable value of the new predicted segment is within the criterion value, and instructing invalidity/invalidity of the energy saving control in the new segment to the energy saving control switching unit depending on a presence or absence of the invalid segment by a validity/invalidity judgement unit.

2. The method of calculating an energy saving effect according to claim 1, further comprising:

in calculating the energy saving effect, calculating a stratified energy saving effect during the effect calculation period by integrating the differences relating to the pairs, each of which includes a valid segment and an invalid segment whose external condition variable values are within the specified ranges, among all the pairs.

3. The method of calculating an energy saving effect according to claim 1 or 2, wherein

the criterion value is an allowable range individually set per the external conditions variable values.

4. The method of calculating an energy saving effect according to any one of claims 1 to 3, further comprising:

extending a range of the criterion value if the percentage or the number of the pair of the valid segment and the invalid segment in the segment data is not more than the threshold

value, where the difference between the external condition variable value of the valid segment and the external condition variable value of the invalid segment is within the criterion value, by an adjustment unit.

5. A method of calculating an energy saving effect used in an energy saving effect calculation apparatus for calculating an energy saving effect of an energy saving control based on an energy consumption amount consumed at facilities in a pre-specified effect calculation period, when the energy saving control in the facilities is valid/invalid, comprising:

switching validity/invalidity of the energy saving control in the facilities based on unit segments provided by dividing an effect calculation period by a time length, during which the energy saving effect is at least expressed, by an energy saving control switching unit;

recording, as segment data showing a content of a control performed in each of the unit segments, an external condition variable value showing an external condition having an impact on the energy saving effect measured in the segment, validity/invalidity of the energy saving control in the segment, and an energy consumption amount in the facilities measured in the segment, on the storage unit for each of the unit segments by a segment data recording unit;

selecting a pair of a valid segment and an invalid segment from the segment data, a difference between an external condition variable value of the valid segment and an external condition variable value of the invalid segment being within a criterion value, and calculating the energy saving effect during the effect calculation period based on the difference between the energy consumption amount of the valid segment and the

energy consumption amount of the invalid segment per a pair by an energy saving effect calculation unit; and

shortening the time length of the segment if the percentage or the number of the pair of the valid segment and the invalid segment in the segment data is not more than the threshold value, where the difference between the external condition variable value of the valid segment and the external condition variable value of the invalid segment is within the criterion value, by an adjustment unit.

6. An energy saving effect calculation apparatus for calculating an energy saving effect of an energy saving control based on an energy consumption amount consumed at facilities in a pre-specified effect calculation period, when the energy saving control in the facilities is valid/invalid, comprising:

an energy saving control switching unit for switching validity/invalidity of the energy saving control in the facilities based on unit segments provided by dividing an effect calculation period by a time length, during which the energy saving effect is at least expressed;

a segment data recording unit for recording, as segment data showing a content of a control performed in each of the unit segments, an external condition variable value showing an external condition having an impact on the energy saving effect measured in the segment, validity/invalidity of the energy saving control in the segment, and an energy consumption amount in the facilities measured in the segment, on the storage unit for each of the unit segments;

an energy saving effect calculation unit for selecting a pair of a valid segment and an invalid segment from the segment data, a difference between an external condition variable value of the valid segment and an external condition variable value of

the invalid segment being within a criterion value, and calculating the energy saving effect during the effect calculation period based on the difference between the energy consumption amount of the valid segment and the energy consumption amount of the invalid segment per a pair;

an external condition prediction unit for predicting in advance, when a new segment is started during the effect calculation period, the external condition variable values in the new segment; and

a validity/invalidity judgement unit for confirming a presence of an invalid segment (or a valid segment) in the segment data, where the energy saving control is invalid (or valid) with the proviso that a difference between the external condition variable value of the invalid segment (or the valid segment) and the external condition variable value of the new predicted segment is within the criterion value, and instructing invalidity/invalidity of the energy saving control in the new segment to the energy saving control switching unit depending on a presence or absence of the invalid segment.

7. An energy saving effect calculation apparatus for calculating an energy saving effect of an energy saving control based on an energy consumption amount consumed at facilities in a pre-specified effect calculation period, when the energy saving control in the facilities is valid/invalid, comprising:

an energy saving control switching unit for switching validity/invalidity of the energy saving control in the facilities based on unit segments provided by dividing an effect calculation period by a time length, during which the energy saving effect is at least expressed;

a segment data recording unit for recording, as segment data showing a content of a control performed in each of the

unit segments, an external condition variable value showing an external condition having an impact on the energy saving effect measured in the segment, validity/invalidity of the energy saving control in the segment, and an energy consumption amount in the facilities measured in the segment, on the storage unit for each of the unit segments;

an energy saving effect calculation unit for selecting a pair of a valid segment and an invalid segment from the segment data, a difference between an external condition variable value of the valid segment and an external condition variable value of the invalid segment being within a criterion value, and calculating the energy saving effect during the effect calculation period based on the difference between the energy consumption amount of the valid segment and the energy consumption amount of the invalid segment per a pair; and

an adjustment unit for shortening the time length of the segment if the percentage or the number of the pair of the valid segment and the invalid segment in the segment data is not more than the threshold value, where the difference between the external condition variable value of the valid segment and the external condition variable value of the invalid segment is within the criterion value.