MICRO-GRID SYSTEM CONSTRUCTION METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a micro-grid system construction method having a configuration in which plural types of power supplies are connected by a network.

Description of Related Art

As widely known, various distributed power supplies, such as natural gas cogeneration and fuel cells, have been developed in recent years. By adopting such distributed power supplies as in-house power generation facilities in a building, there are advantages in that an excellent total energy efficiency in electricity and heat supply can be obtained, a reduction in the discharge amount of greenhouse gases can be expected, a cost reduction by a reduction in the contract demand (purchased power from an electric power company) or capacity reduction of an electricity distribution facility can be achieved, and reliability of power supply in case of an earthquake disaster or a fire can also be progressive by a stand-alone operation. Accordingly, electric power supply systems using distributed power supplies have the potential to be widely spread in future. For example, a system in which the distributed power supplies are shared by a plurality of consumers is suggested (for example, refer to JP-A-2002-238168).

Meanwhile, in the aforementioned electric power supply system using distributed power supplies, if distributed power supplies and a commercial system (a power network of an electric power company) are used together and a base load operation of the distributed power supplies is operated, the electric power company is forced to

single-handedly undertake the ancillary service of a voltage and frequency variation. As a result, the commercial system will be continually asked for compensation of a load variation, and the burden on the electric power company will become large. Accordingly, in recent years, a technique of making the distributed power supplies operate load follow-up operation has been suggested. For example, a technique have been proposed in which a whole micro-grid system is collectively controlled, wherein the system is built by networking a plurality of distributed power supplies and a plurality of consumers to make the system optimally operate to follow-up the load variation. According to such a technology, not only that the burden of the load variation compensation on the commercial system can be relieved, but also an operation of the micro-grid system independent from the commercial system (a stand-alone operation) can be realized, wherein the load variation compensation does not depend on the commercial system (For example, refer to JP-A-2005-160286).

However, in order to make the aforementioned micro-grid system perform load follow-up operation in connection with a commercial system, power supply and power demand are required to be balanced with each other at all times. Furthermore, in a case wherein a micro-grid system is to perform a stand-alone operation independently from the commercial system, it is required that a stable electric power be stably supplied throughout the system area, and that the power generation and power load (demand) be balanced with each other at all times. In a system such as a micro-grid system constituted with small-scale power supplies, there is a possibility that electric power quality may be degraded significantly due to collapse of the balance between supply and demand of electric power. That is, in order to realize a load follow-up operation during in connection with the commercial system, and also to realize a stable electric power supply during a stand-alone operation, power generation and power load must be balanced with each other

at all times.

SUMMARY OF THE INVENTION

The invention has been made in consideration of the aforementioned problems. It is therefore an object of the invention to provide a micro-grid system construction method capable of balancing power supply and power demand, by planning from the system configuration designing phase, to realize an operation that is in consistence with the capacity of each power source.

The present invention provides, a micro-grid system construction method, wherein the micro-grid system supplies an electric power to a specific area, by configuring a network which integrally controls and operates a distributed power supplies including plural types of power supplies, includes: a step of measuring a load variation of the specific area and performing a frequency-analysis of a measured data of the load variation; and a step of determining an assigned frequency which is assigned to each of the plural types of power supplies based on a frequency response characteristics of each of the plural types of power supplies, and calculating a capacity required for each of the plural types of power supplies, by assigning a frequency-analysis result of the load variation to each of the plural types of power supplies based on the assigned frequency.

According to the present invention, since the measurement data of a load variation is frequency-analyzed, the load variation of a specific area, which is constituted with overlapping load variations of various rates, from a very slow load variation to an instantaneous load variation, is recognized by decomposing it into various frequency components. Furthermore, since plural types of power sources have different load follow-up characteristics (response characteristics), a frequency assignment is determined to each power supply on the basis of the frequency response characteristics. Also, since

the assigned frequency is assigned to each power supply on the basis of frequency-analysis result (a decomposed frequency component), the frequency bandwidth suitable for each power supply can be assigned to each power supply. Moreover, since the capacity of each power supply is calculated based on the aforementioned frequency-analysis result and the assigned frequency, each power supply will have a proper capacity.

In another aspect of the invention, a measurement cycle of the load variation may be determined by creating at least one of a first transition probability distribution of a load variation amount or a second transition probability distribution of a load variation rate.

According to the above aspect of the invention, by examining transition probability distribution of either load variation amount or load variation rate, range of recognizable load variation at the particular measurement cycle, can be visualized. Thus, the measurement cycle that is required to properly compensate the load variation can be made clear.

In yet another aspect of the invention, a fuel-consumption characteristics of a fuel-consumption-type power supply may be evaluated on a basis of a first power generation efficiency in a steady-state operation and a second power generation efficiency in a transient operation, and an operation of the fuel-consumption-type power supply may be determined on a basis of a result of an evaluation of the fuel-consumption characteristics.

According to the above aspect of the invention, the fuel-consumption-type power supply can be run efficiently, and operation of the micro-grid system where economical efficiency is taken into consideration can be realized.

In yet another aspect of the invention, a system frequency deviation to a load variation of a rotor-machine-type power supply may be evaluated, and a range of an output change rate of the rotor-machine-type power supply may be determined on the basis of a

result of an evaluation of the system frequency deviation.

According to the above aspect of the invention, during a stand-alone operation in which the electric power is supplied only from the distributed power supplies, the system frequency deviation can be made to fall within a predetermined deviation, and desired electric power quality can be ensured.

In yet another aspect of the invention, a dummy load for evaluation may be connected to the rotor-machine-type power supply, thereby constructing a simulation system, and the system frequency deviation to the load variation is evaluated using the simulation system.

When an evaluation is made using an actual load, such as electrical equipment, there is a possibility that low-quality electric power may cause a failure in the actual load. However, according to the above aspect of the invention, by conducting the evaluation using a dummy load, the level of the system frequency can be evaluated without damaging the actual load.

According to the micro-grid system construction method of the present invention, since the micro-grid system is constructed on the basis of the rate (frequency component) of a load variation, and the response performance of the distributed power supplies, it is possible to properly recognize the load variation as a compensation target, and it is possible to efficiently compensate the load variation, and it is possible to optimize the capacity of the distributed power supplies, and it is possible to prevent capacity shortage or facility excess of the distributed power supplies. As such, since realization of an operation matching the performance of each distributed power supply is being considered during the stage of selecting and constituting power supplies, the power generation and power load in the micro-grid system can be balanced with each other.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the schematic configuration of a micro-grid system for explaining an embodiment according to the present invention.

FIG. 2 is a graph showing the measurement result of a daily load variation for explaining the embodiment according to the present invention.

FIG. 3 shows a method of creating the transition probability distribution of the load variation amount for explaining the embodiment according to the present invention.

FIG. 4 shows a method of creating the transition probability distribution of the load variation rate for explaining the embodiment according to the present invention.

FIG. 5A is a graph showing the transition probability distribution of the load variation amount for explaining the embodiment according to the present invention.

FIG. 5B is a graph showing the transition probability distribution of the load variation rate for explaining the embodiment according to the present invention.

FIG. 6A is a graph showing the transition probability distribution of the load variation amount for explaining the embodiment according to the present invention.

FIG. 6B is a graph showing the transition probability distribution of the load variation rate for explaining the embodiment according to the present invention.

FIG. 7 is a graph showing the frequency-analysis result of the load variation for explaining the embodiment according to the present invention.

FIG. 8A is a graph showing response characteristics when a reference value of output is changed in the shape of a sine-wave at the same frequency as the limit of the response ability in order to explain the embodiment according to the present invention.

FIG. 8B is a graph showing response characteristics when a reference value of output is changed in the shape of a sine-wave at the frequency twice as large as the limit of the response ability in order to explain the embodiment according to the present invention.

FIG. 9A is a graph showing the amplitude ratio of a sinusoidal output value in response to a sinusoidal reference value for explaining the embodiment according to the present invention.

FIG. 9B is a graph showing the phase difference of the sinusoidal output value in response to the sinusoidal reference value for explaining the embodiment according to the present invention.

FIG. 10 is a graph showing the frequency analysis of the load variation assigned to a nickel-metal-hydride battery for explaining the embodiment according to the present invention.

FIG. 11A is a graph showing the power generation efficiency in a steady-state operation for explaining the embodiment according to the present invention.

FIG. 11B is a graph showing the power generation efficiency in a transient operation for explaining the embodiment according to the present invention.

FIG. 12A is a graph showing a maximum system frequency deviation when ramp operation is performed for explaining the embodiment according to the present invention.

FIG. 12B is a graph showing a maximum system frequency deviation when sinusoidal operation is performed for explaining the embodiment according to the present invention.

FIG. 13 is a system diagram showing a micro grid system when system frequency levels are evaluated for explaining the embodiment according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, an embodiment of a micro-grid system construction method according to the present invention will be described with reference to the accompanying drawings. In the present embodiment, a case where a certain facility is adopted as a

specific area, and a micro-grid system 1 is constructed in the facility will be described as an example.

Firstly, the micro-grid system 1 in the present embodiment will be described.

FIG. 1 is a schematic diagram showing a schematic configuration of a micro-grid system 1 in the present embodiment.

As shown in FIG. 1, the micro-grid system 1 in the present embodiment is a system that configures a network that controls distributed power supplies 20 including plural types of power supplies (i.e., a gas engine A(2), a gas engine B(3), a nickel-metal-hydride battery 4 and an electric double layer capacitor 5) in an integrated manner by means of a control means 6, and thereby supplies electric power to power loads 9 (electrical equipment, etc.) of the specific area. This micro-grid system 1 is connected to a commercial system 7 via an incoming point P. The incoming point P is provided with a switch 8. By operating this switch 8, the micro-grid system 1 can be freely connected to the commercial system 7, or can be freely disconnected from the commercial system 7. Accordingly, when the micro-grid system 1 is connected to the commercial system 7 by the switch 8, an operation (connected operation), that covers all the power loads 9 of the specific area (facility) by means of the purchased power from the commercial system 7 and the power generation by each of the distributed power supplies 20, is performed. On the other hand, when the micro-grid system 1 is disconnected from the commercial system 7, the operation that covers all the power loads 9 of the specific area simply by means of the power generation of each of the power supplies (2, 3, 4, and 5; stand-alone operation) is performed.

The steps of constructing the micro-grid system 1 having the aforementioned configuration will be described.

(Property investigation of load variation)

Since it is first necessary to determine the total capacity of the distributed power supplies 20 in constructing the micro-grid system 1, a step of measuring the load variation of the specific area is performed.

The process of measuring the load variation is described in detail hereinafter. Electric power measuring instruments (not shown) are installed at the power loads 9 in the scheduled construction sites of the micro-grid system 1. And electric power measuring instruments are also installed at the scheduled site of the incoming point P which is to be connected to the commercial system 7. Then, the daily load variation throughout a year is measured by the measuring instruments. Then, the total capacity of the distributed power supplies 20 is determined on the basis of the measured power values.

FIG. 2 is a daily load curve showing an example of the measurement result of a daily load variation. As shown in FIG. 2, when there is a maximum load power of about 600 kW as the example of a daily load variation, the total capacity of the distributed power supplies 20 is set to be 600 kW.

Furthermore, in order to realize a load follow-up operation during a connected operation and stable electric power supply during a stand-alone operation, it is necessary to perform variation compensation of a steep load variation by the distributed power supplies 20. In this case, it is necessary to clarify what degree of time frame does the "steep" means. Therefore, the step of determining the measurement cycle of a load variation is performed.

The process of determining the measurement cycle of a load variation is described in detail hereinafter. The measurement cycle of a load variation is determined by creating the transition probability distribution of the load variation amount, and the transition probability distribution of the load variation rate. This makes it possible to adopt a

measurement cycle that is required to properly perform load variation compensation. A transition probability distribution is obtained by plotting the transition of a measurement value or the change rate of the measurement value from a certain measurement time to the following measurement time. A transition probability distribution visually expresses recognizable range of variation depending on the measurement cycle.

FIG. 3 shows a method of creating a transition probability distribution of the load variation amount, and FIG. 4 shows a method of creating a transition probability distribution of the load variation rate.

As shown in FIG. 3, the transition probability distribution of the load variation amount is a graph in which the current measurement result (P(n)), while being measured at a predetermined cycle, is represented on the x-axis, and the next measurement result (P(n+1)) is represented on the y-axis. The load variation amount graph is created by plotting each measurement cycle using the current measurement result (P(n)) and the next measurement result (P(n+1)). Furthermore, as shown in FIG. 4, the transition probability distribution of the load variation rate is a graph in which the variation rate in the current measurement (dP(n)), while being measured at a predetermined cycle, is represented on the x-axis, and the variation rate in the next measurement (dP(n+1)) is represented on the y-axis. The transition probability distribution graph is created by plotting each measurement cycle using the current variation rate (dP(n)) and the next variation rate (dP(n+1)).

FIGS. 5A to 6B are graphs showing specific examples of the transition probability distribution of the load variation amount, and the transition probability distribution of load variation rate. Specifically, FIG. 5A shows the transition probability distribution of the load variation amount when measured at a cycle of 10 seconds, FIG. 5B shows the transition probability distribution of the load variation rate when measured at a cycle of 10

seconds, FIG. 6A is the transition probability distribution of the load variation amount when measured at a cycle of 1 second, and FIG. 6B is the transition probability distribution of the load variation rate when measured at a cycle of 1 second.

As shown in FIG. 5A and FIG. 5B, when measured at a cycle of 10 seconds, the feature of the transition probability distribution of the load variation amount or the load variation rate is vague, and cannot be clearly recognized. However, as shown in FIG. 6A and FIG. 6B, when measured at a cycle of 1 second, the feature of the transition probability distribution of the load variation amount or the load variation rate is expressed in a visible pattern, and is recognized clearly. Accordingly, in the micro-grid system 1 in this specific example, it can be understood that it is necessary to measure power load at a cycle of 1 second and compensate the variation thereof.

The process of frequency-analyzing the load variation measured as described above is performed hereafter. Specifically, the effective electric power data measured at a predetermined cycle is frequency-decomposed by Fourier transform. This causes the measured data to be decomposed into each frequency component.

FIG. 7 is a graph showing a specific example of the frequency-analysis result of a load variation. As shown in FIG. 7, since it can be confirmed that the load variation of various frequency bandwidths is included, it can be understood that it is necessary to select a power supply (2, 3, 4, or 5) suitable for compensation of each frequency bandwidth. In addition, in this example, since measurement is made at a cycle of 1 second, the frequency-analysis result is decomposed only into a variation component that is slower than 0.5 Hz (i.e., cycle of 2 seconds).

(Power supply performance evaluation)

It is necessary to know which type of power supply (2, 3, 4, or 5) has the

response performance that can follow-up the above-described frequency bandwidth. Thus, output response characteristics, from the moment each power supply (2, 3, 4, or 5) receives an output reference until the power supply actually reaches its output, are measured, and the frequency response characteristics are evaluated. In order to evaluate response performance, sine-wave response characteristics while the output reference changes from a maximum to a minimum, for each power supply (2, 3, 4, or 5) are measured.

FIGS. 8A and 8B show the response characteristics when an output reference value changes in the shape of a sine wave. Specifically, FIG. 8A shows a case where the frequency of the output reference value change is as large as the response limit, and FIG. 8B shows a case where the frequency of output reference value change is twice as large as the response limit.

As shown in each of FIGS. 8A and 8B, when the frequency of a sinusoidal reference value become large, it becomes impossible for the output (Pout) to follow the reference (Pref). As a result, the amplitude of the sine wave of the output (Pout) becomes smaller, and the phase difference between the sine wave of the reference (Pref) and the sine wave of the output (Pout) becomes larger. Accordingly, the frequency response characteristics of each power supply (2, 3, 4, or 5) can be evaluated for each power supply (2, 3, 4, or 5), using the amplitude ratio of the sinusoidal output value in response to a sinusoidal reference value while the frequency of a reference value is changed, and using the phase difference of the sinusoidal output value in response to a sinusoidal reference value while the frequency of a reference is changed.

In the present embodiment, as power supplies, a gas engine A(2) and another gas engine B(3), that can follow a slow variation, a nickel-metal-hydride battery 4 that can follow a quick variation, and an electric double layer capacitor 5 are selected. In this

case, the ratio of the amplitude of a sinusoidal output value to a sinusoidal reference value when the frequency of reference value is changed will be as shown in the graph of FIG. 9A. Furthermore, the phase difference of a sinusoidal output value to a sinusoidal reference value when the frequency of reference value is changed will be as shown in the graph of FIG. 9B.

As shown in FIGS. 9A and 9B, as for the gas engine A(2), the amplitude ratio (gain) is 0 (dB) until the frequency of reference value reaches about 0.01 Hz, but the amplitude ratio (gain) will fall if the frequency of reference value exceeds 0.01 Hz. This means that, if the frequency is within a range up to about 0.01 Hz, the gas engine A(2) can properly respond to a reference. Furthermore, it can be understood from the graphs of FIG. 9A and 9B that the gas engine B(3) can also respond to a frequency of reference value of about 0.03 Hz. Furthermore, it can be understood that the nickel-metal-hydride battery 4 can respond to a frequency of reference value of about 0.1 Hz, and the electric double layer capacitor 5 can respond to a frequency of reference value of at least 0.1 Hz or more.

Subsequently, the assigned frequency of each power supply (2, 3, 4, or 5) is determined on the basis of the frequency response characteristics of each power supply (2, 3, 4, or 5) evaluated as described above. Specifically, frequency lower than 0.01 Hz is assigned to the gas engine A(2), frequency of 0.01 to 0.03 Hz is assigned to the gas engine B(3), frequency of 0.03 to 0.10 Hz is assigned to the nickel-metal-hydride battery 4, and frequency higher than 0.1Hz is assigned to the electric double layer capacitor 5.

Furthermore, each power supply (2, 3, 4, or 5) needs to compensate for all the load variations of the frequency bandwidth assigned thereto. However, if the capacity of each power supply (2, 3, 4, or 5) was not enough, it becomes impossible to compensate for all the load variations of the assigned frequency. On the other hand, if

the capacity of each power supply (2, 3, 4, or 5) is excessively large, this will make the power supply excessive and uneconomical. Therefore, a capacity calculated from the frequency-analysis of a load variation is assigned to each power supply (2, 3, 4, or 5) on the basis of the aforementioned assigned frequency of each power supply (2, 3, 4, or 5), and the optimal capacity of each power supply (2, 3, 4, or 5) is calculated. Specifically, by integrating the intensity of the assigned frequency bandwidth of each power supply (2, 3, 4, or 5), the optimal capacity of the power supply is calculated.

FIG. 10 is a graph showing the frequency analysis of the load variation assigned to the nickel-metal-hydride battery 4 in the aforementioned example.

If the nickel-metal-hydride battery 4 is taken as an example, as shown in FIG. 10, the optimal capacity of the nickel-metal-hydride battery 4 can be calculated by integrating the intensity of the frequency bandwidth assigned to the nickel-metal-hydride battery 4.

For the load variation of a long-term cycle, an output determination with the economical efficiency taken into consideration, similarly to the use of a commercial system, is desirable. However, power supplies that can be operated with fixed output are considerably limited in the micro-grid system 1 with few power supplies. Then, as for the gas engine A(2) and gas engine B(3) that uses fuel, the fuel-consumption characteristics of the gas engine A(2) and gas engine B(3) are evaluated on the basis of the power generation efficiency in a steady-state operation and the power generation efficiency in a transient operation, and the operation of the gas engine A(2) and gas engine B(3) is determined on the basis of the result of the evaluation. The power generation efficiency in the steady-state operation is calculated from an electric power generation amount and a fuel consumption amount, with the output level of each power supply (2, 3, 4, or 5) fixed. On the other hand, the power generation efficiency in the

transient operation is calculated from an electric power generation amount and a fuel consumption amount when a sinusoidal output reference is given at the maximum amplitude for each frequency.

FIG. 11A is a graph showing the power generation efficiency in a steady-state operation, and FIG. 11B is a graph showing the power generation efficiency in a transient operation.

As shown in FIG. 11A, as the gas engine A(2) and gas engine B(3) in the steady-state operation have higher output, they can generate electric power at higher efficiency. On the other hand, it can be understood that the power generation efficiency of the gas engine A(2) and gas engine B(3) in the transient operation does not depend on the rate of change of the output. This shows that the power generation efficiency of the gas engine A(2) and gas engine B(3) depends only on the average output. Consequently, it is not a problem when output is frequently changed during operation. Therefore, the gas engine A(2) and gas engine B(3) is operated so that high output is maintained on the average.

Meanwhile, if at least one of the aforementioned power supplies is a rotor-machine-type power generator, the rotation speed of the power generator changes according to a load variation during a stand-alone operation. Therefore, a variation occurs in system frequency. By substituting the variation of this power generator with the variation of the purchased power at the incoming point during a connected operation, the quality level of the system frequency during the stand-alone operation is determined from the load follow-up operation control during the connected operation. This makes it possible to evaluate the quality of the system frequency when a shift to the stand-alone operation is made, while the connected operation is performed.

Specifically, the relationship between the rate of change in power generator

output and the system frequency deviation, when the output of the power generator is changed, from a minimum output to a maximum output, during a ramp operation is evaluated. Thereby, the magnitude of an output change of the power generator per unit time that is required to suppress the system frequency to a certain range of deviation becomes clear. Furthermore, the system frequency deviation to the sine-wave response when the output reference to the power generator is changed from a maximum to a minimum during a sinusoidal operation is evaluated. Thereby, load frequency response characteristics are obtained.

FIG. 12A is a graph showing a system frequency deviation when a ramp operation is performed by the gas engine A(2), and FIG. 12B is a graph showing a system frequency deviation when a sinusoidal operation is performed by the gas engine A(2).

As shown in FIG. 12A, if the system frequency deviation during a stand-alone operation is set, the range of the allowable variation rate of generator output that is required to fall within the deviation will be determined. For this reason, considering the control precision of an operation where the purchased power during a connected operation is fixed, the generator output can be used as a standard, during a stand-alone operation, for measuring the precision of the control of variation suppression. Furthermore, as shown in FIG. 12B, the frequency bandwidth that is required to make the system frequency deviation be less than a set value can be determined. Accordingly, when a stand-alone operation is actually performed, control is made so that the generator output can follow up a load variation in the aforementioned frequency bandwidth.

FIG. 13 is a schematic diagram showing a system when a system frequency level is evaluated.

In order to maintain the electric power quality of a system constant during a stand-alone operation, it is necessary to evaluate the system frequency deviation with

respect to a load variation in a rotor-machine-type power generator. However, among actual loads, there is a load that causes a failure, etc., if high-quality electric power is not provided, such as a computer. Therefore, it is difficult to actually make a test using an actual load. Thus, as shown in FIG. 13, a dummy load 10 is connected to the distributed power supplies 20, thereby constructing a simulated stand-alone system. Then, various load variations are simulated by controlling the dummy load 10, and response of the distributed power supplies 20 to the variations is confirmed.

According to the micro-grid system construction method including the aforementioned processes, since a step of measuring the load variation of a specific area and frequency-analyzing the data measured is performed, the load variation of the specific area that is constituted with load variations of various rates from a very slow load variation to an instantaneous load variation overlapping each other, is decomposed into frequency components and are recognized. Furthermore, a frequency assignment is determined to each power supply (2, 3, 4, and 5) on the basis of the frequency response characteristics. Since the assigned frequency is assigned to each power supply (2, 3, 4, and 5) on the basis of frequency-analysis result, the frequency bandwidth suitable for each power supply (2, 3, 4, and 5) can be assigned to each power supply (2, 3, 4, and 5). Moreover, since the capacity of each power supply (2, 3, 4, or 5) is calculated based on the aforementioned frequency-analysis result and assigned frequency, each power supply (2, 3, 4, or 5) will have a proper capacity. As such, since the micro-grid system 1 is constructed on the basis of the rate of a load variation and the response performance of each power supply (2, 3, 4, or 5), it is possible to properly understand a load variation as a compensation target and perform efficient compensation of load variation, and it is possible to prevent any capacity shortage or facility excess of the power supply (2, 3, 4, or 5). As such, since realization of an operation matching the performance of each power

supply (2, 3, 4, or 5) is being considered during the stage of selecting and constituting power supplies (2, 3, 4, or 5), the power generation and power load in the micro-grid system 1 can be balanced with each other. Thereby, the micro-grid system 1 can be made to perform a stand-alone operation or a load follow-up operation during a connected operation.

Furthermore, since the measurement cycle of a load variation is determined by creating the transition probability distribution of the load variation amount and the transition probability distribution of the load variation rate, the interval of a variation to be the target of variation compensation can be made clear.

Furthermore, as for the gas engine A(2) and gas engine B(3) that use fuel, their fuel-consumption characteristics are evaluated on the basis of the power generation efficiency in a steady-state operation and the power generation efficiency in a transient operation, and the operation of the gas engine A(2) and gas engine B(3) is determined on the basis of the result of the evaluation. Therefore, the gas engine A(2) and gas engine B(3) that uses fuel, can be run efficiently, the fuel consumption of the gas engine A(2) and gas engine B(3) can be decreased, and the operation of the micro-grid system 1 where economical efficiency is taken into consideration can be realized.

Furthermore, as for the distributed power supplies 20 including a rotor-machine-type power generator, evaluation of a system frequency deviation to a load variation is made, and the range of the output change rate of the power generator is determined on the basis of the result of the evaluation. Therefore, the system frequency deviation may be made to fall within a predetermined deviation during a stand-alone operation, and desired electric power quality can be ensured.

Moreover, since the dummy load 10 is connected to the distributed power supplies 20 including a power generator, thereby constructing a simulation system, and

evaluation of a system frequency deviation to a load variation is made using this simulation system, the level of the system frequency may be evaluated without damaging an actual load.

As described above, although the embodiment of the micro-grid system construction method according to the present invention has been described, the present invention is not limited to the aforementioned embodiment and can be properly changed without departing from the spirit or scope thereof. For example, in the aforementioned embodiment, the measurement cycle of a load variation is determined using the transition probability distribution of the load variation amount and the transition probability distribution of the load variation rate. However, in the present invention, the measurement cycle of a load variation may be determined using only the transition probability distribution of the load variation amount, or the measurement cycle of a load variation may be determined using only the transition probability distribution of the load variation rate. Moreover, the present invention may also be carried out by setting a measurement cycle, without using the transition probability distribution of the load variation amount, or the transition probability distribution of the load variation rate. For example, the measurement cycle may be set in advance, or the measurement cycle may be set by measuring load variations continuously.

Furthermore, in the aforementioned embodiment, as for the gas engine A(2) and gas engine B(3) that uses fuel, their fuel-consumption characteristics are evaluated on the basis of the power generation efficiency in a steady-state operation and the power generation efficiency in a transient operation, and the operation of the gas engine A(2) and gas engine B(3) is determined on the basis of the result of the evaluation. However, in the present invention, it is also possible to operate a power supply that uses a fuel, without evaluating the fuel-consumption characteristics by combining the power

generation efficiency in both steady-state operation and transient operation. For example, fuel-consumption characteristics may be evaluated in consideration of only the power generation efficiency in a steady-state operation, or fuel-consumption characteristics may be evaluated in consideration of only the power generation efficiency in a transient operation. And a power supply may be operated without considering fuel-consumption characteristics.

Furthermore, in the aforementioned embodiment, as for the distributed power supplies 20 including a rotor-machine-type power generator, evaluation of a system frequency deviation to a load variation is made, and the range of the output value of the power generator is determined on the basis of the result of the evaluation. However, in the present invention, the range of the output value of a power generator may be determined without conducting evaluation of a system frequency deviation to a load variation in the power generator. For example, the range of the output change rate may be set in advance, or the range of the output change rate of the power generator may yet not be determined.

Furthermore, in the aforementioned embodiment, the dummy load 10 is connected to a power generator, thereby constructing a simulation system, and evaluation of a system frequency deviation to a load variation is made using this simulation system. However, in the present invention, evaluation of a system frequency deviation to a load variation may be made without constructing a dummy load. For example, if the actual load is a load that does not fail when low-quality electric power is supplied thereto, evaluation of a system frequency deviation to a load variation may be made using an actual load and an actual system, without constructing a dummy load.

Furthermore, in the aforementioned embodiment, the case where a certain facility is adopted as a specific area, and the micro-grid system 1 is constructed within

the facility has been described. However, the present invention is not limited to a case where a micro-grid system is constructed within one facility. For example, a district where a plurality of houses, etc. are gathered may be adopted as a specific area, and a micro-grid system may be constructed within the area.

Furthermore, in the aforementioned embodiment, the gas engine A(2), the gas engine B(3), the nickel-metal-hydride battery 4, and the electric double layer capacitor 5 are selected as power supplies. However, the power supply according to the present invention is not limited to the aforementioned power supplies, and the type of power supply may be changed suitably. For example, fuel cells and gas turbines having fixed output in principle may also be selected, NAS batteries other than the nickel-metal-hydride battery or secondary batteries (electric power storage apparatuses), such as a lead acid battery, may also be selected, and electric power storage facilities, such as a superconducting electric power storage system, which can follow-up a very quick load variation, may also be selected. Furthermore, the number of power supplies according to the present invention is not limited to that in the aforementioned embodiment, and the number of power supplies may be suitably changed if it is two or more.

In addition, it is possible to suitably substitute the components in the aforementioned constructional elements with well-known constructional elements without departing from the major point of the present invention, and the aforementioned modified examples may be suitably combined with each other.

What is claimed is:

1. A micro-grid system construction method, wherein the micro-grid system supplies an electric power to a specific area, by configuring a network which integrally controls and operates a distributed power supplies including plural types of power supplies, comprising:

a step of measuring a load variation of the specific area and performing a frequency-analysis of a measured data of the load variation; and

a step of determining an assigned frequency which is assigned to each of the plural types of power supplies based on a frequency response characteristics of each of the plural types of power supplies, and calculating a capacity required for each of the plural types of power supplies, by assigning a frequency-analysis result of the load variation to each of the plural types of power supplies based on the assigned frequency.

2. The micro-grid system construction method according to claim 1, wherein

a measurement cycle of the load variation is determined by creating at least one of a first transition probability distribution of a load variation amount or a second transition probability distribution of a load variation rate.

3. The micro-grid system construction method according to claim 1 or 2, wherein

a fuel-consumption characteristics of a fuel-consumption-type power supply is evaluated on a basis of a first power generation efficiency in a steady-state operation and a second power generation efficiency in a transient operation, and an operation of the fuel-consumption-type power supply is determined on a basis of a result of an evaluation of the fuel-consumption characteristics.

4. The micro-grid system construction method according to claim 1, wherein

a system frequency deviation to a load variation, of a rotor-machine-type power supply is evaluated, and a range of an output change rate of the rotor-machine-type power supply is determined on a basis of a result of an evaluation of the system frequency deviation.

5. The micro-grid system construction method according to claim 4, wherein

a dummy load for evaluation is connected to the rotor-machine-type power supply, thereby constructing a simulation system, and the system frequency deviation to the load variation is evaluated using the simulation system.