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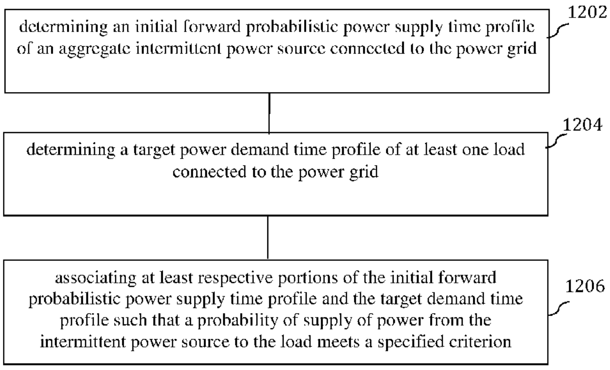


1200 **Fig. 12**

(57) Abstract: A method of supplying power in a power grid, a system supplying power in a power grid, a method of consolidating power injection and consumption in a power grid, a system for consolidating power injection and consumption in a power grid, a metering system for a power grid, and a metering method for a power grid. The method of supplying power in a power grid, the method comprises determining an initial forward probabilistic power supply time profile of an aggregate intermittent power source connected to the power grid,; determining a target power demand time profile of at least one load connected to the power grid; and associating at least respective portions of the initial forward probabilistic power supply time profile and the target demand time profile such that a probability of supply of power from the intermittent power source to the load meets a specified criterion.

WO 2016/064341 A1

AUDIT METHOD AND SYSTEM AND SUPPLY METHOD AND SYSTEM FOR PV POWER INJECTION AND CONSUMPTION IN A POWER GRID SYSTEM

FIELD OF INVENTION

The present invention relates broadly to a method of supplying power in a power grid, a system supplying power in a power grid, a method of consolidating power injection and consumption in a power grid, a system for consolidating power injection and consumption in a power grid, a metering system for a power grid, and a metering method for a power grid.

BACKGROUND

Renewable electricity is becoming a prominent candidate for the supply of electricity to consumers, and certain consumers have different requirements in their desire to obtain renewable electricity products. For example, photovoltaic electricity provides clean energy to consumers which offset carbon dioxide and other toxic emissions when used to replace conventional fossil fuel sources. Photovoltaic generators can be installed behind an energy meter to serve to a specific load, or can be installed to supply into an energy grid or energy pool through connection to the power grid network, or by consolidation methods for settlement of energy in an energy market, for example as described in Singapore patent application no. 10201406883U. This energy can also be supplied through a power network to the consumer. Moreover, an aggregate of various generators can be connected so to supply to a plurality of energy consumers' loads.

One problem in the supply of energy from photovoltaic sources is that the energy is intermittent. The generators cannot be determined to precisely contribute an amount of electricity at any given point in time. As such, supply systems which provide photovoltaic energy to end consumers have been relatively underdeveloped, especially through a grid connected scenario. Exacerbating this problem is that, in most commercial and industrial settings, an embedded generation scenario wherein the photovoltaic system is connected behind the meter of a load is typically inadequate to provide for the renewable energy needs of that load, and cannot be optimized so that the consumer of the renewable energy can establish specific constraints in terms of their required renewable supply constraints such as the total penetration desired to their loads. The constraints on the supply of renewable energy to those consumers in such embedded generation scenarios is only determined from the amount of physical space local to their own load demand (for example a building rooftop) in the "behind-the-meter" schemes.

Another problem in the supply of renewable energy to a load or a group of loads is that, when the renewable energy generators are contributing clean electricity to the end customer loads, those customers would like to determine the amount of renewable energy penetration that is associated with their energy consumption. This can facilitate the adoption of clean energy with energy consumers.

Embodiments of the present invention provide a method of supplying power in a power grid, a system supplying power in a power grid, a method of consolidating power injection and consumption in a power grid, a system for consolidating power injection and consumption in a power grid, a metering system for a power grid, and a metering method for a power grid that seek to address at least one of the above problems.

SUMMARY

In accordance with a first aspect of the present invention there is provided a method of supplying power in a power grid, the method comprising determining an initial forward probabilistic power supply time profile of an aggregate intermittent power source connected to the power grid; determining a target power demand time profile of at least one load connected to the power grid; and associating at least respective portions of the initial forward probabilistic power supply time profile and the target demand time profile such that a probability of supply of power from the intermittent power source to the load meets a specified criterion.

In accordance with a second aspect of the present invention there is provided a system supplying power in a power grid, the system comprising means for determining an initial forward probabilistic power supply time profile of an aggregate intermittent power source connected to the power grid; means for determining a target power demand time profile of at least one load connected to the power grid; and means for associating at least respective portions of the initial forward probabilistic power supply time profile and the target demand time profile such that a probability of supply of power from the intermittent power source to the load meets a specified criterion.

In accordance with a third aspect of the present invention there is provided a method of consolidating power injection and consumption in a power grid, the method comprising determining an actual power supply of an aggregate intermittent power source connected to the power grid at a time; determining an actual power consumption of a load connected to the power grid at the time; associating at least respective portions of the actual power supply and the actual power consumption; and determining an actual intermittent power supply contribution for the load based on the associated respective portions of the actual power supply and the actual power consumption.

In accordance with a fourth aspect of the present invention there is provided a system for consolidating power injection and consumption in a power grid, the system comprising means for determining an actual power supply of an aggregate intermittent power source connected to the power grid at a time; means for determining an actual power consumption of a load connected to the power grid at the time; means for associating at least respective portions of the actual power supply and the actual power consumption; and means for determining an actual intermittent power supply contribution for the load based on the associated respective portions of the actual power supply and the actual power consumption.

In accordance with a fifth aspect of the present invention there is provided a metering system for a power grid comprising means for metering power supply of an aggregate intermittent power source connected to the power grid; means for metering power consumption of a load connected to the power grid at the time; and means for metering an intermittent power supply contribution for the load based on the metered power supply and the metered power consumption.

In accordance with a sixth aspect of the present invention there is provided a metering method for a power grid comprising metering power supply of an aggregate intermittent power source connected to the power grid; metering power consumption of a load connected to the power grid at the time; and metering an intermittent power supply contribution for the load based on the metered power supply and the metered power consumption.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

Figure 1 shows a schematic drawing illustrating a set of intermittent generators of associated statistical generation capacity supplying to a set of loads of associated consumption capacity wherein said loads are classified by their supply constraints, according to an example embodiment.

Figures 2 a) and b) show schematic drawings illustrating the evaluation of a statistically intermittent supply profile, according to an example embodiment.

Figures 3 a) – c) shows an image demonstrating a measured statistical variation of the annual output of three individual generating facilities connected to the same AC electrical power grid network, wherein the total electrical output is represented by a colour scale, and time is represented with the day plotted horizontally and the time of day plotted vertically, according to an example embodiment.

Figures 4 a) – d) shows a schematic drawings illustrating characteristics of an established consumer load profile, according to an example embodiment.

Figure 5 shows a schematic drawing illustrating the supply of energy through a market pool P from the intermittent generating facilities G to the consumer loads L, according to an example embodiment.

Figure 6 shows a schematic drawing illustrating the characteristics of a wholesale energy pool on a particular day at a particular time, wherein the wholesale energy pool characteristics determine available resources and constraints of a secondary generation resources, according to an example embodiment.

Figures 7 a) and b) show schematic drawings showing the process of implementation of an offset for a case of a flat percentage of energy and associated secondary generation supply to a load, according to an example embodiment.

Figures 8 a) – d) show a schematic drawings illustrating the peak energy offset supply scenario wherein the base load energy derived from wholesale energy pool is passed to the consumer and the supply load is decoupled from the wholesale market volatility from correlation to the periods of peak energy demand by supply of photovoltaic energy under an optimized renewable penetration scenario; where a) is assumed load profile, b) is probability density distribution of aggregated generation resources, c) is the modified load profile, and d) is a characteristic wholesale pool profile showing correlation of demand to the intermittent energy resource, according to an example embodiment.

Figure 9 shows a schematic drawing illustrating the relationship between the supply and audit process wherein the supply projects forward to time t, and the audit looks back to time t, according to an example embodiment.

Figure 10 shows a schematic drawing showing the process flow chart for associated supply and audit methodology, according to an example embodiment.

Figure 11 is an architectural illustration of a representative construction of the information technology system, according to an example embodiment.

Figure 12 shows a flowchart illustrating a method of supplying power in a power grid according to an example embodiment.

Figure 13 shows a schemtic drawing illustrating a system for supplying power in a power grid.

Figure 14 shows a flowchart illustrating a method of consolidating power injection and consumption in a power grid according to an example embodiment.

Figure 15 shows a schemtaic diagram illustratig a system for consolidating power injection and consumption in a power grid.

Figure 16 shows a schematic diagram illustrating a metering system for a power grid.
Figure 17 shows a flowchart illustrating a metering method for a power grid caccording to an example embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Embodiments of the present invention provide a system and method for establishing both the energy supply service to provide various options for energy consumers who seek to obtain renewable energy or photovoltaic energy as a part of their energy blend, wherein the various levels of minimum renewable penetrations and other limits can be determined for an energy consumer prior to establishing the measurement of the supply; while in addition, an associated audit methodology solves for presenting on a look back basis those energy consumers with the historical renewable penetration levels of supply so as to confirm those consumers do receive said terms of renewable energy supply.

In a forward looking scenario, a supply method in an example embodiment accounts for the stochastic nature of a set of intermittent energy generators. In a look back scenario, an audit method according to an example embodiment accounts for the actual historical renewable energy penetration levels. In such a scenario, both the supply and audit methods can then be used to establish energy products and associated constraints demanded by consumers in both a forward-looking and backward-looking basis, while establishing an empirical method of measurement to verify these product constraints are being met by the energy utility operating the plurality of intermittent generation facilities.

Example embodiments can meet the consumers need for a method of reviewing the levels of supply and the associated renewable energy levels under an audit that confirms they receive supply under the constraints that they have determined in their supply contracts, and can meet the supplier need a forward-looking supply method that can allocate the aggregated intermittent resources to those consumer loads in a probabilistic manner so that they can provide guaranties and warranties to those consumers that they will be able to meet those constraints required. For this purpose a Probability Distribution Function (PDF) representing the generation resources as well as the loads to be supply can advantageously be determined.

In the following description, generating facilities are assumed to be renewable generators that can provide energy to energy consumers through a power grid. The supply scenario can be assumed to implement an energy pool where energy is put in and taken out to provide for customers. The flow of energy will be indicated by the metering apparatus used to establish individual loads and generators demand and supply, respectivtly. The consumer loads are assumed to have various constraints or requests in terms of the amounts of intermittent energy that they require to be blended into their loads demand. For example, a consumer may require 100% energy from the intermittent generator, while others only request a particular renewable penetration ratio. It is assumed in the following that the information associated wth the loads is made available by the consumers to the electricity supplier when they are requesting their supply contract, and establishing its associated constraints. The electricity supply operates an aggregates supply system conprising a variety of generating facilities that together form the basis of their generation. The supplier may also obtain additional eergy to meet the consumers load demands from a secondary source, such as a energy market pool or a back up generator.

The present specification also discloses apparatus for (herein also referred to as "means for" performing the operations of the methods. Such apparatus may be specially constructed for the required purposes, or may comprise a computign device selectively activated or reconfigured by a computer program stored in the computer. The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general purpose machines may be used with programs in accordance With the teachings herein. Alternatively, the construction of more specialized apparatus to perform the required method steps may be appropriate. In addition, the present specification also implicitly discloses a computer program, in that it would be apparent to the person skilled in the art that the individual steps of the method described herein may be put into effect by computer code. The computer program is not intended to be limited to any particular programming language and implementation thereof. It will be appreciated that a variety of programming languages and coding thereof may be used to implement the teachings of the disclosure contained herein. Moreover, the computer program is not intended to be limited to any particular control flow. There are many other variants of the computer program, which can use different control flows without departing from the spirit or scope of the invention.

Furthermore, one or more of the steps of the computer program may be performed in parallel rather than sequentially. Such a computer program may be stored on any computer readable medium. The computer readable medium may include storage devices such as magnetic or optical disks, memory chips, or other storage devices suitable for interfacing with a general purpose computer. The computer readable medium may also include a hard-wired medium such as exemplified in the Internet system, or Wireless medium such as exemplified in the GSM mobile telephone system. The computer program When loaded and executed on such a general-purpose computer effectively results in an apparatus that implements the steps of the preferred method.

The invention may also be implemented as hardware modules. More particular, in the hardware sense, a module is a functional hardware unit designed for use with other components or modules. For example, a module may be implemented using discrete electronic components, such as for metereing power supplied by a generating facility or for metereing power consumed by a load, or it can form a portion of an entire electronic circuit such as an Application Specific Integrated Circuit (ASIC). Numerous other possibilities exist. Those skilled in the art will appreciate that the system can also be implemented as a combination of hardware and software modules.

Overview description of the figures and illustrations as embodiments of the invention

In this section, an overview of each element of the example embodiments of the present invention as represented in the illustrations and drawings is described, where each element is further elaborated on in the proceeding sections.

Figure 1 shows an illustrated embodiment of information flows and the relationships between the generating facilities 100, or the generating facilities probability density function output profiles; the consumer load profiles 106 and 108, and the consolidation and reconciliation system 118.

Numeral 100 represents the aggregated generating facilities or the associated Probability Distribution Function (PDF) of this generating profile over time which accounts for the aggregated probability of output from individual generating facilities, e.g. 102.

Numeral 102 represents an individual generating facility or the associated individual generating facilities PDF and is accounting for performance factors of the specific generating facility installation including but not limited to shading losses, thermal losses, or electrical specifications of a generating facility 102.

Numeral 104 is a consumer load profile which is classified to have priority access to the generating facilities or associated PDF profiles 100, and numeral 108 is a set of consumer load profiles that are classified to have priority access to solar generation facilities or associated PDF profiles 100 and/or 102, or classified to have priority to a subset of generating facilities, for example subset 120 of generating facilities 100.

Numeral 116 is a consumer load profile which is classified to have no priority access to the generating facilities or associated PDF profiles 100, and numeral 106 is a set of consumer load profiles that are classified to have no priority access to solar generation facilities or associated PDF profiles 100 and/or 102, or classified to have no priority to any subset of generating facilities, for example subset 120 of generating facilities 100. As described, numerals 106, 108, 116, or 104 may each be associated with a PDF characterising the load demand profile and probabilistic demand scenario of the electricity consumer.

Numeral 112 is a sub-classification of consumer load profiles 108 which have priority to solar and at least a second specific constraint requirement representing the amount of exposure and delivery required for association from generating facilities 100 or a subset of generating facilities 120. For example, numeral 112 classification could be all those consumer loads which require a particular level of penetration as measured by the ratio of supply from intermittent generating facilities 100 or 120 to the load consumption of the set of loads of classification 112.

Numeral 114 is a sub-classification of consumer load profiles 108 which have no priority to solar and at least a second specific constraint requirement representing the amount of exposure and delivery required for association from generating facilities 100 or a subset of generating facilities 120. For example, numeral 114 classification could be all those consumer loads which have an optional level of penetration as measured by the ratio of supply from intermittent generating facilities 100 or 120 to the load consumption of the set of loads of classification 112.

Numeral 110 is a secondary supply resource, which may be embodied by, for example, a wholesale or spot energy market, an energy futures market, or physical delivery of electrical power from a secondary generating facility, or could be embodied by energy drawn from an energy storage medium.

Numeral 118 is a consolidation computation module which computes both forward looking supply models and associated probabilities of the expectation values of meeting constraints associated with consumer load classifications 106, 114, 108, or 112; and backward-looking audits and reconciliation methods verifying the associated expectation values of meeting said constraints associated with consumer load classifications 106, 114, 108, or 112 are established through historical measurements, wherein a back-ward looking audit as described within may involve, for example, shifting energy resources 100 or 120 from no-priority consumption loads 106, 116, or 114 to priority consumption loads 108, 112, or 104.

Numeral 119 represents the information provided for publication which may be a presentation of delivery, historical measurements of the consumer load demands of 106, 116, 114, 108, 112, or 104; historical measurements of the generation facilities 100, 102, or 120; or may be ratios and verifications of various constraints as computed at the consolidation module 118. Example embodiments of such a audit publication system may take the form of an Application Programme Interface (API), a mechanism allowing presentation of information to social media, allowance for distribution of information to the internet, or for adaption into a consumer billing system.

Figures 2a)-b) illustrate intermittency of associated generating facilities 100, wherein numerals 201, 202, and 203 are individual probability density functions of the electricity output from an individual intermittent supply source, for example, numeral 102 (Figure 1). In 201, 202, and 203, the vertical axis represents the energy output, while the horizontal axis represents time of day.

Numeral 222 is a embodiment of an aggregate Probability Distribution Function (PDF) characterised by particular output metrics 206, 204, 205, 207, 208, and 209 in an example embodiment. In plot 222, the horizontal axis is time whereas the vertical axis is the expected output in terms of electrical output or energy units associated with a particular probability model associated with metrics 206, 204, or 205.

Here, numeral 207 is a line profile of a continuous PDF representing the maximum output of aggregated generating facilities taken together, wherein numeral 206 is the maximum energy output that would occur in the event of maximum output from a system. Numeral 208 is a line profile of a continuous PDF representing the average output of aggregated generating facilities taken together, wherein numeral 204 is the average energy output that would occur in the event of average output from the aggregated system of generating facilities. Numeral 209 is a line profile of a continuous PDF representing a lower level of output of aggregated generating facilities taken together, wherein numeral 205 is the lower level energy output that would occur in the event of maximum output from a system.

Any of the PDFs 207, 208, or 209 may be represented as discrete probability density models, for example, as an array in a database and can take the form as a forward-looking probability of generation from a generation facility 100, or a subset of generating facilities 120.

Figures 3 a)-c) illustrate the measured annual output 301, 302, and 303 of three separated energy generating facilities connected to the same AC electrical power grid network, wherein the generation profile may be developed through numerical synthesis of the measured electrical output. The statistical nature or the said generating facilities is apparent by the fluctuations in the plots 301, 302, and 303. In plots 301, 302, and 303 the horizontal axis represents the day of the year, the vertical axis represents the time of the day, and the colour scale in greyscale represents the total energy output in units as reflected in the scale bars at the right of each image.

Figures 4a)–d) illustrate characteristics reflecting the probabilistic nature of consumer supply demand such as 106, 114, 116, 104, 108, or 112 (compare Figure 1), according to example embodiments. Numeral 400 is a probability density of the demand of an aggregated class of consumer loads, while numeral 401 is a continuous line profile representing the level of energy demand of the aggregated class of consumer loads. The continuous line profile may also be presented as a discrete probability model such as a vector array computed in a database.

Numeral 402 is an illustration of a daily load demand profile, herein as a discrete measured set of events, wherein the horizontal axis is the time of day and the vertical axis is the consumer load demand level.

Numeral 406 illustrates the measured annual input of an individual consumer load connected to the same AC electrical power grid network to which generating facilities are interconnected, wherein the demand profile may be developed through numerical synthesis of the measured electrical output. In plot 406 the horizontal axis represents the day of the year, the vertical axis represents the time of the day, and the colour scale in greyscale represents the total energy output in units as reflected in the scale bars at the right of each image.

Numeral 404 illustrates an additional manner in which statistical profiles of the consumer load profile may be assessed quantitatively, wherein a variance as a max, daily high, daily mean, min and daily low are measured and plotted. The horizontal axis of the chart is time while the vertical axis of the chart is the load demand.

Such a profile 402, 404, or 406 may be used to create a synthetic probability model of consumption if required. The statistical nature or the said consumer load demands is apparent by the fluctuations in the plots 402, 406, and/or 404. Implementing aggregation of various consumer loads to form a PDF of all consumer loads associated with a particular classification may be completed by quantitative evaluation of consumer demands and the associated statistics of them as illustrated within Figure 3.

Figure 5 is an illustration of a model of supply and delivery to a consumer in example embodiments by implementing a intermittent source G along with a secondary source P to fulfil the energy demands of a load L; wherein G may represent a aggregated generating facility 100, a subset of an aggregated generating facility 120, or a individual generating facility 102; and wherein a load L may represent a aggregation of consumer load demand or an aggregation of consumer load demand of a particular classification. P may be assumed to be a wholesale energy market established by the energy flows on a single AC electrical power grid network.

As discussed within, any classification or sub-classification within loads L may be associated with one or more constraints of which must be established both through forward-looking supply expectations as well as backward-looking audit and reconciliation systems to establish all constraints are met as measured.

In an example embodiment, loads L may be supplied through label B via a secondary supply resource P being a wholesale energy pool such that only the load requirements of supply are met but no constraints are established, wherein any constraint as established from generating facility G may be verified by supply to the secondary market P, and associated establishments of the audit and reconciliation through label C determined directly to the loads. As embodied herein, the physically measured flows of energy as represented and recorded as vectors within a database may be indexed in time, and thus matched through to loads L such that all associated constraints of L may be thus audited from generators G.

In this embodiment, L and P may be established to match, while supply through label C may be an offsetting of the load L equivalent to the input via label A. As such, though label A and label B represent to separate levels of supply through to L, the association of physical supply at G and secondary supply at P establish together the requirements in time of L represented only by the demand levels, wherein any constraint must be established through label C between G and L by time indexing generation and loads as a forward-looking probability density, or as a measurement of delivery in a backward-looking audit with reconciliation.

Figures 6 a)-b) illustrates a wholesale energy market by demand level and price, wherein discrete time intervals are apparent. The horizontal axis is time, and the vertical axis displays both demand and price. A forward looking demand is displayed as reflected by the region 699 of the white rectangle as the backdrop of the chart, while a past delivery is displayed as reflected by the region 688 of the grey rectagle as the backdrop of the chart. Here, three separate pricing reference levels are shown, including a Uniform Electricity Price (USEP) associated with this particular electricity pool market, a Liquefied Natural Gas (LNG) vesting price, and a oil linked contract price BVP. Arrows indicate the USEP, BVP, and LVP lines drawn into the time plot of the wholesale market respectively. Numeral 611 indicates a particular USEP time series as the grey line, numeral 622 indicates the BVP price as a dark line, and numeral 633 is the LVP price as a light grey line. The demand profile can be reflected as the rise and fall of the vertical bar chart component 608. Both charts exhibit a daily increase in demand correlated with periods of the middle of the day. This profile which occurs time to time is implemented as a secondary resource as described in example embodiments of this document.

Figures 7 a)-b) illustrate a method of offsetting energy as presented in patent number 10201406883U add intermittent supply patent idea] where a correlation from a generating facility is used to reshape a load

Curve 708 schematically shows the PV power generation profile from the PV power generator during the specified period. As will be appreciated by the person skilled in the art, the power generation peaks e.g. 710 coincide with the day time, while essentially no power is generated during the night time e.g. 712. That is, the generation profile 708 and the consumption profile 702 of the chosen source/load pair (or pairs) are preferably matched. Such a matching criterion may be associated with a quantitative correlation coefficient between the secondary supply as in a wholesale energy market and the consumer load demand.

Curve 714 schematically shows the portion of the power consumption that will be met by supply from a mains grid portion through a secondary supply source, for example, from wholesale markets or another energy generator. As can be seen from a comparison of curves 702 and 714, the amount of power that needs to be met during the peak periods e.g. 704 is reduced accordingly.

If the consumer can anticipate a lower peak demand due to the supplemental power supply from the PV power generator, then the risk profile considered by the retailer will be “reduced”, corresponding to the flattened supply profile represented by curve 714. Thus, the supply model to such a consumer load has a reduce exposure to the secondary source and as correlated to the demand period of lower availability of resources on the power grid network. This benefit is extended to a load or loads of specific characteristics being supplied to via the power grid. In Figure 7b), curves 716 and 718 schematically show the required supply needed from other sources/the contestable retailer without and with the PV power generator capacity offset respectively.

Figures 8 a)-d) illustrate four representative time profiles according to example embodiments which show a hypothetical load L at numeral 800, a hypothetical generation profile G at numeral 802, a hypothetical secondary energy market as a pool P at numeral 806, and a derived load shape function accounting for supply from both G and P. In the plots, the horizontal axis is time and the vertical axis is energy capacity. Energy capacity may either be generation capacity for G at 802, demand capacity for L at 800, demand capacity for R at 804, or relative market supply/demand availability for P at 806.

Numerals 821, 822, and 823 reflect three assumed probability generation profiles similarly reflected in Figure 2 by numerals 207, 208, and 209. Such generation profiles may be assumed to be derived from generating facilities 100, or a subset of generating facilities 120. A forward looking supply profile at 802 can account for the various probability assumptions such as a maximum output 821, a lower level of output 823, or a more likely average output profile 822.

Forward looking probability profiles at G 802 are assumed to supply to load profile 800 meeting any specified constraints if required, wherein a secondary load exposure R at 804 may be formed. This secondary load exposure 804 is formed considering various profiles of generation 821, 822, or 823 to result in various secondary load exposures of 841, 842 or 843 respectively. Various kinds of probabilities can be assumed when generating a load profile. As such, the resultant exposure of the secondary load R at 804 to the secondary generation source P at 806 can be formed.

Utilising 802, 804, or 806, various kinds of correlations may also be determined between profiles 800, 802, and 806 by derivation of 804 through adjustment of 802. An adjustment at 802 can be performed through allocation of resources from generating facilities 100 into priority resources as a subset of generating facilities 120. Physical resources from 100 that are allocated into a subset 120 can be optimised based on a quantitative correlation to the wholesale pool P at numeral 806 where a wholesale market is available for transacting for secondary energy supplies.

By utilising a wholesale pool, and a system as shown in Figure 5 for implementing supply from a intermittent generating facility and a wholesale pool, the problem of allocation of a plurality of intermittent resources to a particular load profile 800 can be solved. Moreover, using the above mechanisms that create time profiles as Probability Density Functions (PDFs), forward looking probability models, quantitative correlations between a load demand, a generating profile of intermittent resources, and a wholesale pool or other secondary supply resource (such as a second generator set) can be formed.

Figure 8 forms the basis of which PDFs can be utilised reflecting various resources and consumer load demands as time profiles, wherein quantitative derivations such as time correlations, or specific consumer constraints reflecting requirements of particular amounts of generation G to load L to complete a resized secondary load demand R can be implemented. These same PDFs are studied on a look-back audit as described further in Figure 9.

Figure 9 illustrates the temporal relationship of the supply 900, audit 902, and reconciliation 904 procedures with respect to a delivery of power to match a set of consumer load constraints at time 988, according to example embodiments. Prior to time of delivery 988, a forward-looking Probability Density Function (PDF) profile is established as a discrete vector in a database array (or alternatively as continuous algebraic PDF) of both the loads and the generation from generating facilities, and an expectation value of establishing at least a consumer load constraint is evaluated and the level of resources 120 from generating facilities 100 is allocated such that a high enough probability of expectation is found. The level of expectation can be set by requirements of a local administrator, governor, or internal risk management policies, or by the terms or conditions requested from the consumers.

Post-delivery, a backward-looking audit utilising actual measured results of the given loads and generators in a vector array of a database or evaluated, wherein said constraint or constraints are tested. Wherein a shortfall of any constrain occurs, reconciliation is performed, and resources allocated to low priority consumers receive less energy from generating facilities until all of such shortfall is made up for. In the event of a shortfall, said resources 120 are thus re-established such that an expectation value may be made to be high enough.

Reconciliation may account for various circumstances, and an operation can adjust the resources 120 established to meet priority constraints considering the various ranges of supply from generating facilities that can be made available as presented in Figure 2. For example, where a minimum level of delivery is assumed during resource allocation to said constraints as per probability model 209, it is less likely that the outcome of the expectation of meeting such constraints would be false. Alternatively, a operator of the solar utility who wishes to be less conservative may assume a probability model 208 or 207 which have varying degrees of which the required constrain may not be satisfied. The probability model assumes will impact in the frequency of the requirements of providing a reconciliation exercise in practise.

Figure 10 illustrates a process flow 1000 of the procedure herein described of forming a supply scenario to match consumer load constraints from a plurality of intermittent generating facilities and a secondary supply facility such as a wholesale market, electricity futures market, or a secondary generator. In this process, a broad classification of priority consumers and no-priority consumers is stated at 1006, while the balance of matching supply constraints on a forward-looking basis is buffered by some allowance for a certain amount of reconciliation. During reconciliation, resources allocated to no-priority loads are utilised to make up for shortfalls in the event that a look-back audit establishes that an event involving a shortfall of a consumer constraint has occurred.

The process involves establishing the consumer load constraints/requirements at 1002 wherein consumer constraints form a classification set or classification sets, and the consumer load PDFs are then derived and associated within various sets which are embodied by the particular constrain or constraints requested. At 1004, the availability of resources is evaluated, including a plurality of intermittent generating facilities and a secondary supply facility. At 1006 consumer loads may then be divided into the priority and no-priority consumption loads. Process element 1006 may occur before or after or in parallel to process element 1004. Process element 1004 involves deriving the PDF of generating facilities, and computing a expectation value of an outcome of various constraints as formed from process step 1002 by utilising assumed probability models. Herein, a resource allocation can be formed which allows certain consumer constraints evaluated at process step 1012 to be provided by dedicated priority resources.

At process element 1008, consumer load constraints as established at 1002 may be adjusted, for example, by offering a different product package of a particular constrain to consumers, such that an expectation value of an outcome representing a particular constraint is higher or lower depending on the choice of the utility. At process element 1010, additional generating facilities may be optionally built according to the results of process 1004, 1012, and reconciliation stage 1016

At process stage 1012, expectation values of the probability of supplying to all constraints of loads are evaluated by computing the expectation value in a forward-looking basis accounting for provision of one or more constraints as associated with the PDF of the load demand profile assumed and the PDF of generating facilities allocated to meet those constraints.

At process element 1014, based on the resultant supply that is detected to be measured and delivered at the time of settlement of energy flows (for example, as associated continuously or in particular time intervals of trade), remaining amounts of energy of the generating facilities is then allocated to no-priority loads assuming a particular quantitative model. For example, the energy may be divided by the number of loads and provided then to each load as a same amount, or may be computed as a percentage of supply to the consumers' total capacity of consumption and provided to the loads on an equal percentage basis.

At process element 1014, reconciliation of any shortfalls is applied, wherein based on a measurement, in the event of a shortfall or violation of a constraint to a consumer load, energy derived from resources that was unallocated to priority consumers is provided to make up shortfalls until no shortfalls occur. If there is not enough energy measured to make up for shortfalls, the information flows back to process element 1004 where resources allocated to meet constraints may be adjusted, or additional resources may be built. In process element 1014, if no violation occurs, no reconciliation is applied.

In process element 1016, publication of results of measurements, expectation values, results of audits, or results of reconciliation is enabled either by active publication of the utility or service provider operating the generating facilities and/or supplying the loads, or by allowing the consumers to access the information and publish the results. Publication may go to the world wide web, through the internet, and can be done so that information can be automatically presented based on a schedule or based on establishing specific communication channels and account platforms on websites; for example, on social media, or through post of results to a particular location on a website.

In process element 1020, information flows from each of the process steps can be associated with the balance of establishing new generating facilities, providing and guaranteeing consumer load constraints, or balancing the amount of priority and no-priority account such that the frequency of reconciliation requirements are adjusted.

Figure 11 illustrates an example embodiment of architecture of information technology systems used to implement said supply, audit, and reconciliation models. Numeral 1188 is an individual generating facility with associated electrical systems 1186 embodied here by a control interface, and associated revenue grade power meters and communication networking apparatus (not shown). The control unit 1186 is connected through Ethernet to a Router 1171. The Wide Area Network (WAN) port of the Router 1171 will be connected to a local Internet provider (not shown) which will give the router access to the Internet 1101. The router 1171 connects to the server 1111 using a built-in encrypted Virtual Private Network (VPN) connection 1172 and 1102. All communication packets between the Router 1171 and the server 1111 will be encrypted while travelling through the Internet 1101.

Numeral 1111 comprise various units including a database 1104, which for example could be a MySQL database; a web server 1115 to display a user interface for data with respect to the generating facilities 1187; a customer energy usage application 1114 to oversee customer transactions and customer energy usage; a billing application 1113 to generate and send billing information; and an energy output application 1112 to send reports on the energy generated by operational generating facilities.

Numeral 1161 illustrates a solar generating facility installation technician connect to the web server 1115 of the operating platform over the Internet using a web browser on an encrypted Secure Sockets Layer (SSL) connection.

Numeral 1162 illustrates a Power Operator or Power Grid Administrator connect to the web server 1115 over the Internet 1101 using a web browser on an encrypted Secure Sockets Layer (SSL) connection.

Numeral 1163 illustrates an energy customer connect to the web server 1115 over the Internet 1101 using a web browser on an encrypted Secure Sockets Layer (SSL) connection.

Numeral 1143 illustrated a system associated with the energy market transactions which handles customer transactions connected to our server over the Internet 1101 using an encrypted connection such as Secure Sockets Layer (SSL).

Numeral 1144 illustrate a system associated with the energy market which handles energy generation monitoring connected to the server 1115 over the internet 1101 using an encrypted connection such as Secure Sockets Layer (SSL).

Statistical methods for modeling projected generation capacity and probability of distribution of generation capacity to load capacity

The implementation of the supply scenario for distribution of generated photovoltaic's in an example embodiment involves a system implementing both a statistical approach to project forward the total resources available for supply to a particular load, and an external variable resource that can be implemented to project forward the total resources available for supply to a particular load. A consolidation module 101 (see Figure 1) can assist in allocating aggregated resources from a plurality of generating facilities to the associated supply loads of consumers, and establish the associated probability of meeting the characteristics of the supply loads that are provided to the consumers. A measurement system can compare the actual generation on a real time basis and compute the actual supply of energy from the associated generating facilities so as to audit the blend of the energy provided to a particular load including from aggregated renewable energy facilities. A remaining amount of energy can then be distributed and represented under audit on the consumer loads with no priority to renewable energy. Finally, for incidences in which a shortfall in energy has occurred, and reconciliation is required, a reconciliation process can be implemented to make up the shortfall to the priority accounts and potentially to modify the constraints on the supply terms to the loads on a forward looking basis.

Figure 1 shows a set 100 of generating facilities e.g. 102, each of various capacities, locations, electrical connection systems, and other information which could generally comprise all of the technical specifications of the installed energy system, and each having its own statistical output defined from its own specification as well as the variable external information that can be measured or that can be projected on a forward basis. The external data can be obtained as well and regression can be performed to establish all historical statistical variables of such external information on a look back basis. This includes the generation time profile divided into time bins, the mean, mode, median, and other relevant statistical variables.

Figure 1 also shows a plurality of consumer loads e.g. 104 divided into differing classifications e.g. 106, 108. The various classifications 106, 108 can be associated with characteristics of sets of consumer requirements as specified in their supply agreements, and may be of the form of guaranteed minimum renewable energy requirements of the consumers. The consumers equally may be associated into their own demand profiles showing the total consumption capacity of their loads to be supplied to. Supply arrangements for the consumers comprise energy from the intermittent generating facilities 100, and energy from a secondary source 110. For example, the secondary source 110 may comprise a wholesale energy pool or one or more combustion generators running on fuel.

As a matter of setting the analysis so that the relevant constraints on the supply terms to the loads e.g. 104 can be validated, the first step in the process can be to form the probabilistic distribution representing generation capacity over time, the probabilistic distribution representing energy demand over time, and a division of the distribution of probabilistic demand into the relevant classifications of which will each individually can be validated against a specific set probability.

Division of supply loads into priority access and penetration levels

Figure 1 shows the division of supply of the consumer loads e.g. 104 into two particular example classifications 106, 108, among other classifications e.g. 112, 114 represented internally to the initial division classification 106, 108. The upper level classification 106, 108 is used to form a division of the generating facilities 100 energy across the energy consumers' loads demands. The classification 108 in this embodiment is of those consumers' loads e.g. 104 who have priority to the energy derived from the generating facilities 100, against those consumers' loads e.g. 116 in the classification 106 that have no priority to the energy derived from the generating facilities 100. Priority here means, for example, that the consumers require a minimum amount of energy blended into their supply and as such, a portion of the energy from the generation facilities 100 is to be set aside to satisfy the particular constraint of that load demand. For any individual classification e.g. 114 within priority, the validation considers that the total demands of that set 114 must be performed considering all loads e.g. 104 under priority classification 108 against all generating facilities 100 considering all generating facilities that are online at the time of supply evaluation.

Assuming these generating facilities 100 are providing clean renewable electricity, for example as obtained from an intermittent photovoltaic generator, this priority classification 108 refers to the consumers who require a minimum amount of renewable electricity as may be specified in terms of different parameters (for example, as the renewable penetration ratio, the percentage minimum solar energy available, etc. as will be described in more detail below) and the no-priority classification 106 of consumers who do not require a minimum amount of renewable electricity. Classification parameters can include the renewable penetration ratio, the fraction of clean energy blended to a load, the amount of clean energy allocated into a particular time bin, a minimum numerical value in terms of a specific amount of clean energy in a given day, month, or year (e.g. "at least 10 MWh clean energy per year"), or can also be described as a correlation value associating the blend of energy obtained from the renewable energy resource against the fluctuations in demand in the secondary energy market which refers to the supply and demand characteristic in that energy pool.

Consumer loads e.g. 104 are thus divided to express the constraints associated with the supply to those loads. Under the supply allocation mechanism in an example embodiment, the total intermittent generation capacity that will be available at the period of supply is simulated, modeled, or otherwise derived statistically. The total generation profile is then allocated to the projected consumer loads' e.g. 104 demands in a manner in which all of the constraints of the priority loads e.g. 104 are first met.

In one example, the supply demand is analyzed such that the individual loads are evaluated based on their own total demand profiles, then divided into two broad classifications. The broad classification refers to consumer load demand of priority to the intermittent renewable resources and consumer load demand with no priority to the intermittent renewable resources. Sub classifications can then be identified within the classifications. The total probabilistic demand of each sub-classification is then formed and the constraint or constraints associated to those loads is formed. A statistical validation of each supply constraint is then computed accounting for all the subsets of constraints and the probabilistic aggregated generation facilities generation distribution profile. The remainder of the process in terms of supply contracts and reconciliation in different embodiments will be described below.

Satisfying the allocation of aggregated intermittent generation to associated load demand

The classification of the consumers' priority forms the principle division of consumer loads e.g. 104 for association with generating facilities 100 wherein an excess of any remaining energy supplied by the generating facilities 100 over the priority constraints of the prioritized consumer loads e.g. 104 is supplied to the loads with no priority e.g. 116. Those priority loads e.g. 104 form hard constraints against which the electricity supply must achieve at least a minimum level. As such, the determined forward looking probability density profile or other quantitative factor (such as for example, done via Monte-Carlo simulation) which represents the total energy available through the aggregated generating facilities is prioritized to meet the multiple constraints posed by the consumer load requirements and embodied in the probability density function of the consumer loads within the particular sets.

Any remaining generation capacity of the intermittent generating facilities 100 may be then allocated to the loads e.g. 116 which have no priority access to those generating facilities 100 or for use during the backward looking audit during the reconciliation process described in more detail within. This can be done on a backward looking basis where an audit 118 of the actual loads' demands and actual supply from the intermittent resources is measured, and the constraints are verified. In addition, during the backward looking audit, any shortfall in meeting the constraints can be made up for by providing any remaining resource to make up for those short falls.

The remaining power after the reconciliation procedure that is measured is blended to the loads e.g. 116 of no priority. This energy can be blended into the loads e.g. 116 of no priority in a number of different ways. For example, the total aggregated demand of all of the loads e.g. 116 with no priority may be established, and the remaining energy allocated to those loads e.g. 116 to reflect a particular constraint as a renewable penetration level to those loads e.g. 116. This will comprise an amount of energy that is delivered to the loads e.g. 116 in comparison to the maximum energy demand periods of the loads. Alternatively, the energy can be divided by the total loads without regard to the amount of energy consumed by that load. In this manner, each load would obtain the same amount of renewable energy, but would individually have a different percentage blend of renewable energy within the individual load consumption.

For facilitation of this above process, Figure 2 shows an embodiment of the formation of a probability density function of the aggregation of all generating facilities supplying intermittent energy. Figure 2 a) illustrates outputs from individual generating facilities 201-203 within a single day. Each of the illustrations shows that the output on any given day may show various characteristics. The data is presented in discrete time bins in this example. A combination of such systems can lead to the probability density distribution function (PDF), an example of which is illustrated in Figure 2 b).

Figure 2 b) illustrates that for an aggregated energy generation profile, the final PDF 222 can be associated with three key levels 203-205. The PDF 222 can represent the output over various time periods. For example, yearly, monthly, daily, etc. As the time period decreases the PDF 222 will display a more variable distribution profile, while as the time variable is lengthened it will converge to the average PDF (curve 208). The PDF 222 also can be determined using continuous variables, or can be determined using discrete variables. When an energy market operates assuming a particular time bin during which an exchange is made, the discrete time intervals may be assessed assuming this time bin. The PDF 222 can display a minimum level 205 which can be assessed assuming the lower level of output within a particular time period, as well as a maximum level 203 which is the constrained total power output associated with the generating facilities during times in which the renewable energy resource is maximized and the optimal output of the power system is assumed. This maximum output level 203 can also be assumed to account for the power system degradation over the years during which it is operated.

When a supply constraint is assessed, it may be assessed against all of the maximum, minimum, and average PDFs, see curves 207, 209 and 208 respectively. This allows the utility to evaluate a number of additional quantities which can be used when implementing the reconciliation exercise during the backward-looking audit process. The utility can evaluate, for example, the amount of energy that can be provided to the no-priority loads in all of the average and maximum scenarios, and can attempt to set the provisions for allocation of energy to the no-priority loads to a low level under the assumption of the minimum PDF 209. Or, the utility can assume that they would more frequently need to provide for energy blending in a backward looking reconciliation exercise by raising the provision for blending of energy to the no-priority loads closer to the average PDF 208. In this latter scenario, the shortfalls that occur in the priority loads occur closest to the average PDF 208 determination rather than the minimum PDF 209 determination. Using this process, the utility is prepared quantitatively to provide both guarantees of the supply constraints to the consumer load demands, and an auditing method and reconciliation method such that there is limited probability that a constraint to the loads is not met.

As a summary, the constraints which are to be supplied in regard to a quantitative determination of an amount of intermittent energy provided to a consumer load profile is evaluated by preparing the PDF 222 of the generating facilities and examining the PDF 222 at various scenario levels, then allocating resources from the generators to provide to specific sets of constraints in parallel to each other. The constraints are assessed against the real measurements upon which a backward-looking audit is performed, and reconciliation of any shortfalls is performed. The audit may then be published so that the consumers obtain certainty in regard to the provisions of intermittent renewable energy that they have obtained from the utility based on their specific requirements. Those consumers who have requested no constraints are considered to have no priority to the intermittent resources, and can obtain an amount of energy that is associated with the remaining energy upon completion of the backward-looking auditing procedure and the backward-looking reconciliation procedure.

Statistical basis of supply from aggregated generating facilities to form probabilistic generation capacity

To determine the PDF 222 of the aggregated generating facilities, the Performance Ratio (PR) can be used which represents the output and the electrical performance of an individual generating facility. The generating facilities are associated with all of the specifications of the installation, including the electrical parameters of all of the material components and devices comprising the installation. In addition, the local factors can be considered. For example, an installation which is located near to an obstruction will have a particular shading loss at a time of day. This generating facility will be known to have a different output PDF individually, and as such, the final PDF 222 of the aggregated generating facilities will be the PDF 222 that is the normalized integral of all individual generating facilities accounting for their specific performance criterion. A good resource which presents the design parameters, specifications, and other performance metrics is Antonio Luque (Ed.) and Steven Hegedus (Co-Ed.), Handbook of Photovoltaic Science and Engineering 2nd Edition, Wiley 2011 (ISBN: 978-0-470-72169-8)]. We will discuss herein some of the relevant points that can be used to determine the individual PDFs for a specific site, wherein the PDF 222 of the entire aggregated generating facilities can then be more accurately formulated.

The time of turn on or commissioning of a new generating facility can be accounted for in the determination of the PDF of the generating facilities. For example, the known period of construction of a new generating facility, along with the associated loss factors, local performance metrics, and electrical specifications of the installation can allow the utility to formulate the output of this generating facility over a long time period. Its PDF can be assumed to be added into the aggregated generating facilities PDF 222 at a future time. Once that system is constructed and outputting energy through its energy meter, it can be considered to be providing to the aggregated generating facility as a resource starting at the time of turn on. The degradation of these new generating facilities that are turned on will be evaluated starting from the date of commissioning and going forward. The generating facilities can also account for the warranties of the energy systems as well, so that a minimum level of failure can be quantified based on the warranties. For example, a solar panel warranty normally assumes a minimum amount of yearly degradation and otherwise the components can be replaced.

Figure 2 a) shows respective measured outputs 201-203 from respective single generating facilities. As can be seen, at particular times the output of such intermittent generating facilities is limited, while the average output is classified by a correlation to an external variable (for example, the amount of sunlight at the system location). The generating facility can also be characterized by a maximum output from the generating facility based on the capacity of the particular generating facility.

Figures 3 a) – c) show three separate measurements 301-303 representing the output of three individual generating facilities connected to the same power grid network. As can be seen, intermittency of the generating of energy is observed by the variance in the output of electricity measured at the inverters of the system. The horizontal axis of the plots represents the day in a single year and the data spans one year. The vertical axis represents the hour in the day and spans 24 hours. The output of the individual systems is represented by the grayscale scale bars.

The PDF of the aggregated generating facility or of the allocation of the generating facilities that is set aside to cover particular supply load constraints can be assessed with particular time intervals. The market time interval may define an interval during which trading and settlement is done. The PDF can thus be formulated using the same interval as used in the specific market such that the trading and settlement of energy can be accurately reflected as probabilities reflecting those market cash flows.

A PDF can be generated to reflect the time of day thermal loss evaluation of the site, and a time of day shading loss evaluation. These two factors will provide an accurate representation of the total output of a specific generating facility. The time of day then among all the generating facilities would then be one manner in which all of the individual PDFs of the generating facilities can be computed into a PDF of the aggregated generating facility.

Statistical basis of consumer supply loads to form probabilistic demand capacity

A PDF of the consumer loads is similarly formulated so that the consumer load demands may be computed. However, those consumer loads demand can also be sorted into classification based on the constraints that the consumers request to be satisfied and guaranteed in their supply contracts. Consumer load can be determined by looking at the past historical energy consumption of the consumer. Where this is unavailable the intended activities of the building and the estimated size of the loads can be used to formulate a demand profile. These PDFs can be formed using discrete time intervals of continuous probability densities. The case of using a discrete time interval allows the time interval to be matched to that of the market trading intervals for electricity as a commodity (e.g. Electricity futures or spot markets, or time periods of settlement).

Figure 4 a) shows a representative consumer load PDF 401. It is characterized in addition by the maximum amount 422 of electricity that can physically flow into the building at the distribution board or other electrical connection gear for the energy grid. This load profile rarely is zero given that the building consumes some electricity at all times, hence the minimum amount 433 of electricity indicated in Figure 4 a). Figure 4 b) shows a measured average daily profile 402 of energy of a building, Figure 4 c) is the annual statistical variation chart 404 of the load profile, and Figure 4 d) is a map 406 of the annual load profile over one year. In Figure 4 d) the horizontal axis is the day of the year and the vertical axis is the hour of the day. The scale bar represents the amount of energy consumed in the building.

By obtaining the data that reflects the profile of demand of a building, a PDF can be formed for that consumer load demand. When the constraint the particular consumer has requested is added to reflect that the load must be supplied with a specific quantitative amount of variable energy from the generating facilities, an expectation value may be computed by associating both PDFs of the allocated resources 120 of 100 toward the constraint of the load, and the PDF of the consumer load demand. As such, a forward-looking probability density function allows the probability of a specific consumer constraint requirement to be quantitatively evaluated as a numerical value or strength as an expectation value or probability.

Statistics of supply modes considering supply and demand profiles, and supply profile simulations

Formulation of the constraints from which to assess the forward looking probability of meeting demands are determined from qualification on the manner in which the yield from intermittent generating facilities 100 are provided to satisfy the portion of the consumer load demand. There are various ways in which the amount of intermittent generation yield is provided for within the consumer load demand that has priority to the renewable resource. Each quantity is considered as a constraint on the provision of resources to each individual consumer load demand, and a consumer load demand moreover may be associated with more than one such quantified constraint. For example, determination of statistics of priority guarantees may include one or more of:

a. Renewable penetration level
b. Percentages of blended renewable energy
c. Correlation to an energy supply pool or secondary generator resource
d. Total amount of energy provided (e.g. 10 kWh)

A renewable penetration level measures the amount of energy providing to the load during the period the renewable resource provides maximum output and considering the amount of demand during the associated period of time. A percentage of blended renewable energy is a normalized amount of total renewable energy integrated through the period of time it provides to a specific load, divided by the integral of the load demand over the associated period of time. This percentage may refer to a plurality of loads or an individual one, or to a plurality of generating facilities or to an individual one. A correlation value to a secondary supply resource refers to the amount of renewable or intermittent energy provided during a time as associated with a correlation measurement of that supply level or amount with the secondary resource. This secondary resource could be evaluated qualitatively by its relative availability, its demand and supply level, or a price linked to the physical availability of the resource. A total amount of energy provided refers to a specific absolute yield of energy over a particular period of time. For example, a total amount of energy to be provided may be 10 units of energy from the intermittent resource each month.

The classifications of constraints is to be associated with each consumer load demand in descending subsets, and assessed against the total probabilistic generating capacity assuming the aggregation of generating facilities. The broadest classification is the consumer load priority, followed by various quantities for subsets as described above. All of the quantified constraints are assessed to determine a probability of satisfying all constraints considering the probabilistic generation capacity available. In an example embodiment a maximum, minimum, and average of the statistical generating capacity available is also preferably implemented so as to assess a potential amount of resource available to supply the consumer load demand constraints, as described above with reference to Figures 2 and 3.

Wholesale supply and demand integration

In Figure 5 the case of a dual supply system which incorporates a financial market is shown. Consumer load demand L can be supplied by physically available intermittent solar energy from the generating facilities G, and a wholesale pool P. The energy may be supplied to the loads L through a wholesale pool P while any constraint that requires energy to be derived through generating facilities G must be computed for by an allocation and auditing systems and described herein. As can be understood by a person skilled in the art, generating facilities G are long the price of the wholesale market P when the secondary supply resource takes the form of a wholesale energy market, and the loads L that are being supplied to at specified fixed pricing are short to the wholesale market P when the secondary supply resource takes the form of a wholesale energy market.

Figure 6 shows actual wholesale energy date of a particular energy market as described in detail above. Variations in the supply and demand of this market reflect a profile of an energy market, and can be considered to be represented quantitatively by both a discrete or continuous Probability Distribution Function (PDF). The particular wholesale market data displays a higher energy demand and thus higher energy price during daytime.

Figure 7 illustrates a method of establishing an energy offset through generating facilities G to loads L as represented by a supply scenario as presented in Figure 6. This has been described above and also in Singapore patent Application no. 10201406883U, the contents of which are incorporated here by reference.

Exposure to energy pool supply and demand

Figure 8 shows a schematic drawing illustrating the peak energy offset supply scenario wherein the base load energy derived from the wholesale energy pool is passed to the consumer and the supply load is decoupled from the wholesale market volatility from correlation to the periods of peak energy demand by supply of photovoltaic energy under an optimized renewable penetration scenario in an example embodiment; where Figure 8 a) illustrates an assumed load demand profile 800, Figure 8 b) illustrates a probability density distribution 802 of aggregated generation resources 100 or dedicated resources 120 (compare Figure 1), Figure 8c) is the modified load profile 804 incorporating various assumed PDFs of the dedicated generating facilities 120, i.e. the modified demand that is to be derived from the wholesale energy pool. Figure 8d) illustrates a characteristic wholesale pool demand profile 806, showing correlation of peak demand 808 to the supply profile of the aggregated intermittent energy resources (compare probability density distribution 802 of aggregated generation resources in Figure 8 b). As will be appreciated by a person skilled in the art, the wholesale pool pricing will substantially mirror the wholesale pool demand profile 806, meaning that the exposure of the load to the energy pool supply is advantageously reduced during periods in which the purchase price of energy from the wholesale pool market is expected to be higher than during other periods, e.g. during off-peak periods.

Figure 6 shows an illustration of an energy pool supply and demand level and associated pricing fluctuations in the said energy pool due to the changes in demand and supply. In this case, a daytime correlation can be found while both demand and prices for energy rise in the pool. As a secondary generation source to fulfill those consumer load demand requirements which cannot be supplied for from only the intermittent generating facilities, the pool may comprise the secondary supply resource.

In such a case, the consumer load demand for electricity can be directly supplied by the wholesale pool while the intermittent energy generation is blended into their account through metering allocation and assignment of rights, as shown in Figure 5 at arrow C. Through this relationship, any constraints are formed, and audits are implemented to verify they are met. Intermittent generation may still be provided directly to the pool at arrow A of Figure 5.

Figure 5 shows the arrangement of the generation (labeled G), energy pool (labeled P), and the consumer supply loads (labeled L). Between the meter readings of the loads, the readings at the meters of the generators are associated. Auditing of all metering is performed as described within this document. In consideration of the energy products supply constraints; the statistics of the energy pool can also be accounted for when creating a structured energy product. Such products are described below, wherein the statistics of the energy pool are described here.

Specification of energy supply product classes

Formulation of the energy supply components to energy consumers associated to the consumer load demand profiles and consumer constraints can take into account the available energy that is generated and represented by the PDF of the aggregated generating facilities over time. New systems that are installed will be added into the PDF so that it accurately represents to amount of energy that is statistically available for supply to consumers. The remainder of the consumers energy demand can be made up with a secondary source of energy if it is not possible to make all of it from the intermittent sources. The secondary source may be an alternative generator that uses fuel, or could be a financial market such as a spot market or a futures market.

As a first formation of supply constraints formed for electricity supply, a particular value of supply from intermittent generators can be derived through comparison of the time profiles of generation and demand consumption on both a forward-looking basis and a look-back basis. Minimum quantities may then characterize the supply to the load from the intermittent resources, for example, those minimum levels may be the absolute percentage of intermittent energy that makes up the total consumption at the load, the cross correlation values between the intermittent generator time profiles and the load consumption time profiles, a maximum penetration level of the intermittent energy resources to the load demand, or a relative determination of the generation profile characteristic to the load profile characteristic over a period of time (for example, normally a day).

An additional formation of supply may be implemented wherein a dedicated intermittent resource to a particular load is specified. For example, this may be 2 dedicated intermittent generators as installed on the power grid network, and one quarter of the power from a third generator. Thereafter, the load is provided for by utilizing the dedicated resource to that load while otherwise making up for any shortfall in supply to the load or loads by deriving it through a secondary source, such as a wholesale energy pool. In such a scenario, the intermittent generation can at least make up as much of the demand as correlated based on the time profiles of the energy sources and time profiles of the load demands.

Another supply mode can involve obtaining a higher amount of intermittent generation that required by the loads at a particular time, such that the penetration ratio of the generator is well over the load demand. In such a scenario, the excess energy that is generated above the supply can then be sold into time slots in the evening using products that exchange power or utilize futures contracts. The excess energy can be traded forward into time period that the intermittent generation was not able to physically supply to the load demands. In this scenario, large percentages of intermittent energy can comprise the load supply with no requirements of energy storage systems. The target will be such that 100% of the load demand is made up through intermittent generation. In this scenario, the load is set as priority, and the dedicated intermittent resources established to supply to the load are sized such that the total generation is able to total supply. The excess at periods of time when the load demand is below the intermittent generators supply is then trades into periods of time when the load demand is above the intermittent generators supply. In this scenario, on a look-back basis, the formation of 100% supply to the loads can be validated while any remaining energy of the intermittent generators may then be blended into low priority loads.

Given the above energy management systems and physical consolidation mechanisms, and access to resources including physical generating facilities 100, 120, 102 of an intermittent nature, and secondary resources such as a secondary generator or a wholesale or futures energy market, various product packages can be implemented with particular features. The features of the product packages maybe represented in the form of a quantitative constraint, and the supply method and audit method for verifying of any required constraints that is described within this document may be used to implement a supply and audit methodology over a period of time.

Products features may be formed by reflecting quantities and features. A list of particular features of a particular consumer load are described here below, while they may then later be grouped into classification sets as they are provided to energy consumers. As energy consumers accept the energy supply quantities, the procedure of forming the supply constraints as sets of classification and PDFs of the consumer loads is established.

Quantities or features that are introduced as classifications or characterisations of the supply mode to the target consumption load are described one by one as follows:

1. Priority to Solar :
    a. Field: Binary
    b. Values: Yes or No
    c. Description: Priority means a constraint that prioritises access of the consumer load demand to the generating facilities as quantified by a constraint. This would take the form where the generating facilities are solar energy generators as a guaranteed amount of solar electricity

provisions for supply to the consumer. Where no priority is required by the consumer, the consumer load demand profile requires no guaranteed amount of solar provided.

2. Minimum solar percentage:
    a. Expressed as X % of consumer load demand derived from the total intermittent supply to the load divided by the total load consumption over a period of time
    b. Description: Minimum percent solar requested in absolute terms with respect to the consumer load demand profile.
3. Penetration Ratio:
    a. Expressed as a percentage X % of a consumer load demand profile as a ratio of the maximum demand to maximum output from generating facilities.
    Description: Target ratio as correlation of load profile to solar power profile.
4. Optimised Penetration ratio as a correlation coefficient:
    a. SE engineer optimised the penetration ratio accounting for wholesale volatility.
    b. Description: The penetration ratio is derived to form an optimal level of intermittent energy that reduces the exposure of the load demand profile to a secondary resource such as a wholesale energy pool as presented in Figure 6. The correlation of the load to the wholesale energy pool is evaluated assuming a dedicated amount of intermittent energy generators supplying to the load. In this scenario, the dedicated resources are then implemented to reduce the correlation of the time profile of the loads to the wholesale market time profile.

Specific product classification can be formed using such an implementation. For example, energy consumers' loads can be provided for by a fixed amount of intermittent generation and the remaining energy from a wholesale energy market. When the utility introduced the above options, the energy loads may get a variety of supply features satisfying various forms of classifications reflecting the quantity of intermittent energy that is supplied to them in respect of alternative resources used, and their own demand consumption.

Pass through CFD or Transfer pricing between long and short exposure

The supply contract in example embodiments will allocate renewable energy to the loads from the generating facilities. The supplier can be expected to invariably be purchasing additional energy from a second source due to the intermittency of the generating facilities. Figure 5 illustrates the relationship between the generating facilities (G), the consumer loads (L) and the energy pool (P). The loads can be supplied from the energy pool, while the generation is distributed into the energy pool. In such a scenario, the fluctuations in the supply and demand in the energy pool which also faces the forces of various other generation sources which input energy to this pool will affect the pricing. To remedy any variations in the prices of the generators, transfer pricing or purchases of the renewable energy rights can be performed between the generator G and the supplier to the loads L. This allows the generators to incorporate pricing from an off-take to the consumer load rather than from a volatile market price such as a wholesale market.

In addition to the energy pool, secondary supply can also be obtained in the futures market if an electricity futures market is providing for future delivery. This contract will be settled off of actual delivery. Various securities contracts can be used to lock in the pricing as well, including HSFO, Brent, or other energy linked securities that are traded in the market. This allows for a variety of resources to be used to form a second supply source to the customer's loads.

Auditing and reporting methodology

For the matter of auditing the energy supply, an operation center is employed in example embodiments to collect both data from the generators and data from the supply loads. The flows of energy on the power network associated with the plurality of generators and the plurality of loads will be measured using a suitable revenue grade energy meter. This information is collected at a central server or other information system for audit. An example of a central server system that can be used to implement such an operation center can be found in Singapore patent application no. 10201502972V, the contents of which are hereby incorporated by reference.

The audit will compare the actual generation over the time periods of supply to the loads, and the actual load demand over those periods of time, and verify the levels of renewable energy that are provided to those loads. Those levels are assessed against the constraints that have been applied for those consumer loads. The total generation and consumption, renewable penetration levels, total percentage blend, and other numerical information representing the amount of renewable energy from intermittent sources that was allocated to those consumer loads is computed and stored on the server.

As a matter of performing a transparent audit, those consumers can obtain the information from the audit through a platform and may publish that information. Consumers may log into their accounts and publish the total renewable energy consumption information through an Application Programmer Interface (API) so that the data can be fed out to their own IP address. On an ongoing basis, the consumer may publish this information via the internet to their site. The publishing platform will advantageously be equipped such that those consumers can also publish their audit information to social media platforms, such as Twitter, Facebook, Google plus, or other platforms. Their information can also be published through to a dedicated publishing platform where all consumer information can be voluntarily published.

The building owners who contribute the space from their premises to provide for generation facility installations can also publish the total generation statistics of supply measured from the generation facilities at their premises. In this case, the amount of clean energy that these property owners contribute is publishable as an audit in terms of only the generation of electricity information. This can be also provided via API to the internet so that the information can be posted through an internet protocol (IP) address of the property owner's choice, or on social media etc. as stated above. In this sense, the total audit provides that all the generation and consumption data is made available for voluntary publication by both the consumers and producers of the energy. The result of the audit in terms of the validation of supply constrains can also be made available to the energy consumers.

Reconciliation of supply on audit

Figure 9 shows a diagram illustrating the relationship between the supply allocation and the audit in example embodiments. The supply allocation 900 is forward looking to determine the allocation of resources which satisfy the particular constraints of the loads to the delivery at a particular time. In figure 9, the settlement takes place at time t and the settlements are then measured in real time. This time t could also be embodied by a time period, such as a month, or other periods in that the measurement can be expressed as a representative quantity over that particular time bin. The supply constraints are specified given the particular time period chosen as well.

The audit 902 is a backward looking process that determined the measured delivery of any specific constraint by reviewing the actual delivery of energy from the intermittent resources, and compares those to the measured supply allocation. Where all constraints are satisfied, no reconciliation of supply is required. Where the audit uncovers a divergence between the supply constraints and the actual measured energy on a look-back audit, a reconciliation method is then implemented.

Reconciliation 904 involves obtaining additional energy that was not set aside within those resources that were allocated to priority loads. This will reduce the amount of resources allocated to the no-priority loads. Reconciliation is completed to make up for all shortfalls on constraints to the limit at which the no-priority loads receive no allocations of energy from the intermittent resources.

Wherein there is still a shortfall in the energy, additional installation of generating facilities are provided for such that the shortfalls are met. As an ongoing process, the balance of energy distribution allocated between those priority loads which have associated constraints and those no-priority loads which have no associated constraints is assessed over time on an ongoing basis. As new constraints are provided for and new generating facilities are installed, the balance determined from the PDF such as the PDF 222 as described above with reference to Figure 2 can be adjusted such that a firm commitment in terms of a high probability of satisfying the constraints through measured auditing process is larger than a particular set probability (e.g. 99%, 99,9%, 99.999%, …) depending on the amount of demand in the market for intermittent renewable energy resources.

Summary of audit and supply method as a process according to one embodiment

Figure 10 shows a flowchart 1000 illustrating the process of forming the statistical supply system and an auditing methodology for an association of aggregated generating facilities and a plurality of loads according to one embodiment, and comprises the following steps:

Establishing the consumer loads requirements and obtaining or adjusting the associated constraints and computing the PDF of the consumer load demands and the intermittent generating facility resources and computing the PDF of the generation supply; 1002.

Dividing the consumer loads into priority and no-priority consumers and forming classifications of constraints and subsets of loads associated with one or more similar quantitative constraints; 1004.

Computing the probability of supply to the priority loads and establishing that to a high probability (eg. 99.9%, 99.99%, 99.999%, etc.) those loads will obtain the amounts of renewable energy from the intermittent supply resources, and that all other constraints imposed through contract are obtained, on a forward looking basis; 1006.

As an option, adjusting the establishment of priority and no-priority on an ongoing basis depending on the availability of supply (as computed at 1002), 1008.

As an option, adjusting the establishment of new generating facilities based on the supply (as computed at 1002); 1010.

Delivery of supply to consumer loads at time t; 1012

Auditing the actual generation of electricity measured against the actual consumption of energy measured as a cross correlation of the time profiles of the aggregate intermittent generating facilities dedicated to provide to particular loads constraints against the time profiles of the particular loads, and allocating any remaining amount to no-priority loads; 1014.

In the event of a violation of a constrain on a consumer load, making up for the said violation by allocating additional provisions to the consumer and reconciling the supply scenario on a forward looking basis while next establishing the consumer loads requirements and constraints (see 1002); 1016.

Providing for publication of various measured amounts or variables representing the supply levels and the validation of consumer load supply constraints from audit to public communication channels; 1018.

Implementing process steps 1002-1018 on an on-going basis (e.g. Monthly, daily, on establishing new generating facilities and new consumer loads, every minute, etc.) while adjusting for the amounts of dedicated intermittent resources established for supply to particular load constraints based on the measurement outcomes of process step 1014; 1020

Information systems technology architecture in an example embodiment

The server architecture is to be established to preferably handle operation with a large set of solar generators scattered across a specific location/region, such as across a city, the country or even the world as installed in multiple locations. Or, this same architecture may be implemented multiple times per city and an allowance for individual servers to communicate with each other may be added such that the information from various servers and/or various e.g. cities can be compared and published by users, if they are granted access. All of the connections into the server are made using the internet in an example implementation and encrypted in some form to keep the data secure. The main aspects that the architecture solves preferably include.

1) The ability to constantly receive status data from our generators.
2) Have the ability to control or change how the generator operates.
3) Generate audits and reports on the energy output

Figure 11 shows the basic overview of the connections with the server 1111 incorporating the elements which may be implemented to allow for computation of satisfaction of the constraints provided to or by consumers, a method of user log ins, publishing platform, as well as a communication link for an AC power grid network administrator and a power system operator (PSO). This embodiment of an information technology architecture provides networking elements for assistance in operating and reading in information from energy metering equipment.

The control unit e.g. 1186 element is described here. The control units e.g. 1186 include programmable logic controllers (PLC) designed to control and maintain a solar generating facility e.g. 1188 system. There may be installed one or many such PLC elements in a particular solar generating facilities e.g. 1188 location. The control units e.g. 1186 are coupled to sensors (not shown) to provide the central server 1111 with information about power output, electricity interference, sun exposure, and to indicate any equipment failure. This information is sent from the control units e.g. 1186 (which may also be referred to as “monitoring units” herein) to a router e.g. 1171 with an encrypted virtual private network (VPN) e.g. 1172 connection to the server 1111, and directly into the server’s 1111 database 1104. If there are problems with the connection, the control unit e.g. 1186 stores the status updates until a connection is made, and then uploads the queued status updates. While connected to the structured query language (SQL) server 1111 in this embodiment, the control unit e.g. 1186 also checks if there are any remote commands that need to be executed, and applies them in the order they were sent to the database 1104, or by the assigned time signature, or by an assigned priority. Assignment of priority and/or the timing schedule of routines will take precedence over implementation of routines by order that they were sent to the database 1104, in this embodiment.

The server element 1111 is described here. The central core of the server 1111 revolves around a SQL database 1104. There are two connections for obtaining information that provide most of the SQL database 1104 with information: The control units e.g. 1186, the sensors, the metering systems (not shown) associated with the generating facilities e.g. 1188 that produce electricity, and energy market customer data which may be received by reading consumer load data (see e.g. 1114) from a secondary service provider 1143 or by directly reading the energy meters into the database 1104. Using this detailed information, the server 1111 is advantageously able to generate all of its other data like audits, billing, etc. Computations of audits will be done according to the time periods of which information received is represented, and especially in regard to the reconciliation and auditing procedures according to example embodiments described herein, the database 1104 will assist in indexing information representing the actual flows of energy in a look-back scenario and verifying that constraints that have been provided to consumers are met without double counting of any energy generation form intermittent supply sources to meet such constraints.

The server 1111 hosts a VPN server 1102 to receive connections from all of its control units e.g. 1186. The server 1111 also hosts a web server 1115 to display information about specific generators or the system as a whole. Energy customers 1163 can log in and see the status of the solar energy that was produced for them. They may select options to publish their consumption information through various application programmer interfaces (APIs) to addresses on the internet 1101 such as their home page, and may also select options to publish their energy usage and audits to social media sites like twitter, Facebook, linked in or other locations. The list of social media sites is not an exhaustive list and other information sharing locations can be used. Consumers who provide roof-space or otherwise provide for generating facilities to be located on their land can choose to publish the generation data from those associated generating facilities through APIs as well, and to social media platforms, and as such they may present their own clean energy contribution to a particular power grid. Power operators or power grid administrators 1162 can log in and see a particular solar generator's output and have the ability to shut it down in case of emergency. Company staffs who are in charge of operating solar energy infrastructure such as installers 1161 can also log in to see the status on particular solar generators, send commands, and also fill in detailed information when installing a new solar generator.

Another connection that the server 1111 receives in this embodiment is from the energy market customer transaction server 1143. This connection can receive transactions about customers that are entering or terminating energy contracts with the utility company. The energy market representative may also send updates regularly about customer energy usage (see e.g. 1114) through this connection. The solar utility can correlate this information with the energy output (e.g. 1112) to produce an audit on how much each customer's energy came from the clean energy generating facilities e.g. 1188. The billing component 1113 on the server 1111 gathers the audits to generate a bill for each customer with detailed information on when they received our energy.

The server 1111 also makes a secure connection with the energy market 1144 to send information about the energy each solar generator is generating to the energy pool. The total output reported should closely match the output on each solar generator's meter. It can also be used to ensure the utility is not overbilling or under billing.

Where the security of a connection to a particular identity is required, such as where a power system operator should be the only entity which may send a dispatching command, or a power grid network administrator is the only entity who may send an isolation request, the exchange of certificates may be implemented to secure the communication. There are multiple layers of security in place in an embodiment to preferably ensure the security of the system. The connection used between different entities and the server will be secured with secure sockets layer (SSL). This connection ensures the server is communicating only with the entity's system and protects from eavesdropping on the internet. The login and password will be required to gain access. Lastly, we will store a whitelist of the accepted internet IP ranges that are allowed with each user. Access will only be given to users with the correct login, password, and accepted IP. The IP whitelist will be primarily used for entities that can send commands to our system. These entities will need a static IP and provide IP ranges for systems that will connect to the server. These certificates can be updated time to time to ensure they are not interfered with, and they will be implemented at both the server side of the utility and the computer of the entity who is communicating to the utilities server.

Figure 12 shows a flowchart 1200 illustrating a method of supplying power in a power grid according to an example embodiment. At step 1202, an initial forward probabilistic power supply time profile of an aggregate intermittent power source connected to the power grid is determined. At steo 1204, a target power demand time profile of at least one load connected to the power grid is determined. At step 1206, at least respective portions of the initial forward probabilistic power supply time profile and the target demand time profile are associated such that a probability of supply of power from the intermittent power source to the load meets a specified criterion.

The method may further comprise generating an updated forward probabilistic power supply profile based on the associated portion of the initial forward probabilistic power supply time profile being dedicated to the load.

The method may further comprise outputting a forward probabilistic intermittent power supply contribution for the load based on the associated at least respective portions of the initial forward probabilistic power supply time profile and the target demand time profile.

The probability may be calculated based on an expectation value of a cross-correlation of the initial forward probabilistic power supply time profile and the target demand time profile.

Associating the at least respective portions of the forward probabilistic power supply profile and the target demand time profile maz be based on a priority level of the load, the method further comprising dedicating a subset of intermittent power generating facilities of the aggregated intermittent power source to the supply for a highest priority load and generating the updated forward probabilistic power supply profile based on excluding the subset.

The method may further comprise determining whether a measured supply of power from the aggregate intermittent power source to the load meets the specified criterion and generating an actual intermittent power supply contribution for the loads based on the measured supply of power.

The method may further comprise validating one or more consumer constraints associated with the loads.

The aggregate intermittent power source may comprise one or more intermittent power generating facilities connected to the power grid.

The specified criterion may comprise one or more of a group consisting of at least one percentage blend, at least one penetration ratio, at least one cross-correlation, and at least one correlation among a secondary source and the load.

Figure 13 shows a schemtic drawing illustrating a system 1300 for supplying power in a power grid, the system 1300 comprising means 1302 for determining an initial forward probabilistic power supply time profile of an aggregate intermittent power source connected to the power grid; means 1304 for determining a target power demand time profile of at least one load connected to the power grid; and means 1306 for associating at least respective portions of the initial forward probabilistic power supply time profile and the target demand time profile such that a probability of supply of power from the intermittent power source to the load meets a specified criterion.

The system may further comprise means for generating an updated forward probabilistic power supply profile based on the associated portion of the initial forward probabilistic power supply time profile being dedicated to the load.

The system may further comprise means for outputting a forward probabilistic intermittent power supply contribution for the load based on the associated at least respective portions of the initial forward probabilistic power supply time profile and the target demand time profile.

The probability may be calculated based on an expectation value of a cross-correlation of the initial forward probabilistic power supply time profile and the target demand time profile.

Associating the at least respective portions of the forward probabilistic power supply profile and the target demand time profile may be based on a priority level of the load, the method further comprising dedicating a subset of intermittent power generating facilities of the aggregated intermittent power source to the supply for a highest priority load and generating the updated forward probabilistic power supply profile based on excluding the subset.

The system may further comprise means for determining whether a measured supply of power from the aggregate intermittent power source to the load meets the specified criterion and generating an actual intermittent power supply contribution for the loads based on the measured supply of power.

The system may further comprise means for validating one or more consumer constraints associated with the loads.

The aggregate intermittent power source may comprise one or more intermittent power generating facilities connected to the power grid.

The specified criterion may comprise one or more of a group consisting of at least one percentage blend, at least one penetration ratio, at least one cross-correlation, and at least one correlation among a secondary source and the load.

Figure 14 shows a flowchart 1400 illustrating a method of consolidating power injection and consumption in a power grid according to an example embodiment. At step 1402, an actual power supply of an aggregate intermittent power source connected to the power grid at a time is determined. At step 1404, an actual power consumption of a load connected to the power grid at the time; is determined. At steo 1406, at least respective portions of the actual power supply and the actual power consumption are associated. At step 1408, an actual intermittent power supply contribution for the load based on the associated respective portions of the actual power supply and the actual power consumption is determined.

The method may further comprise determining whether the determined actual intermittent power supply contribution from the aggregate intermittent power source to the load meets a specified criterion.

The method may further comprise updating a forward probabilistic intermittent power supply contribution for the load based on whether the actual supply of power from the aggregate intermittent power source to the load meets the specified criterion.

The specified criterion maz comprise one or more of a group consisting of at least one percentage blend, at least one penetration ratio, at least one cross-correlation, and at least one correlation among a secondary source and the load.

Associating the at least respective portions of the actual power supply and the actual power consumption may be based on a priority level of the load.

The method may further comprise associating respective portions of the actual power supply and the actual power consumption of a highest priority level load, prior to associating respective portions of a remaining actual power supply and the actual power consumption of a lower priority level load.

The method may further comprise validating one or more consumer constraints associated with the load.

The aggregate intermittent power source may comprise one or more intermittent power generating facilities connected to the power grid.

Figure 15 shows a schemtaic diagram illustratig a system 1500 for consolidating power injection and consumption in a power grid, the system 1500 comprising means 1502 for determining an actual power supply of an aggregate intermittent power source connected to the power grid at a time; means 1504 for determining an actual power consumption of a load connected to the power grid at the time; means 1506 for associating at least respective portions of the actual power supply and the actual power consumption; and means 1508 for determining an actual intermittent power supply contribution for the load based on the associated respective portions of the actual power supply and the actual power consumption.

The system may further comprise means for determining whether the determined actual intermittent power supply contribution from the aggregate intermittent power source to the load meets a specified criterion.

The system may further comprise means for updating a forward probabilistic intermittent power supply contribution for the load based on whether the actual supply of power from the aggregate intermittent power source to the load meets the specified criterion.

The specified criterion may comprise one or more of a group consisting of at least one percentage blend, at least one penetration ratio, at least one cross-correlation, and at least one correlation among a secondary source and the load.

Associating the at least respective portions of the actual power supply and the actual power consumption may be based on a priority level of the load.

The system may further comprise means for associating respective portions of the actual power supply and the actual power consumption of a highest priority level load, prior to associating respective portions of a remaining actual power supply and the actual power consumption of a lower priority level load.

The system may further comprise means for validating one or more consumer constraints associated with the load.

The aggregate intermittent power source may comprise one or more intermittent power generating facilities connected to the power grid.

Figure 16 shows a schematic diagram illustrating a metering system 1600 for a power grid comprising means 1602 for metering power supply of an aggregate intermittent power source connected to the power grid; means 1604 for metering power consumption of a load connected to the power grid at the time; and means 1606 for metering an intermittent power supply contribution for the load based on the metered power supply and the metered power consumption.

The means for metering the intermittent power supply contribution may be configured to associate at least respective portions of the metered power supply and the metered power consumption.

The means for metering the intermittent power supply contribution may be configured to associate the respective portions of the metered power supply and the metered power consumption based on a priority level of the load.

The means for metering the intermittent power supply contribution may be configured to associate the respective portions of the metered power supply and the metered power consumption of a highest priority level load, prior to associating respective portions of a remaining portion of the metered power supply and the metered power consumption of a lower priority level load.

The system may further comprise means for determining whether the intermittent power supply contribution meets a specified criterion.

The system may further comprise means for updating a forward probabilistic intermittent power supply contribution for the load based on whether the intermittent power supply contribution meets the specified criterion.

The specified criterion may comprise one or more of a group consisting of at least one percentage blend, at least one penetration ratio, at least one cross-correlation, and at least one correlation among a secondary source and the load.

The system may further comprise means for validating one or more consumer constraints associated with the load.

The aggregate intermittent power source may comprise one or more intermittent power generating facilities connected to the power grid.

Figure 17 shows a flowchart 1700 illustrating a metering method for a power grid caccording to an example embodiment. At step 1702, power supply of an aggregate intermittent power source connected to the power grid is metered. At step 1704, power consumption of a load connected to the power grid at the time is metered. At step 1706, an intermittent power supply contribution for the load based on the metered power supply and the metered power consumption is metered.

The metering the intermittent power supply contribution may be configured to associate at least respective portions of the metered power supply and the metered power consumption.

The metering the intermittent power supply contribution may be configured to associate the respective portions of the metered power supply and the metered power consumption based on a priority level of the load.

The metering the intermittent power supply contribution may be configured to associate the respective portions of the metered power supply and the metered power consumption of a highest priority level load, prior to associating respective portions of a remaining portion of the metered power supply and the metered power consumption of a lower priority level load.

The method may further comprise determining whether the intermittent power supply contribution meets a specified criterion.

The method may further comprise updating a forward probabilistic intermittent power supply contribution for the load based on whether the intermittent power supply contribution meets the specified criterion.

The specified criterion may comprise one or more of a group consisting of at least one percentage blend, at least one penetration ratio, at least one cross-correlation, and at least one correlation among a secondary source and the load.

The method may further comprise validating one or more consumer constraints associated with the load.

The aggregate intermittent power source may comprise one or more intermittent power generating facilities connected to the power grid.

It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive. Also, the invention includes any combination of features, in particular any combination of features in the patent claims, even if the feature or combination of features is not explicitly specified in the patent claims or the present embodiments.

CLAIMS

1. A method of supplying power in a power grid, the method comprising:

determining an initial forward probabilistic power supply time profile of an aggregate intermittent power source connected to the power grid;

determining a target power demand time profile of at least one load connected to the power grid; and

associating at least respective portions of the initial forward probabilistic power supply time profile and the target demand time profile such that a probability of supply of power from the intermittent power source to the load meets a specified criterion.

2. The method as claimed in claim 1, further comprising generating an updated forward probabilistic power supply profile based on the associated portion of the initial forward probabilistic power supply time profile being dedicated to the load.

3. The method as claimed in claims 1 or 2, further comprising outputting a forward probabilistic intermittent power supply contribution for the load based on the associated at least respective portions of the initial forward probabilistic power supply time profile and the target demand time profile.

4. The method as claimed in any one of claims 1 to 3, wherein the probability is calculated based on an expectation value of a cross-correlation of the initial forward probabilistic power supply time profile and the target demand time profile.

5. The method as claimed in any one of claims 1 to 4, wherein associating the at least respective portions of the forward probabilistic power supply profile and the target demand time profile is based on a priority level of the load, the method further comprising dedicating a subset of intermittent power generating facilities of the aggregated intermittent power source to the supply for a highest priority load and generating the updated forward probabilistic power supply profile based on excluding the subset.

6. The method as claimed in any one of claims 1 to 5, further comprising determining whether a measured supply of power from the aggregate intermittent power source to the load meets the specified criterion and generating an actual intermittent power supply contribution for the loads based on the measured supply of power.

7. The method as claimed in any one of claims 1 to 6, further comprising validating one or more consumer constraints associated with the loads.

8. The method as claimed in any one of claims 1 to 7, wherein the aggregate intermittent power source comprises one or more intermittent power generating facilities connected to the power grid.

9. The method as claimed in any one of claims 1 to 8, wherein the specified criterion comprises one or more of a group consisting of at least one percentage blend, at least one penetration ratio, at least one cross-correlation, and at least one correlation among a secondary source and the load.

10. A system supplying power in a power grid, the system comprising:

means for determining an initial forward probabilistic power supply time profile of an aggregate intermittent power source connected to the power grid;

means for determining a target power demand time profile of at least one load connected to the power grid; and

means for associating at least respective portions of the initial forward probabilistic power supply time profile and the target demand time profile such that a probability of supply of power from the intermittent power source to the load meets a specified criterion.

11. The system as claimed in claim 10, further comprising means for generating an updated forward probabilistic power supply profile based on the associated portion of the initial forward probabilistic power supply time profile being dedicated to the load.

12. The system as claimed in claims 10 or 11, further comprising means for outputting a forward probabilistic intermittent power supply contribution for the load based on the associated at least respective portions of the initial forward probabilistic power supply time profile and the target demand time profile.

13. The system as claimed in any one of claims 10 to 12, wherein the probability is calculated based on an expectation value of a cross-correlation of the initial forward probabilistic power supply time profile and the target demand time profile.

14. The system as claimed in any one of claims 10 to 13, wherein associating the at least respective portions of the forward probabilistic power supply profile and the target demand time profile is based on a priority level of the load, the method further comprising dedicating a subset of intermittent power generating facilities of the aggregated intermittent power source to the supply for a highest priority load and generating the updated forward probabilistic power supply profile based on excluding the subset.

15. The system as claimed in any one of claims 10 to 14, further comprising means for determining whether a measured supply of power from the aggregate intermittent power source to the load meets the specified criterion and generating an actual intermittent power supply contribution for the loads based on the measured supply of power.

16. The system as claimed in any one of claims 10 to 15, further comprising means for validating one or more consumer constraints associated with the loads.

17. The system as claimed in any one of claims 10 to 16, wherein the aggregate intermittent power source comprises one or more intermittent power generating facilities connected to the power grid.

18. The system as claimed in any one of claims 10 to 17, wherein the specified criterion comprises one or more of a group consisting of at least one percentage blend, at least one penetration ratio, at least one cross-correlation, and at least one correlation among a secondary source and the load.

19. A method of consolidating power injection and consumption in a power grid, the method comprising:

determining an actual power supply of an aggregate intermittent power source connected to the power grid at a time;

determining an actual power consumption of a load connected to the power grid at the time;

associating at least respective portions of the actual power supply and the actual power consumption; and

determining an actual intermittent power supply contribution for the load based on the associated respective portions of the actual power supply and the actual power consumption.

20. The method as claimed in claim 19, further comprising determining whether the determined actual intermittent power supply contribution from the aggregate intermittent power source to the load meets a specified criterion.

21. The method as claimed in claim 20, further comprising updating a forward probabilistic intermittent power supply contribution for the load based on whether the actual supply of power from the aggregate intermittent power source to the load meets the specified criterion.

22. The method as claimed in claims 20 or 21, wherein the specified criterion comprises one or more of a group consisting of at least one percentage blend, at least one penetration ratio, at least one cross-correlation, and at least one correlation among a secondary source and the load.

23. The method as claimed in any one of claims 19 to 22, wherein associating the at least respective portions of the actual power supply and the actual power consumption is based on a priority level of the load.

24. The method as claimed in claim 23, further comprising associating respective portions of the actual power supply and the actual power consumption of a highest priority level load, prior to associating respective portions of a remaining actual power supply and the actual power consumption of a lower priority level load.

25. The method as claimed in any one of claims 19 to 24, further comprising validating one or more consumer constraints associated with the load.

26. The method as claimed in any one of claims 19 to 25, wherein the aggregate intermittent power source comprises one or more intermittent power generating facilities connected to the power grid.

27. A system for consolidating power injection and consumption in a power grid, the system comprising:

means for determining an actual power supply of an aggregate intermittent power source connected to the power grid at a time;

means for determining an actual power consumption of a load connected to the power grid at the time;

means for associating at least respective portions of the actual power supply and the actual power consumption; and

means for determining an actual intermittent power supply contribution for the load based on the associated respective portions of the actual power supply and the actual power consumption.

28. The system as claimed in claim 27, further comprising means for determining whether the determined actual intermittent power supply contribution from the aggregate intermittent power source to the load meets a specified criterion.

29. The system as claimed in claim 28, further comprising means for updating a forward probabilistic intermittent power supply contribution for the load based on whether the actual supply of power from the aggregate intermittent power source to the load meets the specified criterion.

30. The system as claimed in claims 28 or 29, wherein the specified criterion comprises one or more of a group consisting of at least one percentage blend, at least one penetration ratio, at least one cross-correlation, and at least one correlation among a secondary source and the load.

31. The system as claimed in any one of claims 27 to 30, wherein associating the at least respective portions of the actual power supply and the actual power consumption is based on a priority level of the load.

32. The system as claimed in claim 31, further comprising means for associating respective portions of the actual power supply and the actual power consumption of a highest priority level load, prior to associating respective portions of a remaining actual power supply and the actual power consumption of a lower priority level load.

33. The system as claimed in any one of claims 27 to 32, further comprising means for validating one or more consumer constraints associated with the load.

34. The system as claimed in any one of claims 27 to 33, wherein the aggregate intermittent power source comprises one or more intermittent power generating facilities connected to the power grid.

35. A metering system for a power grid comprising:

means for metering power supply of an aggregate intermittent power source connected to the power grid;

means for metering power consumption of a load connected to the power grid at the time; and

means for metering an intermittent power supply contribution for the load based on the metered power supply and the metered power consumption.

36. The system as claimed in claim 35, wherein the means for metering the intermittent power supply contribution is configured to associate at least respective portions of the metered power supply and the metered power consumption.

37. The system as claimed in claim 36, wherein the means for metering the intermittent power supply contribution is configured to associate the respective portions of the metered power supply and the metered power consumption based on a priority level of the load.

38. The system as claimed in claim 37, wherein the means for metering the intermittent power supply contribution is configured to associate the respective portions of the metered power supply and the metered power consumption of a highest priority level load, prior to associating respective portions of a remaining portion of the metered power supply and the metered power consumption of a lower priority level load.

39. The system as claimed in any one of claims 35 to 38, further comprising means for determining whether the intermittent power supply contribution meets a specified criterion.

40. The system as claimed in claim 39, further comprising means for updating a forward probabilistic intermittent power supply contribution for the load based on whether the intermittent power supply contribution meets the specified criterion.

41. The system as claimed in claims 39 or 40, wherein the specified criterion comprises one or more of a group consisting of at least one percentage blend, at least one penetration ratio, at least one cross-correlation, and at least one correlation among a secondary source and the load.

42. The system as claimed in any one of claims 35 to 41, further comprising means for validating one or more consumer constraints associated with the load.

43. The system as claimed in any one of claims 35 to 42, wherein the aggregate intermittent power source comprises one or more intermittent power generating facilities connected to the power grid.

44. A metering method for a power grid comprising:

metering power supply of an aggregate intermittent power source connected to the power grid;

metering power consumption of a load connected to the power grid at the time; and

metering an intermittent power supply contribution for the load based on the metered power supply and the metered power consumption.

45. The method as claimed in claim 44, wherein the metering the intermittent power supply contribution is configured to associate at least respective portions of the metered power supply and the metered power consumption.

46. The method as claimed in claim 45, wherein the metering the intermittent power supply contribution is configured to associate the respective portions of the metered power supply and the metered power consumption based on a priority level of the load.

47. The method as claimed in claim 46, wherein the metering the intermittent power supply contribution is configured to associate the respective portions of the metered power supply and the metered power consumption of a highest priority level load, prior to associating respective portions of a remaining portion of the metered power supply and the metered power consumption of a lower priority level load.

48. The method as claimed in any one of claims 44 to 47, further comprising determining whether the intermittent power supply contribution meets a specified criterion.

49. The method as claimed in claim 48, further comprising updating a forward probabilistic intermittent power supply contribution for the load based on whether the intermittent power supply contribution meets the specified criterion.

50. The method as claimed in claims 48 or 49, wherein the specified criterion comprises one or more of a group consisting of at least one percentage blend, at least one penetration ratio, at least one cross-correlation, and at least one correlation among a secondary source and the load.

51. The method as claimed in any one of claims 44 to 50, further comprising validating one or more consumer constraints associated with the load.

52. The method as claimed in any one of claims 44 to 51, wherein the aggregate intermittent power source comprises one or more intermittent power generating facilities connected to the power grid.

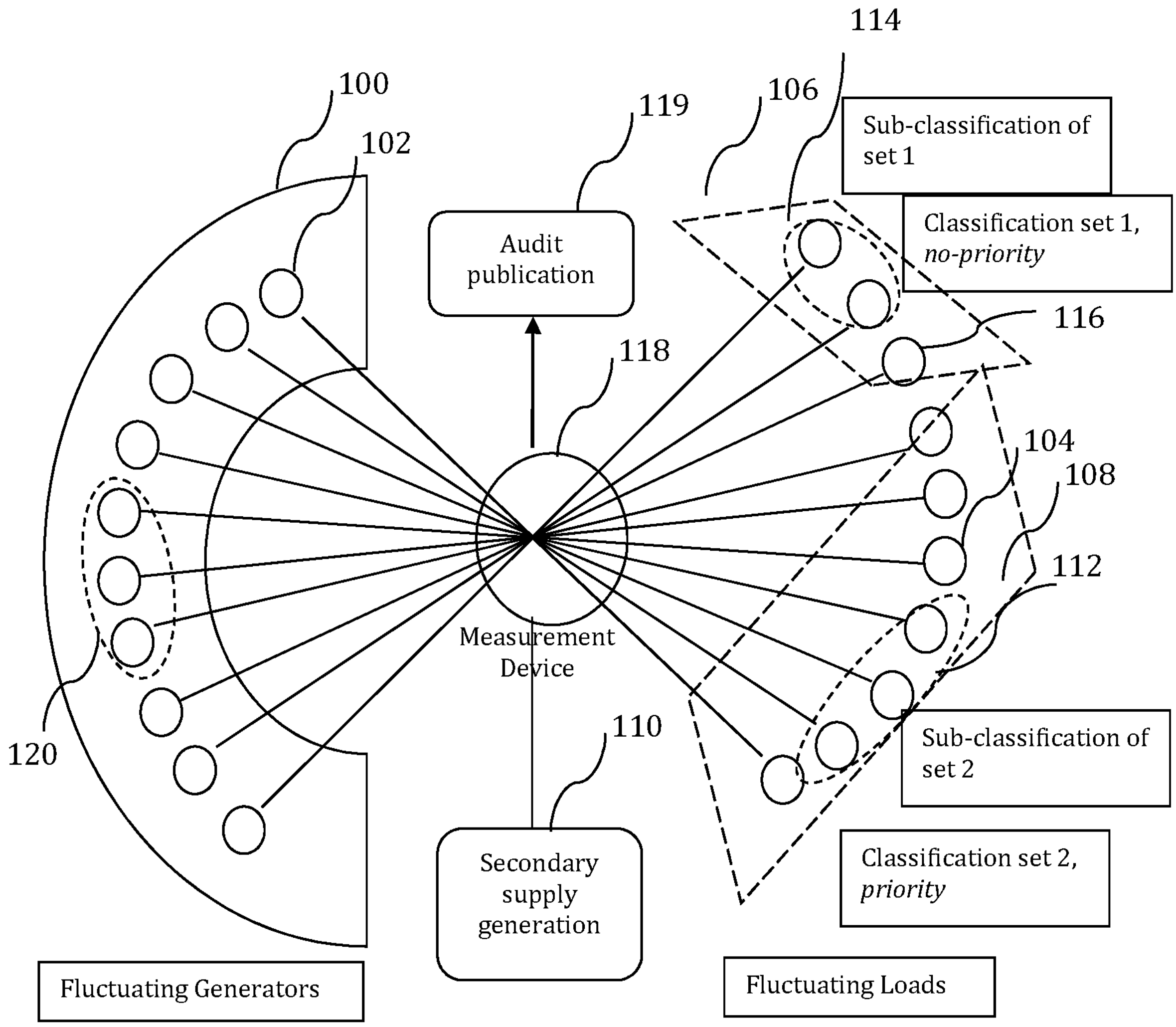

114
100
119
106
102
Sub-classification of set 1
Audit publication
Classification set 1, *no-priority*
116
118
104
108
112
Measurement Device
110
120
Sub-classification of set 2
Secondary supply generation
Classification set 2, *priority*
Fluctuating Generators
Fluctuating Loads

Fig. 1

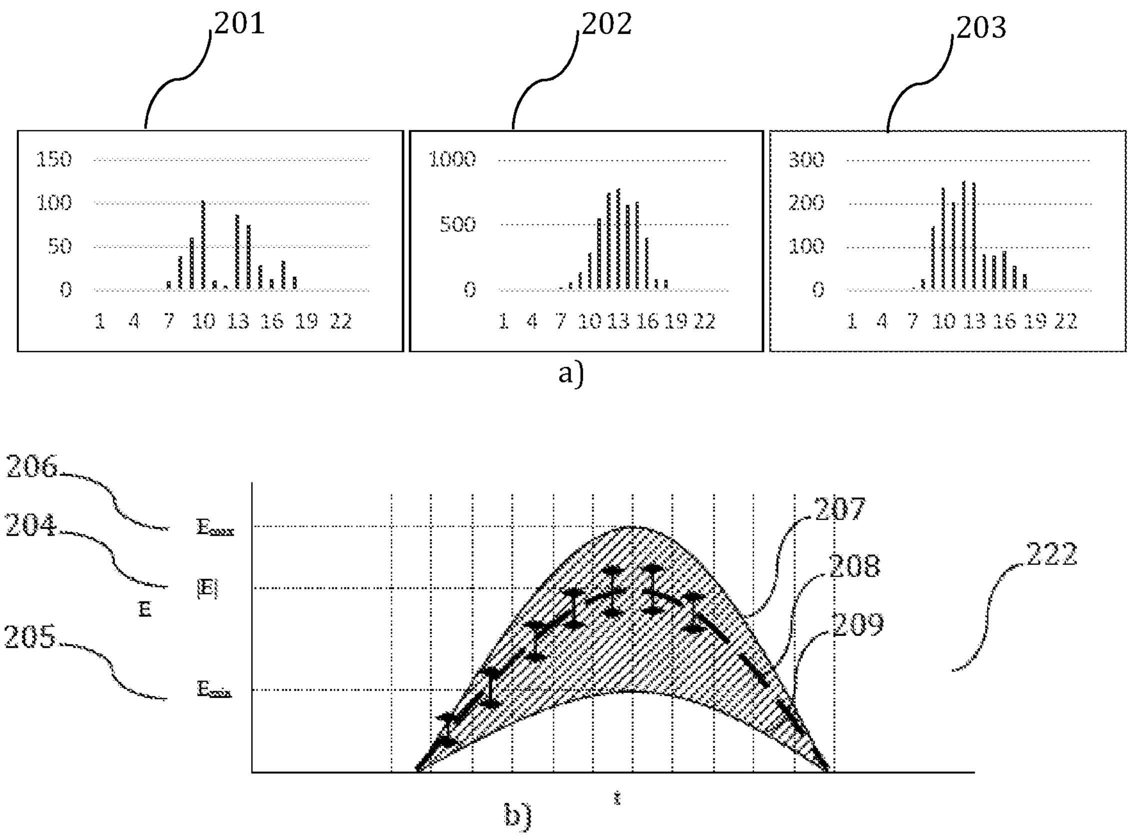

201
202
203
150
100
50
0
1 4 7 10 13 16 19 22
1000
500
0
1 4 7 10 13 16 19 22
300
200
100
0
1 4 7 10 13 16 19 22
a)
206
204
205
E
E_{max}
|E|
E_{min}
207
208
209
222
t
b)

Fig. 2

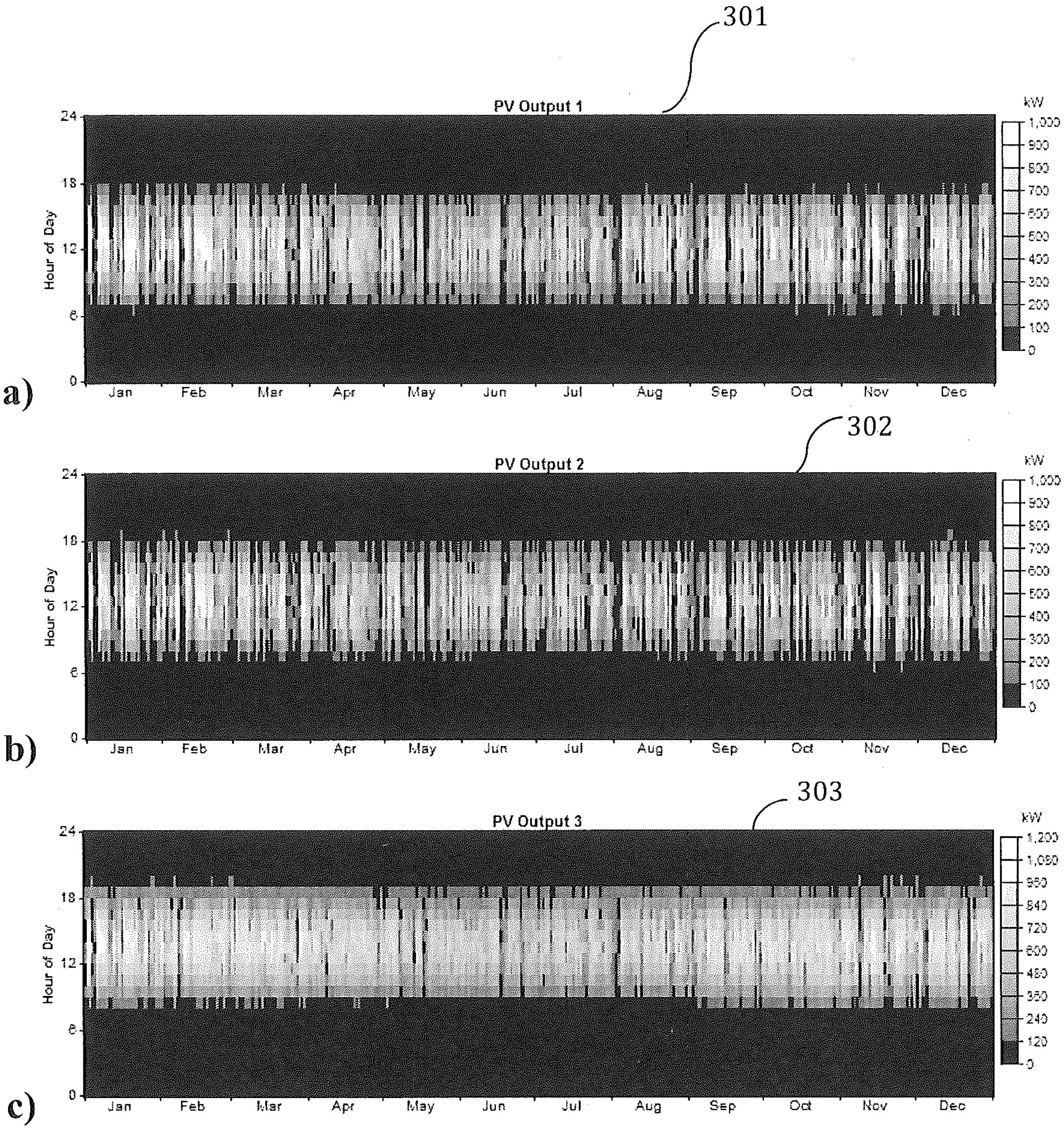

301
PV Output 1
Hour of Day
kW
a)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
302
PV Output 2
b)
303
PV Output 3
c)

Fig. 3

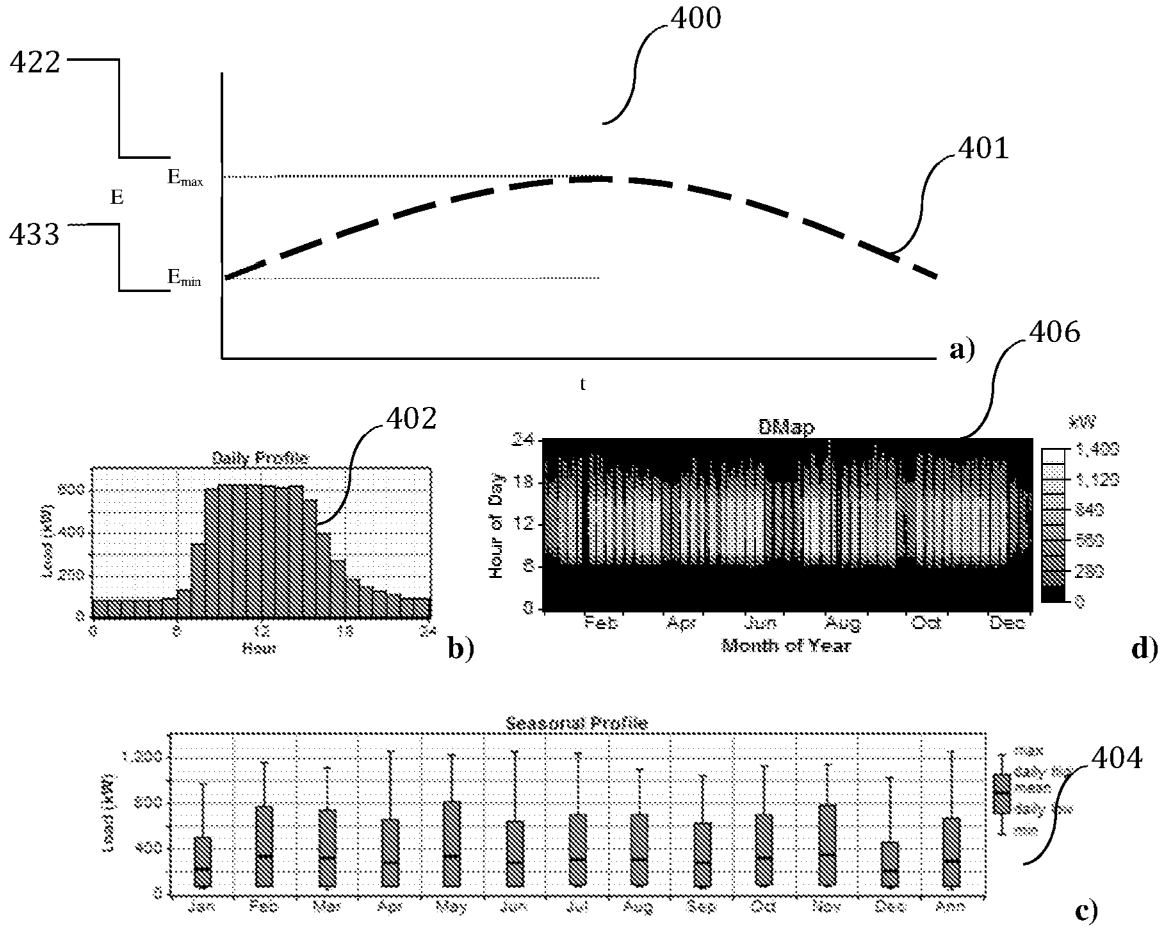

400
422
433
401
E
Emax
Emin
t
a)
406
402
Daily Profile
Load (kW)
Hour
b)
DMap
Hour of Day
Month of Year
Feb
Apr
Jun
Aug
Oct
Dec
kW
d)
Seasonal Profile
404
Load (kW)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Ann
max
mean
min
c)

Fig. 4

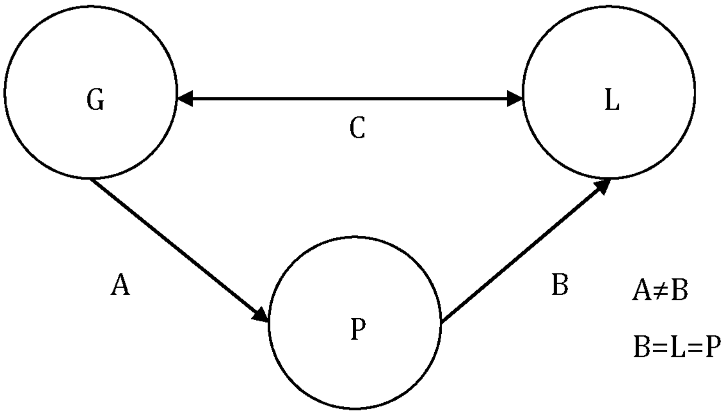


Fig. 5

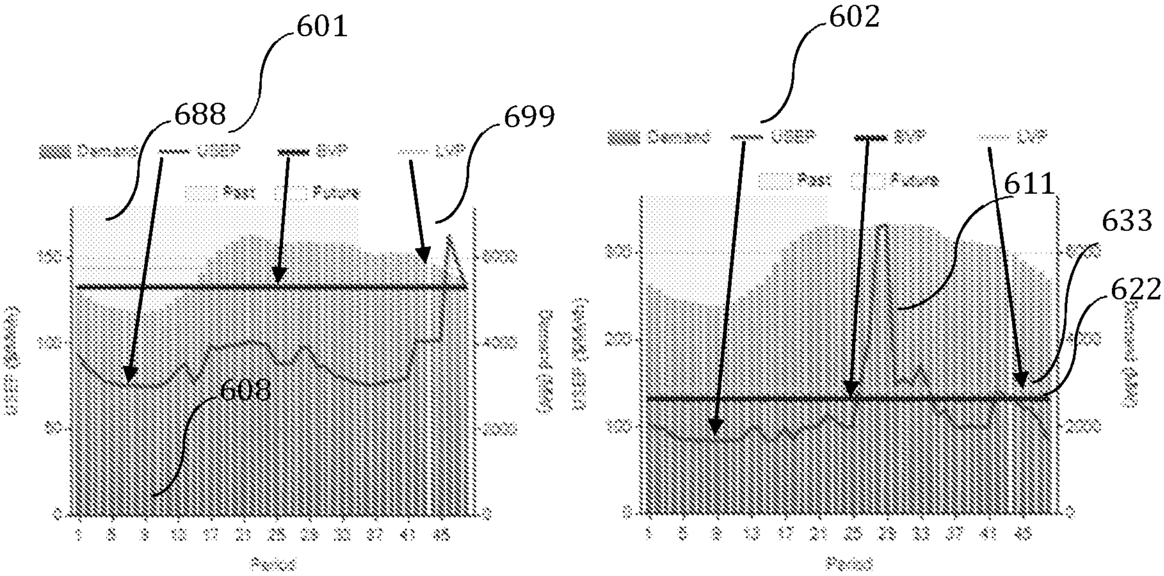


Fig. 6

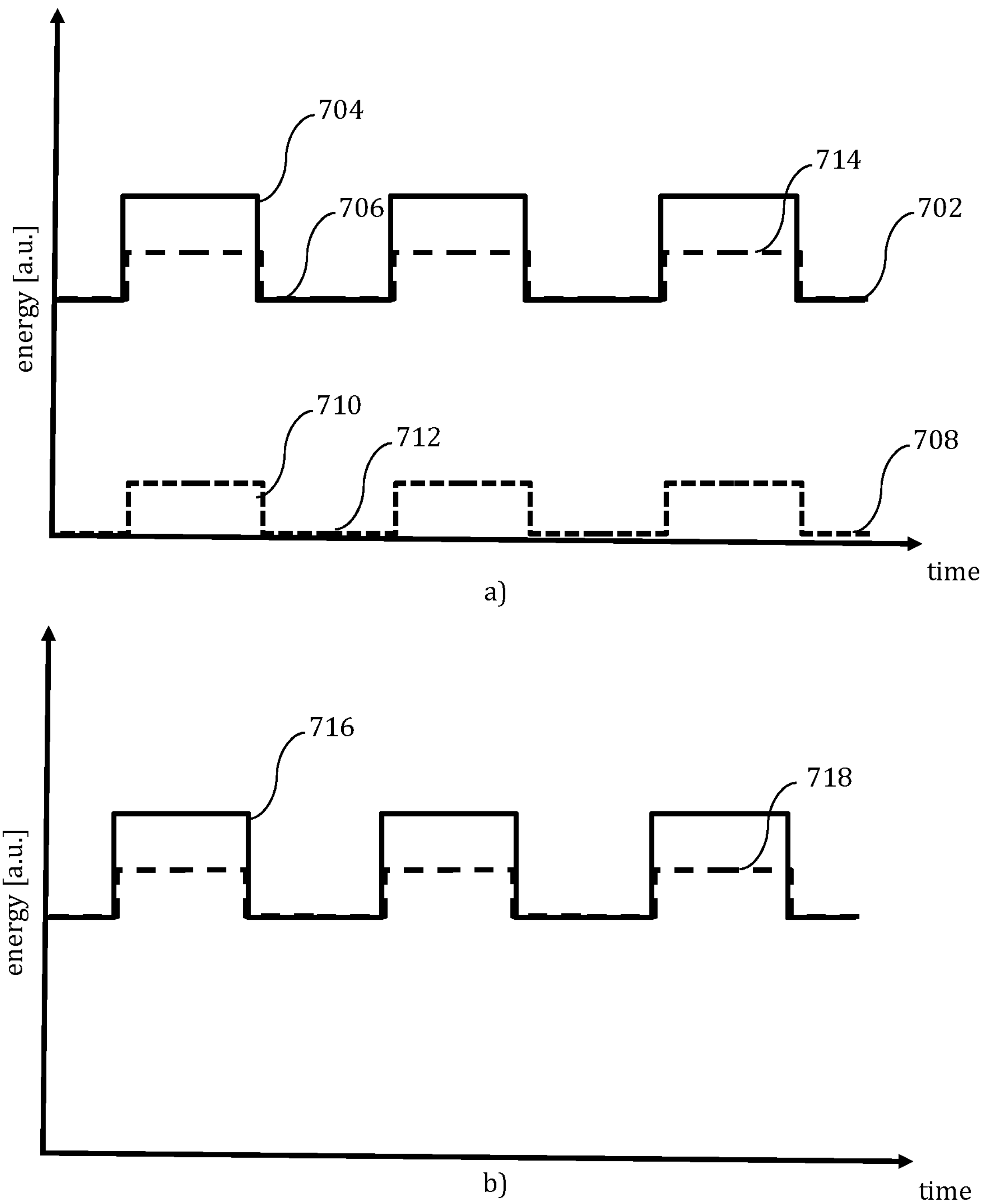

704
706
714
702
energy [a.u.]
710
712
708
time
a)
716
718
energy [a.u.]
time
b)

Fig. 7

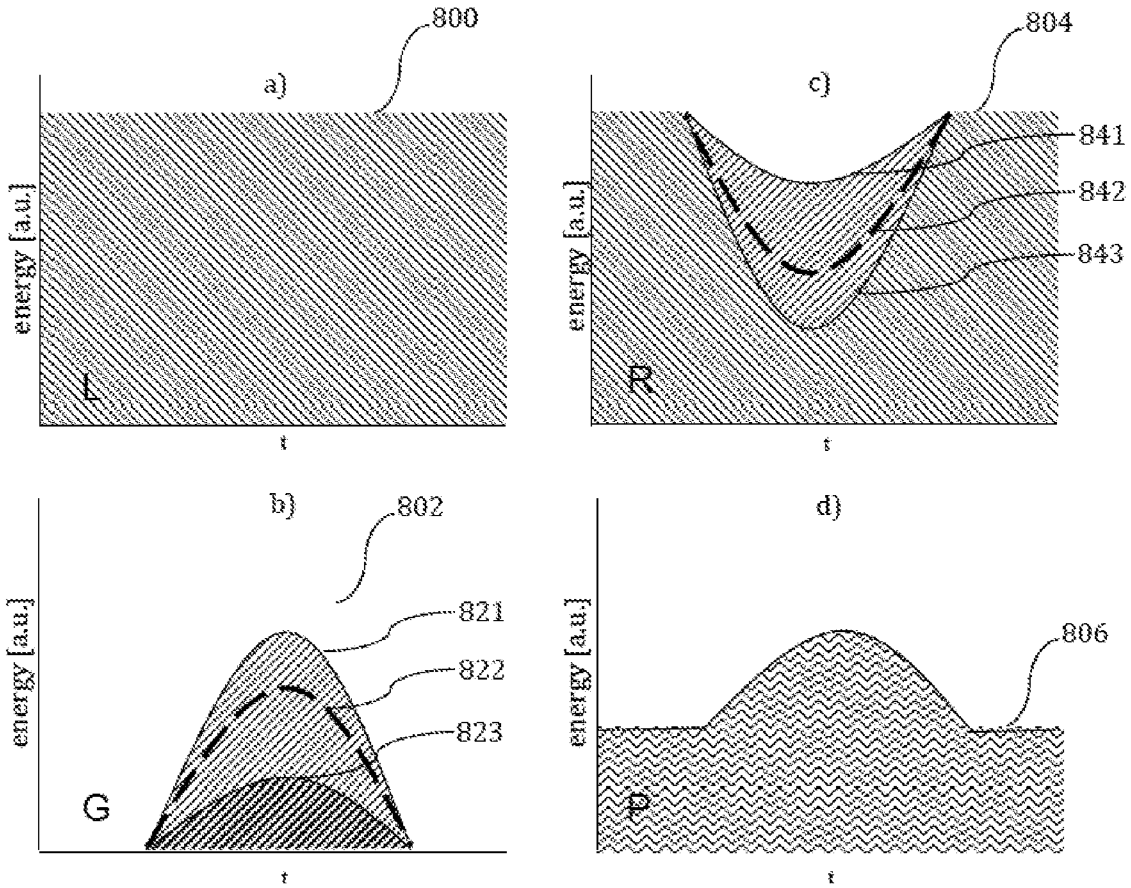

800
a)
energy [a.u.]
L
t
804
c)
841
842
843
energy [a.u.]
R
t
b)
802
821
822
823
energy [a.u.]
G
t
d)
806
energy [a.u.]
P
t

Fig. 8

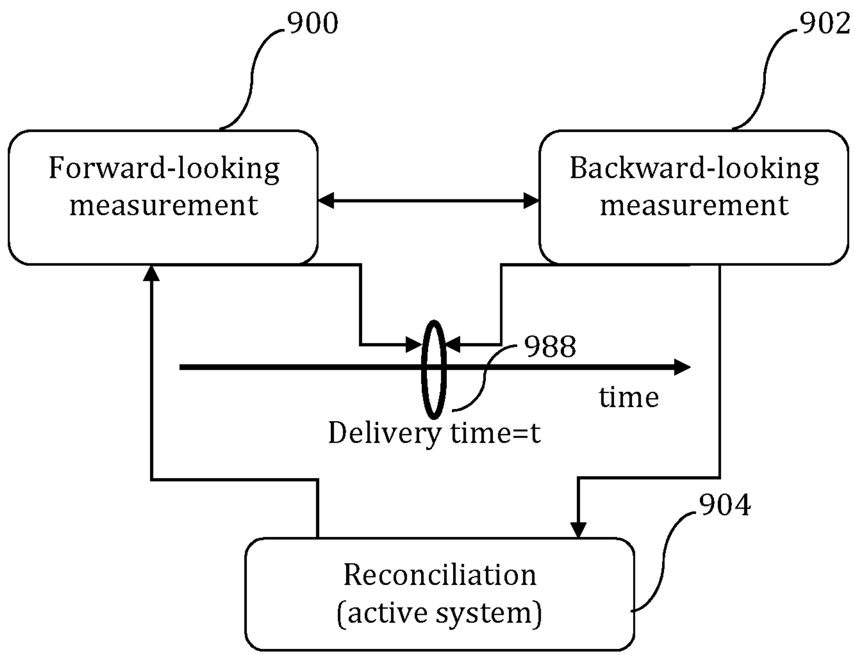

900
902
Forward-looking measurement
Backward-looking measurement
988
time
Delivery time=t
904
Reconciliation (active system)

Fig. 9

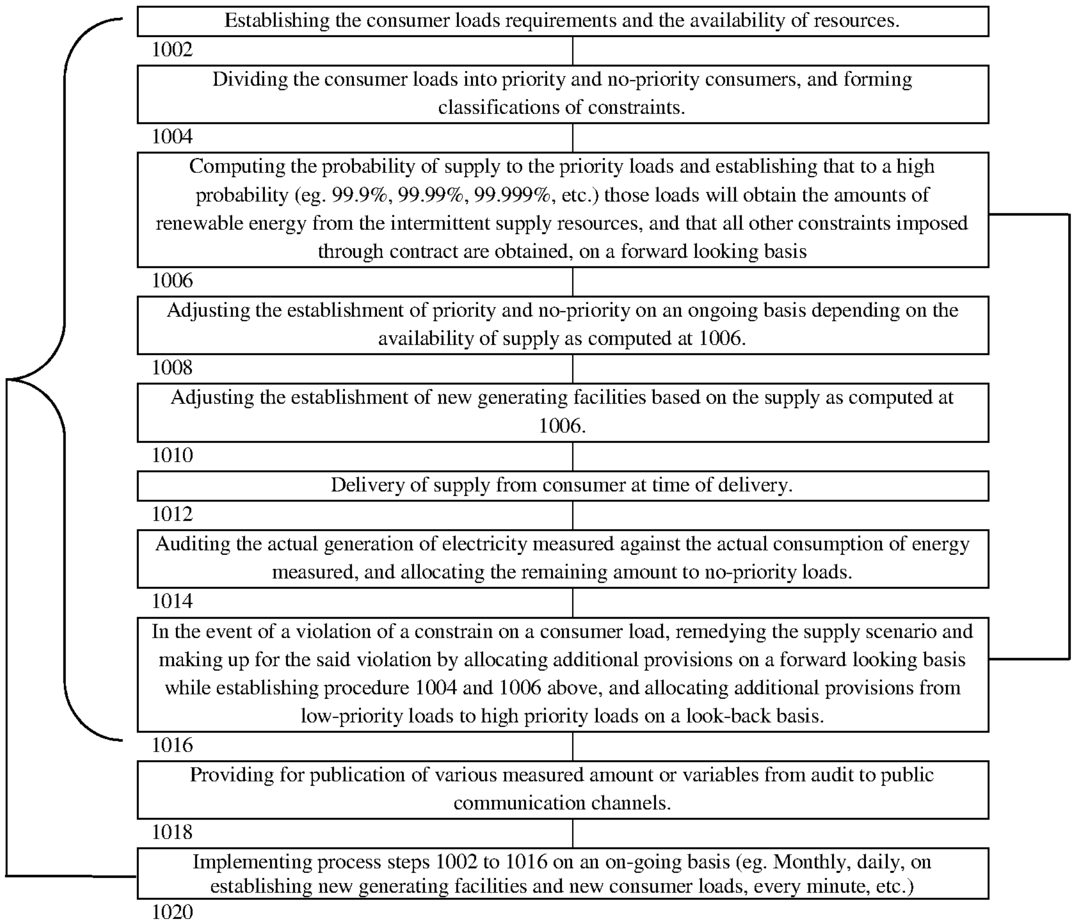

Establishing the consumer loads requirements and the availability of resources.
1002
Dividing the consumer loads into priority and no-priority consumers, and forming classifications of constraints.
1004
Computing the probability of supply to the priority loads and establishing that to a high probability (eg. 99.9%, 99.99%, 99.999%, etc.) those loads will obtain the amounts of renewable energy from the intermittent supply resources, and that all other constraints imposed through contract are obtained, on a forward looking basis
1006
Adjusting the establishment of priority and no-priority on an ongoing basis depending on the availability of supply as computed at 1006.
1008
Adjusting the establishment of new generating facilities based on the supply as computed at 1006.
1010
Delivery of supply from consumer at time of delivery.
1012
Auditing the actual generation of electricity measured against the actual consumption of energy measured, and allocating the remaining amount to no-priority loads.
1014
In the event of a violation of a constrain on a consumer load, remedying the supply scenario and making up for the said violation by allocating additional provisions on a forward looking basis while establishing procedure 1004 and 1006 above, and allocating additional provisions from low-priority loads to high priority loads on a look-back basis.
1016
Providing for publication of various measured amount or variables from audit to public communication channels.
1018
Implementing process steps 1002 to 1016 on an on-going basis (eg. Monthly, daily, on establishing new generating facilities and new consumer loads, every minute, etc.)
1020

Fig. 10

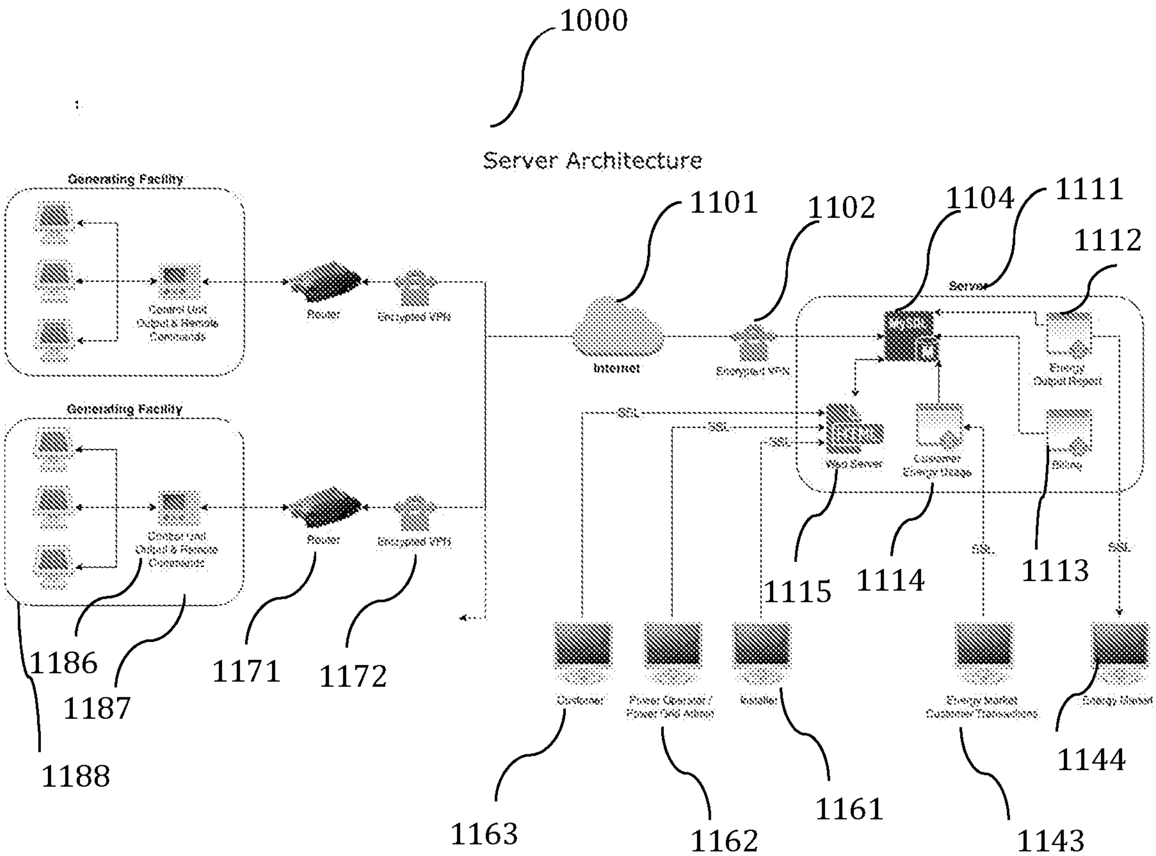

1000
Server Architecture
Generating Facility
Generating Facility
Router
Router
Encrypted VPN
Encrypted VPN
Internet
Encrypted VPN
Server
SSL
SSL
SSL
SSL
SSL
1101
1102
1104
1111
1112
1113
1114
1115
1186
1187
1188
1171
1172
1163
1162
1161
1143
1144

Fig. 11

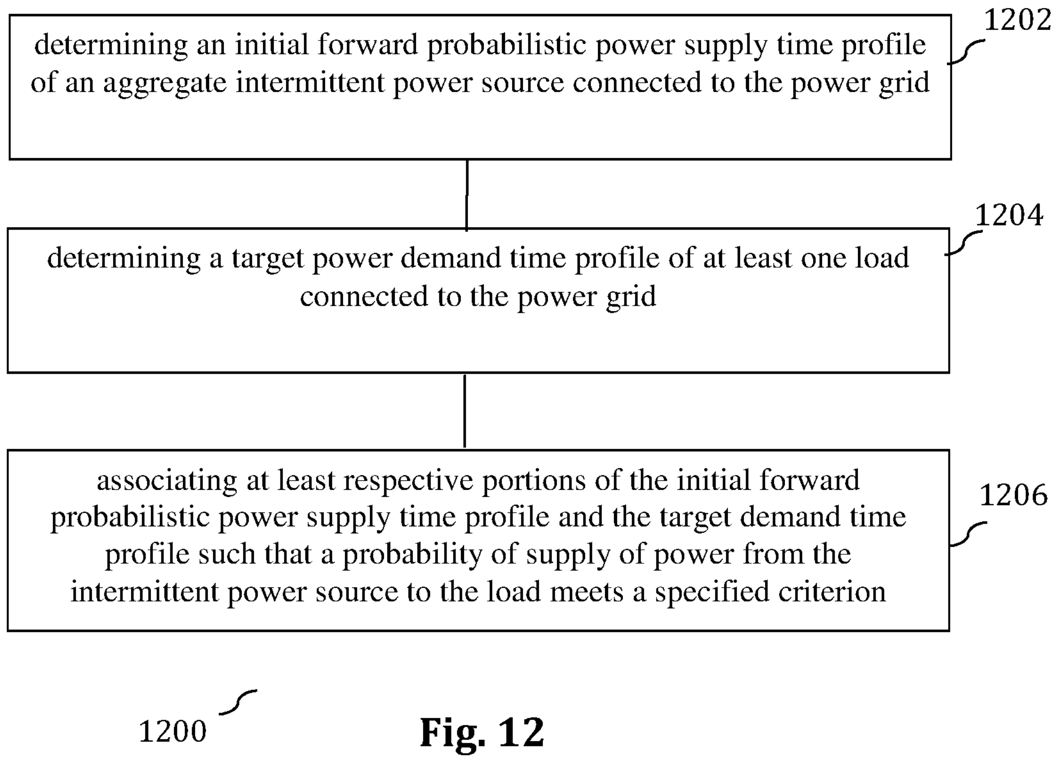

determining an initial forward probabilistic power supply time profile of an aggregate intermittent power source connected to the power grid
1202
determining a target power demand time profile of at least one load connected to the power grid
1204
associating at least respective portions of the initial forward probabilistic power supply time profile and the target demand time profile such that a probability of supply of power from the intermittent power source to the load meets a specified criterion
1206
1200

Fig. 12

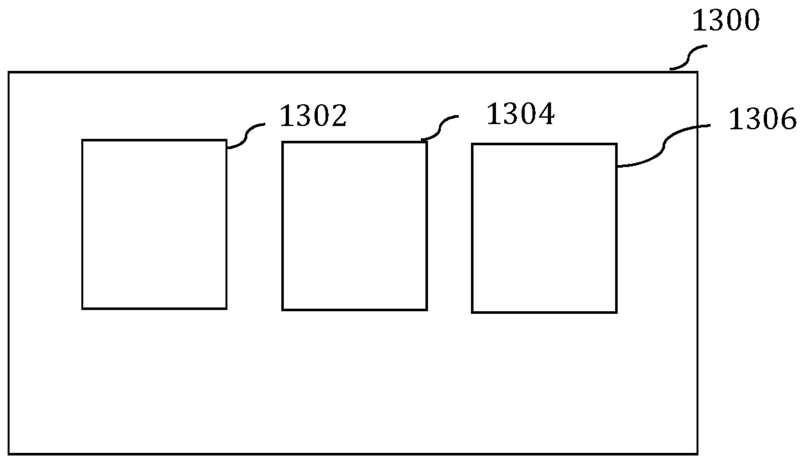
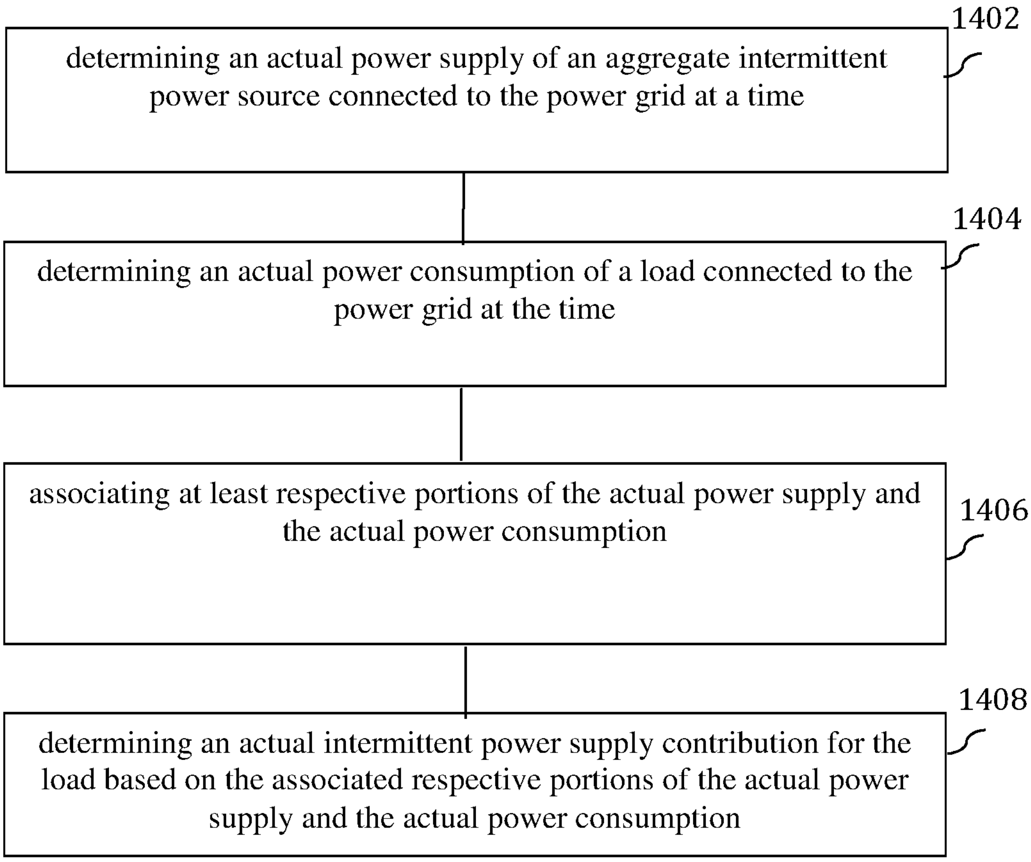

1300
1302
1304
1306

Fig. 13



1400

Fig. 14

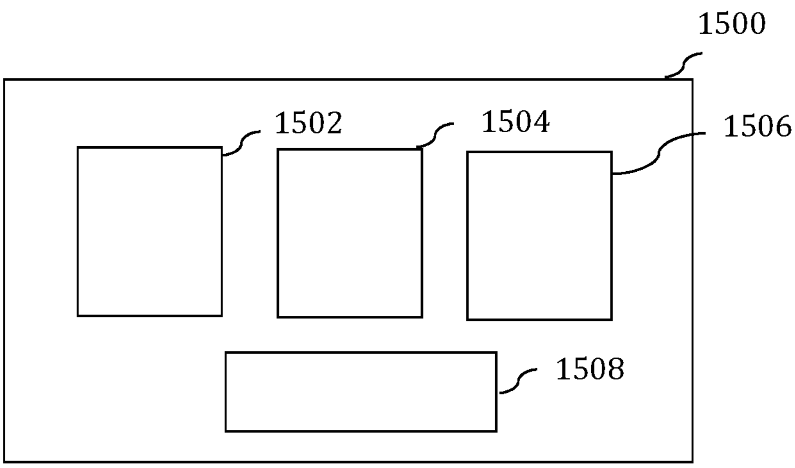


Fig. 15

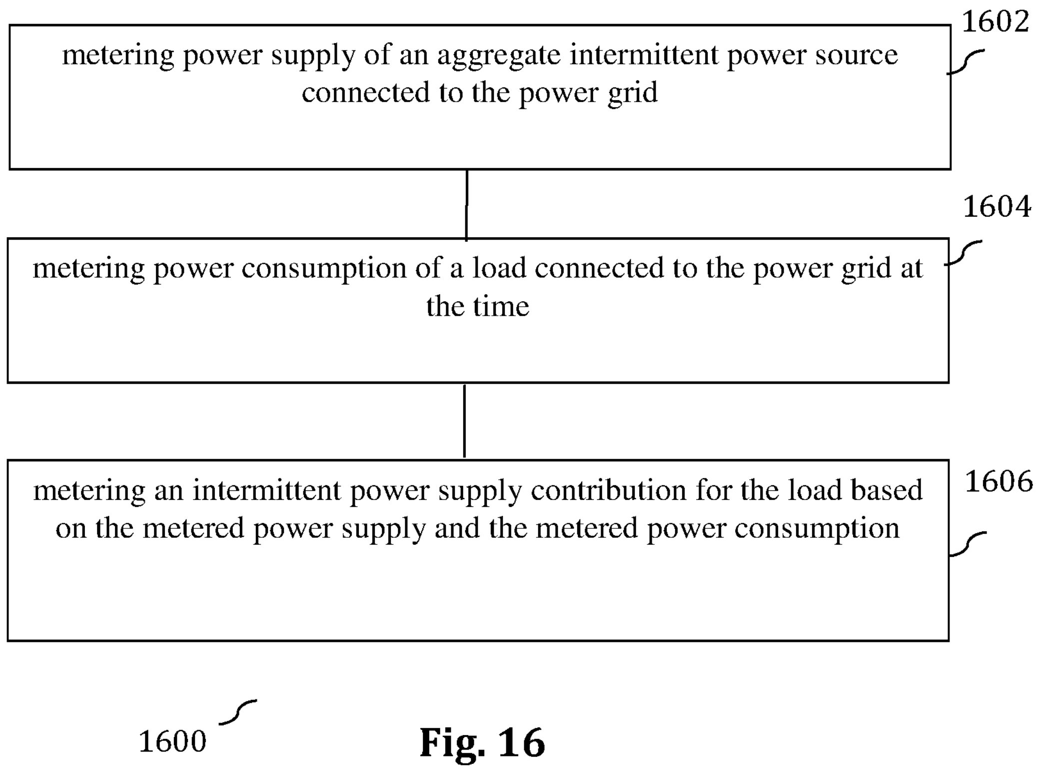

metering power supply of an aggregate intermittent power source connected to the power grid
1602
metering power consumption of a load connected to the power grid at the time
1604
metering an intermittent power supply contribution for the load based on the metered power supply and the metered power consumption
1606
1600

Fig. 16

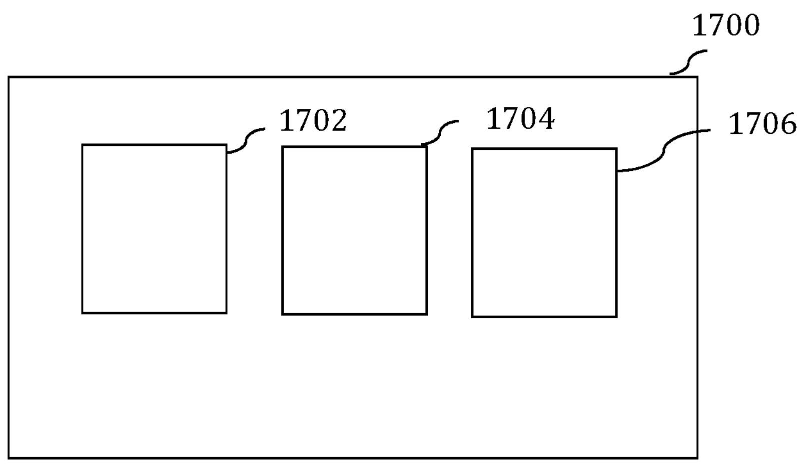

1700
1702
1704
1706

Fig. 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2015/050152

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H02J3/00(2006.01)i, H02J3/38(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. H02J3/00, H02J3/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2015
Registered utility model specifications of Japan 1996-2015
Published registered utility model applications of Japan 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2014-192981 A (CLEAN CRAFT CO., LTD.) 2014.10.06, paragraphs [0032], [0079], [0133], [0136], Fig. 1 (No Family)	19-20,22-28, 30-39,41-48, 50-52
Y	WO 2014/115556 A1 (KABUSHIKI KAISHA TOSHIBA) 2014.07.31, paragraphs [0052]-[0061] & JP 2014-143835 A	1-2,7-8, 10-11,16-17
Y	JP 2014-068426 A (HITACHI LIMITED) 2014.04.17, paragraph [0031] (No Family)	1-2,7-8, 10-11,16-17
A	US 2014/0214219 A1 (KABUSHIKI KAISHA TOSHIBA) 2014.07.31, paragraphs [0060]-[0061], Figs. 11,16-17 & JP 2014-150641 A & WO 2014/119153 A1	1-52

☑ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24.08.2015	01.09.2015

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office	Jun IWATA 5T 4052
3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No. +81-3-3581-1101 Ext. 3568

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2012-010549 A (FUJITSU LIMITED) 2012.01.12, paragraph [0056] (No Family)	1-52

(19)中华人民共和国国家知识产权局

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2017.06.23

(86)PCT国际申请的申请数据

PCT/SG2015/050152 2015.06.10

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WO2016/064341 EN 2016.04.28

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(51)Int.Cl.

H02J 3/00(2006.01)

H02J 3/38(2006.01)

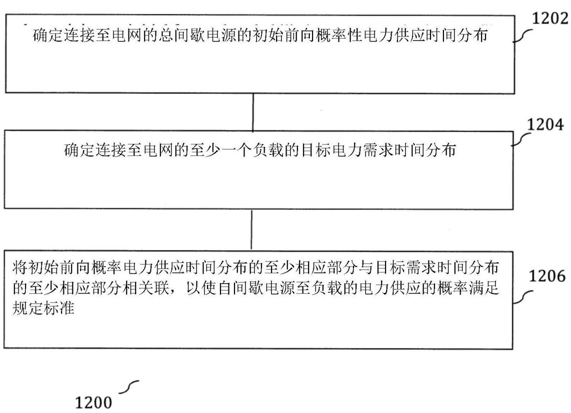
权利要求书4页 说明书24页 附图12页

(54)发明名称

电力网系统中的审计方法及系统、光伏功率注入及消耗的供电方法及系统

(57)摘要

一种在电力网中供应电力的方法、一种在电力网中供应电力的系统、一种在电力网中合并功率注入及消耗的方法、一种在电力网中合并功率注入及消耗的系统、一种用于电力网的计量系统、以及一种用于电力网的计量方法。在电力网中供应电力的方法,该方法包括:确定连接至该电力网的集合间歇性电源的初始前向概率性电力供应时间分布;确定连接至该电力网的至少一个负载的目标电力需求时间分布;以及将该初始前向概率性电力供应时间分布和该目标需求时间分布的至少相应部分进行关联,以使从该间歇性电源至该负载的电力供应的概率符合规定标准。



CN 107182219 A

1.一种在电力网中供应电力的方法,所述方法包括:

确定连接至所述电力网的集合间歇性电源的初始前向概率性电力供应时间分布;

确定连接至所述电力网的至少一个负载的目标电力需求时间分布;以及

将所述初始前向概率性电力供应时间分布及所述目标电力需求时间分布的至少相应部分进行关联,以使从所述间歇性电源至所述负载的电力供应的概率符合规定标准。

2.如权利要求1所述的方法,进一步包括基于所述初始前向概率性电力供应时间分布的所关联的部分而产生更新的前向概率性电力供应分布,所述更新的前向概率性电力供应分布专用于所述负载。

3.如权利要求1或2所述的方法,进一步包括基于所述初始前向概率性电力供应时间分布及所述目标电力需求时间分布的所关联的至少相应部分,而输出用于所述负载的前向概率性间歇性电力供应贡献。

4.如权利要求1至3中任一项所述的方法,其中基于所述初始前向概率性电力供应时间分布和所述目标电力需求时间分布的互相关的期望值而计算所述概率。

5.如权利要求1至4中任一项所述的方法,其中基于所述负载的优先权等级而将所述前向概率性电力供应分布和所述目标电力需求时间分布的所述至少相应部分进行关联,所述方法进一步包括将所述集合间歇性电源的间歇性发电设施的子集专用于针对最高优先权负载的所述供应、以及基于排除所述子集而产生所述更新的前向概率性电力供应分布。

6.如权利要求1至5中任一项所述的方法,进一步包括确定从所述集合间歇性电源至所述负载的测量电力供应是否符合所述规定标准,以及基于所述测量电力供应而产生用于所述负载的实际间歇性电力供应贡献。

7.如权利要求1至6中任一项所述的方法,进一步包括验证与所述负载关联的一个或多个消费者约束。

8.如权利要求1至7中任一项所述的方法,其中所述集合间歇性电源包括连接至所述电力网的一个或多个间歇性发电设施。

9.如权利要求1至8中任一项所述的方法,其中所述规定标准包括由以下各项组成的组中的一个或多个:次级源和所述负载之间的至少一个相关、至少一个百分比混合、至少一个穿透比、以及至少一个互相关。

10.一种在电力网中供应电力的系统,所述系统包括:

用于确定连接至所述电力网的集合间歇性电源的初始前向概率性电力供应时间分布的设备;

用于确定连接至所述电力网的至少一个负载的目标电力需求时间分布的设备;以及

用于将所述初始前向概率性电力供应时间分布和所述目标电力需求时间分布的至少相应部分进行关联以使从所述集合间歇性电源至所述负载的电力供应的概率符合规定标准的设备。

11.如权利要求10所述的系统,进一步包括用于基于所述初始前向概率性电力供应时间分布的所关联的部分而产生更新的前向概率性电力供应分布的设备,所述更新的前向概率性电力供应分布专用于所述负载。

12.如权利要求10或11所述的系统,进一步包括用于基于所述初始前向概率性电力供应时间分布和所述目标电力需求时间分布的所关联的至少相应部分而输出用于所述负载

的前向概率性间歇性电力供应贡献的设备。

13.如权利要求10至12中任一项所述的系统，其中基于所述初始前向概率性电力供应时间分布和所述目标电力需求时间分布的互相关的期望值而计算所述概率。

14.如权利要求10至13中任一项所述的系统，其中基于所述负载的优先权等级而将所述前向概率性电力供应分布和所述目标电力需求时间分布的所述至少相应部分进行关联，所述方法进一步包括将所述集合间歇性电源的间歇性发电设施的子集专用于针对最高优先权负载的所述供应、以及基于排除所述子集而产生所述更新的前向概率性电力供应分布。

15.如权利要求10至14中任一项所述的系统，进一步包括用于确定从所述集合间歇性电源至所述负载的测量电力供应是否符合所述规定标准、以及基于所述测量电力供应而产生用于所述负载的实际间歇性电力供应贡献的设备。

16.如权利要求10至15中任一项所述的系统，进一步包括用于验证与所述负载关联的一个或多个消费者约束的设备。

17.如权利要求10至16中任一项所述的系统，其中所述集合间歇性电源包括连接至所述电力网的一个或多个间歇性发电设施。

18.如权利要求10至17中任一项所述的系统，其中所述规定标准包括由以下各项组成的组中的一个或多个：次级源和所述负载之间的至少一个相关、至少一个百分比混合、至少一个穿透比、以及至少一个互相关。

19.一种在电力网中合并功率注入和消耗的方法，所述方法包括：

确定在一时间连接至所述电力网的集合间歇性电源的实际电力供应；

确定在所述时间连接至所述电力网的负载的实际功率消耗；

将所述实际电力供应和所述实际功率消耗的至少相应部分进行关联；以及

基于所述实际电力供应和所述实际功率消耗的所关联的相应部分而确定用于所述负载的实际间歇性电力供应贡献。

20.如权利要求19所述的方法，进一步包括确定从所述集合间歇性电源至所述负载的所确定实际间歇性电力供应贡献是否符合规定标准。

21.如权利要求20所述的方法，进一步包括基于从所述集合间歇性电源至所述负载的所述实际电力供应是否符合所述规定标准，而更新用于所述负载的前向概率性间歇性电力供应贡献。

22.如权利要求20或21所述的方法，其中所述规定标准包括由以下各项组成的组中的一个或多个：次级源和所述负载之间的至少一个相关、至少一个百分比混合、至少一个穿透比、以及至少一个互相关。

23.如权利要求19至22中任一项所述的方法，其中基于所述负载的优先权等级而将所述实际电力供应和所述实际功率消耗的所述至少相应部分进行关联。

24.如权利要求23所述的方法，进一步包括在将较低优先权等级负载的剩余实际电力供应和所述实际功率消耗的相应部分进行关联之前，将最高优先权等级负载的所述实际电力供应和所述实际功率消耗的相应部分进行关联。

25.如权利要求19至24中任一项所述的方法，进一步包括验证与所述负载关联的一个或多个消费者约束。

26.如权利要求19至25中任一项所述的方法，其中所述集合间歇性电源包括连接至所述电力网的一个或多个间歇性发电设施。

27.一种用于在电力网中合并功率注入及消耗的系统，所述系统包括：

用于确定在一时间连接至所述电力网的集合间歇性电源的实际电力供应的设备；

用于确定在所述时间连接至所述电力网的负载的实际功率消耗的设备；

用于将所述实际电力供应和所述实际功率消耗的至少相应部分进行关联的设备；以及

用于基于所述实际电力供应和所述实际功率消耗的所关联的相应部分而确定用于所述负载的实际间歇性电力供应贡献的设备。

28.如权利要求27所述的系统，进一步包括用于确定从所述集合间歇性电源至所述负载的所确定实际间歇性电力供应贡献是否符合规定标准的设备。

29.如权利要求28所述的系统，进一步包括用于基于从所述集合间歇性电源至所述负载的所述实际电力供应是否符合所述规定标准，而更新用于所述负载的前向概率性间歇性电力供应贡献的设备。

30.如权利要求28或29所述的系统，其中所述规定标准包括由以下各项组成的组中的一个或多个：次级源和所述负载之间的至少一个相关、至少一个百分比混合、至少一个穿透比、以及至少一个互相关。

31.如权利要求27至30中任一项所述的系统，其中基于所述负载的优先权等级而将所述实际电力供应和所述实际功率消耗的所述至少相应部分进行关联。

32.如权利要求31所述的系统，进一步包括用于在将较低优先权等级负载的剩余实际电力供应和所述实际功率消耗的相应部分进行关联之前，将最高优先权等级负载的所述实际电力供应和所述实际功率消耗的相应部分进行关联的设备。

33.如权利要求27至32中任一项所述的系统，进一步包括用于验证与所述负载关联的一个或多个消费者约束的设备。

34.如权利要求27至33中任一项所述的系统，其中所述集合间歇性电源包括连接至所述电力网的一个或多个间歇性发电设施。

35.一种用于电力网的计量系统，所述计量系统包括：

用于计量在一时间连接至所述电力网的集合间歇性电源的电力供应的设备；

用于计量在所述时间连接至所述电力网的负载的功率消耗的设备；以及

用于基于所计量电力供应和所计量功率消耗而计量用于所述负载的间歇性电力供应贡献的设备。

36.如权利要求35所述的计量系统，其中用于计量所述间歇性电力供应贡献的所述设备被配置为将所计量电力供应和所计量功率消耗的至少相应部分进行关联。

37.如权利要求36所述的计量系统，其中用于计量所述间歇性电力供应贡献的所述设备被配置为基于所述负载的优先权等级而将所计量电力供应和所计量功率消耗的所述至少相应部分进行关联。

38.如权利要求37所述的计量系统，其中用于计量所述间歇性电力供应贡献的所述设备被经配置为在将较低优先权等级负载的所计量电力供应和所计量功率消耗的剩余部分的相应部分进行关联之前，将最高优先权等级负载的所计量电力供应和所计量功率消耗的所述相应部分进行关联。

39.如权利要求35至38中任一项所述的计量系统,进一步包括用于确定所述间歇性电力供应贡献是否符合规定标准的设备。

40.如权利要求39所述的计量系统,进一步包括用于基于所述间歇性电力供应贡献是否符合所述规定标准,而更新用于所述负载的前向概率性间歇性电力供应贡献的设备。

41.如权利要求39或40所述的计量系统,其中所述规定标准包括由以下各项组成的组中的一个或多个:次级源和所述负载之间的至少一个相关、至少一个百分比混合、至少一个穿透比、以及至少一个互相关。

42.如权利要求35至41中任一项所述的计量系统,进一步包括用于验证与所述负载关联的一个或多个消费者约束的设备。

43.如权利要求35至42中任一项所述的计量系统,其中所述集合间歇性电源包括连接至所述电力网的一个或多个间歇性发电设施。

44.一种用于电力网的计量方法,所述计量方法包括:

计量在一时间连接至所述电力网的集合间歇性电源的电力供应;

计量在所述时间连接至所述电力网的负载的功率消耗;以及

基于所计量电力供应及所计量功率消耗,而计量用于所述负载的间歇性电力供应贡献。

45.如权利要求44所述的计量方法,其中所述计量所述间歇性电力供应贡献被配置为将所计量电力供应和所计量功率消耗的至少相应部分进行关联。

46.如权利要求45所述的计量方法,其中所述计量所述间歇性电力供应贡献被配置为基于所述负载的优先权等级而将所计量电力供应和所计量功率消耗的所述至少相应部分进行关联。

47.如权利要求46所述的计量方法,其中所述计量所述间歇性电力供应贡献被配置在将较低优先权等级负载的所计量电力供应和所计量功率消耗的剩余部分的相应部分进行关联之前,将最高优先权等级负载的所计量电力供应和所计量功率消耗的所述相应部分进行关联。

48.如权利要求44至47中任一项所述的计量方法,进一步包括确定所述间歇性电力供应贡献是否符合规定标准。

49.如权利要求48所述的计量方法,进一步包括基于所述间歇性电力供应贡献是否符合所述规定标准,而更新用于所述负载的前向概率性间歇性电力供应贡献。

50.如权利要求48或49所述的计量方法,其中所述规定标准包括由以下各项组成的组中的一个或多个:次级源和所述负载之间的至少一个相关、至少一个百分比混合、至少一个穿透比、以及至少一个互相关。

51.如权利要求44至50中任一项所述的计量方法,进一步包括验证与所述负载关联的一个或多个消费者约束。

52.如权利要求44至51中任一项所述的计量方法,其中所述集合间歇性电源包括连接至所述电力网的一个或多个间歇性发电设施。

电力网系统中的审计方法及系统、光伏功率注入及消耗的供电方法及系统

技术领域

[0001] 本发明大致地涉及一种在电力网中供应电力的方法、一种在电力网中供应电力的系统、一种在电力网中合并功率注入及消耗的方法、一种在电力网中合并功率注入及消耗的系统、一种用于电力网的计量系统、以及一种用于电力网的计量方法。

背景技术

[0002] 可再生电正成为用于向消费者供电的突出候选对象,某些消费者在其获得可再生电产品的需求上有不同要求。例如,当使用光伏电替代惯常的化石燃料源时,光伏电向消费者提供抵消二氧化碳及其他毒性排放物的清洁能量。可在能量计后方安装光伏发电机以用于特定负载,或可安装光伏发电机以经由连接至电力网网络而供应至能量网格或能量池中,或通过用于结算能源市场中的能量的合并方法,例如如在新加坡专利申请案第10201406883U号中所描述。还可经由电源网络将此能量供应给消费者。此外,可连接各种发电机的集合,以供应给多个能量消费者的负载。

[0003] 由光伏源供应能量的一个难题为该能量是间歇性的。无法确定使发电机在任何给定时间点精确贡献电量。同样,向终端消费者提供光伏能量的供应系统,尤其经由网格连接方案的供应系统的发展已相当不足。使此难题恶化的是,在最商用及最工业用的设定中,光伏系统连接在负载计量后方的嵌入式发电方案通常不适于提供该负载的可再生能量需要,且无法最优化以使该可再生能量的消费者可根据所需可再生供应约束来建立特定约束,这些可再生供应约束诸如为负载所需之总穿透。在此类嵌入式发电方案中,对那些消费者在可再生能量供应上的约束为仅根据对那些消费者在“计量后”规划中所特有的负载要求(例如构造屋顶)而言局部的实体空间量来确定。

[0004] 向负载或一组负载供应可再生能量中的另一难题是,当可再生能量发电机正向终端顾客贡献清洁电力时,那些顾客意欲确定与这些负载的能量消耗相关联的可再生能量穿透的量。这种行为可便于能量消费者采用清洁能量。

[0005] 本发明的实施例提供设法解决上述难题中的至少一个的一种在电力网中供应电力的方法、一种在电力网中供应电力的系统、一种在电力网中合并功率注入及消耗的方法、一种在电力网中合并功率注入及消耗的系统、一种用于电力网的计量系统、以及一种用于电力网的计量方法。

发明内容

[0006] 根据本发明的第一方面,提供一种在电力网中供应电力的方法,该方法包括:确定连接至该电力网的集合间歇性电源的初始前向概率性电力供应时间分布;确定连接至该电力网的至少一个负载的目标电力需求时间分布;以及将该初始前向概率性电力供应时间分布额该目标电力需求时间分布的至少相应部分进行关联,以使从该集合间歇性电源至该负载的电力供应的概率符合规定标准。

[0007] 根据本发明的第二方面，提供一种在电力网中供应电力的系统，该系统包括：用于确定连接至该电力网的集合间歇性电源的初始前向概率性电力供应时间分布的设备；用于确定连接至该电力网的至少一个负载的目标电力需求时间分布的设备；以及用于将该初始前向概率性电力供应时间分布和该目标电力需求时间分布的至少相应部分进行关联以使从该间歇性电源至该负载的电力供应的概率符合规定标准的设备。

[0008] 根据本发明的第三方面，提供一种在电力网中合并功率注入及消耗的方法，该方法包括：确定在一时间连接至该电力网的集合间歇性电源的实际电力供应；确定在该时间连接至该电力网的负载的实际功率消耗；将该实际电力供应及该实际功率消耗的至少相应部分进行关联；以及基于该实际电力供应和该实际功率消耗的这些关联相应部分而确定用于该负载的实际间歇性电力供应贡献。

[0009] 根据本发明的第四方面，提供一种用于在电力网中合并功率注入及消耗的系统，该系统包括：用于确定在一时间连接至该电力网的集合间歇性电源的实际电力供应的设备；用于确定在该时间连接至该电力网的负载的实际功率消耗的设备；用于关联该实际电力供应及该实际功率消耗的至少相应部分的设备；以及用于基于该实际电力供应及该实际功率消耗的这些关联相应部分而确定用于该负载的实际间歇性电力供应贡献的设备。

[0010] 根据本发明的第五方面，提供一种用于电力网的计量系统，该系统包括：用于计量在一时间连接至该电力网之集合间歇性电源的电力供应的设备；用于计量在该时间连接至该电力网的负载之功率消耗的设备；以及用于基于该所计量电力供应及该所计量功率消耗以计量用于该负载的间歇性电力供应贡献的设备。

[0011] 根据本发明的第六方面，提供一种用于电力网的计量方法，该方法包括：计量在一时间连接至该电力网的集合间歇性电源的电力供应；计量在该时间连接至该电力网的负载的功率消耗；以及基于该所计量电力供应及该所计量功率消耗，以计量用于该负载的间歇性电力供应贡献。

附图说明

[0012] 根据以下书面描述且结合附图，仅通过举例，本发明的实施例将得到更好了解且容易地对普通技术人员明显。

[0013] 图1显示例示根据示例性实施例供应给相关联消耗容量的一组负载的相关联统计发电容量的一组间歇性发电机的示意图，其中这些负载经通过供应约束而分类。

[0014] 图2(a)和2(b)显示例示根据示例性实施例的统计间歇性供应分布()的评价的示意图。

[0015] 图3(a)至3(c)显示根据示例性实施例说明连接至同一AC电力网网络的三个单独发电设施的年输出的所测量统计变化的图片，其中通过色度表代表总电输出，且使用水平绘制的天数及垂直绘制的当天时间代表时间。

[0016] 图4(a)至4(d)显示例示根据示例性实施例的所建立消费者负载分布的特性的示意图。

[0017] 图5显示例示根据示例性实施例的经由市场池P从间歇性发电设施G至消费者负载L的能量供应的示意图。

[0018] 图6显示例示根据示例性实施例的在特定日的特定时间的批发能量池(wholesale energy pool)的特性的示意图，其中批发能量池特性确定可用资源及二次发电资源的约束。

[0019]　图7(a)和7(b)显示根据示例性实施例的实现针对能量平百分比(flat percentage of energy)情况及对负载的相关联次级发电供应而言的抵消的过程。

[0020]　图8(a)至8(d)显示例示根据示例性实施例的峰值能量抵消供应方案的示意图，其中将源自批发能量池的基础负载能量传送至消费者，且将供应负载自批发市场波动性而与由最优化可再生穿透方案下的光伏能量的供应峰值能量需求的周期的相关进行分离；其中(a)为假定负载分布，(b)为所集合发电资源的概率密度分布，(c)为所修改负载分布，及(d)为显示对间歇性能量资源的要求相关的特性批发池分布。

[0021]　图9显示例示根据示例性实施例的供应过程与审计过程之间的关系的示意图，其中供应向前投射向时间t，且审计回顾向时间t。

[0022]　图10显示显示根据示例性实施例的用于关联供应方法学及审计方法学的过程流程图。

[0023]　图11为根据示例性实施例的信息技术系统的代表性构造的体系例示。

[0024]　图12显示例示根据示例性实施例的在电力网中供应电力的方法的流程图。

[0025]　图13显示例示用于在电力网中供应电力的系统的示意图。

[0026]　图14显示例示根据示例性实施例的在电力网中合并功率注入及消耗的方法的流程图。

[0027]　图15显示例示用于在电力网中合并功率注入及消耗的系统的示意图。

[0028]　图16显示例示用于电力网的计量系统的示意图。

[0029]　图17显示例示根据示例性实施例的用于电力网的计量方法的流程图。

具体实施方式

[0030]　本发明的实施例提供一种用于建立以下两者的系统及方法：能量供应服务，其向能量消费者提供各种选项，这些能量消费者设法获得可再生能量或光伏能量以作为该能量消费者的能量混合(energy blend)的一部分，其中可在建立供应的测量之前，针对能量消费者而确定最小可再生穿透及其他限制的各种等级；而此外，关联审计方法学解决在回顾基础上将历史可再生穿透等级的供应提供给那些能量消费者，以便确认那些消费者确实接受该可再生能量供应的条件。

[0031]　在前瞻(forward looking)方案中，示例性实施例中的供应方法说明了一组间歇性能量发电机的随机性质。在回顾(backward looking)方案中，根据示例性实施例的审计方法说明了实际历史可再生能量穿透等级。在此类方案中，可随后使用供应方法及审计方法以在前瞻基础及后顾基础上建立通过消费者所要求的能量产品及关联约束，同时建立经验测量方法以验证这些产品约束正由操作多个间歇性发电设施的能量公用设施而符合。

[0032]　示例性实施例可满足消费者对于在审计下审查供应等级及关联的可再生能量等级的方法的需要，该方法确认这些消费者在约束下接收供应，这些约束在这些消费者的供应合同中已确定，且示例性实施例可满足供应商对于前瞻供应方法的需要，该方法可用概率性方式将所集合间歇性资源分配给那些消费者负载，以使得这些资源可向那些消费者提供这些资源将能够满足所需那些约束的保证及担保。为此目的，可有利地确定代表发电资

源及将供应的负载的概率分布函数(Probability Distribution Function;PDF)。

[0033] 在以下说明中,假定发电设施为可经由电力网将能量提供给能量消费者的可再生发电机。可假定供应方案以实现能量池,在该能量池中将能量放入或取出,以提供给顾客。将通过计量装置来指示能量流动,该计量装置用以分别建立单独负载及发电机的需求与供应。假定消费者负载具有根据这些负载所需混入负载需求中之间歇性能量数量的各种约束或请求。例如,消费者可要求来自间歇性发电机的100%的能量,而其他消费者仅请求特定可再生穿透比。以下假定当消费者请求供应合同及建立关联约束时通过消费者使与负载关联的信息对电供应商可用。电力供应运行集合供应系统,该系统包括共同形成发电基础的各种发电设施。供应商还可获得另外的能量以满足次级源的消费者负载需求,该次级源诸如能源市场池或后备发电机。

[0034] 本说明书还公开用于进行这些方法的操作的装置(本文还称为"用于进行这些方法的操作的设备(means)")。可专门构造此类装置用于所要求目的,或此类装置可包括计算器件,该计算器件通过储存于电脑中的电脑程序而可选择地启动或重新配置。本文所提供的算法及显示并非固有地关于任何特定电脑或其他装置。可将各种通用机器用于根据本文教示的程序。可替换地,进行所要求方法步骤的更多专门装置的构造可以是适当的。此外,本说明书还隐含地公开一种电脑程序,其中将对本领域技术人员显而易见的是可通过电脑代码而实施本文描述的方法的单独步骤。该电脑程序不意图限制任何特定程序化语言及该程序化语言的实施方式。应当理解可使用各种程序化语言及这些程序化语言的代码来实现本文所含有的公开的教示。此外,该电脑程序不意图限制任何特定控制流。存在电脑程序的许多其他变体,这些变体可使用不同控制流,而不脱离本发明的精神或范畴。

[0035] 此外,可并行地而非按顺序地进行该电脑程序的步骤的一个或多个。可将此类电脑程序储存于任何电脑可读媒介上。该电脑可读媒介可包括储存器件,这些储存器件诸如磁碟或光碟、记忆体芯片或适于与通用电脑接合的其他储存器件。该电脑可读媒介还可包括诸如互联网系统中所示的硬布线媒介,或GSM行动电话系统中所示的无线媒介。当在此类通用电脑上加载及执行该电脑程序时,该电脑程序有效地使得装置实现优选方法的步骤。

[0036] 本发明还可实现为硬件模块。更特定而言,在硬件意义上,模块为设计用于其他部件或模块的功能性硬件单元。例如,可使用离散电子部件,诸如用于计量通过发电设施所供应的电力或用于计量由负载所消耗的电力,或该模块可形成整个电子电路(诸如专用集成电路(Application Specific Integrated Circuit(ASIC)))的一部分。存在众多其他可能性。本领域技术人员将了解,该系统还可实现为硬件模块与软体模块的组合。本发明的实施例的附图及例示的概述说明

[0037] 在此部分中,描述了本发明的如例示及附图中所表示的示例性实施例的每一元件的概述,其中在所进行部分中进一步详细说明每一元件。

[0038] 图1显示信息流及发电设施100或发电设施概率密度函数输出分布与消费者负载分布106及消费者负载分布108之间的关系、以及合并及调和系统118的所例示实施例。

[0039] 标记100代表所集合发电设施或此发电分布随时间推移的关联概率分布函数(PDF),该概率密度函数说明来自例如102的单独发电设施的输出的所集合概率。

[0040] 标记102代表单独发电设施或关联单独发电设施PDF,且说明特定发电设施安装的性能因素,这些性能因素包括但不限于发电设施102的阴影损耗(shading loss)、热损耗或

电气特性(electrical specification)。

[0041] 标记104为消费者负载分布，该消费者负载分布经分类以具有对发电设施或关联PDF分布100的优先权访问，且标记108为一组消费者负载分布，该组消费者负载分布经分类以具有对太阳能发电设施或关联PDF分布100及/或102的优先权访问，或分类以具有对发电设施的子设备(例如发电设施100的子设备120)的优先权。

[0042] 标记116为消费者负载分布，该消费者负载分布经分类以不具有对发电设施或关联PDF分布100的优先权访问，且标记106为一组消费者负载分布，该组消费者负载分布经分类以不具有对太阳能发电设施或关联PDF分布100及/或102的优先权访问，或分类以不具有对发电设施的子设备(例如发电设施100的子设备120)的优先权。如所描述，标记106、标记108、标记116或标记104可各自与表现电力消费者的负载需求分布及概率性需求方案的特性的PDF联系。

[0043] 标记112为消费者负载分布108的子类别，该消费者负载分布具有对太阳能的优先权以及至少第二特定约束要求，该第二特定约束要求代表来自发电设施100或发电设施的子设备120的关联所需的曝光量及传递。例如，标记112分类可以是在通过从间歇性发电设施100或120至分类负载组112的负载消耗的供应比率而测量时要求穿透的特殊等级的所有那些消费者负载。

[0044] 标记114为消费者负载分布108的子类别，该消费者负载分布不具有对太阳能的优先权以及至少第二特定约束要求，该第二特定约束要求代表自发电设施100或发电设施的子设备120的关联所需的曝光量及传递。例如，标记114分类可以是在通过自间歇性发电设施100或间歇性发电设施120至分类负载组112的负载消耗的供应比率而测量时具有穿透的任选等级的所有那些消费者负载。

[0045] 标记110为二次供应资源，该二次供应资源可通过例如批发或现期能源市场、能量期货市场或来自二次发电设施的电力的物理传递而体现，或可通过自能量储存媒介所取出的能量而体现。

[0046] 标记118为合并计算模块，该合并计算模块计算前瞻供应模型及满足与消费者负载分布106、消费者负载类别114、消费者负载分布108或消费者负载类别112关联的约束的期望值的关联概率；且经由历史测量而建立验证满足与消费者负载分布106、消费者负载类别114、消费者负载分布108或消费者负载类别112关联的这些约束的关联期望值的后顾审计及调和方法，其中如所描述之后顾审计可涉及例如自无优先权消耗负载106、无优先权消耗负载116或无优先权消耗负载114将能量资源100或能量资源120转移至优先权消耗负载108、优先权消耗负载112或优先权消耗负载104。

[0047] 标记119代表针对公开所提供的信息，该信息可以是传递的呈现、消费者负载需求106、116、114、108、112或104的历史测量；发电设施100、发电设施102或发电设施120的历史测量；或可以是如在合并模块118处所计算的各种约束的比率及验证。此类审计公开系统的示例性实施例可采取应用程序界面(Application Programme Interface(API))及一机制的形式，该机制允许对社交媒体的信息呈现、允许将信息分配给互联网，或允许转接至消费者记账系统中。

[0048] 图2(a)至图2(b)例示关联发电设施100的间歇性，其中标记201、标记202以及标记203为来自例如标记102(图1)的单个间歇性电源的电力输出的单独概率密度函数。在概率

密度函数201、概率密度函数202以及概率密度函数203中，纵轴代表能量输出，而横轴代表当天的时刻。

[0049] 标记222为集合概率分布函数(PDF)的实施例，该概率分布函数的特征在于示例性实施例中的特定输出度量206、特定输出度量204、特定输出度量205、特定输出度量207、特定输出度量208以及特定输出度量209。在曲线图222中，横轴是时间而纵轴是根据与特定概率模型关联的电输出或能量单元所期望输出，该特定概率模型与特定输出度量206、特定输出度量204或特定输出度量205关联。

[0050] 此处，标记207为连续PDF的谱线分布，该谱线分布代表合起来的集合发电设施的最大输出，其中标记206是有来自系统的最大输出的情况下将发生的最大能量输出。标记208为连续PDF的谱线分布，该谱线分布代表合起来的集合发电设施的平均输出，其中标记204为在有来自发电设施的集合系统的平均输出的情况下将发生的平均能量输出。标记209为连续PDF的谱线分布，该谱线分布代表合起来的集合发电设施的较低等级的输出，其中标记205为在有来自系统的最大输出的情况下将发生的较低等级能量输出。

[0051] 可将PDF 207、PDF208或PDF209中的任何一个表示为离散概率密度模型，例如数据库中的阵列，且这些模型可采取自发电设施100或发电设施的子设备120的发电的前瞻概率的形式。

[0052] 图3(a)至图3(c)例示连接至同一AC电力网网络的三个单独能量发电设施所测量的年输出301、年输出302以及年输出303，其中可经由所测量电输出的数值综合法来使发电分布显影。通过曲线图301、曲线图302以及曲线图303中的波动，统计性质或这些发电设施是明显的。在曲线图301、曲线图302以及曲线图303中，横轴代表该年的日，纵轴代表该天的时刻，且灰色标度的色度表代表单位总能量输出，如在每一图片右边以比例尺条所反映。

[0053] 图4(a)至图4(d)例示根据示例性实施例的反映消费者供应需求的概率性质的诸如106、114、116、104、108或112(对照图1)的特性。标记400为消费者负载的集合种类的需求的概率密度，而标记401为代表消费者负载的集合种类的能量需求的等级的连续谱线分布。该连续谱线分布还可提供为诸如在数据库所计算的向量阵列的离散概率模型。标记402为每日负载需求分布的例示，在本文中作为事件的离散测量组，其中横轴为该天的时刻且纵轴为消费者负载需求等级。

[0054] 标记406例示连接至同一AC电力网网络的单个消费者负载的所测量年输入，发电设施互连至该电力网网络，其中可经由所测量电输出的数值综合法而生成需求分布。在曲线图406中，横轴代表该年的日，纵轴代表该日的时刻，且灰色标度的色度表代表单位总能量输出，如在每一图片右边以比例尺条所反映。

[0055] 标记404例示另外的方式，在此方式中，可定量评估消费者负载分布的统计分布，其中作为最大值、每日高值、每日平均值、最小值以及每日低值的变化经测量及绘制曲线。图表的横轴为时间，而图表的纵轴为负载需求。

[0056] 此类分布402、分布404或分布406如果需要可用以创造消耗的综合概率模型。通过曲线图402、曲线图406及/或曲线图404中的波动，统计性质或这些消费者负载需求是明显的。可通过对消费者需求的定量评价及如图3内所例示的这些消费者需求的关联统计学来完成各种消费者负载的集合实现，以形成与特殊分类关联的所有消费者负载的PDF。

[0057] 图5是在示例性实施例中通过实施间歇性源G与二次源P以实现负载L的能量需求

以对消费者的供应及传递的模型的例示;其中G可代表集合发电设施100、集合发电设施的子设备120或单独发电设施102;且其中负载L可代表消费者负载需求的集合或特殊分类消费者负载需求的集合。可假定P为通过单个AC电力网网络上的能量流而建立的批发能源市场。

[0058] 如文中所论述,负载L内的任何类别或子类别可与一或多个约束关联,必须经由前瞻供应期望及后顾审计及调和系统来建立这些约束,以建立在测量时满足的所有约束。

[0059] 在示例性实施例中,可经由标记B借助于为批发能量池的二次供应资源P以供应负载L,以使仅满足供应的负载要求但不建立约束,其中可通过对次级市场P的供应以及经由标记C的直接确定至负载的审计及调和的关联建立,以验证如自发电设施G所建立之任何约束。如本文所体现,可及时索引如表示及记录为数据库内的向量的实体测量的能量流,且因此匹配直达负载L,以使可因此由发电机G审计L的所有关联约束。

[0060] 在此实施例中,可建立L及P以匹配,而直达标记C的供应可以是等于经由标记A之输入的负载L的相抵。同样,尽管标记A及标记B代表直达L的供应的单独等级,但G处的实体供应及P处之二次供应的关联共同建立在仅通过需求等级所代表的L的时间内的要求,其中须经由G与L之间的标记C通过时间索引发电及负载以建立任何约束,这些负载为前瞻概率分布或为带调和之后顾审计中的传递的测量。

[0061] 图6(a)至6(b)通过需求等级及价格以例示批发能源市场,其中离散时间间隔是明显的。横轴是时间,且纵轴显示需求及价格。显示如通过作为图表背景的白色矩形区域699所反映的前瞻需求,同时显示如通过作为图表背景的灰色矩形区域688所反映的前期传递。此处,显示三个单独价格参考等级,包括与此特定电力池市场关联的统一电力价格(Uniform Electricity Price;USEP)、液化天然气(Liquefied Natural Gas;LNG)行权价格以及油连锁合同价格BVP。箭头分别指示绘制于批发市场的时间曲线图中的USEP、BVP以及LVP线。标记611将特定USEP时间序列指示为灰线,标记622将BVP价格指示为黑线,且标记633是作为淡灰线的LVP价格。需求分布可反映为纵条图分段608的上升和下降。图表均展现与当日中间周期相关的需求的日增加。逐次发生的此分布实施为如在本文档的示例性实施例中所描述的二次资源。

[0062] 图7(a)至(b)例示如出现于专利第10201406883U号附加间歇性供应专利概念中的抵消能量的方法,其中与发电设施的相关用以重设负载曲线708,该负载曲线示意性地显示在指定周期期间来自PV功率发电机的PV功率发电分布。如将为本领域技术人员所了解,功率发电峰值与日间时间一致(例如710)而在夜间时间期间基本未发电(例如712)。即选定的源/负载对(或一个以上对)的发电分布708及消耗分布702优选而言是匹配的。此类匹配规范可与如在批发能源市场中的二次供应与消费者负载需求之间的数量相关系数有关。

[0063] 曲线714示意性地显示将通过透过二次供应源自主网格部分的供应以满足的功率消耗的部分,例如自批发市场或另一能量发电机。如自曲线702及曲线714的比较可见,因而减少了在例如704之峰值周期期间所满足所需的功率量。

[0064] 若消费者可由于来自PV功率发电机的辅助电源而预期较低的峰值需求,则随后由零售商所考虑的风险分布将“缩小”,对应于通过曲线714所代表的变平供应分布。因此,对此类消费者负载的供应模型具有对二次源的减少之暴露,且与电力网网络上的资源的有效性降低的需求周期关联。此效益延至特定特性的经由电力网所供应的负载或一个以上负

载。在图(7b)中，曲线716及曲线718分别示意性地显示不具有及具有PV功率发电机容量抵消的由其他源/可争论零售商所需的所需供应。

[0065] 图8a)至d)例示根据示例性实施例的四个代表性时间分布，这些时间分布显示标记800处的假设负载L、标记802处的假设发电分布G、标记806处的作为池P的假设二次能源市场，以及说明由G及P的供应的派生负载形状函数。在曲线图中，横轴为时间且纵轴为能量容量。能量容量可以是针对802处的G的发电容量、针对800处的L的需求容量、针对804处的R的需求容量，或针对806处的P的市场供应/需求可用性。

[0066] 标记821、822以及823反映三个假定概率发电分布，这些假定概率发电分布在图2中通过标记207、208以及209类似地反映。此类发电分布可假定为由发电设施100或发电设施的子设备120而得出。802处的前瞻供应分布可说明各种概率假定，诸如最大输出821、较低等级输出823，或更可能说明平均输出分布822。

[0067] 假定G 802处的前瞻概率分布供应至在需要时满足任何指定约束的负载分布800，其中可形成804处的二次负载暴露R。形成此二次负载暴露804，考虑各种发电分布821、822或823分别引起各种二次负载暴露841、二次负载暴露842或二次负载暴露843。当发电负载分布时可假定各种种类的概率。同样，可形成804处的二次负载R对806处的二次发电源P合成的暴露。

[0068] 利用802、804或806，还可通过推导804经由调和802，以确定分布800、802以及806之间的各种种类的相关。可经由将资源从发电设施100分配至作为发电设施的子设备120的优先权资源中而进行802处的调和。可基于与标记806处的批发池P数量相关性以优化从100分配至子设备120中的实体资源，其中批发市场可用于交易二次能量供应。

[0069] 通过利用如图5中所显示的批发池及用于自间歇性发电设施及批发池实施供应的系统，可解决将多个间歇性资源分配给特定负载分布800的问题。此外，可使用以上机制形成负载需求、间歇性资源的发电分布与批发池或其他二次供应资源(诸如第二发电机组)之间的数量相关性，这些机制以概率密度函数(PDF)、前瞻概率模型来产生时间分布。

[0070] 图8形成可经PDF所利用的基础，该基础将各种资源及消费者负载需求反映为时间分布，其中可实施定量推导，诸如时间相关，或反映发电G至负载L以使改变大小的二次负载需求R完整的特定量的要求的特定消费者约束。在如图9中进一步描述的回顾审计中研究这些相同PDF。

[0071] 图9例示根据示例性实施例的供应900、审计902以及调和904程序相对于功率传递以在时间988处匹配一组消费者负载约束的暂时关系。在传递时间988之前，将前瞻概率密度函数(PDF)分布建立为来自发电设施的负载及发电的数据库阵列中的离散向量(或可替换地建立为连续代数PDF)，且评估建立至少一消费者负载约束的期望值以及分配来自发电设施100的资源120的等级，以使发现足够高的期望概率。可通过本地管理人的要求、主管人员或内部风险管理方针，或通过自消费者所请求的条款或条件以设定期望等级。

[0072] 传递后，评估利用数据库的向量阵列中的给定负载及发电机的实际所测量结果的后顾审计，其中该约束或这些约束被试验。其中在发生任何约束的缺损的情况下，进行调和，且分配给低优先权消费者的资源从发电设施接收更少能量，直至补偿所有此类缺损。倘若缺损，则因此将这些资源120重新建立，以使期望值可足够高。

[0073] 调和(reconciliation)可解决各种情况，且操作可调和资源120建立以满足优先

权约束，这些优先权约束考虑来自发电设施的各种范围的供应，可使该各种范围的供应为如出现于图2中可用的。例如，在按照概率模型209将资源分配给这些约束期间假定传递的最小等级情况下，满足此类约束的期望的结果不大可能为错误的。可替换地，想要更稳妥的太阳能公用设施的运营商可假定具有所要求约束未必满足的不同程度的概率模型208或207。概率模型假定将影响在实践中提供调和练习的要求的频率。

[0074] 图10例示本文所描述的程序的处理流程1000，该过程形成供应方案以匹配来自多个间歇性发电设施及二次供应设施的消费者负载约束，该二次供应设施诸如批发市场、电力期货市场或二次发电机。在此流程中，在1006处说明了优先权消费者及无优先权消费者的广泛类别，同时通过定量调和的一些允许而缓冲在前瞻基础上匹配供应约束的平衡。在调和期间，利用分配给无优先权负载的资源以在回顾审计建立涉及发生消费者约束缺损的事件时补偿缺损。

[0075] 该流程涉及在1002处建立消费者负载约束/要求，其中消费者约束形成类别组或一个以上类别组，且随后导出及相关联各种组内的消费者负载PDF，这些PDF通过所请求的特定约束或一个以上特定约束而体现。在1004处，评估资源可用性，这些资源包括多个间歇性发电设施及二次供应设施。在1006处可随后将消费者负载分为优先权负载以及无优先权负载。流程元素1006可在流程元素1004前后发生或同时发生。流程元素1004涉及导出发电设施的PDF，以及计算如通过利用假定概率模型而由流程步骤1002所形成的各种约束的结果的期望值。在本文中，可形成资源分配，该资源分配允许通过专用优先权资源而提供在流程步骤1012处评估的某些消费者约束。

[0076] 在流程元素1008处，可例如通过向消费者提供特定约束的不同产品包装而调和在1002处所建立的消费者负载约束，以使代表特定约束的结果的期望值取决于公用设施的选择而更高或更低。在流程元素1010处，可根据流程1004、1012以及调和阶段1016的结果而视需要建造另外的发电设施。

[0077] 在流程阶段1012处，通过计算前瞻基础中的期望值而评估对负载的所有约束的供应的概率的期望值，该前瞻基础解决供给如与所假定负载需求分布的PDF以及经分配以满足那些约束的发电设施的PDF关联的一个或多个约束。

[0078] 在流程元素1014处，基于经检测而在结算能量流动(例如，如连续关联或尤其贸易的时间间隔)时待测量以及传递的所得供应，随后将发电设施的能量的剩余量分配给假定特定定量模型的无优先权负载。例如，能量可除以负载的数目且随后以相同量提供给每一负载，或可作为对消费者的消耗总容量的供应的百分比来计算，且提供给相等百分比基础上的负载。

[0079] 在流程元素1014处，应用任何缺损的调和，其中基于测量结果，若发生对消费者负载的约束的缺损或违规，则提供来源于资源的未分配给优先权消费者的能量以弥补缺损，直至无缺损发生。若未测量补偿缺损的足够能量，则信息在可调和分配以满足约束的资源的情况下回流至流程元素1004，或可创建另外的资源。在流程元素1014处，若无违规发生，则不应用调和。

[0080] 在流程元素1016中，通过主动公布操作发电设施及/或供应负载的公用设施或服务提供者，或通过允许消费者访问信息及公开结果而致使测量、期望值、审计结果或调解结果的结果的公开。公开可经由互联网上到万维网，且可进行公开以使可基于时间表或基于

建立网站上的特定通信通道及账户平台而自动发布信息；例如在社交媒体上，或经由将结果发布至网站上的特定位置。

[0081]　在流程元素1020中，来自流程步骤中之每一者的信息流可与建立新的发电设施、提供及保证消费者负载约束或平衡优先权账户及无优先权账户的量的平衡有关，以使调和要求的频率经调整。图11例示用以实施该供应、审计及调和模型的信息技术系统的架构的示例性实施例。标记1188为具有相关联电系统1186之单独发电设施，在此处这些关联电系统通过控制界面，以及关联收入等级功率计及通信网络设备(未显示)来体现。控制单元1186经由以太网络连接至路由器1171。路由器1171的广域网络(Wide Area Network;WAN)端口将连接至本地互联网提供者(未显示)，该本地互联网提供者将使路由器能够访问互联网1101。路由器1171使用内置加密虚拟专用网络(Virtual Private Network;VPN)连接1172及1102而连接至服务器1111。路由器1171与服务器1111之间的所有通数据包将在穿过互联网1101时加密。

[0082]　标记1111包括各种单元，这些单元包括：数据库1104，其例如可以是MySQL数据库；网页服务器1115，其相对于发电设施1187而显示针对资料的使用者界面；顾客能量使用应用程序1114，其监督顾客交易及顾客能量使用；记账应用程序1113，其生成及发送记账讯息；以及能量输出应用程序1112，其发送通过操作的发电设施所产生的能量的报告。

[0083]　标记1161例示太阳能发电设施安装技术人员使用加密安全套接层(Secure Sockets Layer;SSL)连接上的网页浏览器连接至互联网上的操作平台的网页服务器1115。

[0084]　标记1162例示电力运营商或电力网管理员使用加密安全套接层(SSL)连接上的网络浏览器连接至互联网1101上的网页服务器1115。

[0085]　标记1163例示能量顾客使用加密安全套接层(SSL)连接上的网络浏览器连接至互联网1101上的网页服务器1115。

[0086]　标记1143例示与操纵顾客交易的能源市场交易关联的系统，该系统使用诸如安全套接层(SSL)的加密连接而连接至我们的互联网1101上的服务器。

[0087]　标记1144例示与操纵能量发电监测的能源市场交易关联的系统，该系统使用诸如安全套接层(SSL)的加密连接而连接至互联网1101上的服务器1115。

[0088]　用于模型化投影发电容量及发电容量至负载容量的分布的概率的统计方法

[0089]　在示例性实施例中实现用于分布所产生光伏的供应方案涉及实施以下的系统：统计途径，其向可用于供应至特定负载的总资源量前投影，以及外部变化资源，其可实施以向可用于供应至特定负载的总资源量前投影。合并模块101(见图1)可帮助将集合资源由多个发电设施分配至消费者的关联供应负载，且建立满足提供给消费者的供应负载的特性的关联概率。测量系统可比较实时基础上的实际发电且计算来自关联发电设施的实际能量供应，以便审计提供给特定负载的能量混合物，该特定负载包括来自集合可再生能量设施。可随后将能量剩余量在审计下分配且表示在对可再生能量无优先权的消费者负载上。最后，对发生能量缺损且要求调和的情况而言，可实施调和过程以弥补对优先权账户的缺损及在前瞻基础上潜在地修改对负载的供应条款的约束。

[0090]　图1显示一组100例如102的发电设施，各种容量、位置、电连接系统以及其他信息中之每一者可通常包括所安装能量系统的所有技术规范，且每一者具有其特有的根据其特有说明书及可变外部信息所界定的统计输出，该统计输出可经测量或可投影到前向基础

上。还可获得外部资料且可进行回归以在回顾基础上建立此类外部信息的所有历史统计变量。这包括分为时间容器(time bin)、平均数、众数、中位数以及其他相关统计变量的发电时间分布。

[0091] 图1还显示例如104的多个消费者负载,这些消费者负载经分为不同类别,例如106、108。各种类别106、108可与如供应协定所指定的消费者要求的组的特性有关,且可呈消费者之所保证最小可再生能量要求的形式。同样可将消费者关联至其特有需求分布中,这些需求分布展示这些消费者的将供应至的负载的总消耗容量。针对消费者的供应布置包括来自间歇性发电设施100的能量,以及来自二次供应资源110的能量。例如,二次供应资源110可包括批发能量池或靠燃料运行的一或多个燃烧发电机。

[0092] 对设定分析以使得可确认供应条款对例如104的负载的相关约束生效而言,流程中的第一步骤可以是形成表示随时间推移的发电容量的概率性分布,该概率性分布表示随时间推移的能量需求,且将概率性需求的分布分为将各自个别地依据特定设定概率而生效的相关类别。

[0093] 将供应负载分为优先权访问及穿透等级

[0094] 图1显示将例如104的消费者负载的供应分为两个特定示例性类别106、108,连同例如112、114的内部地表示最初区分类别106、108的其他类别。上级类别106、108用以形成发电设施100能量的跨能量消费者的负载需求的区分。此实施例中的类别108为例如104之那些消费者的负载的,这些负载具有对来源于发电设施100之能量的优先权,与类别106中的例如116的那些消费者的负载相对比,这些负载对来源于发电设施100的能量不具有优先权。此处优先权例如意谓消费者要求最小量的能量,其混入这些消费者的供应且因此将留出来自发电设施100的能量之一部分以满足负载需求的特定约束。对优先权内的例如114的任何单个类别而言,验证认为组114的总需求须在优先权类别108下考虑例如104的所有负载,与考虑供应评价时在线上的所有发电设施的所有发电设施100相比。

[0095] 假定这些发电设施100提供清洁的可再生电力,例如如自间歇性光伏发电机所获得,此优先权类别108与要求可再生电力之最小量的消费者有关,该可再生电力可根据不同参数(例如,如可再生穿透比,可用之百分比最小太阳能等,如将在以下更详细地描述)及不要求可再生电力之最小量的消费者之无优先权类别106以指定。类别参数可包括可再生穿透比、清洁能量混合物与负载之分率、分配至特定时间容器中之清洁能量数量、就给定日、月、或年(例如,“每年至少10MWh清洁能量”)中之清洁能量的特定量而言的最小数值,还可描述为关联自可再生能量资源所获得的能量混合物与二次能源市场中的需求中的波动的相关值,这些波动与能量池的供应特性与需求特性有关。

[0096] 因此分出例如104的消费者负载以表述与对那些负载的供应关联的约束。在示例性实施例中的供应分配机制下,将在供应周期内可用的总间歇性发电容量模拟、模型化或以其他方式统计地导出。随后将总发电分布以首先满足例如104的优先权负载的所有约束的方式分配给例如104的所投影消费者负载需求。

[0097] 在一个实例中,分析供应需求以使基于负载的特有总需求分布来评估单个负载,随后分为两个广泛类别。该广泛类别与消费者负载需求的对可再生资源的优先权以及无对间歇性可再生资源之优先权的消费者负载需求有关。可随在这些类别内识别子类别。随后形成每一子类别的总概率性需求或形成与那些负载相关的约束。随后计算每一供应约束的

统计验证,说明约束之所有子设备及概率性集合发电设施发电分布分布。以下将描述根据不同实施例中的供应合同及调和的剩余过程。

[0098] 满足对关联负载需求的集合间歇性发电的分配

[0099] 消费者的优先权的类别形成针对与发电设施100的关联的例如104的消费者负载的原理区分,其中将通过例如104的优先消费者负载的优先权约束的发电设施100所供应的任何剩余能量的余量供应给无优先权的例如116的负载。例如104的那些优先权负载形成硬约束,针对这些约束,电力供应必须达成至少最小等级。同样,对经由集合发电设施而表示可用总能量的所确定前瞻概率分布分布或其他定量因素(例如像经由蒙特卡罗(Monte-Carlo)模拟来实现)给予优先权,以满足通过消费者负载要求所提出且体现在特定组内的消费者负载的概率分布函数的多个约束。

[0100] 可随后将间歇性发电设施100的任何剩余发电容量分配给例如116的负载,这些负载不具有对那些发电设施100的优先权访问或用于在后顾审计期间在本文更详细描述的调和过程期间的使用。可在后顾基础上进行该步骤,其中测量实际负载需求及来自间歇性资源的实际供应的审计118,且验证约束。此外,在后顾审计期间,可通过提供任何剩余资源以补偿满足约束的任何缺损,以补偿那些缺损。

[0101] 所测量的调和程序后所剩余的电力经与无优先权的例如116的负载混合。可以以若干不同方式将此能量混入无优先权的例如116的负载中。例如,可建立无优先权的例如116的所有负载的总集合需求,以及分配给例如116的那些负载的剩余能量以反映作为对例如116的那些负载的可再生穿透等级的特定约束。此将包括传递给例如116的负载的相较于负载的最大能量需求周期的能量数量。可替换地,可通过总负载来划分能量,不计及由负载所消耗的能量数量。以此方式,每一负载将获得相同量的可再生能量,但将个别地在单个负载消耗内具有可再生能量的不同百分比混合(percentage blend)。

[0102] 为方便此以上过程,图2显示供应间歇性能量的所有发电设施的集合的概率分布函数的形成的实施例。图2(a)例示在单日内来自单个发电设施201至203的输出。这些例示中的每一者显示任何给定日的输出可显示各种特性。在此实例中资料存在于离散时间容器中。此类系统的组合可产生概率密度分布函数(PDF),在图2(b)中例示了实例。

[0103] 图2(b)例示对集合能量发电分布而言,最终PDF 222可与三个关键等级203至205有关。PDF 222可表示各种时期上的输出。例如每年的、每月的、每日的等等。在时期减小时,PDF 222将显示更可变的分布,而在时间变量变长时,PDF将会聚成平均PDF(曲线208)。还可使用连续变量以确定PDF 222,或可使用离散变量以确定。当能源市场操作假定在交换期间的特定时间容器时,可假定此时间容器而评估离散时间间隔。PDF 222可显示最小等级205,该最小等级可经评估假定特定时期内的输出的较低等级,且可显示最大等级203,该最大等级为在最大化可再生能量资源及假定电力系统的最佳输出期间与发电设施相关联的所约束总功率输出。还可假定此最大输出等级203以解决在操作电力系统期间电力系统若干年的降级。

[0104] 当评估供应约束时,可根据所有最大PDF、最小PDF以及平均PDF来评估,分别见曲线207、209以及208。此举允许公用设施评估在后顾审计过程期间实施调和练习时可使用的若干另外的数量。公用设施可评估例如可以所有平均及最大方案提供给无优先权负载的能量数量,且可试图在最小PDF 209的假定下设定针对将能量以低等级分配给无优先权负载

的供给。或者,公用设施可假定其将更频繁地需要在后顾调和练习中通过产生供给以用于将能量与更靠近平均PDF 208的无优先权负载混合而提供能量混合。在此后者方案中,发生在优先权负载中的缺损在最靠近平均PDF 208确定处发生而非在最小PDF 209确定处。使用此过程,定量预备公用设施以提供对消费者负载需求的供应约束保证以及审计方法及调和方法,以使存在不满足对负载的约束的极限概率。

[0105] 概括而言,通过预备发电设施的PDF 222及检查各种方案等级的PDF 222,随后分配来自发电机的资源以提供给彼此平行的约束的特定组,以评估将关于提供给消费者负载分布的间歇性能量数量的定量确定所供应的约束。根据真实测量结果来评估约束,后顾审计基于这些真实测量结果进行,且调和任何缺损基于这些真实测量结果进行。可随后公开审计以使得消费者获得关于间歇性可再生能量的供给的确定性,这些消费者基于其特定要求而自公用设施获得该间歇性可再生能量。认为已请求无约束的那些消费者不具有对间歇性资源的优先权,且可获得在后顾审计程序及后顾调和程序完成后与剩余能量相关联的能量数量。

[0106] 自集合发电设施的供应至形成概率性发电容量的统计基础

[0107] 为确定集合发电设施的PDF 222,可使用表示单独发电设施的输出及电效能的效能比(Performance Ratio;PR)。发电设施与安装的所有规范有关,包括所有材料部件及元件的电参数,这些部件及元件包括安装。此外,可考虑本地因素。例如,位于障碍物附近的安装设施将在一当天时间具有特定阴影损耗。将知道此发电设施具有个别不同的输出PDF,且同样,集合发电设施的最终PDF 222将为说明发电设施的特定效能标准的所有单个发电设施的归一化积分的PDF 222。提供设计参数、规范以及其他效能标准的良好资源为Antonio Luque(编者)及Steven Hegedus(共编者)、Handbook of Photovoltaic Science and Engineering第2版,Wiley 2011(ISBN:978-0-470-72169-8)]。本文中我们将论述一些可用以确定用于特定场所的单个PDF的相关要点,其中可随后更精确地表达整个集合发电设施的PDF 222。

[0108] 开启或起动新的发电设施的时间可解决发电设施的PDF的确定。例如,新的发电设施的已知建造周期,与关联损耗因素、本地效能标准以及安装设施的电规范一起,可允许公用设施在持久周期内表达此发电设施的输出。它的PDF可假定为在未来时间附加至集合发电设施PDF 222中。一旦系统经构造及经由其能量计而输出能量,则可视为当资源在开启时起动时提供给集合发电设施。将自起动及前进之日开始评估经开启的这些新的发电设施的降级。发电设施还可解决能量系统的担保,以使得可基于这些担保以量化最小等级的故障。例如,太阳能板担保通常假定每年降级的最小量且可以其他方式替代这些部件。图2(a)显示来自各别单个发电设施的各别所测量输出201至203。如可见,在特定时间限制了此类间歇性发电设施的输出,而通过与外部变量(例如,在系统位置处的日光量)的相关而将平均输出分类。发电设施的特征还在于基于特定发电设施的容量的来自发电设施的最大输出。

[0109] 图3(a)至(c)显示三个单独测量结果301至303,这些测量结果表示连接至同电力网网络之三个单个发电设施的输出。如可见,通过在系统的变换器处所测量的电力输出的变化来观测产生的能量之间歇性。曲线图的横轴表示单个年中的日,且资料跨度为一年。纵轴表示一天中的小时,且跨度为24小时。通过灰阶比例尺条以表示单个系统的输出。

[0110] 可以特定时间间隔来评估集合发电设施的PDF或留出以覆盖特定供应负载约束的

发电设施的分配的PDF。市场时间间隔可在贸易及结算进行期间界定间隔。可因此使用如在特定市场中所使用的同一间隔来表述PDF,以使可将能量的贸易及结算精确反映为反映那些市场现金流动的概率。

[0111] 可产生PDF以反映场所的当天时间热损耗评价,以及当天时间阴影损耗评价。这些两个因子将提供特定发电设施的总输出的精确表示。随后在所有发电设施中,当天时间将随后成为一种方式,以此方式可将发电设施的所有单个PDF计算至集合发电设施的PDF中。

[0112] 对形成概率性需求容量的消费者供应负载的统计基础

[0113] 类似地表述消费者负载的PDF,以使得可计算消费者负载需求。然而,还可基于消费者在供应合同中请求以满足及保证的约束而将那些消费者负载需求分类。可通过考察消费者的过去的历史能量消耗而确定消费者负载。在此为不可用的情况下,建筑物的期望活动及所估计负载大小可用以表述需求分布。可使用连续概率分布的离散时间间隔以形成这些PDF。使用离散时间间隔的情况允许将时间间隔匹配至针对电力作为商品(例如电力期货或现货市场,或结算的时期)的市场贸易间隔。

[0114] 图4(a)显示代表性消费者负载PDF 401。此外其特征在于电力的最大量422可在用于能量网格的配电盘或其他电连接齿轮处实体地流入建筑物。假使建筑物始终消耗一些电力,则此负载分布很少为零,因此图4(a)中指示电力最小量433。图4(b)显示建筑物能量的所测量平均每日分布402,图4(c)为负载分布的年统计变化图表404,以及图4(d)为一年中年负载分布的绘图406。在图4(d)中,横轴为日,且纵轴为时刻。比例尺条表示建筑物中所消耗的能量数量。

[0115] 通过获得反映建筑物需求的分布的资料,可形成针对消费者负载需求的PDF。当添加特定消费者已请求的约束以反映须以来自发电设施的可变能量的特定定量的量而供应负载时,可通过关联100的向负载的约束所分配的资源120的PDF与消费者负载需求的PDF以计算期望值。同样,前瞻概率分布函数允许将特定消费者约束要求的概率定量评估为作为期望值或概率的数值或强度。

[0116] 考虑供应及需求分布之供应模式的统计学,以及供应分布模拟

[0117] 根据资格以提供来自间歇性发电设施100的产量以满足消费者负载需求的部分的方式而确定约束的表述,根据该表述以评估满足需求的前瞻概率。存在在具有对可再生资源的优先权的消费者负载需求内提供间歇性发电产量的量的各种方式。每一数量系视为将资源供给至每一单个消费者负载需求的约束,且此外消费者负载需求可与一个以上此类定量约束有关。例如,确定优先权保证的统计学可包括以下中之一个或多个。

[0118] a.可再生穿透等级。

[0119] b.混合可再生能量的百分比。

[0120] c.对能量供应池或二次发电机资源的相关性。

[0121] d.所提供能量的总量(例如10kWh)。

[0122] 可再生穿透等级测量在可再生资源提供最大输出期间提供给负载的能量数量,且考虑在关联时期期间的需求量。混合可再生能量的百分比为经由提供给特定负载的时期所整合的总可再生能量的归一化量,通过关联时期内的负载需求的积分来划分。此百分比可与多个负载或单个负载有关,或与多个发电设施或单个发电设施有关。与二次供应资源的相关值与在一时间期间所提供的可再生能量或间歇性能量的量有关,该时间和与二次资源

的供应等级或供应量的相关测量结果相关联。可通过此二次资源的相对可用性、其需求与供应等级，或与资源的实体可用性相连的价格以定性地评估此二次资源。所提供的能量总量与在特定时期内能量的特定绝对产量有关。例如，将提供的能量总量每月可以是来自间歇性资源的10能量单位。

[0123] 约束类别与下行子设备中的每一消费者负载需求关联，且根据假定发电设施集合的总概率性发电容量来评估。最宽的类别为消费者负载优先权，继之以如上所描述的针对子设备的各种数量。评估所有定量约束以确定满足考虑可用概率性发电容量的所有约束的概率。在示例性实施例中，还优选地实施可用的统计发电容量的最大值、最小值以及平均值，以便评估可用于供应消费者负载需求约束的资源的潜在量，如以上参照图2及图3所描述。

[0124] 批发供应及需求整合

[0125] 在图5中显示了并入金融市场的双供应系统的情况。可通过来自发电设施G的实体可用的间歇性太阳能以及批发池P以供应消费者负载需求L。可经由批发池P以将能量供应给负载L，同时须通过本文所描述的分配及审计系统来计算要求经由发电设施G以导出能量的任何约束。如可由本领域技术人员所了解，当二次供应资源采取批发能源市场的形式时，发电设施G遵循批发市场P的价格，且当二次供应资源采取批发能源市场的形式时，以指定的固定价格供应的负载L在批发市场P上短缺。

[0126] 图6显示如以上详细描述的特定能源市场的实际批发能量日期。此市场的供应及需求的改变反映能源市场的分布，且可视为通过离散概率分布函数或连续概率分布函数(PDF)以定量地表示。特定批发市场资料显示更高的能量需求且因此显示在日间期间更高的能量价格。

[0127] 图7例示建立能量经由发电设施G至负载L的抵消的方法，如通过存在于图6中的供应方案所表示。此已在上文描述且还在新加坡专利申请案第10201406883U号存在，该申请案的内容以引用的方式并入本文。暴露于能量池供应及需求

[0128] 图8显示例示峰值能量抵消供应方案的示意图，其中将来源于批发能量池的基础负载能量传送至消费者，且通过在示例性实施例中的最佳化可再生穿透方案下供应光伏能量而使供应负载根据峰值能量需求的周期相关性而与批发市场波动性去耦；其中图8(a)例示假定负载需求分布800，图8(b)例示集合发电资源100或专用资源120的概率分布分布802(比较图1)，图8(c)为并入专用发电设施120的各种假定PDF的所修改负载分布804，即起源于批发能量池的所修改需求。图8(d)例示特性批发池需求分布806，显示峰值需求808与集合间歇性能量资源的供应分布的相关性(比较图8b中的集合发电资源的概率密度分布802)。如将由本领域技术人员所了解，批发池价格将大致反映批发池需求分布806，意为在时期期间有利地减少了负载对能量池供应的暴露，在这些时期中，期望来自批发池市场的能量的购买价格高于在其他时期期间的价格，例如在非峰值时期期间。

[0129] 图6显示能量池供应及需求等级及该能量池中的归因于需求及供应变动的关联价格波动的例示。在此情况下，尽管池中的对于能量的需求及价格上升，但可发现日间相关性。由于无法仅自间歇性发电设施提供满足那些消费者负载需求要求的二次发电源，故该池可包括二次供应资源。

[0130] 在此类情况下，可通过批发池直接供应针对电力的消费者负载需求，同时经由计

量分配及权利转让而将间歇性能量发电混入账户中，如图5中箭头C处所显示。经由此关系形成任何约束，且实施审计以验证满足了这些审计。在图5的箭头A处可仍将间歇性发电直接提供给池。

[0131]　图5显示发电(标记G)、能量池(标记P)以及消费者供应负载(标记L)的布置。在负载的计量读数之间，关联了发电机的计量的读数。如本文档中所描述而进行所有计量的审计。考虑到能量产品供应约束；当创造结构能量产品时还可说明能量池的统计学。在下文中描述此类产品，其中此处描述能量池的统计学。

[0132]　能量供应产品类别的规范

[0133]　能量供应部件对与消费者负载需求分布及消费者约束相关的能量消费者的表述可考虑可用能量，该可用能量通过集合发电设施随时间推移的PDF以产生及表示。所安装的新系统将添加至PDF以使得该PDF精确地表示对消费者统计地可用的能量数量。若不可能自间歇性源满足所有消费者能量需求，则可使用能量的二次源以弥补剩余消费者能量需求。该二次源可以是使用燃料的替代发电机，或可以是诸如现货市场或期货市场的金融市场。

[0134]　作为针对电力供应所形成的供应约束的第一构成，可将来自间歇性发电机的供应的特定值经由前瞻基础及回顾基础上的发电及需求消耗的时间分布的比较而导出。随后，最小数量可表示自间歇性资源至负载的供应，例如，那些最小等级可以是弥补负载的总消耗的间歇性能量的绝对百分比、间歇性发电机时间分布与负载消耗时间分布之间的互相关值、间歇性能量资源对负载需求的最大穿透等级，或发电分布特性在一段时间内(例如通常为一天)对负载分布特性的相对确定。

[0135]　可实施供应的另外的构成，其中指定对特定负载的专用间歇性资源。例如，这可以是安装于电力网网络上的2个专用间歇性发电机，以及来自第三发电机的四分之一电力。此后，通过利用对负载的专用资源以提供负载，而以其他方式通过经由诸如批发能量池的二次源而导出该负载，以弥补对负载或一个以上负载的供应的任何缺损。在此类方案中，间歇性发电可至少弥补如基于能量源的时间分布及负载需求的时间分布的相关的大部分需求。

[0136]　另一供应模式可涉及获得由特定时间的负载所要求的间歇性发电的更高量，以使发电机的穿透比远高于负载需求。在此类方案中，可随后使用交换电力或利用期货合同的产品以将产生的多于供应的过剩能量出售为晚间时隙。可将该过剩能量远期交易为间歇性发电不能够实体供应至负载需求的时期。在此方案中，间歇性能量的大百分比可包括不要求能量储存系统的负载供应。目标将为经由间歇性发电以弥补100％的负载需求。在此方案中，将负载设定为优先权，且将建立以供应至负载的专用间歇性资源设定大小，以使总发电量足够总供应。随后当负载需求少于间歇性发电机供应时，将时期余量交易为当负载需求多于间歇性发电机供应的时期。在此方案中，在回顾基础上，可使对负载100％供应的形成生效，而可随后将间歇性发电机的任何剩余能量混入低优先权负载中。

[0137]　考虑到以上能量管理系统及实体合并机制，以及对包括间歇性本质二次资源(诸如二次发电机或批发市场或期货能源市场)的实体发电设施100、120、102的资源的访问，可实施具有特定特征的各种产品包装。可以定量约束形式表示产品包装的特征，且用于验证本文档内所描述的任何所要求约束的供应方法及审计方法可用以在一段时间内实施供应及审计方法学。

[0138]　可通过反映数量及特征以形成产品特征。以下描述特定消费者负载的特定特征的

列表，而当将这些特征提供给能量消费者时，可随后将这些特征集合成类别组。在能量消费者接受能量供应数量时，建立将供应约束形成为类别组的程序及消费者负载的PDF。

[0139] 引入为对目标消耗负载的供应模式的类别或特性的数量或特征逐一描述如下：

[0140] 1.对太阳能的优先权。

[0141] a.领域：二元。

[0142] b.值：是或否。

[0143] c.描述：优先权意谓给予消费者负载需求对如通过约束所定量的发电设施的优先权访问的约束。此将采用发电设施为太阳能发电机作为用于供应给消费者的太阳能电力提供的所保证的量的形式。在消费者未要求优先权的情况下，消费者负载需求分布不要求所提供太阳能的所保证的量。

[0144] 2.最小太阳能百分比。

[0145] a.表示为来源于总间歇性供应对负载的消费者负载需求的X％，通过在一段时间内的总负载消耗以划分该负载。

[0146] b.描述：相对于消费者负载需求分布在绝对项方面所请求的最小百分比太阳能。

[0147] 3.穿透比。

[0148] a.表示为消费者负载需求分布的百分比X％，作为来自发电设施的最大需求与最大输出的比率。

[0149] 描述：作为负载分布与太阳能分布的相关性的目标比率。

[0150] 4.作为相关系数的优化穿透比。

[0151] a.SE工程师优化的说明批发波动性的穿透比。

[0152] b.描述：得出穿透比以形成间歇性能量的减少负载需求分布对二次资源之暴露的最佳等级，该二次资源诸如存在于图6中的批发能量池。评估负载与批发能量池的相关性，假定供应给负载之间歇性能量发生器的专用量。在此方案中，随后实施专用资源以减少负载的时间分布与批发市场时间分布的相关性。

[0153] 可使用此类实行方案以形成特定产品类别。例如，可通过间歇性发电的固定量及来自批发能源市场的剩余能量以提供能量消费者负载。当公用设施引入以上选项时，能量负载可得到满足各种形式的类别的反映间歇性能量数量的各种供应特征，该间歇性能量相对于所使用的替代资源及这些能量负载的特有需求消耗而供应给这些能量负载。

[0154] 通过CFD或长暴露与短暴露之间的转换定价

[0155] 示例性实施例中的供应合同将来自发电设施而把可再生能量分配给负载。归因于发电设施的间歇性，可期望供应商自第二源如一地购买另外的能量。图5例示发电设施(G)、消费者负载(L)与能量池(P)之间的关系。可自能量池供应负载，同时将发电机分布至能量池中。在此类方案中，能量池中的供应及需求的波动将影响定价，这些波动还面对将能量输入此池的各种其他发电源的力。为补救发电机的定价中的任何改变，可在发电机G与对负载L的供应商之间进行可再生能量权利的转换定价或购买。此举允许发电机根据对消费者负载的出口而并入定价，而非根据诸如批发市场的不稳定市场价格。

[0156] 除能量池之外，若电力期货市场提供期货传递，则还可在期货市场中获得二次供应。此合同将解决实际传递。各种安全性合同还可用以锁定定价，包括HSFO、Brent或在市场上交易的其他能量相关安全性。这允许使用各种资源以形成对消费者负载的第二供应源。

[0157] 审计及报告方法学

[0158] 对审计能量供应而言，在示例性实施例中采用了操作中心以自发电机收集资料及自供应负载收集资料。将使用适宜之收入等级能量计以测量与多个发电机及多个负载相关联的电源网络上的能量流动。在中央服务器或用于审计的其他信息系统处收集此信息。可在新加坡专利申请案第10201502972V号中发现可用以实施此类操作中心的中央服务器系统的实例，该申请案的内容以引用的方式并入本文。该审计将比较在供应至负载的时期内的实际发电与在那些时期内的实际负载需求，且验证提供给那些负载的可再生能量的等级。根据已适用于那些消费者负载的约束而评估那些等级。计算表示自间歇性源分配给那些消费者负载的可再生能量数量的总发电量及消耗、可再生穿透等级、总百分比混合以及其他标记信息，且储存于服务器上。

[0159] 在透明审计的情况下，那些消费者可自审计经由平台获得信息且可公开信息。消费者可登陆其账户且经由应用程序界面(API)公开总可再生能量消耗信息，以使可将资料提供至这些资料特有的IP地址。在进行基础上，消费者可经由互联网将此信息公开至站点。将有利地配备公布平台以使那些消费者还可将这些消费者的审计信息公开至社交媒体平台，诸如Twitter、Facebook、Google plus或其他平台。还可经由专用公开平台以公开这些消费者的信息，在该专用公开平台上可自愿公开所有消费者信息。

[0160] 自建筑物所有者的用地贡献空间的建筑物所有者还可公开自这些建筑物所有者的用地处的发电设施所测量的供应的总发电量统计学。在此情况下，就仅发电信息而言，这些财产所有者贡献的清洁能量数量可作为审计而公开。还可经由API将此提供至互联网，以使得可经由财产所有者所选的互联网协议(IP)地址或在如上所述的社交媒体等上发布信息。在此意义上，总审计提供使所有发电及消耗资料可用于由能量的消费者及生产者自愿公开。根据供应约束的验证的审计结果还可对能量消费者可用。

[0161] 审计供应的调和

[0162] 图9显示例示示例性实施例中供应分配与审计之间的关系的图表。供应分配900为前瞻的，以确定满足负载对特定时间之传递的特定约束的资源分配。在图9中，结算发生在时间t处，且随后实时测量这些结算。此时间t还可由诸如月份的时期或可将测量结果表示为特定时间容器中的代表性数量的其他时期而体现。指定供应约束，还给出所选特定时期。

[0163] 审计902为通过审查来自间歇性资源的能量的实际传递而确定任何特定约束的所测量传递的后顾过程，且将那些间歇性资源与所测量供应分配相比较。在满足所有约束的情况下，不要求供应的调和。在审计揭露供应约束与回顾审计的实际所测量能量之间的分歧的情况下，随后实施调和方法。

[0164] 调和904涉及获得未在分配给优先权负载的那些资源内留出的另外的能量。这将减少分配给无优先权负载的资源的量。完成调和以补偿对无优先权负载未从间歇性资源接收能量分配的限制的约束的所有缺损。

[0165] 在仍缺损能量的情况下，提供发电设施的另外安装以使弥补缺损。作为进行中的过程，在进行基础上随时间推移而评估分配于具有关联约束之那些优先权负载与不具有关联约束的那些无优先权负载之间的能量分布的平衡。由于提供新的约束及安装新的发电设施，故可取决于市场上对于间歇性可再生能量资源之需求量而调整根据如上参照图2所描述之诸如PDF 222的PDF所确定的平衡，以使在所测量审计过程中就满足约束之高概率而言

的稳固履行大于特定设定概率(例如99%、99.9%、99.999%等)。

[0166] 根据一个实施例的作为过程的审计及供应方法的概要

[0167] 图10显示例示根据一个实施例的形成用于集合发电设施的关联及多个负载的统计供应系统及审计方法学过程的流程图1000,且该过程包括以下步骤:

[0168] 建立消费者负载要求且获得或调整关联约束,且计算消费者负载需求及间歇性发电设施资源的PDF,以及计算发电供应的PDF;1002。

[0169] 将消费者负载分为优先权消费者及无优先权消费者,且形成约束类别及与一或多个类似定量约束关联的负载的子设备;1004。

[0170] 计算对优先权负载的供应的概率及建立那些负载将以高概率(例如99.9%、99.99%、99.999%等)自间歇性供应资源获得可再生能量数量,且在前瞻基础上获得经由合同强加的所有其他约束;1006。

[0171] 作为选项,取决于供应的可用性(如在1002处所计算),在进行基础上调整优先权及无优先权的建立,1008。

[0172] 作为选项,基于供应(如在1002处所计算)而调整新的发电设施的建立;1010。

[0173] 在时间t将供应传递至消费者负载;1012。

[0174] 根据测量为集合间歇性发电设施的时间分布的互相关性的能量的实际消耗而审计所测量电力的实际发电量,这些集合间歇性发电设施专用于根据特定负载的时间分布提供给特定负载约束,以及将任何剩余量分配给无优先权负载;1014。

[0175] 倘若对消费者负载的约束违规,则通过将额外的提供分配给消费者以补偿该违反,且在前瞻基础上调和供应方案,同时其后建立消费者负载要求及约束(见1002);1016。

[0176] 提供表示供应等级的各种所测量量或变量的公布,以及自审计至公众通信通道的消费者负载供应约束的验证;1018。

[0177] 在进行基础上实施过程步骤1002至1018(例如每月、每日、建立新的发电设施及新的消费者负载、每分钟等等),同时基于过程步骤1014的测量结果而调整建立用于供应给特定负载约束的专用间歇性资源量;1020。

[0178] 示例性实施例中的信息系统技术架构

[0179] 将建立服务器架构以优选地操纵大型太阳能发电机组的操作,该太阳能发电机组横跨特定地点/区域散布,诸如因安装在多个地点而横跨城市、国家或甚至世界。或者,可每一城市多次实施此同一架构且可添加对单个服务器以相互通信的允许,以使若准许使用者访问,则可由使用者比较及公布来自各种服务器及/或各种例如城市的信息。所有进入服务器的连接经使用示例性实行方案中的互联网而制造及以一些形式加密,以维护资料安全。该架构解决的主要方面优选地包括以下。

[0180] 1)由我们的发电机不断接收状态资料的能力。

[0181] 2)具有控制或改变如何操作发电机的能力。

[0182] 3)生成能量输出的审计及报告。

[0183] 图11显示与并入可实施来允许计算提供给消费者或由消费者所提供的约束的满足的元件的服务器1111的连接的基本概述、使用者登陆公布平台的方法,以及用于AC电力网网络管理员及电力系统运营商(PSO)的通信线路。信息技术架构的此实施例提供网络元件,用于帮助自能量计量仪器操作及读取信息。

[0184] 此处描述例如1186的控制单元元件。例如1186的控制单元包括设计以控制及保养例如1188的太阳能发电设施系统的可编程逻辑控制器(PLC)。在例如1188的特定太阳能发电设施位置中可安装一个或多个此类PLC元件。将例如1186的控制单元耦接至感测器(未显示)以将关于功率输出、电力干扰、日光暴露的信息提供给中央服务器1111,且以指示任何仪器故障。将此信息自例如1186的控制单元(本文中还可称为"监测单元")发送至例如1171的路由器,且直接进入服务器1111数据库1104,该路由器与服务器1111具有例如1172的加密虚拟专用网络(VPN)连接。若存在连接难题,则例如1186的控制单元储存状态更新直至建立连接,且随后上传排队状态更新。当连接至此实施例中的结构化查询语言(SQL)服务器1111时,例如1186的控制单元还检查是否存在需执行的任何远程命令,且以将这些命令发送至数据库1104的顺序或通过所分派时间签章,或通过所分派优先权而应用这些命令。在此实施例中,优先权的分配及/或例行程序的进度表将通过将这些例行程序发送至数据库1104的顺序而优先于例行程序的实行方案。

[0185] 此处描述服务器元件1111。服务器1111的中央核心围绕SQL数据库1104循环。存在用于获得信息的两个连接,这些连接为SQL数据库1104的大部分提供信息:例如的1186的控制单元、感测器、与产生电力的例如1188的发电设施相关联的计量系统(未显示),以及可通过读取来自二次服务提供者1143的消费者负载资料(见例如1114)或通过直接读取进入数据库1104的能量计而接收的能源市场顾客数据。使用此详细信息,服务器1111有利地致能生成所有该服务器的其他资料,如审计、记账等等。将根据表示所接收信息的时期以计算审计标记,且尤其就根据本文所描述的示例性实施例的调和及审计程序而论,数据库1104将帮助索引表示在回顾方案中能量的实际流动及验证已提供给消费者的约束的信息,在未重复计算任何能量发电形式间歇性电源的情况下以满足此类约束。

[0186] 服务器1111主持VPN服务器1102以接收来自所有该服务器的例如1186的控制单元的连接。服务器1111还主持网页服务器1115以总体显示关于特定发电机或系统的信息。能量顾客1163可登陆且看见为其所产生的太阳能的状态。这些顾客可选择选项以经由各种应用程序界面(API)而将其消耗信息公布至互联网1101上的地址,诸如这些顾客的主页,且还可选择选项以将其能量用途及审计公布至社交媒体站点,如twitter、Facebook、linkedin或其他位置。社交媒体站点列表不为详尽列表且可使用其他信息共享位置。提供屋顶空间或以其他方式提供位于这些消费者的土地上的发电设施的消费者可选择还经由API以公布来自那些相关联发电设施的发电资料,以及公布至社交媒体平台,且同样这些消费者可对特定电力网提供其特有的清洁能量贡献。电力运营商或电力网管理员1162可登陆及看见特定太阳能发电机的输出且具有在紧急情况下关闭该发电机的能力。负责操作太阳能基础设施的诸如安装者1161的公司工作人员还可登陆以看见特定太阳能发电机的状态、发送命令以及当安装新的太阳能发电机时还填写详细信息。

[0187] 在此实施例中服务器1111接收的另一连接来自能源市场顾客交易服务器1143。此连接可接收关于顾客的交易,这些顾客开始或终止与公用设施公司的合同。能源市场代表还可经由此连接而定期发送关于顾客能量用途(见例如1114)的更新。太阳能公用设施可使此信息与能量输出(例如1112)相关,以产生每一顾客的能量有多少来自例如1188的清洁能量发电设施的审计。当顾客接收我们的能量时,服务器1111上的记账部件1113收集审计标记以为每一顾客生成带有详细信息的账单。

[0188] 服务器1111还与能源市场1144制造安全连接，以将关于每一太阳能发电机生成的能量的信息发送至能量池。所报告的总输出应精密匹配每一太阳能发电机的计量的输出。还可使用该总输出以确保公用设施未超出记账或记账不足。

[0189] 在要求对特定身份的连接的安全性的情况下，诸如在电力系统运营商应为可发送调度命令的唯一实体的情况下，或在电力网网络管理员为可发送隔离请求的唯一实体的情况下，可实施证书交换以使通信安全。在实施例中在适当位置存在多层安全性，以优选地确保系统的安全性。将使用安全套接层(SSL)以使不同实体与服务器之间所使用的连接安全。此连接确保服务器仅与实体系统通信，且保护互联网免遭窃听。将要求登陆及密码以获得访问权。最后，我们将储存允许每一使用者使用的所接受互联网IP范围的白名单。将仅给予具有正确登陆、密码以及所接受IP的使用者访问权。IP白名单将主要用于可将命令发送至我们系统的实体。这些实体将需要静态IP且提供用于将连接至服务器的系统的IP范围。可逐次更新这些证书以确保这些证书不冲突，且将在公用设施的服务器侧及实体的与公用设施服务器通信的电脑上实施这些证书。

[0190] 图12显示例示根据示例性实施例的在电力网中供应电力的方法的流程图1200。在步骤1202处，确定连接至电力网的集合间歇性电源的初始前向概率性电力供应时间分布。在步骤1204处，确定连接至电力网的至少一个负载的目标电力需求时间分布。在步骤1206处，关联初始前向概率性电力供应时间分布及目标需求时间分布的至少各别部分，以使自间歇性电源至负载的电力供应的概率符合规定标准。

[0191] 该方法可进一步包括基于专用于负载的初始前向概率性电力供应时间分布的相关联部分而生成更新的前向概率性电力供应分布。该方法可进一步包括基于初始前向概率性电力供应时间分布及目标需求时间分布的关联至少各别部分而输出用于负载的前向概率性间歇性电力供应贡献。

[0192] 可基于初始前向概率性电力供应时间分布与目标需求时间分布的互相关的期望值而计算概率。

[0193] 可基于负载的优先等级而关联前向概率性电力供应曲线及目标需求时间分布的至少各别部分，该方法进一步包括将集合间歇性电源的间歇性发电设施的子设备专用于针对最高优先权负载的供应，以及基于排除子设备而生成更新的前向概率性电力供应分布。

[0194] 该方法可进一步包括确定自集合间歇性电源至负载的所测量电力供应是否满足规定标准，以及基于所测量电力供应以生成用于负载的实际间歇性电力供应贡献。

[0195] 该方法可进一步包括使与负载相关联的一或多个消费者约束生效。

[0196] 集合间歇性电源可包括连接至电力网的一或多个间歇性发电设施。

[0197] 该规定标准可包括由以下各项组成的组中的一个或多个：次级源和负载之间的至少一个相关、至少一个百分比混合、至少一个穿透比、以及至少一个互相关。

[0198] 图13显示例示用于在电力网中供应电力的系统1300的示意图，系统1300包括：设备1302，其用于确定连接至电力网的集合间歇性电源的初始前向概率性电力供应时间分布；设备1304，其用于确定连接至电力网的至少一个负载的目标电力需求时间分布；以及设备1306，其用于关联初始前向概率性电力供应时间分布及目标需求时间分布的至少各别部分，以使自间歇性电源至负载的电力供应的概率符合规定标准。

[0199] 该系统可进一步包括设备，该设备用于基于专用于负载的初始前向概率性电力供

应时间分布的关联部分而生成更新的前向概率性电力供应分布。

[0200] 该系统可进一步包括设备,其用于基于初始前向概率性电力供应时间分布及目标需求时间分布的关联至少各别部分而输出用于负载的前向概率性间歇性电力供应贡献。

[0201] 可基于初始前向概率性电力供应时间分布与目标需求时间分布的互相关的期望值而计算概率。

[0202] 可基于负载的优先等级而关联前向概率性电力供应分布及目标需求时间分布的至少各别部分,该方法进一步包括:将集合间歇性电源的间歇性发电设施的子设备专用于对最高优先权负载的供应,且基于排除子设备而生成更新的前向概率性电力供应分布。

[0203] 该系统可进一步包括设备,该设备用于确定自集合间歇性电源至负载的所测量电力供应是否满足规定标准,且基于所测量电力供应而生成用于负载的实际间歇性电力供应贡献。

[0204] 该系统可进一步包括设备,该设备用于使与负载相关联的一个或多个消费者约束生效。

[0205] 集合体间歇性电源可包括连接至电力网的一个或多个间歇性发电设施。

[0206] 该规定标准可包括由以下各项组成的组中的一个或多个:次级源和负载之间的至少一个相关、至少一个百分比混合、至少一个穿透比,以及至少一个互相关。

[0207] 图14显示例示根据示例性实施例的在电力网中合并功率注入及消耗的方法的流程图1400。在步骤1402处,将确定在一时间连接至电力网的集合间歇性电源的实际电力供应。在步骤1404处,确定在该时间连接至电力网的负载的实际功率消耗。在步骤1406处,关联实际电力供应及实际功率消耗的至少各别部分。在步骤1408处,基于实际电力供应及实际功率消耗的关联各别部分以确定用于负载的实际间歇性电力供应贡献。

[0208] 该方法可进一步包括自集合间歇性电源至负载的所确定实际间歇性电力供应贡献是否满足规定标准。

[0209] 该方法可进一步包括基于自集合间歇性电源至负载的实际电力供应是否满足指定标准,以更新用于负载的前向概率性间歇性电力供应贡献。

[0210] 该规定标准可包括由以下各项组成的组中的一个或多个:次级源和负载之间的至少一个相关、至少一个百分比混合、至少一个穿透比、以及至少一个互相关。

[0211] 可基于负载的优先等级以关联实际电力供应及实际功率消耗的至少各别部分。

[0212] 该方法可进一步包括在关联较低优先等级负载之剩余实际电力供应及实际功率消耗的各别部分之前,关联最高优先等级负载之实际电力供应及实际功率消耗的各别部分。

[0213] 该方法可进一步包括使与负载关联的一个或多个消费者约束生效。

[0214] 集合间歇性电源可包括连接至电力网的一个或多个间歇性发电设施。

[0215] 图15显示例示用于在电力网中合并功率注入及消耗的系统1500的示意图,系统1500包括:设备1502,其用于确定在一时间连接至电力网的集合间歇性电源的实际电力供应;设备1504,其用于确定在该时间连接至电力网的负载的实际功率消耗;设备1506,其用于关联实际电力供应及实际功率消耗的至少各别部分;以及设备1508,其用于基于实际电力供应及实际功率消耗的关联各别部分而确定用于负载的实际间歇性电力供应贡献。

[0216] 该系统可进一步包括设备,该设备用于确定自集合间歇性电源至负载的所确定实

际间歇性电力供应贡献是否满足规定标准。

[0217] 该系统可进一步包括设备，该设备用于基于自集合间歇性电源至负载的实际电力供应是否满足指定标准，以更新用于负载的前向概率性间歇性电力供应贡献。

[0218] 该规定标准可包括由以下各项组成的组中的一个或多个：次级源和负载之间的至少一个相关、至少一个百分比混合、至少一个穿透比、以及至少一个互相关。

[0219] 可基于负载的优先等级以关联实际电力供应及实际功率消耗的至少各别部分。

[0220] 该系统可进一步包括设备，该设备用于在关联较低优先等级负载的剩余实际电力供应及实际功率消耗的各别部分之前，关联最高优先等级负载的实际电力供应及实际功率消耗的各别部分。

[0221] 该系统可进一步包括设备，该设备用于使与负载相关联的一个或多个消费者约束生效。

[0222] 集合间歇性电源可包括连接至电力网的一个或多个间歇性发电设施。

[0223] 图16显示例示用于电力网的计量系统1600的示意图，该计量系统包括：设备1602，其用于计量连接至电力网的集合间歇性电源的电力供应；设备1604，其用于计量在该时间连接至电力网的负载的功率消耗；以及设备1606，其用于基于所计量电力供应及所计量功率消耗，以计量用于负载的间歇性电力供应贡献。

[0224] 用于计量间歇性电力供应贡献的设备可经配置以关联所计量电力供应及所计量功率消耗的至少各别部分。

[0225] 用于计量间歇性电力供应贡献的设备可经配置以基于负载的优先等级而关联所计量电力供应及所计量功率消耗的各别部分。

[0226] 用于计量间歇性电力供应贡献的设备可经配置以在关联较低优先等级负载的所计量电力供应及所计量功率消耗的剩余部分的各别部分之前，关联最高优先等级负载的所计量电力供应及所计量功率消耗的各别部分。

[0227] 该系统可进一步包括设备，该设备用于确定间歇性电力供应贡献是否满足规定标准。

[0228] 该系统可进一步包括设备，该设备用于基于间歇性电力供应贡献是否满足规定标准，以更新用于负载的前向概率性间歇性电力供应贡献。

[0229] 该规定标准可包括由以下各项组成的组中的一个或多个：次级源和负载之间的至少一个相关、至少一个百分比混合、至少一个穿透比、以及至少一个互相关。

[0230] 该系统可进一步包括设备，该设备用于使与负载相关联的一个或多个消费者约束生效。

[0231] 集合间歇性电源可包括连接至电力网的一个或多个间歇性发电设施。

[0232] 图17显示例示根据示例性实施例的用于电力网的计量方法的流程图1700。在步骤1702处，计量连接至电力网的集合间歇性电源的电力供应。在步骤1704处，计量在该时间连接至电力网的负载的功率消耗。在步骤1706处，计量基于所计量电力供应及所计量功率消耗的用于负载的间歇性电力供应贡献。

[0233] 计量间歇性电力供应贡献可经配置以关联所计量电力供应及所计量功率消耗的至少各别部分。

[0234] 计量间歇性电力供应贡献可经配置以基于负载的优先等级而关联所计量电力供

应及所计量功率消耗的各别部分。

[0235] 计量间歇性电力供应贡献的设备可经配置以在关联较低优先等级负载的所计量电力供应及所计量功率消耗的剩余部分的各别部分之前,关联最高优先等级负载的所计量电力供应及所计量功率消耗的各别部分。

[0236] 该方法可进一步包括确定间歇性电力供应贡献是否满足规定标准。

[0237] 该方法可进一步包括基于间歇性电力供应贡献是否满足规定标准,以更新用于负载的前向概率性间歇性电力供应贡献。

[0238] 该规定标准可包括由以下各项组成的组中的一个或多个:次级源与负载之间的至少一个相关性、至少一个百分比混合、至少一个穿透比、以及至少一个互相关。

[0239] 该方法可进一步包括使与负载相关联的一个或多个消费者约束生效。

[0240] 集合间歇性电源可包括连接至电力网的一个或多个间歇性发电设施。

[0241] 本领域技术人员将了解,可在不脱离如本发明广泛描述的精神或范畴的情况下对本发明作出众多改变及/或修改。本实施例因此在所有方面中皆视为说明性而非限制性的。此外,虽然在专利申请范围或本实施例中未明确指定特征或特征的组合,但本发明包括特征的任何组合,尤其而言包括专利申请范围中的特征的任何组合。

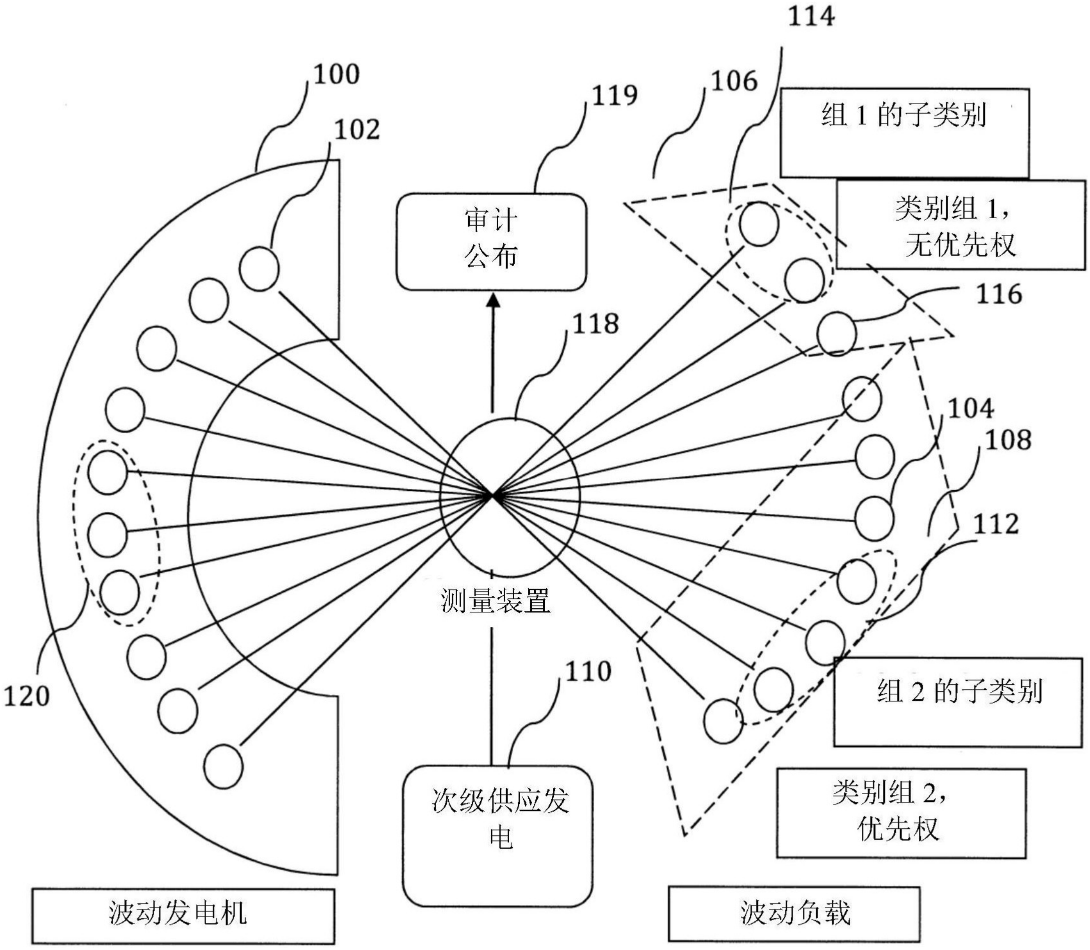

114
100
106
119
组 1 的子类别
102
类别组 1，
无优先权
审计
公布
116
118
104
108
112
测量装置
120
110
组 2 的子类别
次级供应发电
类别组 2，
优先权
波动发电机
波动负载

图1

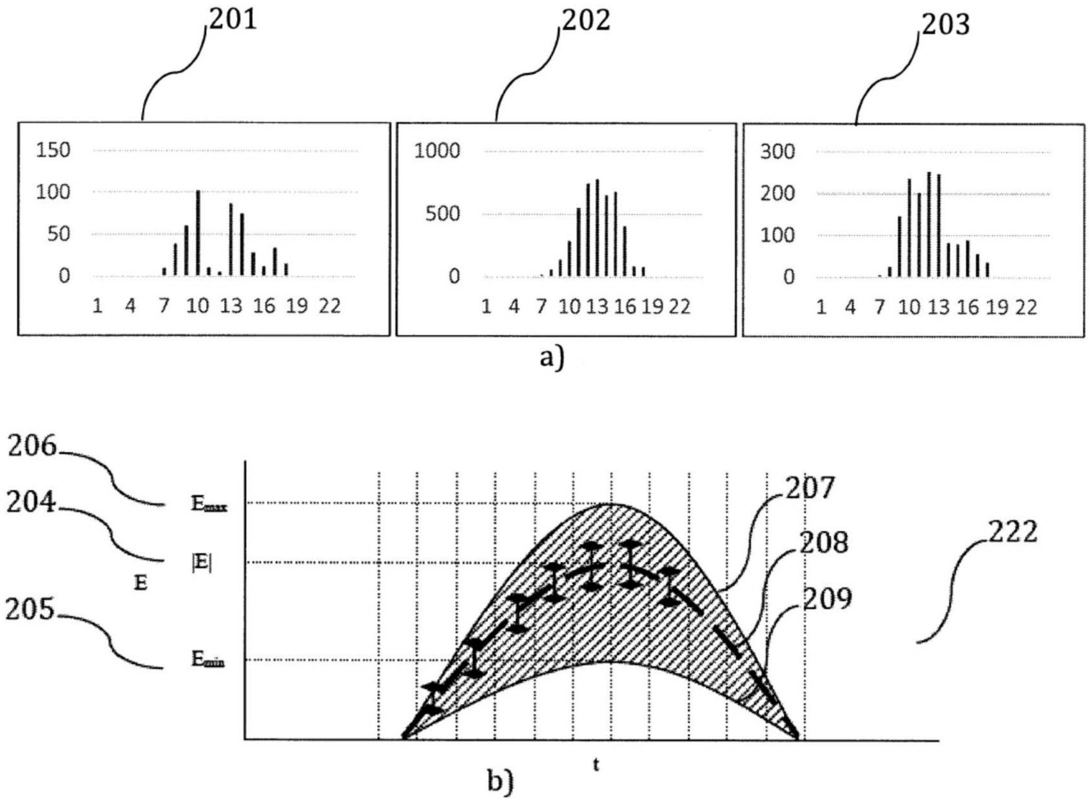

201
202
203
150
100
50
0
1 4 7 10 13 16 19 22
1000
500
0
1 4 7 10 13 16 19 22
300
200
100
0
1 4 7 10 13 16 19 22
a)
206
204
205
E
207
208
209
222
t
b)

图2

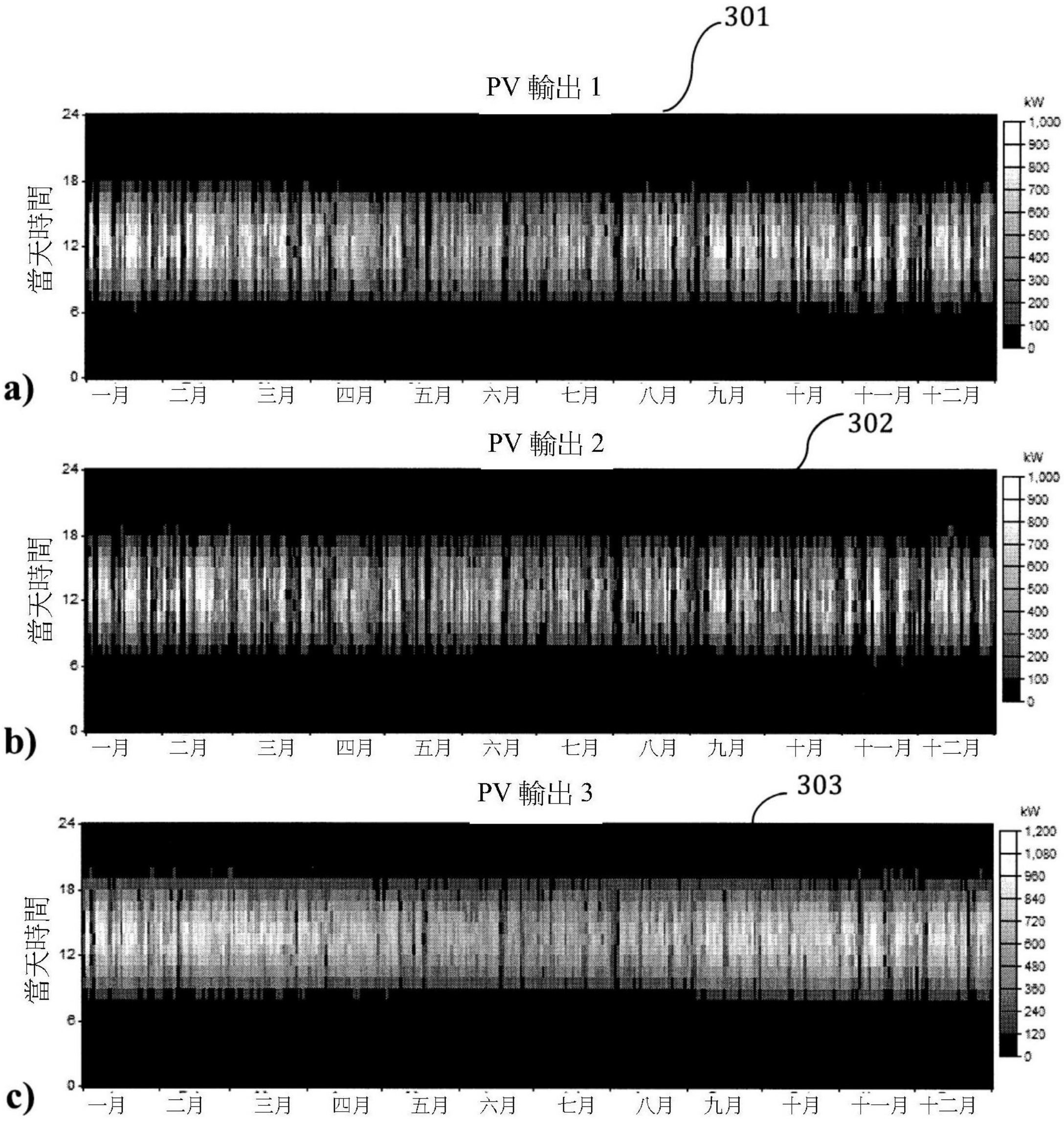

301
PV 輸出 1
當天時間
kW
1,000
900
800
700
600
500
400
300
200
100
0
24
18
12
6
0
a)
一月 二月 三月 四月 五月 六月 七月 八月 九月 十月 十一月 十二月
302
PV 輸出 2
b)
303
PV 輸出 3
1,200
1,080
960
840
720
600
480
360
240
120
c)

图3

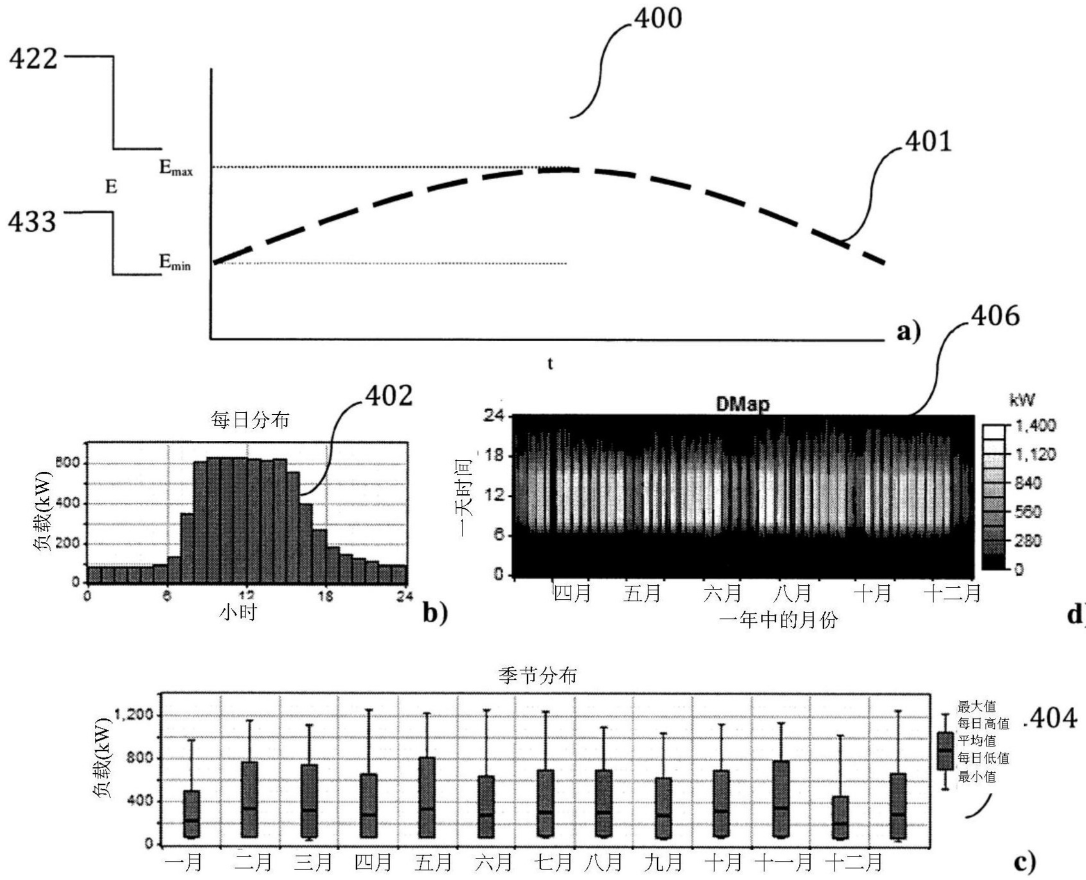

400
422
433
E
Emax
Emin
401
t
a)
406
402
每日分布
负载(kW)
小时
b)
DMap
kW
一天时间
一年中的月份
四月
五月
六月
八月
十月
十二月
d)
季节分布
负载(kW)
最大值
每日高值
平均值
每日低值
最小值
.404
一月
二月
三月
四月
五月
六月
七月
八月
九月
十月
十一月
十二月
c)

图4

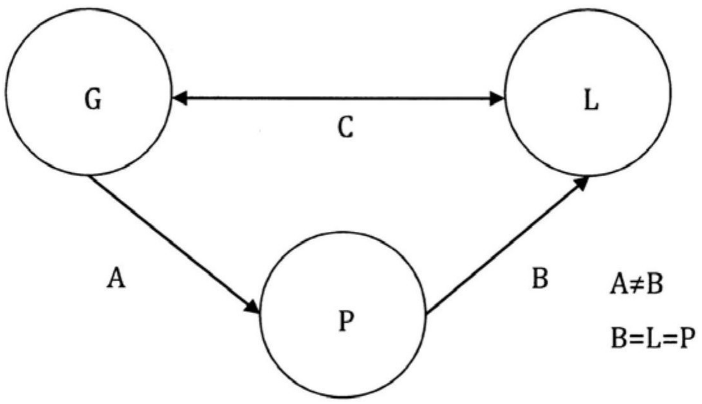

G
L
C
A
P
B
A≠B
B=L=P

图5

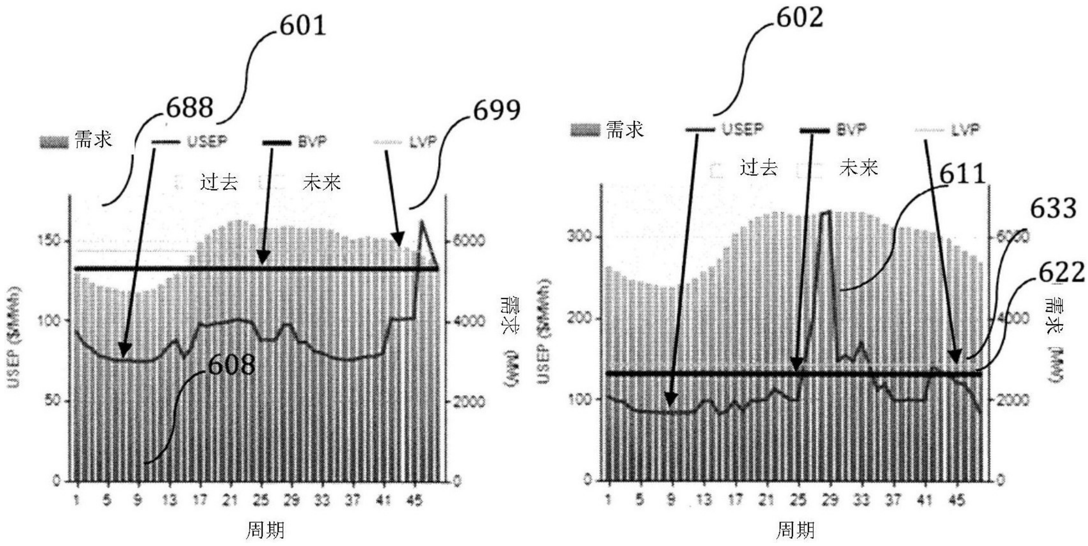
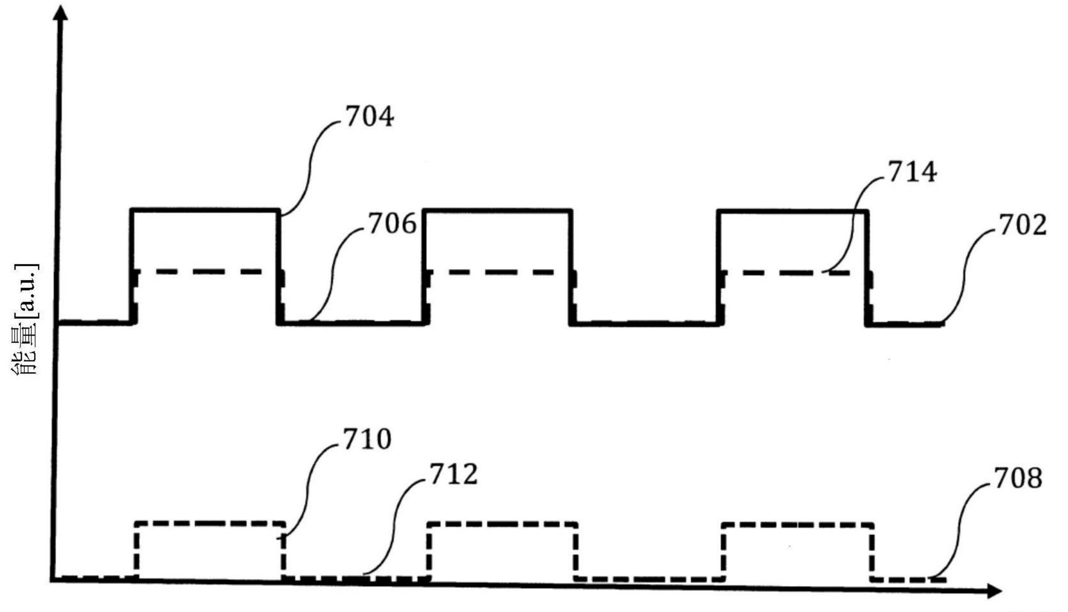
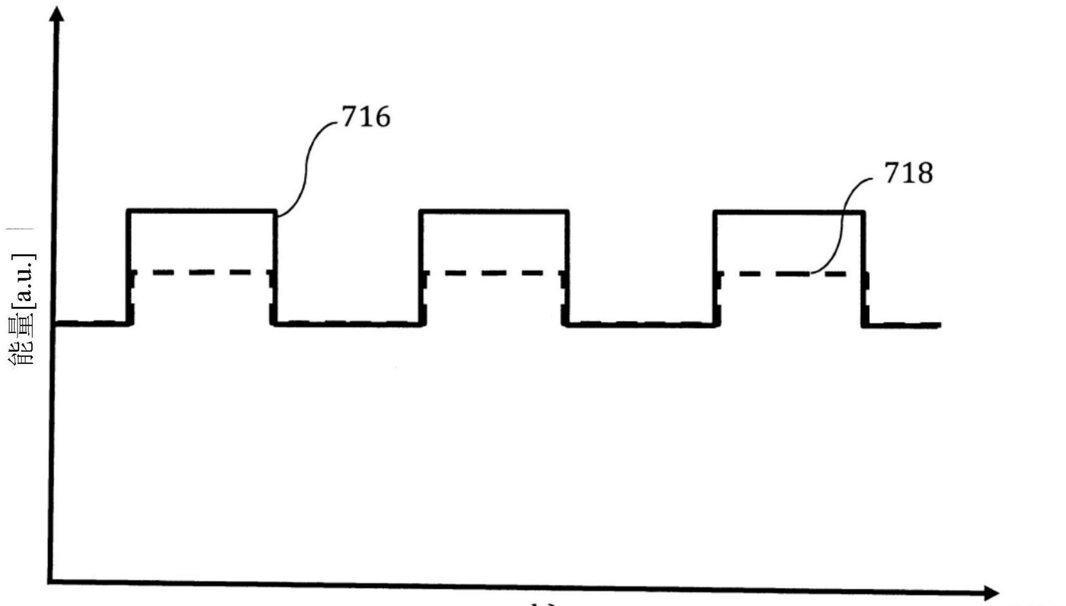

601
688
699
需求
USEP
BVP
LVP
过去
未来
608
USEP ($/MWh)
需求 (MW)
周期
602
611
633
622

图6



a)



b)

图7

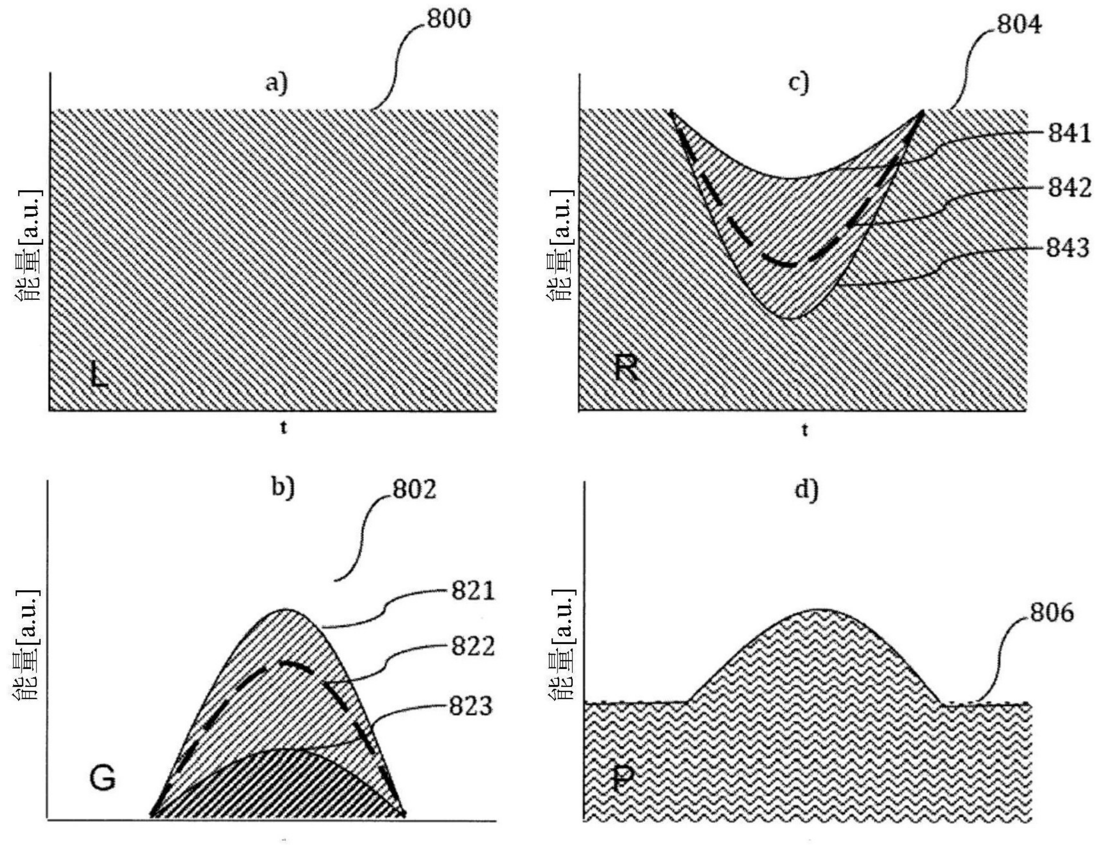

800
a)
能量[a.u.]
L
t
804
c)
841
842
843
能量[a.u.]
R
t
b)
802
821
822
823
能量[a.u.]
G
d)
806
能量[a.u.]
P

图8

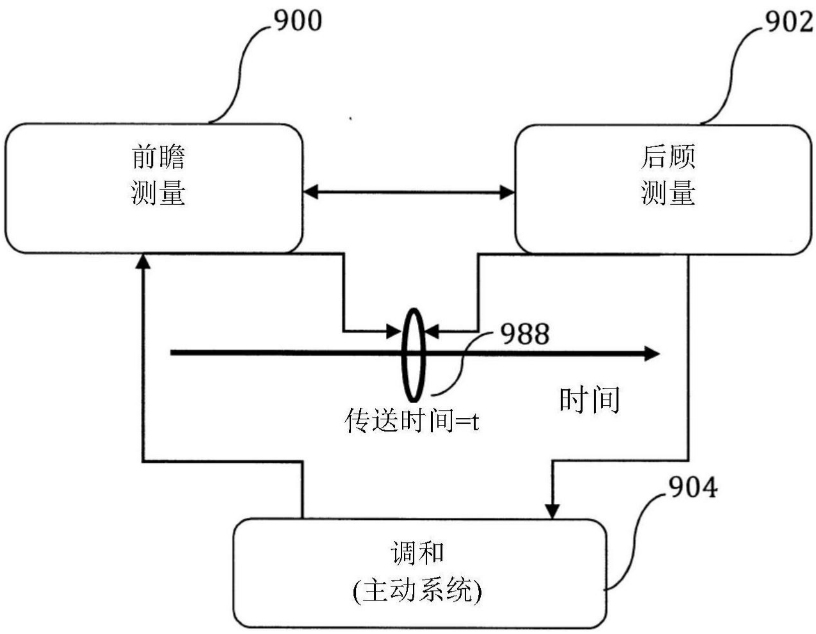

900
902
前瞻
测量
后顾
测量
988
时间
传送时间=t
904
调和
(主动系统)

图9

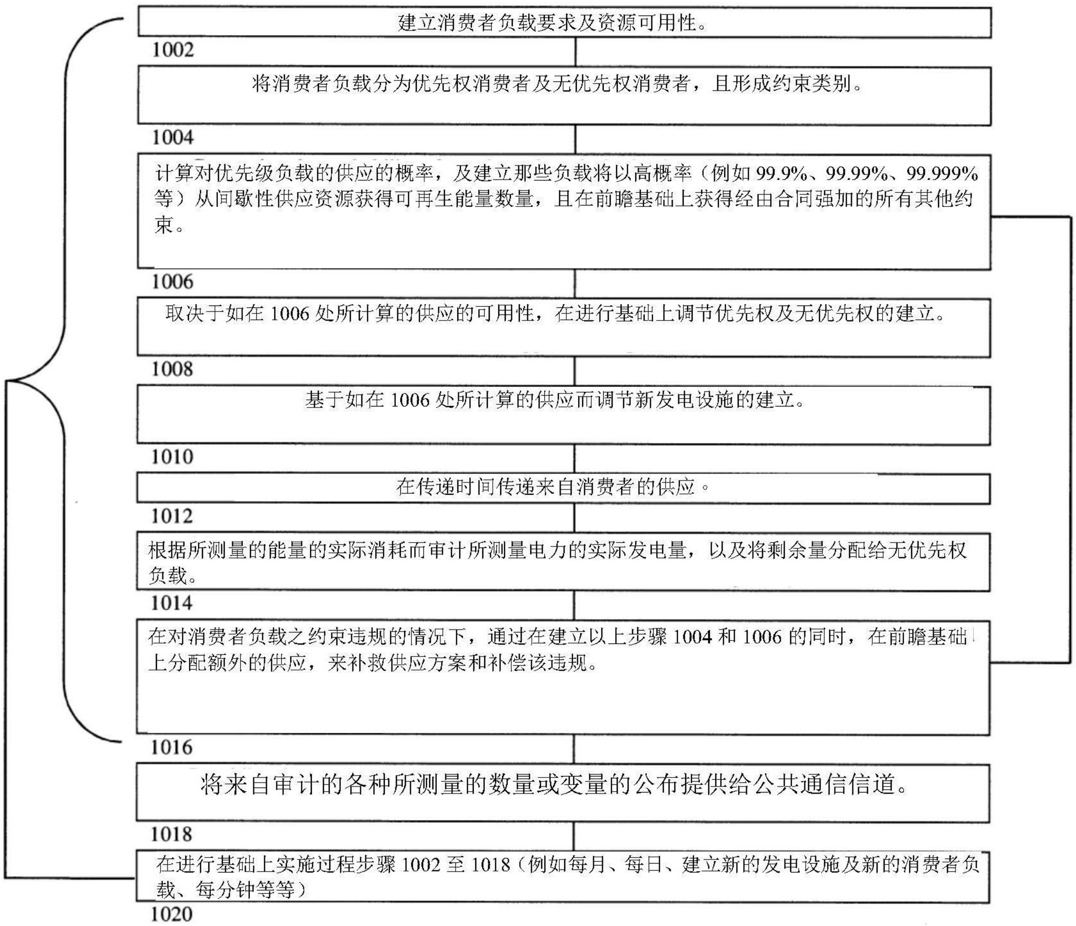

建立消费者负载要求及资源可用性。
1002
将消费者负载分为优先权消费者及无优先权消费者，且形成约束类别。
1004
计算对优先级负载的供应的概率，及建立那些负载将以高概率（例如99.9%、99.99%、99.999%等）从间歇性供应资源获得可再生能量数量，且在前瞻基础上获得经由合同强加的所有其他约束。
1006
取决于如在1006处所计算的供应的可用性，在进行基础上调节优先权及无优先权的建立。
1008
基于如在1006处所计算的供应而调节新发电设施的建立。
1010
在传递时间传递来自消费者的供应。
1012
根据所测量的能量的实际消耗而审计所测量电力的实际发电量，以及将剩余量分配给无优先权负载。
1014
在对消费者负载之约束违规的情况下，通过在建立以上步骤1004和1006的同时，在前瞻基础上分配额外的供应，来补救供应方案和补偿该违规。
1016
将来自审计的各种所测量的数量或变量的公布提供给公共通信信道。
1018
在进行基础上实施过程步骤1002至1018（例如每月、每日、建立新的发电设施及新的消费者负载、每分钟等等）
1020

图10

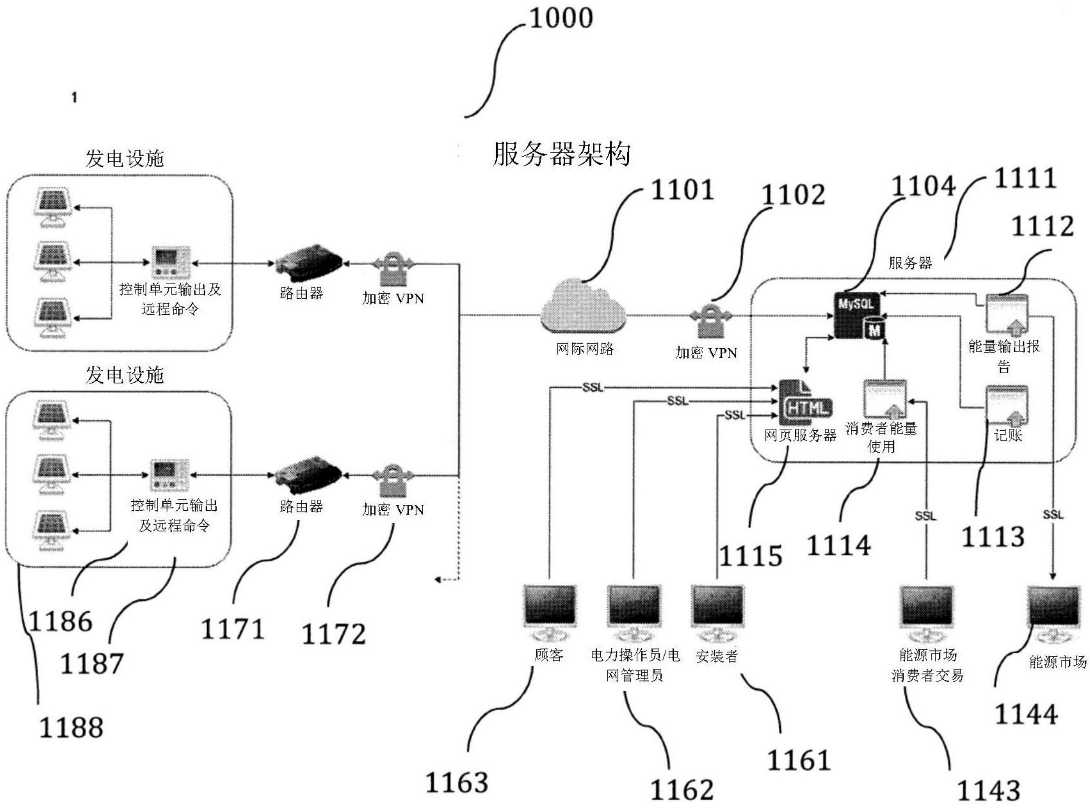

1000
1
服务器架构
发电设施
控制单元输出及远程命令
路由器
加密 VPN
发电设施
控制单元输出及远程命令
路由器
加密 VPN
1101
1102
1104
1111
1112
服务器
网际网路
加密 VPN
MySQL
M
能量输出报告
SSL
SSL
SSL
HTML
网页服务器
消费者能量使用
记账
SSL
SSL
1186
1187
1188
1171
1172
1115
1114
1113
顾客
电力操作员/电网管理员
安装者
能源市场消费者交易
能源市场
1144
1163
1162
1161
1143

图11

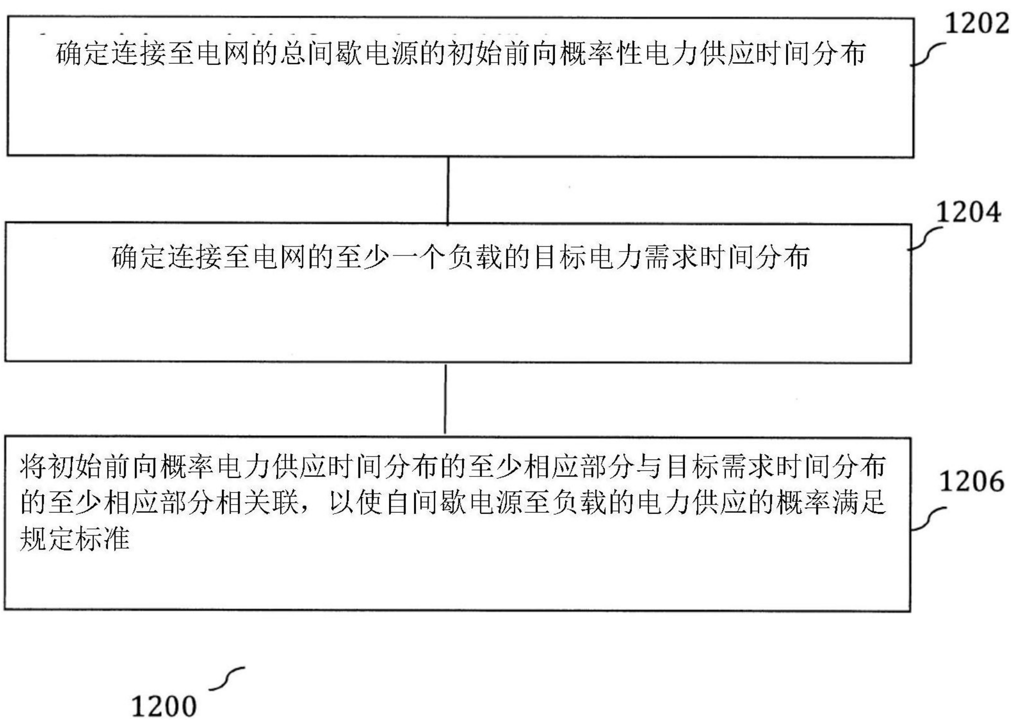

确定连接至电网的总间歇电源的初始前向概率性电力供应时间分布
1202
确定连接至电网的至少一个负载的目标电力需求时间分布
1204
将初始前向概率电力供应时间分布的至少相应部分与目标需求时间分布的至少相应部分相关联，以使自间歇电源至负载的电力供应的概率满足规定标准
1206
1200

图12

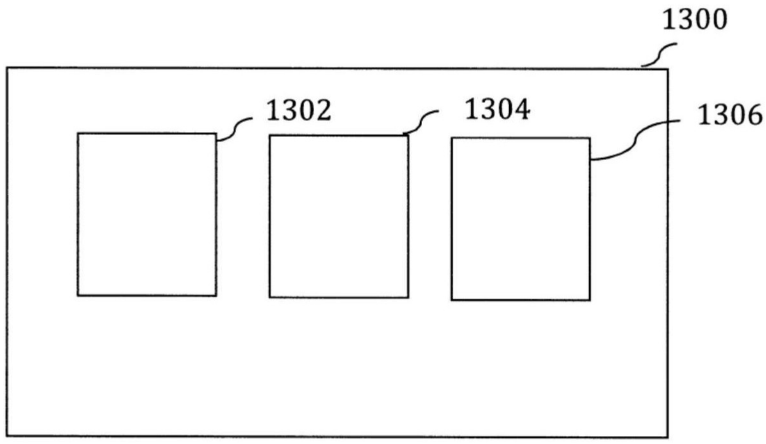

1300
1302
1304
1306

图13

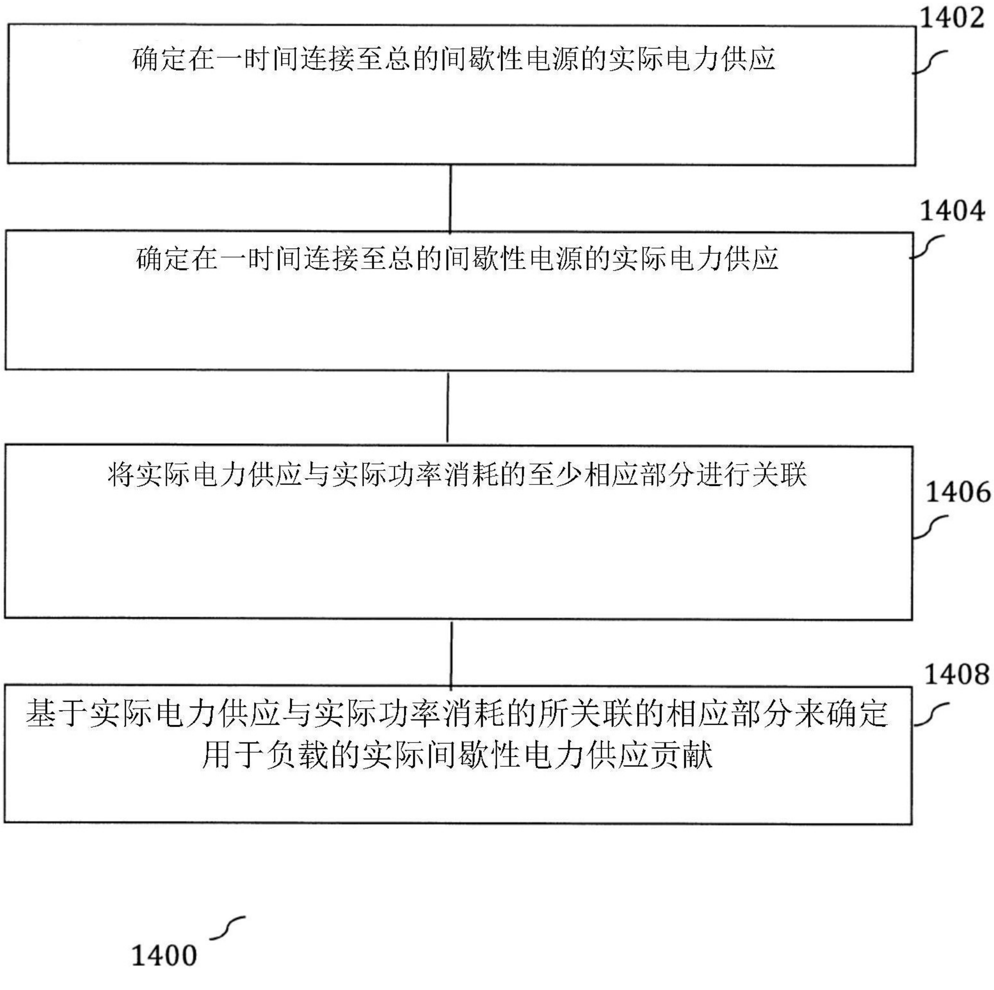

确定在一时间连接至总的间歇性电源的实际电力供应
1402
确定在一时间连接至总的间歇性电源的实际电力供应
1404
将实际电力供应与实际功率消耗的至少相应部分进行关联
1406
基于实际电力供应与实际功率消耗的所关联的相应部分来确定用于负载的实际间歇性电力供应贡献
1408
1400

图14

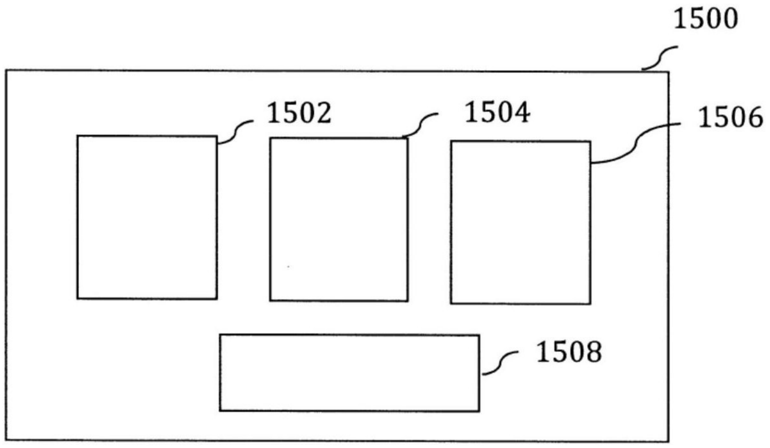

1500
1502
1504
1506
1508

图15

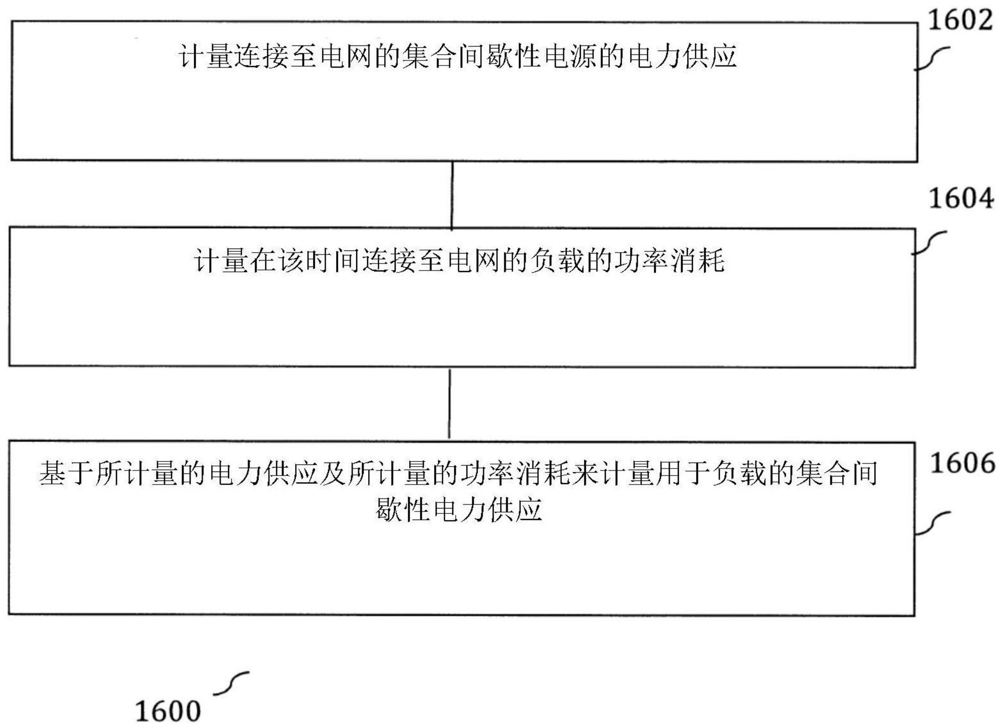

计量连接至电网的集合间歇性电源的电力供应
1602
计量在该时间连接至电网的负载的功率消耗
1604
基于所计量的电力供应及所计量的功率消耗来计量用于负载的集合间歇性电力供应
1606
1600

图16

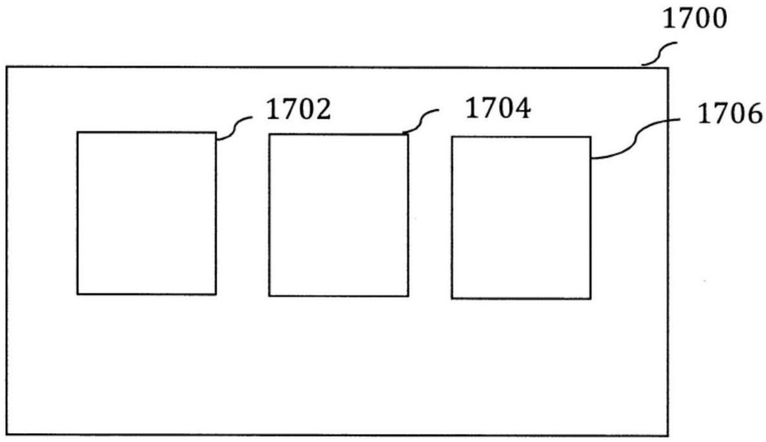


图17