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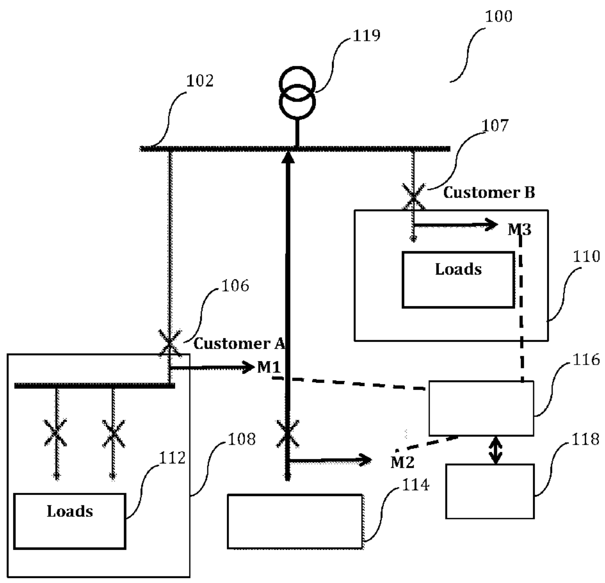

Figure 1

(57) Abstract: A power grid system and a method of consolidating power injection and consumption in a power grid system. The power grid system comprises a power grid; at least one load connected to the power grid; a first meter configured for metering power imported from the power grid to the load; at least one intermittent power source connected to the power grid, a second meter configured for metering power generated by the intermittent power source; and a consolidation unit configured for associating readings from the first and second meters such that at least a portion of the power generated by the intermittent power source is offsettable with the power imported from the power grid to the load.

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POWER GRID SYSTEM AND METHOD OF CONSOLIDATING POWER INJECTION AND CONSUMPTION IN A POWER GRID SYSTEM

FIELD OF INVENTION

The present invention relates broadly to a power grid system and to a method of consolidating power generation and consumption in a power grid system.

BACKGROUND

To date, the majority of buildings, in particular commercial buildings such as shopping malls or industrial buildings, obtain all their power from a mains power grid system where a generator such as a coal-fired power plant or another combustion engine supply power to the power network pool through a power grid network as adjusted by the load demand on the power grid network. Generation of power from auxiliary generators associated with the buildings load may be performed independently of the mains power grid system as an embedded generator to the building solely reducing the total energy drawn by the buildings loads from the power network. For example, a solar power system may be connected directly through the buildings distribution board to supply the buildings loads with priority to the power grid.

Within the mains power grid system, intermittent sources for power generation may be used together with dispatchable sources such as coal-fired power plant or another combustion engine to contribute to the power network pool, i.e. in meeting the overall demand experienced in the mains power grid system. However, given the nature of the intermittent sources such as their inability to follow directly a changing load profile, and an output dependent on external factors like the weather, the availability of an environmental resource at a particular time local to the generator (eg. the flow of water or sunlight incident on a photovoltaic (PV) plate), their adoption as a means of supplying power through a mains power grid system to a load connected to the mains power grid system remains relatively underdeveloped.

Embodiments of the present invention provide a power grid system and a method of consolidating power generation and consumption in a power grid system 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 power grid system comprising a power grid; at least one load connected to the power grid; a first meter configured for metering power imported from the power grid to the load; at least one intermittent power source connected to the power grid, a second meter configured for metering power generated by the intermittent power source; and a consolidation unit configured for associating readings from the first and second meters such that at least a portion of the power generated by the intermittent power source is offsettable with the power imported from the power grid to the load.

In accordance with a second aspect of the present invention there is provided a method of consolidating power injection and consumption in a power grid system, the method comprising metering power imported from a power grid to a load using a first meter; metering power generated by an intermittent power source connected to the power grid using a second meter; and associating readings from the first and second meters such that at least a portion of the power generated by the intermittent power source is offsettable with the power imported from the power grid to the load.

In accordance with a third aspect of the present invention there is provided a method of supplying power using the power grid system as defined in the first aspect.

In accordance with a fourth aspect of the present invention there is provided a method of supplying power using the method as claimed in the second aspect.

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 power grid system 100 according to an example embodiment.

Figure 2 shows a series of voltages on a network associated with electrical conduction through various voltage transformers, each voltage level associated to a particular market settlement pool (.eg. Low Voltage, High Voltage, Extra High Voltage, etc.).

Figures 3a) and b) show graphs illustrating power consumption by, and power supply to, loads in the power grid system 100 as a function of time over a specified period, according to an example embodiment.

Figure 4 shows a histogram illustrating the probabilistic capacity of supply from an intermittent source assuming one time bin interval of supply, according to an example embodiment.

Figures 5a) – c) show a set of look-back supply profiles illustrating characteristic fluctuations in power capacity associated with particular time periods, according to an example embodiment.

Figure 6 shows a flow chart illustrating a method of consolidating power injection and consumption in a power grid system, according to an example embodiment.

DETAILED DESCRIPTION

Figure 1 shows a schematic drawing illustrating a power grid system 100 according to an example embodiment. The system 100 comprises a power grid 102. The power grid 102 is associated through flow of electrons and holes through the network and is associated with various voltages defined through the placement of voltage transformers matching a corresponding specification. Typically, the mains supply for a load or loads connected to the power grid 102 is from a transformer 119, as a step down from a higher voltage level. The application of transformers for establishing the various voltages on a power grid network is understood in the art and will not be described herein in any detail. Figure 2 shows example voltage levels, e.g. Low Voltage 203, High Voltage 204, and Extra High Voltage 205 in a power grid network 200. Each of the transformers 201, 202 or the Extra High Voltage generator 206 can take the role of the transformer 119 illustrated in Figure 1.

Returning to Figure 1, the power grid 102 establishes network used to transfer power among loads from various sources of electricity also establishes an energy market and settlement in a pool associated to the specific voltage range.

The power grid system 100 further comprises a plurality of building connections e.g. 106, 107, each building connection e.g. 106, 107 comprising power meters e.g. M1, M3, configured for metering power imported from the power grid 102 to a loads or loads 112 e.g. in the associated building 108.

One or more intermittent sources 114 are also connected to the power grid 102. Meter M2 is configured for metering power exported by the intermittent source 114 to the power grid 102. The intermittent source 114 may for example be a photovoltaic (PV) power generator.

It is understood that the person skilled in the art could additionally adapt the following protocol where the interconnection of the source is through an intermediary or injective power to an intermediate grid connected apparatus. For example, the source may inject power to a distribution board of a building attached to the grid, wherein the offset of power drawn by the building is in turn providing additional power at the grid from the supply of power through the intermittent source. Below the interconnection is referred to as "to the grid" but it is understood that for the purposes of establishing energy flow from an intermittent source to a load the consolidation unit may utilize the metering protocol described herein for a variety of kinds of interconnections of the source.

It has been recognized by the inventors that electricity from an intermittent source cannot be retailed "on demand" to any given load on the grid network, as is typically done for electricity from contestable energy sources on the power grid 102, i.e. from sources that "continuously" supply electricity from power conversion using e.g. natural gas or other fuel-based resources and flow adjusting to the capacity of a load. Such a source is limited by available fuel and the maximum capacity of the combustion engine, but is not limited by an external environmental variable and thus can follow the load profile.

For the purpose of supplying intermittent power to one or more characteristic loads on a power network, electricity transactions to a specific load are performed by accounting for at least one of the loads own characteristic profile (in time and in capacity – referred to herein as a "load profile" or a "demand profile") based on the reading from e.g. meters M1, M3, and accounting for a market based pricing scenario, such as an energy pool price and/or the relative level of energy demand at a specific point in time. Transactions on the market can be based on a particular period of time allocated to a time bin, for example one second, one minute, a half hour, or hour, etc. For example, the National Electricity Market of Singapore accounts for energy supply and demand on a half hourly basis – i.e in thirty minute intervals. The given time bin during which energy settlements occur is referred to by the inventor below and it is understood that this particular period of time is associated with a given market and may be a variety of time periods.

In example embodiments of the present invention, a characteristic generation of power from the intermittent source, as metered by e.g. M2 over a given period of time, for example spanning at least one time bin during which energy is settled in a given energy market, forms the retail basis for supply of power from the intermittent source 114, such as a PV power generator, to the consumer associated with the building 108/the loads e.g. 112. The supply characteristic is referred to herein as a supply profile and accounts for fluctuations in the resources and energy supply over time as associated to a given intermittent energy source.

In the example embodiment, the consumer associated with the building 108/the loads e.g. 112 is provided with an agreed amount of power from the intermittent source 114 over a billing period under a supply arrangement with the operator of the intermittent source 114. This billing period spans one or more than one interval as associated to the minimum time bin of settlement on a given market platform. This means that the uncertainty in the availability of the resource, here solar power, may be reduced by accounting for the statistics of the load profile (demand profile) and supply profile over time, and can be improved by adjusting the supply level over a variety of time bins associated to the load profile.

In an example embodiment, the histogram 400 of Figure 4 illustrates the probabilistic capacity of supply from an intermittent source assuming one time bin interval of supply. In this example, the total supply capacity at the specific time interval is associated with the probability of injection of power from the intermittent source and this distribution can be utilized for providing power to a load or loads connected to the power grid network. Such a scenario can be extrapolated for more than one time bin of power supply and consumption. In this sense, discrete probability models can be utilized to represent the supply characteristics of the intermittent source(s) and can be factored into a supply contract based on an associated demand profile of the load or loads. It will be appreciated by a person skilled in the art that a histogram illustrating probabilistic demand of the load(s) may be similarly derived.

As an example embodiment, the supply from the intermittent source 114 can be delivered to a specific load or loads on the power grid 102 by providing an average amount of power distributed over more than one time bin for supply. This allows the supplier of power from the intermittent source 114 to associate the characteristics of their source in time and capacity to the consumer and formulate a contract to supply energy to the consumer on the basis of e.g. a maximum and minimum amount of power that may be delivered in any given time interval to the consumer, or a minimum average amount of power that can be delivered over a specified time period spanning at least more than one time interval. The supplier can in addition use an adjusted transaction for the power on a look back basis by receiving or delivering the consumer with energy settlement transactions on the basis of any modification of the actual supply of power over the look back period as compared to the projected supplies of power associated with specific time intervals, or with a combination of those intervals.

The consumer advantageously avails themselves of an additional or supplemental power supply from the power grid 102 which offsets an alternative means of obtaining power from the power grid 102, which may for example be based on a separate power retail arrangement.

In example embodiments, the total supply and demand characteristics of a given market (i.e. by aggregating all the loads that demand power from the main power grid) may be accounted for using e.g. a consolidation unit 116 as will be described in more detail below. In the event that the time periods of the intermittent supply, i.e. the supply profile(s) of the intermittent source(s), show positive correlations to the total demand profile associated to the pool, the offsetting mechanisms obtained by the implementation of the supply source(s) to deliver intermittent power to a load or loads will in turn adjust the total capacities of power that are required to be delivered from the second supply source(s), as associated to a given period of time. A consumer may utilize these offsets to reduce the requirements of power at times associated with a peak or peaks in the total demand profile associated to the pool. When the peak or peaks are also correlated with a higher market rate, the supply of the intermittent source(s) advantageously reduces the amount of demand to be met from the second supply sources and thus the amount of cost associated with obtaining a supply of power from the second source(s). For example, the second source(s) can be a conventional power source that may deliver power to the power network, e.g. a dispatchable power source, however, the second source(s) can also generally be associated with the wholesale pool, i.e. irrespective of the type of power source(s) that provide the power for the wholesale pool.

For example Solar PV power is typically generated during peak demand periods, i.e. during the day time and in sunny, thus warm, conditions. This positively correlates to the total energy demand of a consumer, for example from air-conditioning units that cool the building e.g. 108. In addition, industrial and commercial activities are typically performed during normal business hours, and thus the energy that is demanded from these activities is positively correlated in time to the supply of Solar PV power (on average). It is noted that by accounting for a clearness index and an irradiance index, the total intermittency of a Solar PV supply source can be determined on average for any given time bin for the supply of power to a load.

By using the total capacity offsets obtained from the supply of the intermittent source 114, the consumer may negotiate a favorable power supply contract with a secondary retailer in the market at the relevant voltage of the power grid 102, since a peak demand that forms part of the power supply contract can be anticipated as lower than without the supply from the intermittent source 114.

A contestable retailer is obligated to procure wholesale electricity on the spot to fill the retail contract. Thus, the retailer bears a risk profile at the peak periods, which the retailer will consider in the terms of the supply contract offered to the consumer. If the consumer can anticipate a lower peak demand due to the power supply from the intermittent source 114, then the risk profile considered by the retailer will be "reduced" in the sense that the retailer can expect having to procure wholesale electricity less often for this consumer, or at a lower capacity of demand on average and as associated with the probabilities of supply determined for the specific intermittent source, putting the contestable retailer in a position to offer more favorable terms based on observing a modified supply profile, and modified risk profile associated with such supply, as determined by observing the alternative supply demand characteristics of the energy pool.

In the following, technical means for facilitating the implementation of the injection of power from the intermittent source 114 into the power grid 102, or supplied to the power grid through an intermediate or indirect manner, and associating the injected power with consumption at a specific load or loads e.g. 112 will be described.

A consolidation unit 116 in the example embodiment is configured for determining power supplied or injected by the intermittent source into the power grid 102 on the basis of the reading from the meter M2.

The consolidation unit 116 of the system 100 is also configured for determining power imported from the power grid 102 via the building connection e.g. 106 to the load or loads e.g. 112 at the relevant voltage of the power grid 102, based on readings from the meter M1.

The consolidation unit 116 in the example embodiment is configured to associate the readings from meter M1 and M2 such that respective time profiles of the power injected by the intermittent source 114 into the power grid 102 and of the power imported from the power grid 102 to the one or more loads e.g. 112 via the building connection e.g. 106 are associated with each other. At least a portion of the power injected by the intermittent source 114 into the power grid 102 through direct or indirect means, such as an intermediary, is offsetable against the power imported from the power grid 102 to the one or more loads e.g. 112 via the building connection e.g. 106

For example, that the intermittent source 114 may produce and inject 50 kW over a specified consolidation or billing period via the meter M2 into the power grid 102. The loads e.g. 112 in the associated building 108 may consume 100 kW over the specified period.

For the specified period, M1 meters 100 kW were imported from the power grid 102 into the building 108.

By providing the consolidation unit 116, i.e. a technical means to associate at least a portion of the power injected from the intermittent source into the power grid 102 with the power imported to the load or loads e.g. 112 in a time resolved manner, power from the intermittent source 114 can in effect be directly provided to a specific load or loads/consumed over the power grid 102.

Figure 3a) shows a graph illustrating power consumption by, and power supply to, the load(s) e.g. 112 (Figure 1) as a function of time over a specified period. Curve 302 schematically shows the consumption by a load, chosen in this example on account of having the peaks e.g. 304 and troughs e.g. 306 coincide with day and night time respectively. As will be appreciated by the person skilled in the art, during the day time power consumption is typically increased for e.g. an office building due to working hours and associated operation of appliances such as computers, printers, fans, air conditioning etc.

Curve 308 schematically shows the PV power generation profile from the PV power generator 114 (Figure 1) during the specified period. As will be appreciated by the person skilled in the art, the power generation peaks e.g. 310 coincide with the day time, while essentially no power is generated during the night time e.g. 312. That is, the generation profile 308 and the consumption profile 302 of the chosen source/load pair (or pairs) are preferably matched. In addition or alternatively the matching can also involve controlling the load or a subset of the load so that the controlled consumption profile matches a particular generation profile of the intermittent source(s) and/or vice versa.

Curve 314 schematically shows the portion of the power consumption that will be met by supply from the power grid 102 (Figure 1) using secondary energy source(s). As can be seen from a comparison of curves 302 and 314, the amount of power that needs to be met during the peak periods e.g. 304 is reduced accordingly. As mentioned above, the contestable retailer is obligated to procure wholesale electricity on the spot to fill the retail contract. Thus, the retailer bears a risk profile at the peak periods e.g. 304, which the retailer will consider in terms of the supply contract offered to the consumer. If the consumer can anticipate a lower peak demand due to the supplemental power supply from the PV power generator 114 (Figure 1), then the risk profile considered by the retailer will be "reduced", corresponding to the flattened supply profile represented by curve 314. Thus, the retailer can expect having to procure wholesale electricity less often for this consumer, putting the retailer in a position to offer more favorable terms to that consumer for the supply of the secondary energy source. This benefit is extended to a load or loads of specific characteristics being supplied to via the power grid. In Figure 3b), curves 316 and 318 schematically show the required supply needed from other (secondary) sources/the contestable retailer without and with the PV power generator capacity offset respectively.

Returning to Figure 1, upon installation of the intermittent source 114, an initial time profile of power to be supplied or injected into the power grid 102 may be based on calculations using the technical specifications of intermittent source 114, and available and/or historical statistical environment conditions such as the total irradiance, day-light hours and intensity, the clearness index, cloud formation, weather conditions etc. at the location of a PV power generator or in proximity to that generator as an example of the intermittent source 114 over a time period. In the later, for example, the formation of cloud cover within a few hours from the generator, and traveling in the direction of that generator, can be used as a forward supply prediction data point. Various external data may be incorporated into the consolidation unit 116 to achieve additional refinements to the forward looking supply available from the intermittent source 114, and can be adapted into the supply arrangement by varying characteristic profiles of associated demand and supply. In turn, this data may also be used to adapt a dispatch strategy actively given that the supply from intermittent sources has been predicted or refined.

Based on the initial amount, arrangements with consumers on the power grid 102 for supply of power via the power grid 102 can be made taking into account respective load profiles (demand profiles). Advantageously, the arrangements can be adjusted periodically, based on historic actual power supply data obtained by the consolidation unit 116, thus continually improving the cost/actual supply balance of the retail arrangement. Alternatively or additionally, the supply profile can be changed by adding additional intermittent sources and/or modifying an existing intermittent source.

As an example embodiment, a set of look-back supply profiles 500, 502, 504 are shown in Figures 5a) – c) having characteristic fluctuations in power capacity associated with particular time periods, derived from data over one single day each, wherein each of the Figures displays a unique look-back profile of supply from the source on three separate days. It will be appreciated by a person skilled in the art that the demand profile(s) of the load(s) may be similarly found e.g. on a look back basis from which a capacity offset can be determined, on average. Using the measured data, a consolidation can be technically enabled and can be performed according to example embodiments, to account for changes in the actual supply and the supply profile that was determined to be provided for the specific load. The supply profile statistics may be determined by aggregate of various determined fluctuations on the source determined through relevant factors, for example, but not limited to, the generators location, the local irradiance, wind speeds, cloud formation patterns as imaged via satellite, other meteorological information, etc.

Referring to the exemplary supply scenario described above, an optimization of the second source price through the use of the pool volatility and price can then be performed. The time correlation of the loads along with the sources can be combined to derive the capacity of remaining demand of the load/loads as associated to the pool supply and demand characteristics. By utilizing a cross correlation between the reduced demand of the remaining load capacity to be supplied through an alternate means, the load demand from the alternate means can be derived. In addition, deriving the quantitative risk as associated with a second supply can be technically enabled and be performed according to example embodiments. In turn, the second supply of power can be modified so as to account for the statistically modified demand associated with the load or loads which are offsetable utilizing the intermittent power supplied. In turn, the supply and demand as well as pricing of the second supply system can be modified to reflect an optimized scenario wherein the intermittent supply source is utilized.

In example embodiments, a Power Systems Operator may utilize the statistics of the supply source from the PV generator using e.g. the consolidation unit 116, along with a metrological unit 118 to adjust their dispatch systems to call on a secondary source (for example a conventional or dispatchable source). This can result in an operator of the power grid system 100 to modify their dispatch system against the pool demand. Through the technical implementation of embodiments of the present invention, the cost of electricity and the amount of resources consumed from conventional sources can be reduced, and instead harvested from renewable sources, while providing a technical means of optimization of the supply demand scenario of a given market.

In one embodiment, a power grid system comprises a power grid; at least one load connected to the power grid; a first meter configured for metering power imported from the power grid to the load; at least one intermittent power source connected to the power grid, a second meter configured for metering power generated by the intermittent power source; and a consolidation unit configured for associating readings from the first and second meters such that at least a portion of the power generated by the intermittent power source is offsettable with the power imported from the power grid to the load.

The consolidation unit may be configured to associate the readings from the first and second meters such that respective time profiles of the power generated by the intermittent power source and of the power imported from the power grid to the load are associated with each other.

One or both of the intermittent source and the load may be configured to be controllable for facilitating matching the respective time profiles to each other.

The consolidation unit may be configured to calculate a power supply cost for the load based on one or both of the associated readings from the first and second meters.

The power grid system may further comprise at least one dispatchable power source connected to the power grid and may be configured such that a power injection by the dispatchable power source into the power grid is adjustable responsive to one or both of the associated readings from the first and second meters.

The intermittent source may be directly connected to the power grid or via an intermediate grid-connected apparatus.

The intermittent source and the load may be located at different locations relative to the power grid or substantially at a same location relative to the power grid.

The consolidation unit may be configured for deriving a histogram of a probabilistic demand of the load over one or more time bin intervals.

The consolidation unit may be configured for deriving a histogram of a probabilistic capacity of supply from the intermittent source over one or more time bin intervals.

A power injection by one or more dispatchable power sources into the power grid may be adjustable as associated with the histogram of the probabilistic capacity of supply from the intermittent source over the one or more time bin intervals.

A risk profile associated with supply to the load from one or more dispatchable power sources over the power grid may be modifiable as determined by observing a modified demand profile taking into account the histogram of the probabilistic capacity of supply from the intermittent source over the one or more time bin intervals.

The consolidation unit may be configured to receive external data such as location data, radiation data, wind speed data, cloud formation patterns as imaged via satellite, other meteorological information etc.

The consolidation unit may be configured to predict or refine a supply from the intermittent source to the load.

The consolidation unit may be configured to determine a look-back supply profile or profiles of the supply from the intermittent source to the load.

The consolidation unit may be configured to determine a look-back demand profile or profiles of a demand of the load.

Figure 6 shows a flow chart 600 illustrating a method of consolidating power injection and consumption in a power grid system, according to an example embodiment. At step 602, power imported from a power grid to a load is metered using a first meter. At step 604, power generated by an intermittent power source connected to the power grid is metered using a second meter. At step 606, readings from the first and second meters are associated such that at least a portion of the power generated by the intermittent power source is offsettable with the power imported from the power grid to the load.

The method may comprise associating the readings from the first and second meters such that respective time profiles of the power generated by the intermittent power source and of the power imported from the power grid to the load are associated with each other.

The method may comprise controlling one or both of the intermittent source and the load for facilitating matching the respective time profiles to each other.

The method may comprise calculating a power supply cost for the load based on one or both of the associated readings from the first and second meters.

The method may further comprise adjusting a power injection by at least one dispatchable power source into the power grid responsive to one or both of the associated readings from the first and second meters.

The intermittent source may be directly connected to the power grid or via an intermediate grid-connected apparatus.

The intermittent source and the load may be located at different locations relative to the power grid or substantially at a same location relative to the power grid.

The method may comprise deriving a histogram of a probabilistic demand of the load over one or more time bin intervals.

The method may comprise deriving a histogram of a probabilistic capacity of supply from the intermittent source over one or more time bin intervals.

The method may comprise adjusting a power injection by one or more dispatchable power sources into the power grid as associated with the histogram of the probabilistic capacity of supply from the intermittent source over the one or more time bin intervals.

The method may comprise modifying a risk profile associated with supply to the load from one or more dispatchable power sources over the power grid as determined by observing a modified demand profile taking into account the histogram of the probabilistic capacity of supply from the intermittent source over the one or more time bin intervals.

The method may comprise considering external data such as location data, radiation data, wind speed data, cloud formation patterns as imaged via satellite, other meteorological information etc.

The method may comprise predicting or refining a supply from the intermittent source to the load.

The method may comprise determining a look-back supply profile or profiles of the supply from the intermittent source to the load.

The method may comprise determining a look-back demand profile or profiles of a demand of the load.

In one embodiment, a method of supplying power using the power grid system of the above embodiments is provided.

In one embodiment, a method of supplying power using the method of the above embodiments is provided.

Example embodiments can advantageously also enable methods for settlement and transaction of energy supply and demand over a power grid network.

In example embodiments, power generated from an intermittent source or a plurality of such sources is implemented so as to supply a load using the source or sources based on characteristic statistics of the source or sources; or characteristic statistics of the source or sources and other external factors such as local irradiance, wind speed, temperature, other meteorological factors, or the like. The supply to the load may account for characteristic statistics of that load. This contrasts with the supply of power from a source to a load is on a basis that supply of power is isolated at a specific time of supply of the power, given the dispatchable nature of a conventional electricity generator.

In one example embodiment, the specific time characteristics of the intermittent energy supply source is a solar energy generator supplying power to a load through a power grid network. In an alternative embodiment, supply of power by a plurality of generators including one or more intermittent or none or more non-intermittent generators, and supplying power through a power grid network to a load or plurality of loads connected to the power grid network.

Example embodiments can also provide transactional aspects of power settlement of intermittent generation to a load in terms of the transactional settlement of electricity, and in terms of optimization of the transaction of supply from any generator connected to the grid network through use of the characteristic time statistics of one or more generators supplying to a particular load. The optimization of the transaction of supply of power to the load or loads may in addition account for the characteristic time statistics of the load or loads.

Example embodiments can uniquely allow an intermittent source to be transacted as a generator to a particular load on a power grid network.

The present specification also discloses apparatus for implementing or performing the operations of the methods. Such apparatus may be specially constructed for the required purposes, or may comprise a device selectively activated or reconfigured by a computer program stored in the device. 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 device. 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 the device effectively results in an apparatus that implements the steps of the 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, 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.

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.

For example, while PV power generators have been described in example embodiments, in different embodiments different intermittent sources may be used such as wind-based generators or water-based generators, etc., wherein the person skilled in the art would appreciate that each of the generators has a characteristic time based profile that may additionally be determined through various external information, and may in addition be correlated to the risk profile(s) and/or load profile(s) of a given power consumption scenario according to example embodiments.

CLAIMS

1. A power grid system comprising:

a power grid;

at least one load connected to the power grid;

a first meter configured for metering power imported from the power grid to the load;

at least one intermittent power source connected to the power grid,

a second meter configured for metering power generated by the intermittent power source; and

a consolidation unit configured for associating readings from the first and second meters such that at least a portion of the power generated by the intermittent power source is offsettable with the power imported from the power grid to the load.

2. The power grid system as claimed in claim 1, wherein the consolidation unit is configured to associate the readings from the first and second meters such that respective time profiles of the power generated by the intermittent power source and of the power imported from the power grid to the load are associated with each other.

3. The power grid as claimed in claim 2, wherein one or both of the intermittent source and the load are configured to be controllable for facilitating matching the respective time profiles to each other.

4. The power grid system as claimed in any one of the preceding claims, wherein the consolidation unit is configured to calculate a power supply cost for the load based on one or both of the associated readings from the first and second meters.

5. The power grid system as claimed in any one of the preceding claims, further comprising at least one dispatchable power source connected to the power grid and configured such that a power injection by the dispatchable power source into the power grid is adjustable responsive to one or both of the associated readings from the first and second meters.

6. The power grid system as claimed in any one of the preceding claims, wherein the intermittent source is directly connected to the power grid or via an intermediate grid-connected apparatus.

7. The power grid system as claimed in any one of the preceding claims, wherein the intermittent source and the load are located at different locations relative to the power grid or substantially at a same location relative to the power grid.

8. The power grid system as claimed in any one of the preceding claims, wherein the consolidation unit is configured for deriving a histogram of a probabilistic demand of the load over one or more time bin intervals.

9. The power grid system as claimed in any one of the preceding claims, wherein the consolidation unit is configured for deriving a histogram of a probabilistic capacity of supply from the intermittent source over one or more time bin intervals.

10. The power grid system as claimed in claim 9, wherein a power injection by one or more dispatchable power sources into the power grid is adjustable as associated with the histogram of the probabilistic capacity of supply from the intermittent source over the one or more time bin intervals.

11. The power grid system as claimed in claims 9 or 10, wherein a risk profile associated with supply to the load from one or more dispatchable power sources over the power grid is modifiable as determined by observing a modified demand profile taking into account the histogram of the probabilistic capacity of supply from the intermittent source over the one or more time bin intervals.

12. The power grid system as claimed in any one of the preceding claims, wherein the consolidation unit is configured to receive external data such as location data, radiation data, wind speed data, cloud formation patterns as imaged via satellite, other meteorological information etc.

13. The power grid system as claimed in any one of the preceding claims, wherein the consolidation unit is configured to predict or refine a supply from the intermittent source to the load.

14. The power grid system as claimed in any one of the preceding claims, wherein the consolidation unit is configured to determine a look-back supply profile or profiles of the supply from the intermittent source to the load.

15. The power grid system as claimed in any one of the preceding claims, wherein the consolidation unit is configured to determine a look-back demand profile or profiles of a demand of the load.

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

metering power imported from a power grid to a load using a first meter;

metering power generated by an intermittent power source connected to the power grid using a second meter; and

associating readings from the first and second meters such that at least a portion of the power generated by the intermittent power source is offsettable with the power imported from the power grid to the load.

17. The method as claimed in claim 16, comprising associating the readings from the first and second meters such that respective time profiles of the power generated by the intermittent power source and of the power imported from the power grid to the load are associated with each other.

18. The method as claimed in claim 17, comprising controlling one or both of the intermittent source and the load for facilitating matching the respective time profiles to each other.

19. The method as claimed in any one of claims 16 to 18, comprising calculating a power supply cost for the load based on one or both of the associated readings from the first and second meters.

20. The method as claimed in any one of claims 16 to 19, further comprising adjusting a power injection by at least one dispatchable power source into the power grid responsive to one or both of the associated readings from the first and second meters.

21. The method as claimed in any one of claims 16 to 20, wherein the intermittent source is directly connected to the power grid or via an intermediate grid-connected apparatus.

22. The method as claimed in any one of claims 16 to 21, wherein the intermittent source and the load are located at different locations relative to the power grid or substantially at a same location relative to the power grid.

23. The method as claimed in any one of claims 16 to 22, comprising deriving a histogram of a probabilistic demand of the load over one or more time bin intervals.

24. The method as claimed in any one of claims 16 to 23, comprising deriving a histogram of a probabilistic capacity of supply from the intermittent source over one or more time bin intervals.

25. The method as claimed in claim 24, comprising adjusting a power injection by one or more dispatchable power sources into the power grid as associated with the histogram of the probabilistic capacity of supply from the intermittent source over the one or more time bin intervals.

26. The method as claimed in claims 24 or 25, comprising modifying a risk profile associated with supply to the load from one or more dispatchable power sources over the power grid as determined by observing a modified demand profile taking into account the histogram of the probabilistic capacity of supply from the intermittent source over the one or more time bin intervals.

27. The method as claimed in any one of claims 16 to 26, comprising considering external data such as location data, radiation data, wind speed data, cloud formation patterns as imaged via satellite, other meteorological information etc.

28. The method as claimed in any one of claims 16 to 27, comprising predicting or refining a supply from the intermittent source to the load.

29. The method as claimed in any one of claims 16 to 28, comprising determining a look-back supply profile or profiles of the supply from the intermittent source to the load.

30. The method as claimed in any one of claims 16 to 29, comprising determining a look-back demand profile or profiles of a demand of the load.

31. A method of supplying power using the power grid system as claimed in any one of claims 1-15.

32. A method of supplying power using the method as claimed in any one of claims 16 to 30.

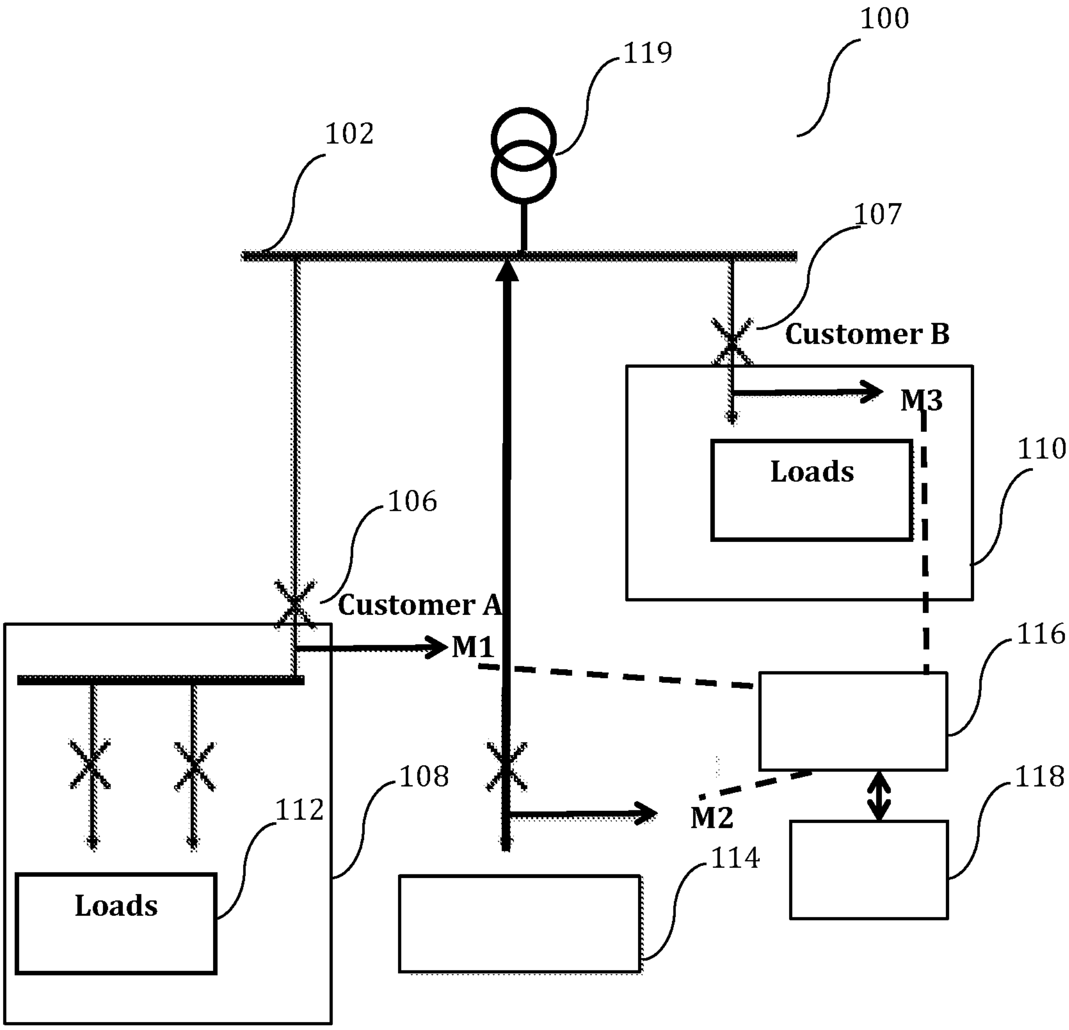

100
119
102
107
Customer B
M3
Loads
110
106
Customer A
M1
116
108
112
118
M2
114
Loads

Figure 1

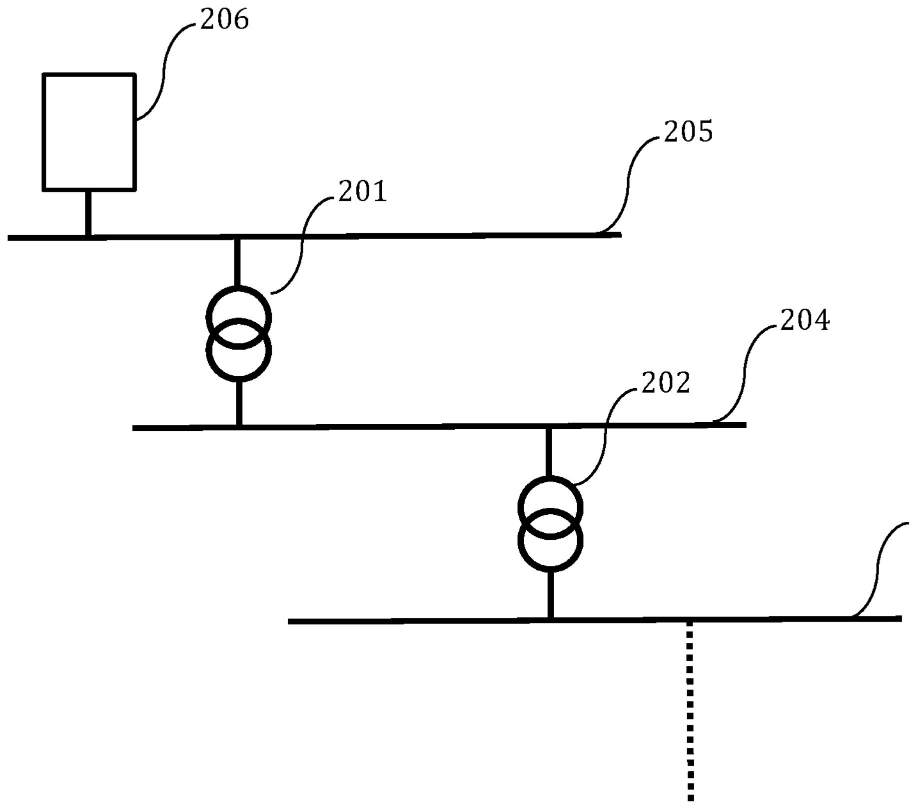
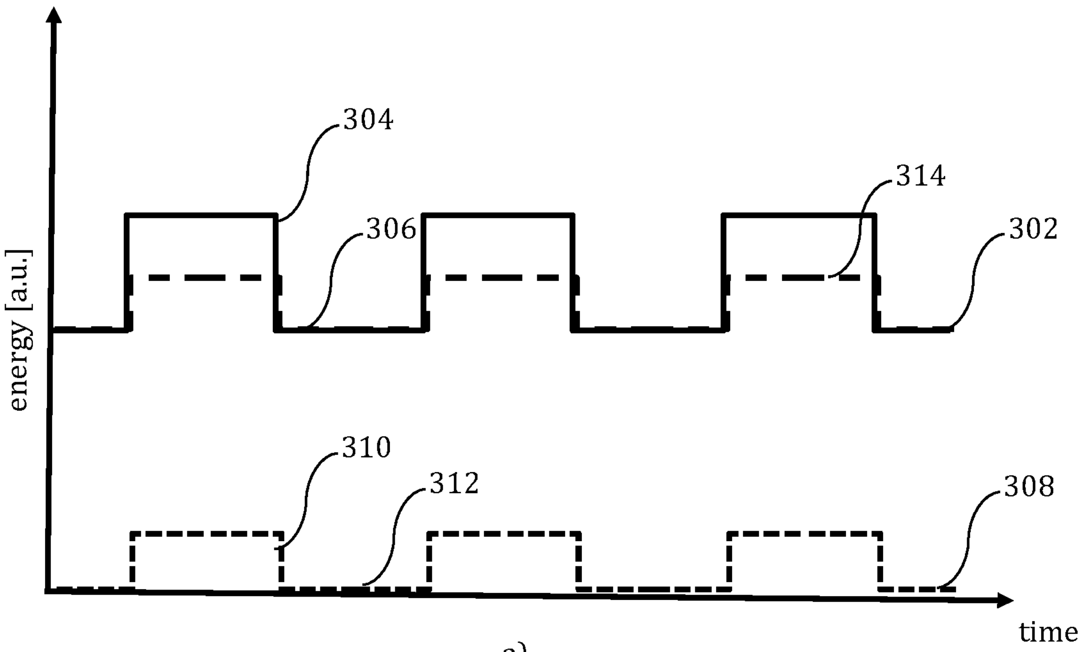
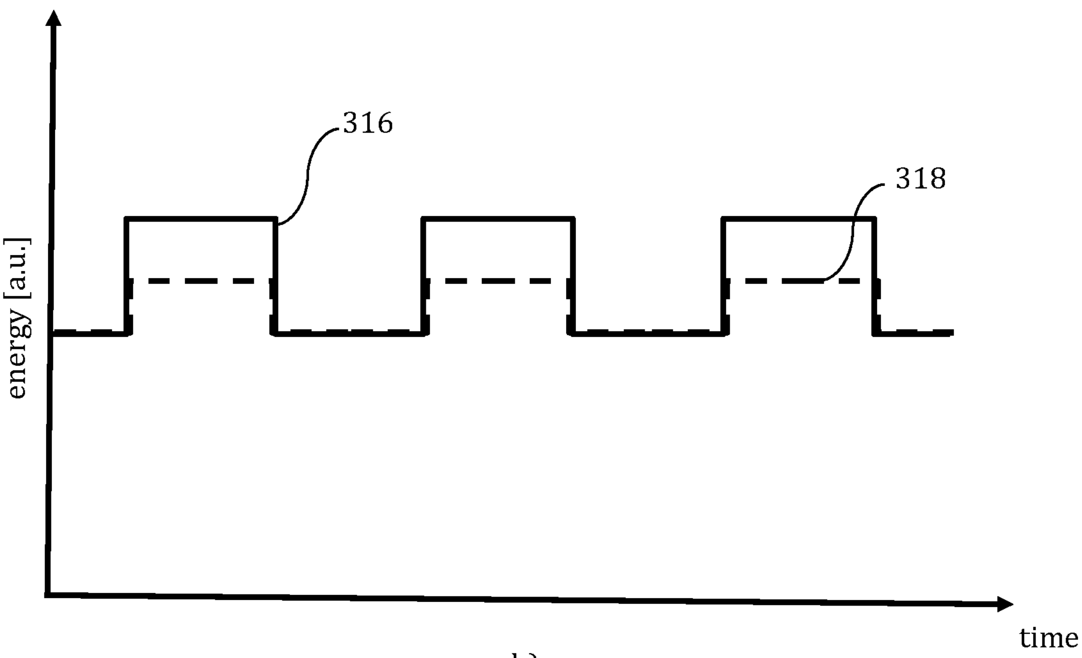


Figure 2


304
314
306
302
energy [a.u.]
310
312
308
time

a)


316
318
energy [a.u.]
time

b)

Figure 3

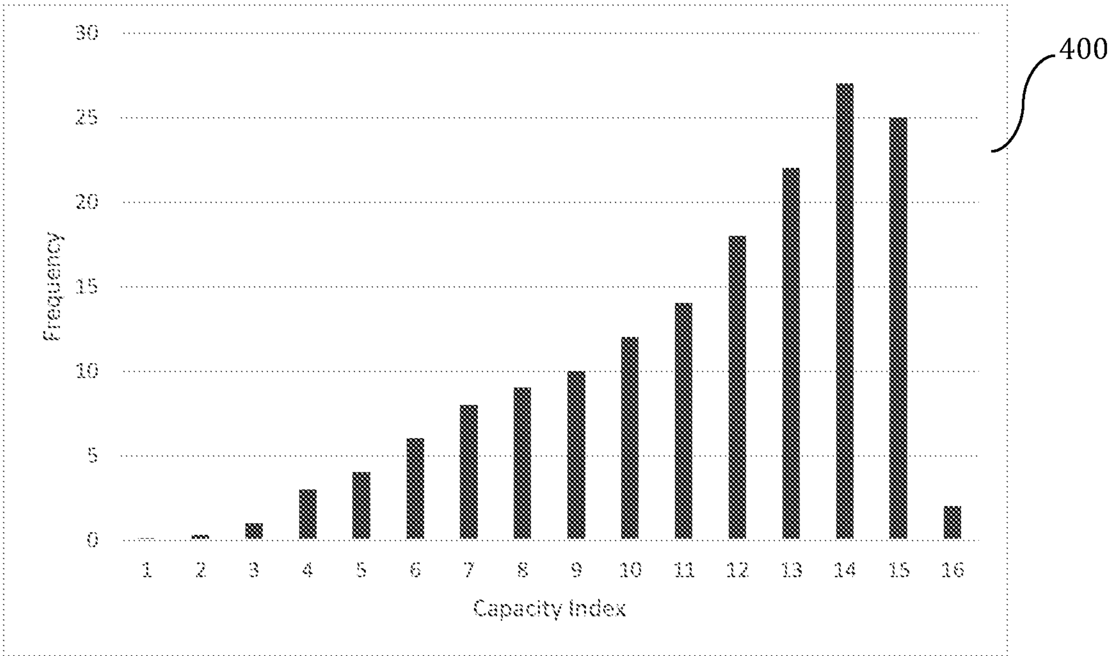

400
30
25
20
15
10
5
0
Frequency
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Capacity Index

Figure 4

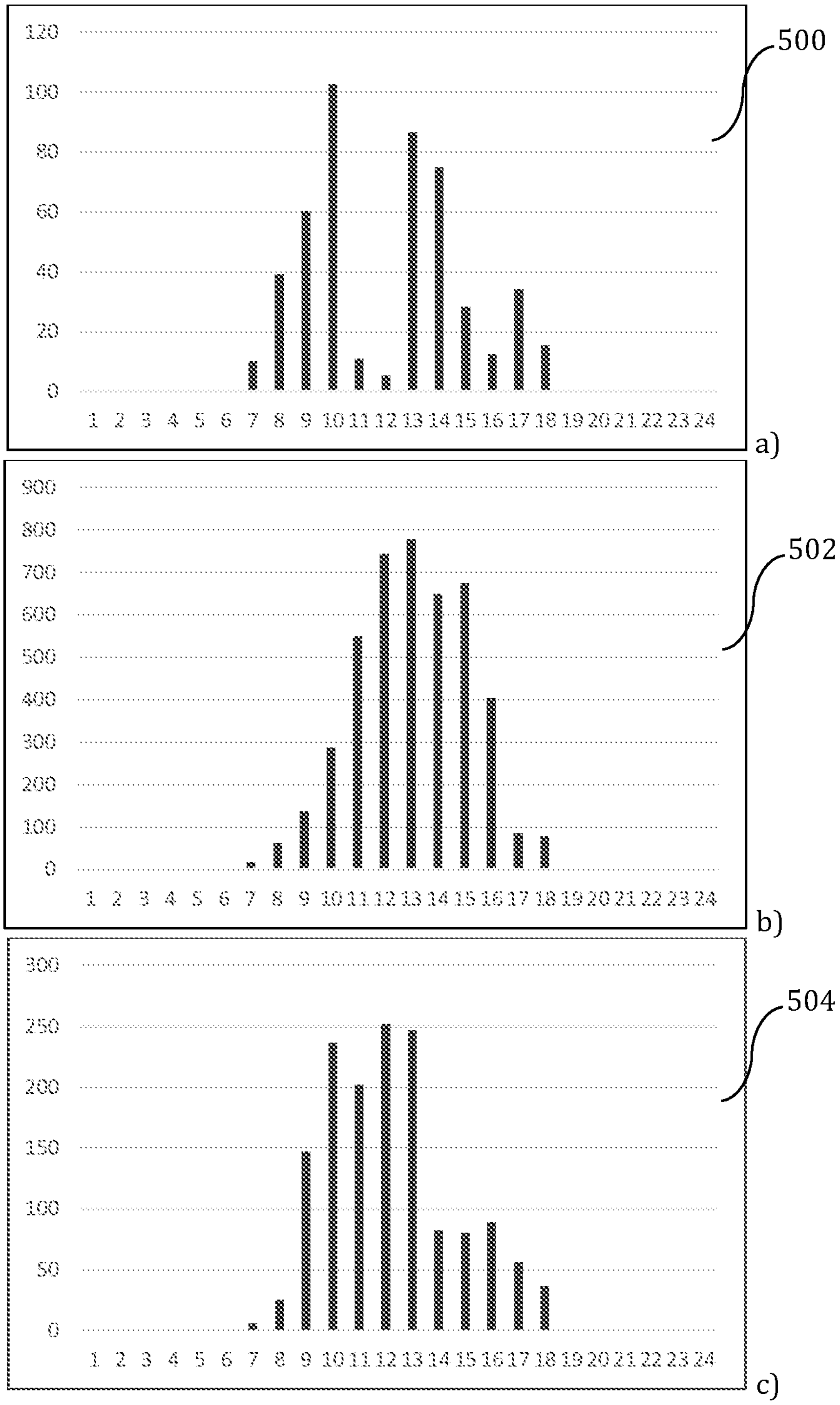

500
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
a)
502
900
800
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
b)
504
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
c)

Figure 5

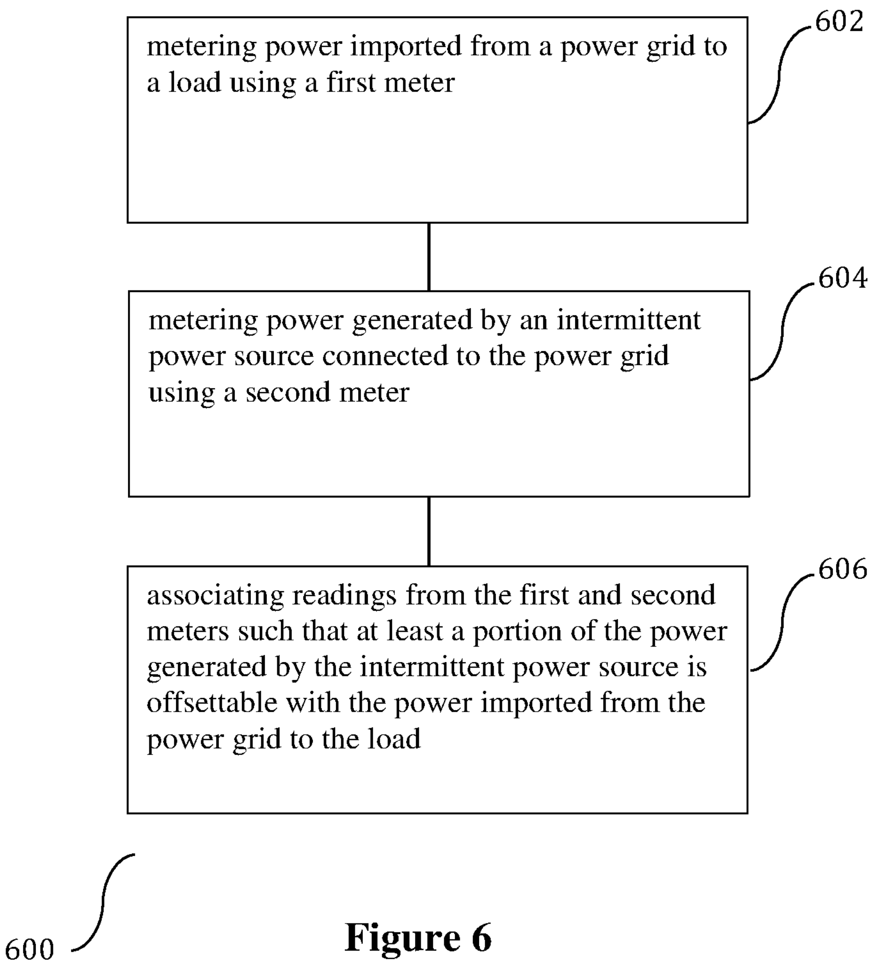

metering power imported from a power grid to a load using a first meter
602
metering power generated by an intermittent power source connected to the power grid using a second meter
604
associating readings from the first and second meters such that at least a portion of the power generated by the intermittent power source is offsettable with the power imported from the power grid to the load
606
600

Figure 6