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(71) Applicant(s)
REX Energy Pty Ltd

(72) Inventor(s)
Graham, Scott;Howe, David;Simmons, David

(74) Agent / Attorney
FOUNDRY INTELLECTUAL PROPERTY PTY LTD, PO Box Q1466, Queen Victoria Building, NSW, 1230, AU

Abstract

An energy management system for managing energy supply from a shared renewable energy source to a plurality of users sharing the renewable energy source includes a data interface and a processor. The data interface is configured to receive energy parameters from a renewable energy system supplying energy. The processor is configured to process the energy parameters to determine energy use information of each of the plurality of users, the energy use information being indicative of individual user consumption. The processor is also configured to process the energy parameters to determine control parameters for the energy supply. The data interface is configured to provide the control parameters to the energy system so as to provide energy to the plurality of users from the single shared renewable energy source based on individual user consumption.

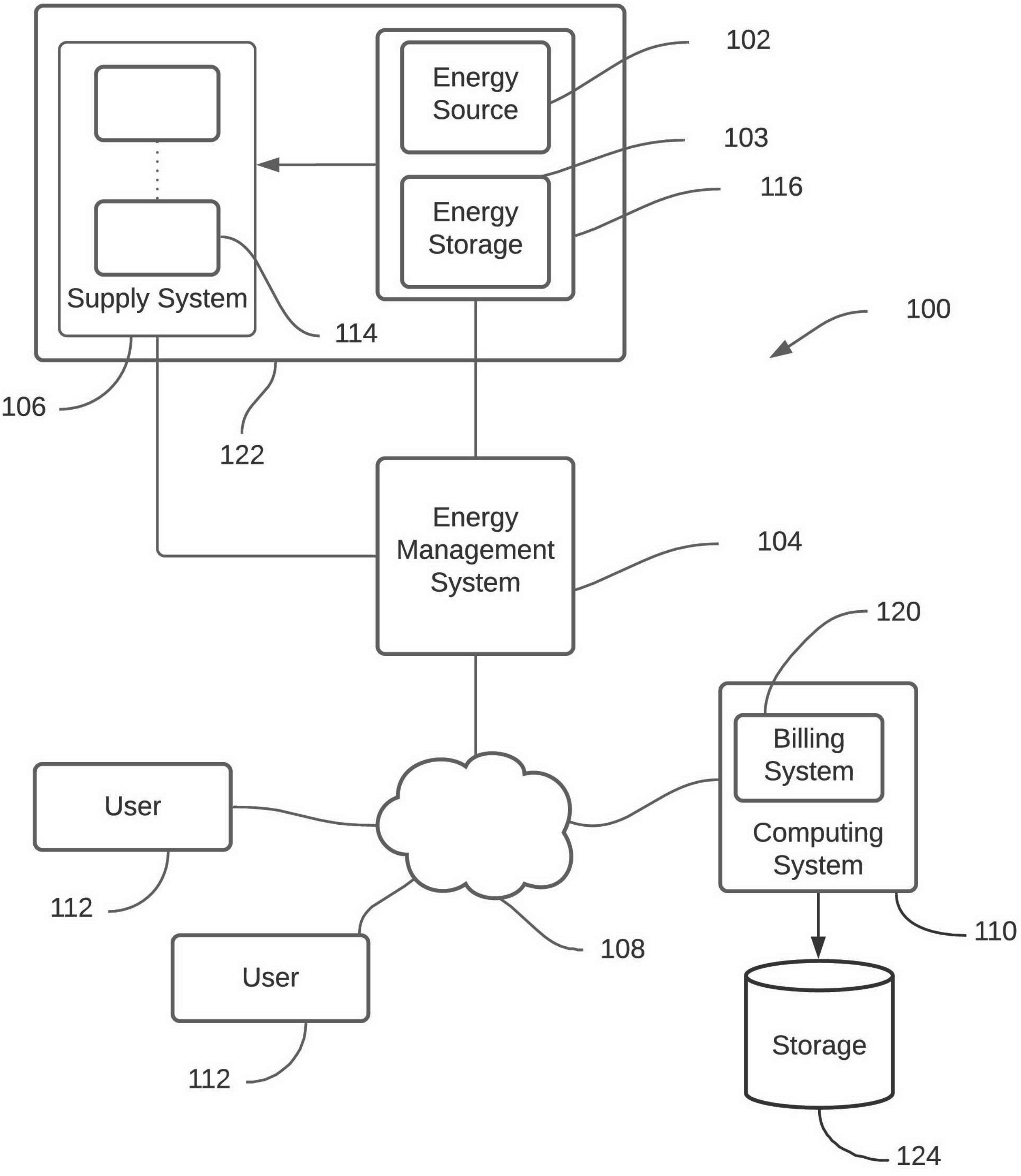

Energy Source
Energy Storage
Supply System
Energy Management System
Billing System
Computing System
User
User
Storage
100
102
103
104
106
108
110
112
112
114
116
120
122
124

Figure 1

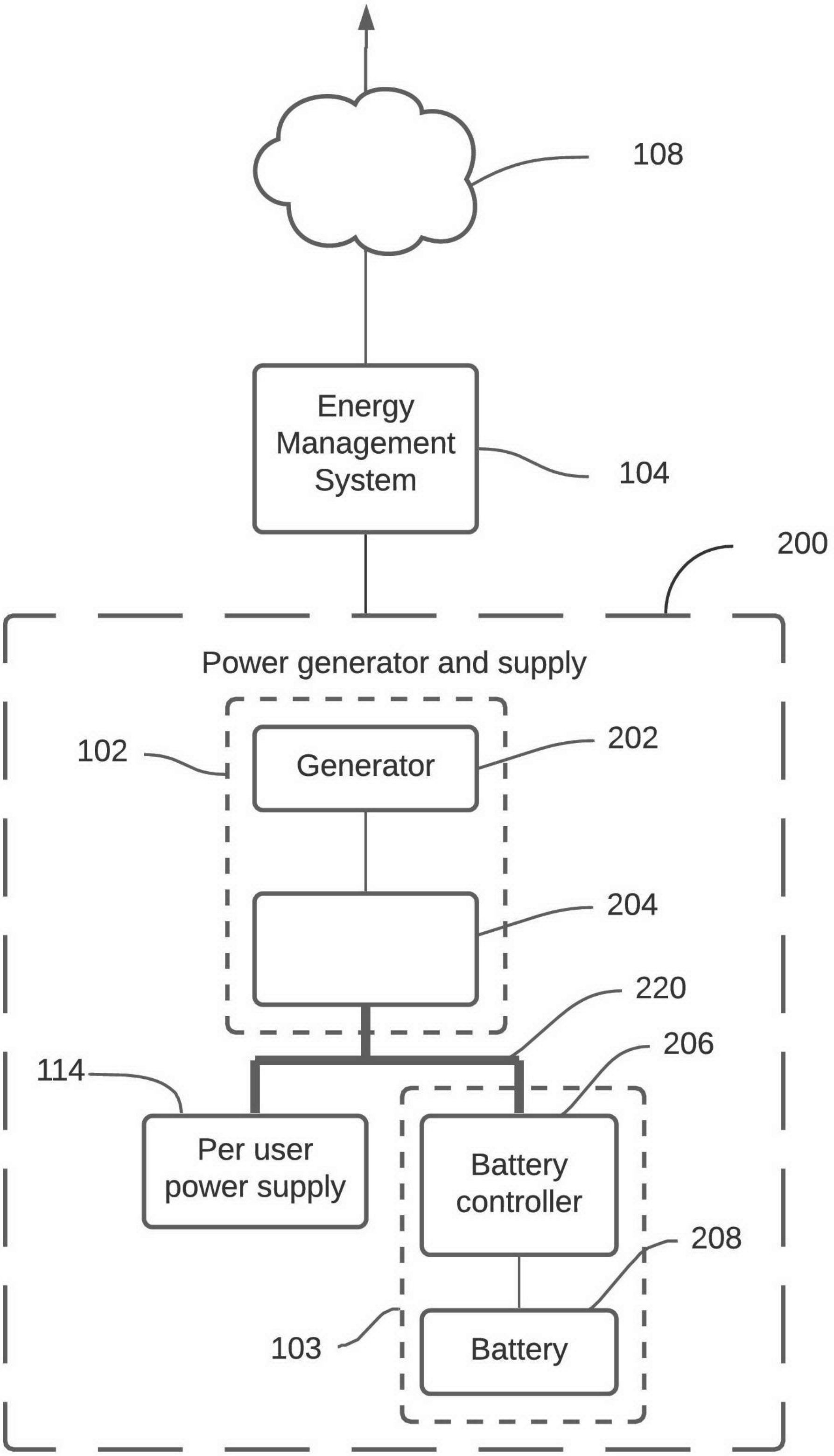

108
Energy Management System
104
200
Power generator and supply
102
Generator
202
204
220
206
114
Per user power supply
Battery controller
208
103
Battery

Figure 2

Energy Provision System and Method

Technical Field

[0001] The present disclosure relates, generally, to renewable energy provision to multiple users and, more particularly, to a system for, and a method of, managing renewable energy provision for multiple users.

Background

[0002] Solar panels are used on the roofs of buildings to provide solar energy during daylight hours. Typically, the solar panels on a building are used to provide energy for that building. Where excess energy is produced, it is usually possible for owners of the solar energy systems to feed the excess energy into an electrical grid, for example according to a solar feed-in arrangement with an electricity distributor where a tariff is credited for the excess solar energy that the solar system generates and exports back to the grid.

[0003] One drawback of solar power is that it can only be generated when there is sunlight. For residential energy provision, the average home consumes about 30-35 kWh per day. Assuming around 4-6 peak sunlight hours, that means a typical residential solar system is designed to produce around 6-7 kW. Although the generated power can be stored in batteries, current battery technology can be prohibitively expensive, especially for small users such as for residential solar panel systems.

[0004] Solar power is one example of renewable energy, being energy collected from a renewable source as opposed to fossil fuels. Other types of on-site renewable energy can also be used in the built environment (i.e. for residential or commercial buildings) such as solar thermal cooling or solar heating systems, small wind electric systems, microhydropower systems, and hybrid (solar and wind) electric systems.

[0005] Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present disclosure as it existed before the priority date of each claim of this application.

Summary

[0006] Described herein is a system that provides renewable energy to buildings 24 hours per day. Where the renewable energy is solar energy, energy provision is not limited to peak daylight hours. The method in which the renewable energy is provided enables the sharing of the renewable energy system by multiple users within the same building (for example in multi-tenant buildings), or by multiple users in separate buildings where the buildings are connected to the same renewable energy system.

[0007] In one embodiment, there is provided an energy management system for managing energy supply from a shared renewable energy source to a plurality of users sharing the renewable energy source, the energy management system including: a data interface configured to receive energy parameters from a renewable energy system supplying energy; a processor configured to: process the energy parameters to determine energy use information of each of the plurality of users, the energy use information being indicative of individual user consumption; and process the energy parameters to determine control parameters for the energy supply; and wherein the data interface is further configured to provide the control parameters to the energy system so as to provide energy to the plurality of users from the single shared renewable energy source based on individual user consumption.

[0008] The energy system may include a renewable energy system.

[0009] The processor may process the energy parameters to determine, based on the determined energy use information of the users, the control parameters for the energy supply.

[0010] The energy management system may further comprise a communication interface configured to communicate one or more of: the received and processed energy parameters to a computing system, and wherein the communication interface communicates the energy use information with a billing system.

[0011] In another embodiment there is provided a method of managing renewable energy provision for multiple users, the method including: at a data interface, receiving status data from an energy system supplying energy; processing, by a processor, the status data to determine control parameters for the energy supply; and communicating, via a communication interface, the control parameters to the energy system.

[0012] The status data may include energy parameters that describe operation of a renewable energy source and an energy storage connected to the renewable energy source.

[0013] The control parameters may be used to control operation of at least one of: the renewable energy source, and the energy storage.

[0014] The method may further include storing the received and processed status data in data storage.

[0015] In another embodiment there is provided a renewable energy system including: a renewable energy source shared by a plurality of users; an energy storage connected to the shared renewable energy source and configured to store energy from the shared renewable energy source; a supply system configured to supply energy from the shared renewable energy source and the energy storage to the plurality of users; and an energy management system configured to manage energy supply to the plurality of users by controlling at least one of: the energy source, the energy storage, and the supply system. The energy management system may be configured to communicate with a billing system to provide the billing system with the energy use information of individual users.

Brief Description of the Drawings

[0016] Embodiments of the disclosure are now described by way of example with reference to the accompanying drawings in which:

[0017] Figure 1 is a diagram of an embodiment of an energy provision system.

[0018] Figure 2 is a diagram that illustrates an embodiment of a power generator and supply subsystem of the energy provision system of Figure 1.

[0019] Figure 3 is a diagram that illustrates an embodiment of a per user power supply subsystem of the energy provision system of Figure 1.

[0020] Figure 4 is a diagram of an embodiment of an energy management system of the energy provision system of Figure 1.

[0021] Figure 5 is a flow diagram illustrating an embodiment of a method of managing renewable energy provision.

[0022] Figure 6 is a flow diagram illustrating how status data is received in the method of Figure 5.

[0023] Figure 7 is a flow diagram illustrating how status data is processed in the method of Figure 5.

[0024] Figure 8 is a flow diagram illustrating how energy provision is controlled in the method of Figure 5.

[0025] Figure 9 is a flow diagram illustrating how received and processed status data is further processed and stored according to the method of Figure 5.

[0026] Figure 10 is a flow diagram illustrating an embodiment of a method of managing billing for the energy provision system of Figure 1.

[0027] Figure 11 is a block diagram of an embodiment of a part of the energy provision system of Figure 1.

[0028] Figure 12 is a system diagram of an embodiment of a part of the energy provision system of Figure 1.

[0029] Figure 13 is a Single Line Diagram (SLD) illustrating an embodiment of a part of the energy provision system of Figure 1.

[0030] Figure 14 is a flow diagram of an exemplary embodiment of a method of controlling energy generation and storage.

[0031] Figure 15 is an embodiment of a user interface of an energy app.

[0032] Figure 16 is another embodiment of a user interface of an energy app.

[0033] In the drawings, like reference numerals designate similar parts.

Description

[0034] ***Energy Provision System Overview***

[0035] Referring to **Figure 1** of the drawings, an energy provision system 100 is shown that provides renewable energy to a plurality of users 112. The energy provision system 100 includes an energy provision system 116 that has a renewable energy source 102, and an energy storage 103 that is connected to the renewable energy source 102. The energy storage 103 is configured to store energy from the renewable energy source 102. The energy provision system 100 has a supply system 106 configured to supply energy from the renewable energy source 102 and the energy storage 103 to the plurality of users 112. The system 100 has an energy management system 104 configured to manage energy supply to the plurality of users 112 by controlling at least one of: the energy source 102, the energy storage 103, and the supply system 106. The supply system 106 includes per user power supply 114.

[0036] In some embodiments, the energy management system 104 is also in communication with a communication network 108. The communication network 108 may be (or include) for example the Internet, a wide area network (WAN) (for example spanning one or more urban regions), a local area network (LAN) (for example an Ethernet of Wi-Fi network across one or more buildings), etc. In some embodiments the communication network 108 may provide cloud services, such as cloud servers or cloud storage, to support operation of the energy provision system 100.

[0037] In the embodiment illustrated in Figure 1, the communication network 108 connects the energy management system 104 with a computing system 110 and the users 112. The computing system 110 may include a billing system 120 that uses information provided by the energy management system 104 to determine billing information associated with one or more of the plurality of users 112. The billing information from the billing system is then provided to the users 112 via the communication network 108. The computing system 110 also includes and/or is in communication with data storage 124 used to store records of energy system data, such as user energy consumption data and/or user billing information.

[0038] In some embodiments, the energy management system 104 may include or be in communication with the data storage 124. In some embodiments the energy management system 104 may include the computing system 110.

[0039] In some embodiments, the billing system may also provide feedback to the energy management system 104. For example, where a user has not paid a bill, this information may be provided to the energy management system 104. In the event that an unpaid billing threshold is reached, the energy management system 104 may control energy supply to the relevant user, for example by limiting, reducing, pausing and/or terminating energy supply.

[0040] In some embodiments, the energy management system 104 may provide information to the users 112 via the communication network 108. For example, the user 112 may be able to access energy consumption information. In a preferred embodiment, each tenant can download an application ("app") on a personal computing device (for example a portable device such as a tablet or smart phone), or log in online and view their real-time energy usage details, and renewable energy versus grid energy consumed on a second by second basis. Advantageously, this may aid in educating consumers about energy efficiency, especially as users will likely engage with the app on a regular basis due to the granular nature of its responsiveness to the activation of energy loads. The energy app also enables users to set an energy consumption budget target, and the app tracks their progress towards their individual energy consumption target on a daily basis. The app then makes recommendations as to how each tenant might curtail their energy consumption to meet their budget target. Refer to the description of the energy app elsewhere herein.

[0041] **Figure 2** of the drawings illustrates an embodiment of a power generator and supply subsystem 200 of the energy provision system 100. The renewable energy source 102 has a generator 202 and a generator controller 204. The energy storage 103 includes one or more batteries 208 and a battery controller 206. In some embodiments, the energy storage 103 may additionally or alternatively include other forms of storage, such as capacitors, flywheels, hydro or hydraulic storage, gravity storage, etc. In such embodiments, the battery controller be a suitable controller configured for the relevant type(s) of energy storage utilised.

[0042] In the exemplary embodiment, the generator 202 is in the form of a passive component, for example the Phono Solar TwinPlus module PS370M4-20UH 1000V 370W. The generator 202 may be in the form of renewable energy generation strings that may comprise solar panels, a solar system, a photovoltaic (PV) system, or other renewable energy generator e.g., a wind generator.

[0043] The renewable energy source 102 includes an interface used for providing control of the energy generator 202 to ensure that the energy generation is as required by the energy provision system 100, that is, a generator controller 204. In summary, the generator controller 204 is itself controlled by the energy management system 104, and in turn controls (e.g. curtails or isolates) energy production by the generators 202. The generator controller 204 also reports live energy production to the energy management system 104.

[0044] Referring to the embodiment illustrated in Figure 2, a power optimiser 204 is used that provides the functionality of a generator controller, for example in the form of Alencon's String Power Optimizers and Transmitter (SPOT), which is an actively controlled component.

[0045] A power optimiser is a DC to DC converter that takes the DC power from a solar photovoltaic (PV) system at an optimal voltage and current and converts that to a different voltage and current that best suits the central / string inverter thereby maximizing the energy harvested from the solar panels. This is done by (a) individually tuning the performance of the solar panels through maximum power point tracking (MPPT), i.e. maintaining the load characteristics for maximum power extraction from the PV system, and (b) optionally tuning the output to match the performance of a string inverter (i.e., a DC to AC inverter). Power optimisers are useful when the performance of the power generating components in a distributed system vary, for example due to differences in equipment, shading of light or wind, or being installed facing different directions.

[0046] The SPOT power optimiser 204 used in the exemplary embodiment provides MPPT tracking at a renewable energy generation string level, maps PV voltage to any DC bus using galvanic isolation, acts as a blocking diode between the renewable energy generation and the DC bus, and monitors string level performance with each SPOT being able to receive up to eight strings of renewable generation inputs. The SPOT power optimiser 204 of the exemplary embodiment may also be used to curtail renewable production (controllable via Modbus as described elsewhere herein), and reports live renewable energy generation details to the energy management system 104.

[0047] In the exemplary embodiment, the power optimiser 204, in the form of a SPOT, is installed in one per each eight strings of renewable generators 202. Larger renewable generation systems will require additional SPOTs, and the number of SPOTs is theoretically unlimited and scalable depending on the size of the renewable generation system(s) onsite. The one or more SPOTs report on live energy production to the energy management system 104 and enable real time, dynamic energy flow control using onboard software or firmware to control the generator 202. The SPOT assists in maintaining a fixed DC bus voltage. The SPOT also protects the renewable energy generator 202; it is directionally connected to the rest of the energy provision system 100 and energy cannot pass through the SPOT in the opposite direction as per its intended forward current application. The SPOT actively monitors the generator 202 string performance and the energy management system 104 can instruct it to curtail energy production.

This may be a timed control, a scheduled control, or an immediate control (e.g. in less than a second or in less than a millisecond). This is executed under rare circumstances to reduce or mitigate grid exposure of onsite generated renewable energy. This may, for example, occur when the one or more batteries 208 are reporting as fully charged and the meter 314 reports site energy requirements are less than the SPOT reports is being generated. When the generator 202 has zero energy production capability, the SPOT isolates the generator 202 strings and prevents reverse current, thereby preserving the life expectancy of the energy source 102.

[0048] In alternative embodiments, the energy source 102 may have a different configuration. In one example, the energy source 102 may comprise a generator only, said generator being adapted to be actively controlled. In another example, the generator and the power optimising functionality may be integrated into a single component. In another example, the energy source 102 is not actively controlled, but is a passive component.

[0049] The renewable energy source 102 may include a DC combiner 1112, as shown in the block diagram of Figure 11. The DC combiner 1112 combines outgoing DC cables from the various SPOT power optimiser boxes 204 into a DC bus 220. As shown in the system diagram in Figure 12, the DC bus 220 interconnects the generators 202, the controller/optimiser 204, the battery controllers 206, the batteries 208, and the current transformers 306 via the user inverters 302.

[0050] The generated power is provided to the users 112 via the supply system 106 that enables per user power supply 114. Any excess power generated by the renewable energy source 102 and not consumed by the users 112 is stored in the energy storage 103. The energy storage 103 includes one or more batteries 208. These can be any suitable battery, preferably adapted to be an actively controlled component, for example vanadium flow batteries such as UniEnergy Technologies (UET) Vanadium Flow ReFlex Batteries.

[0051] The quantity of batteries used in parallel depends on the evening demand and usage of a particular site. For example if one vanadium flow battery has 45kWh capacity, and typical residential evening demand is 6-10kWh, then 7-11 batteries would be required for a building with around 50 tenants. In some embodiments, when the energy system overproduces then energy maybe directed to the power grid 320, the amount of excess energy produced per day (and, in some embodiments, the available excess stored electricity) available for grid feed as described elsewhere herein with reference to Figure 3.

[0052] The batteries 208 can be paralleled for additional storage requirements and, with current vanadium flow battery technology, the number of batteries can be increased up to a total of around 1500 VDC per each paralleled string. Site energy storage can be used for evening energy consumption and/or to feed the power grid via CT chamber 322.

[0053] In the illustrated embodiment, the energy storage 103 includes a battery controller 206 used to control the charge and discharge of the batteries 208. An example of a battery controller 206 that can be used is Alencon's Bi-Directional DC-DC Optimizer for Storage Systems (BOSS), which is an actively controlled component.

[0054] The BOSS battery controller 206 of the exemplary embodiment provides galvanic isolation between input and output to and from the energy storage 103, battery rack level charge and discharge control, and a wide voltage mapping range between the battery 208 and the DC bus 220 (or between batteries 208). Advantageously, the BOSS battery controller 206 of the exemplary embodiment can be installed and controlled in parallel, is able to detect earth leakage, and enables paralleled battery application.

[0055] In the exemplary embodiment, the BOSS units are installed in parallel to the DC bus 220 and actively assist to control DC energy availability to the inverters 302. The BOSS 206 actively assists in maintaining DC Bus 220 voltage. The BOSS 206 is bidirectional and can divert energy into the paralleled battery bank 208 or discharge from the battery bank 208. The energy management system 104 controls the input or output from the BOSS depending on real-time readings from the BOSS and real time summation of live user demand readings from the meter 314. The BOSS passively detects earth leakage.

[0056] In one example, where there are 5 tenant sites, the BOSS reports to the energy management system 104 that energy production is 100kW. Meter 314 reports to the energy management system 104 that energy demand is 40kW. The energy management system 104 instructs the BOSS 206 to divert 60kW to the batteries 208, and the energy management system 104 instructs each tenancy smart inverter 302 to invert the exact amount of energy demanded in real-time.

[0057] Seven example scenarios are described below that illustrate the battery control applied by the battery controller 206, in this exemplary embodiment in the form of a BOSS..

[0058] *Scenario 1: Batteries 208 have charging capacity and renewable energy generation exceeds site demand*

- 100kW energy production
- -40kW live demand for the case where, e.g. Tenant 1 demand is 5kW, Tenant 2 demand is 10kW, Tenant 3 demand is 12kW, Tenant 4 demand is 11kW, and Tenant 5 demand is 2kW
- -60kW (energy diverted to battery 208 from DC bus 220)
- 0kW generator 202 curtail controlled by the SPOT
- 0kW remaining, i.e. 0kW available to export to the power grid.

[0059] In this scenario, 100% of energy produced on site is used on site.

[0060] *Scenario 2: Batteries 208 have charging capacity and renewable energy generation is less than site demand*

- 50kW energy production
- -60kW live demand, provided via inverter 302
- +10kW (energy diverted from battery 208 to the DC bus 220)
- 0kW generator 202 curtail controlled by the SPOT
- 0kW remaining, i.e. 0kW available to export to the power grid.

[0061] In this scenario, 100% of energy produced on site is used on site.

[0062] *Scenario 3: Batteries 208 do not have charging capacity and renewable energy generation is more than site demand*

- 100kW energy production
- -60kW live demand provided via inverter 302
- 0kW energy diverted from battery 208
- -40kW generator 202 curtail controlled by the SPOT
- 0kW remaining, i.e. 0kW exported to the power grid.

[0063] In this scenario, 100% of the energy produced on site is used on site because energy generation by the PV system is actively reduced via the SPOT.

[0064] *Scenario 4: Evening hours, zero renewable energy generation, Batteries 208 have charge.*

- 0kW renewable generation
- -60kW live demand
- +60kW energy diverted from battery 208 to DC bus 220
- 0kW generator 202 curtail controlled by the SPOT
- 0kW remaining, i.e. 0kW exported to the power grid.

[0065] In this scenario, 100% of the energy produced on site is used on site.

[0066] *Scenario 5: Evening hours, zero renewable energy generation, Batteries 208 depleted.*

- 0kW renewable energy generation
- 0kW energy provided via inverter 302
- 0kW energy diverted from battery 208
- 0kW generator 202 curtail controlled by the SPOT
- 0kW remaining.

[0067] All tenant control contactors 308 are open as a safety measure, tenancy supply contactors being controlled by the energy management system 104 via meter 314 and control switch 1110. In this scenario, power is provided to the user from the grid.

[0068] *Scenario 6: Early morning hours, batteries 208 are depleted and renewable power is significantly less than site demand.*

- 20kW renewable energy generation
- 0kW provided to users via the inverter 302
- -20kW energy diverted from the battery 208 via the DC bus 220
- 0kW generator 202 curtail controlled by the SPOT
- 0kW remaining, i.e. 0kW exported to the power grid.

[0069] In this scenario, 100% of the energy produced on site is sold on site, and supplemented from the grid as required.

[0070] *Scenario 7: Any time of day, any scenario above, at the request of power authority.*

[0071] The energy management system 104 signals meter 314 and instructs control switch 1110 to open all tenant renewable power contactors 308, and simultaneously instructs all smart inverters 302 to shut down while closing the grid renewable energy supply contactor 322 and activating the grid power supply inverter.

- 0 – max kW renewable energy generation
- 0kW provided via user inverter 302
- 0 – max kW energy diverted from the Battery 208 via DC Bus 220
- 0kW generator 202 curtail controlled by the SPOT
- kW requested by power authority inverted through grid supply inverter via CT chamber 322.

[0072]

[0073] **Figure 3** of the drawings illustrates an embodiment of a per user power supply subsystem 114 of the energy provision system 100. Refer also to **Figure 11**, which represents a part of the energy provision system 100 in the form of a block diagram 1100. The DC distribution 301 interfaces between the energy source 102 and the per user power supply subsystem 114, and (referring to Figure 11) includes a combined fuse switch 1102 and a circuit breaker 1104, both passive components that, together, provide DC distribution to user inverters 302 and also ensure line side isolation to the user inverters 302. The user inverters 302 are “smart inverters, and are installed per user, and based on per peak demand requirement. The inverters 302 are fed directly from the DC distribution 301 via the DC bus 220. The user inverters 302 are actively controlled components, controlled by the energy management system 104, and the inverters 302 provide data to the energy management system 104 with respect to the user’s real time demand.

[0074] The power supply subsystem 114 includes a circuit breaker 304 providing load side individual inverter isolation, and a metering current transformer 306, which meters each user’s total renewable energy consumption, and this data is provided to the energy management system 104 and may be used for billing. In some embodiments, this data that describes the user’s renewable energy consumption may also be provided to a user application as described elsewhere herein.

[0075] The power supply subsystem 114 includes a per user power contactor 308 (with an associated tenant main switch 1106). The user power contactors 308 are actively controlled components and are used to isolate energy supply to each user. The contactors 308 are controlled by a control switch 1110 associated with meter 314, which in turn is controlled by the energy management system 104.

[0076] The size of the contactor 308 is dependent on the grid power tenancy main switch size in amperage, for example, a three phase, 80A tenancy main switch will receive an 80A, three phase contactor. In some embodiments, the contactor 308 may provide isolation of the tenant renewable power, e.g. in the event of non-payment, emergencies, or if renewable power is supplied from the energy system 122 to the grid (via CT chamber 322).

[0077] The power supply subsystem 114 also has a monitoring current transformer 310. There is one monitoring current transformer 310 per each phase for each user that monitors live demand of each phase of each user. In the exemplary embodiment, both the metering current transformer 306 and the monitoring current transformer 310 are passive devices. The user load 312 in Figure 3 represents the power consumption of a particular user.

[0078] The tenant supply meter 314, is an actively controlled data acquisition device that reports to the energy management system 104. The meter 314 has three main functions. Firstly, the meter 314 meters each phase of each user’s renewable energy supply for the purpose of billing. This operation is executed in conjunction with metering CT 306, and the data is reported to the energy management system 104. Secondly, the meter 314 monitors each phase of each user’s live energy demand for the purpose of managing total system energy production, and managing and/or mitigating grid export. Thirdly, meter 314 includes controller functionality, and controls the energy contactors 308 via a control switch 1110.

[0079] The meter 314 obtains measurements from the metering current transformer 306, the per user power contactor 308, and the monitoring current transformer 310. The tenant supply meter 314 obtains and provides data relating to each user’s live demand, and each user’s total energy consumption (including both renewable energy and grid energy). These measurements are provided to the energy management system 104, which in turn provides control signals to the tenant supply meter 314. The tenant supply meter 314 includes control switch 1110 that turns the current transformer 306 on or off.

[0080] An example of a tenant supply meter 314 is SATEC's Branch Feeder Monitor (BFM), or the BFM-II, that provide energy management metering for multi-point power solutions. The BFM monitors three-phase or single-phase circuits, and utilizes High Accuracy Current Sensors (HACS), which measure and report the current consumed by each of the branch circuits at the panel board. For billing purposes, single or multiple circuits can be defined for each customer.

[0081] In an exemplary embodiment using a BFM-II, the meter 314 has 54 total CT inputs and the ability to add a Relay Output which provides the functionality for the control switch 1110 so that the user supply can be controlled remotely, in this case by switching the user power contactor 308 on or off. In some embodiments the control switch 1110 is separate and not part of the meter 314, the control switch 1110 nevertheless being an actively controlled component. In particular, the control switch 1110 is controlled by the energy management system 104, for example via direct cloud intervention or by automated processes built into the system's onsite operating software.

[0082] Optionally (as shown in broken lines in Figure 3), in some embodiments, if the user load 312 exceeds the renewable energy supply provided by the energy source 102, then the energy supply to the user is supplemented from the grid 320 (i.e. an electrical grid connecting to e.g., a power station via electric power transmission). As shown, the monitoring current transformer 310 is installed load side of the main grid power isolation 1108 situated at the meter panel 318.

[0083] Furthermore, optionally (as shown in broken lines in Figure 3), where the energy supply from the energy source 102 exceeds both the charging energy used by the batteries 208 and the user load 312, the excess renewable energy may be provided to the grid 320 via the inverter, current transformer, and contactor, shown as CT chamber 322 in Figures 3 and 11. The CT chamber 322 has a circuit breaker line side of a CT section and then an isolator load side to meet code and regulation requirements. The grid supply renewable energy contactor is controller by the meter 314, which in turn is controlled by the energy management system 104. The grid supply contactor's purpose is to provide energy to the power grid upon request by the local authority. The grid renewable energy supply inverter is sized according to the requirements of the local power authority and not to exceed the size of the main switch of the system 100. For example, a 400kW main switch cannot have more than a 400kW inverter installed. The grid inverter supplies electricity to the CT chamber where a power authority owned meter is situated. The power authority meter will meter the energy the system 100 sends to their network. The gird inverter's output is connected to the CT chamber line side, load side of the CT chamber has cables outgoing that match that of the site's incoming mains, and are installed in parallel to the line side of the site's grid power main isolator.

[0084] **Figure 13** is a Single Line Diagram (SLD) illustrating an embodiment of a part of the energy provision system 100. From left to right, the generator 202 interfaces with the generator controller 204 which, in turn, interfaces with both the battery controller 206 and battery 208, and the DC distribution 301 via the DC bus 220. The AC distribution 1302 is metered by the meter 314 and the metering CT 306, and energy provision to the user is monitored at the monitoring CT 310. AC supply data is provided to the energy management system 104 from the meter 314 (at 1304) and from the monitoring CT 310 (at 1306).

[0085] ***Energy Management System Overview***

[0086] The energy management system 104 is an edge control device responsible for the management and relay of energy to users through direct control of edge devices and hardware through software control. The software also provides usage information and operational data to both the system's network operations centre (NOC), e.g. at computing system 110, and to the user 112. The energy management system 104 manages energy flow on client sites, to ensure that PV, wind, or other renewable energy is optimised to meet site demand and battery charging during daylight hours, and to then control battery discharge to the site load when renewable energy generation is less than the site load. The energy sources that are controlled include the renewable energy source 102, and the batteries 208.

[0087] In a preferred embodiment, the energy management system 104 functions as a control device that balances energy flow on the DC bus 220 such that as the renewable energy provided by energy source 102 and the user demand vary, energy exported to the grid remains zero (unless a specific request is received from the grid).

[0088] In the exemplary embodiment, the energy management system 104 comprises an edge gateway (i.e. a network entry point for devices talking to cloud services) in a hot standby configuration which is loaded with an energy management program to manage energy, local devices, hardware, billing and environment control local to the site. Hot standby is a redundant method in which one system runs simultaneously with an identical primary system. Upon failure of the primary system, the hot standby system takes over, replacing the primary system. The energy management system 104 then reports back to the remote server 110 and customers 112 via redundant diverse transmission links and cloud infrastructure as outlined in Figure 1.

[0089] Referring to **Figure 4** of the drawings, an embodiment of the energy management system 104 is shown. The energy management system 104 is used for managing energy supply to the plurality of users 112. The energy management system 104 has a data interface 410 configured to receive energy parameters from an energy system 122 (as illustrated in Figure 1), a processor 420, and a communication interface 430. As is typical with computing devices, the processor 420 may have storage 440 and/or memory 450 associated therewith, and sharing data with one another via a bus 460. The processor 420 is configured to process the received energy parameters to determine energy use information of the plurality of users 112 (as described in more detail elsewhere herein). The processor 420 is also configured to process the received energy parameters to determine control parameters for the energy supply (as supplied by the energy system 122). The data interface 410 is further configured to communicate these control parameters to the energy system 122. The communication interface 430 is configured to communicate the received and/or processed energy parameters to computing system 110, where some or all of this information may be stored, further processed, provided to the users 112 via an energy app, etc. The communication interface 430 may also communicate the energy use information with billing system 120.

[0090] In the exemplary embodiment, the energy management system 104 receives data from and also provides control for the following: the generator controller 204 (e.g. the SPOT), the battery controller 206 (e.g. the BOSS), the meter 314 (e.g. the BFM-II), the battery 208, the smart inverter 302, and a grid renewable energy supply smart inverter.

[0091] Referring to **Figure 12** which shows a system diagram of an embodiment of a part of the energy provision system 100, the energy management system 104 is shown interfacing with various components of the system 100. In this embodiment, the data interface 410 is configured to communicate via Modbus (a communication protocol used for industrial electronic devices). In particular, a Modbus Remote Terminal Unit (RTU) connection 1202 (Modbus RTU is a serial transmission mode), is used to exchange data with the generator controller/optimiser 204, the battery controllers 206, and the meter 314. A Sunspec Modbus connection 1204 (Sunspec Modbus is a communication standard used for monitoring and controller Distributed Energy Resource (DER) systems), is used to exchange data with the batteries 208. The data interface 410 provides control signals via the Modbus RTU and Sunspec Modbus connections 1202, 1204.

[0092] As illustrated in Figure 12, the energy management system 104 is in communication with network 108. In this embodiment, the communication interface 430 uses an IP Protocol interface to communicate with connected devices, servers, and/or storage via network 108, for example with computing system 110, billing system 120, and storage 124 as illustrated in Figure 1.

[0093] *In summary, the energy management system 104 receives data as follows.*

[0094] The energy management system 104 receives data via Modbus live readings of each tenancy on the renewable energy exchange, in kWh usage. This information is obtained via a current transformer 310 on the load side of the user's main switch 308. This is the monitoring CT 310. The CT secondary input is read by a multi-input meter 314 (a BMF-II in the exemplary embodiment), which can read individual inputs from 18 to 54 current inputs. The meter 314 has an associated control switch 1110 for each input. The energy management system 104 also receives kWh readings from a current transformer 306 on the input side from the renewable energy supply, which is connected on the line side of the user's main switch (shown as contactor 308 in Figure 3). The energy management system 104 receives data via Modbus live readings of each user of the system, in kWh usage. This metering CT information is then processed and is billable to the individual users. The meter 314 is behind the grid supply energy meter 318. In the exemplary embodiment, the control switch 1110 is an add-on to the BMF-II meter 314 and, using a volt free contact, is connected to a normally open contactor 308. These contactors are installed on the line side of the renewable energy circuit breaker 304 dedicated for each user. This contactor 308 is controlled directly via the meter 314, and serves two main functions:

[0095] Firstly, as long as energy is flowing through a user's main switch measured by the monitoring CT 310, then the control switch 1110 will close the relevant volt free contact. An external voltage source supplied by the community section of the installation will then energize the contactor coil. This auto isolation protocol is a safety protocol of the system whereby a user's renewable energy is automatically isolated if zero voltage is detected on the line side of the user's grid power isolator. This serves a safety role: if a user's main switch is turned off for electrical work within the building there will be no energy flow through the monitoring CT 310 and the control switch 1110 will open circuit the supply to the relevant contactor 308, thereby stopping supply from the energy source 102.

[0096] Secondly, in the event that a user does not want to participate in the renewable energy supply (but instead receive energy from the grid), the energy management system 104 can communicate with the meter 314 and switch 1110 module and open circuit the relevant contactor 308, disconnecting them. The energy management system 104 can also disconnect the renewable energy supply to the user at contactor 308 via meter 314 if their electricity bill is not paid.

[0097] The energy management system 104 is also linked to the billing software. In some embodiments, usage for each user and the building as a whole is available on mobile apps for individuals to access. Site information for load is also stored, providing a source of information regarding energy consumption for the site.

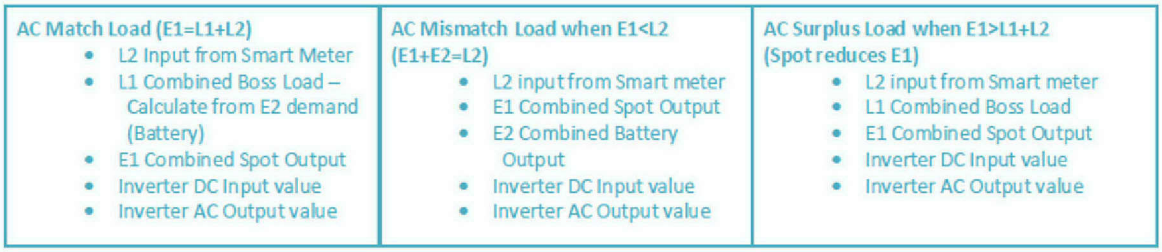
[0098] *In summary, the energy management system 104 controls components of the system 100 as follows.*

[0099] The aggregate power consumption of the users is calculated by the energy management system 104 software, in real-time, based on the data received. This provides the required information to control the output from the renewable energy source 202 at SPOT 204, in kWh required as a maximum demand for the entire site. In addition, the BOSS 206 monitors and controls the battery banks 208.

[0100] The SPOT 204 is an MPPT device and receives a maximum demand indication in kWh via the Modbus RTU connection 1202. This information is provided by the BMF-II meter 314, and is relayed to the SPOT 204 via the energy management system 104. The SPOT 204 provides the ramping control of renewable energy devices 202, and delivers the kWh output from the renewable energy source 202 to the users and battery bank 208. Once the maximum demand of each user and battery storage is full, the spot 204 will reduce the output from the renewable sources 202. The BOSS 206 is also controlled by energy management system 104 via the Modbus RTU connection 1202. This will curtail any renewable energy being sent to the grid (for embodiments where this is a feature). The output to each user from the inverters 302 is controlled to match a percentage of live demand. The inverters 302 are able to receive a set DC bus voltage, nominally 720 VDC, and convert DC to 240-250VAC 50Hz.

[0101] Some embodiments have an export supply separately metered via a utility smart meter 322. The smart meter 322 can either be a direct connect or CT operated meter depending on the size of the installation and the export to the grid current rating as per the energy regulator requirements. This function turns the microgrid of the system described herein into a source of energy to the grid 320 in times of peak demand.

[0102] **Figure 14** illustrates the operation of the energy management system 104 in more detail. The site hardware interfaces to the energy management system 104 over a mixture of data communication protocols, the main ones being: RS485, Modbus RTU, and Direct Digital as detailed in Figure 12. Using these methods, the required data is both retrieved and sent to the devices to meet the required control logic conditions. The control logic conditions can be summarised as shown in Table 1, where E1 is the generated renewable energy, E2 is energy provided by the batteries 208, L2 is the user load, and L1 is the charging load of the battery controller 206 and the batteries 208:



AC Match Load (E1=L1+L2)	AC Mismatch Load when E1<L2 (E1+E2=L2)	AC Surplus Load when E1>L1+L2 (Spot reduces E1)
• L2 Input from Smart Meter • L1 Combined Boss Load – Calculate from E2 demand (Battery) • E1 Combined Spot Output • Inverter DC Input value • Inverter AC Output value	• L2 input from Smart meter • E1 Combined Spot Output • E2 Combined Battery Output • Inverter DC Input value • Inverter AC Output value	• L2 input from Smart meter • L1 Combined Boss Load • E1 Combined Spot Output • Inverter DC Input value • Inverter AC Output value

TABLE 1: Control Logic Conditions

[0103] The control logic conditions of Table 1 may be understood with reference to Figure 14, which illustrates an exemplary embodiment of a method 1400 of controlling energy generation and storage. At 1402 data is input to the energy management system 104 via the data interface 410. This data is input from various components in the system 100, for example, the energy management system 104 receives:

- customer load data from the monitoring CT 310 via the meter 314,
- battery load and charge data is received from the batteries 208 via the Sunspec Modbus connection 1204, and from the battery controller 206 via the Modbus RTU connection 1202,
- the inverter 302 DC input value, and
- the inverter 302 AC output value.

[0104] The input data and the information obtained therefrom may further be understood with reference to Table 2.

Widget	Term	Units	Per Tenant or Location	Definition	Single Source Of Truth	How to calculate?
Live Energy Consumption (All Tenants)	Total Energy Consumed	kWh	Per Location	Total energy consumed by all tenants at the location	Data Stream	Read from Smart Meter
	Energy Consumed	kWh	Per Location	Energy consumed by the tenants that was supplied by renewables	Data Stream	Read from Spots
	Battery Consumed	kWh	Per Location	Energy consumed by the tenants that was supplied by the site battery	Data Stream	Read from Site Battery
	Grid Energy Consumed	kWh	Per Location	Energy consumed by the tenants that was supplied by the grid	Data Stream	Read from Grid Energy
Live Energy Consumption (Per Tenant)	Total Energy Consumed	kWh	Per Tenant	Total energy consumed by the tenant	Data Stream	Read from Smart Meter
	Energy Consumed	kWh	Per Tenant	Energy consumed by the tenant that was supplied by renewables	Data Stream	Read from Spots
	Battery Consumed	kWh	Per Tenant	Energy consumed by the tenant that was supplied by the site battery	Data Stream	Read from Site Battery
	Grid Energy Consumed	kWh	Per Tenant	Energy consumed by the Tenant supplied by the grid	Data Stream	Read from Grid Energy
Performance	Energy Supplied	%	Per Tenant	Percentage of Total Energy Consumed supplied by renewables and batteries	Data Stream	Read from Energy Input
	Grid Energy	%	Per Tenant	Percentage of Total Energy Consumed supplied by the main power grid	Data Stream	Read from Grid Energy Input
	Money Saved	$	Per Tenant	Money saved on energy costs due to Renewable supply	Data Stream	Internal Calculation
Battery Charge	Current Battery Charge	%	Per Location	Percentage of total battery capacity currently charged	Data Stream	Read from Site Battery
Tenant Comparison	Total Energy Consumed	kWh	Per Tenant	Total energy consumed by the tenant	Data Stream	Read from Smart Meter
	Energy Consumed	kWh	Per Tenant	Energy consumed by the tenant that was supplied by renewables	Data Stream	Read from Spots
	Battery Consumed	kWh	Per Tenant	Energy consumed by the tenant that was supplied by the site battery	Data Stream	Read from Site Battery
	Grid Energy Consumed	kWh	Per Tenant	Energy consumed by the Tenant supplied by the grid	Data Stream	Read from Grid Energy
	The Beginning of Time	Years	N/A	Referring to showing data in a way that shows the entire history of transactions		

TABLE 2: Software Data Dictionary

[0105] At 1404, the energy provided from the energy source 102 and from the batteries 308 are determined, and the user load and the battery load are determined from the data received. For example, the total customer load L2 may be determined from the customer load data received from the monitoring CT 310 via the meter 314. The inverter 302 DC input value equals the total power provided by the energy source 102, and the inverter 302 AC output value equals the per customer load.

[0106] . For the example case where E1=L1+L2, some of the generated power E1 is used to meet user demand L2 while the rest of the generated power E1 is used to recharge the batteries 208.The energy management system 104 uses the input data received at 1402 to calculate, at 1404, the customer load value, and to confirm the power supplied to the inverter 302 from the energy source 102. If, at 1406, it is determined that the solar power equals the user load, E1=L2, then no additional battery power is required (1408) and neither is any power available to recharge the batteries. If it is determined, at 1410, that the user load exceeds the renewable energy, i.e., E1<L2, then at 1412 energy supply may be supplemented from the batteries 308, and if required also from the grid (at 1416). Alternatively, if the renewable energy exceeds the load, i.e. E1>L2, then at 1418, the excess generated energy is used to recharge the batteries. In the exemplary embodiment, once the batteries are charged, the production of any additional excess generated energy (as per 1420) may be limited by the SPOT 204 at 1422 so that E1=L1+L2.

[0107] ***Method of managing renewable energy provision***

[0108] **Figure 5** of the drawings shows an embodiment of a method 500 of managing renewable energy provision. At 510, the data interface 410 receives status data from the energy system 122 supplying energy. At 520, the processor 420 processes the status data to determine control parameters for the energy supply. Then at 530, the control parameters are communicated to the energy system 122 via the data interface 410. Optionally, at 540, the received and processed status data is stored in data storage, for example the data storage 124 associated with the computing system 110.

[0109] As shown in **Figure 6**, *receiving the status data 510* may include one or more of the following: at 610, receiving energy consumption data; at 620, receiving battery status data; and at 630, receiving energy generator data.

[0110] Optionally, at 640, user-specific data may also be received. For example, where user behaviour (such as energy consumption or bill payments) is taken into consideration when managing the renewable energy system. This user-specific data may, in one exemplary embodiment, be received from the computing system 110, for example from the billing system 120. In the event that an unpaid billing threshold is reached, the energy management system 104 may control energy supply to the relevant user, for example by limiting, reducing, pausing and/or terminating energy supply. The user-specific data may, in another exemplary embodiment, be received from the tenant supply meter 314.

[0111] As shown in **Figure 7**, *processing the status data 520* may include one or more of the following:

[0112] At 710, aggregating per user energy consumption. In some embodiments, aggregating per user energy consumption may be achieved by receiving, at the data interface 410 of the energy management system104, real time discrete energy consumption values from one or more of the current transformer(s) 306 via the meter(s) 314. The real time values are stored locally in storage 440, and summed via the processor 420. This sum is the real time aggregated energy consumption. The real time aggregate value and real time discrete values are timestamped by the processor 420 and then sent via the communications interface 430 to the computing system 110 and stored in storage 124 for subsequent processing.

[0113] At 720, determining per user usage parameters. In some embodiments, determining per user usage parameters may be performed in the computing system 110 by using the discrete values from the current transformer(s) 306 (as collected via the meter(s) 314 and ultimately stored in storage 124 of the computing system 110). For example, in some embodiments the energy consumption values from the current transformer(s) 306 are recorded over a period of time and compared against one or more similar historical timeframes for the same current transformer(s) 306. The comparison data may then be processed at computing system 110 to predict short term future energy requirements for the site, for example using statistical prediction models which may be implemented using machine learning techniques such as regression techniques. At 722, both the current per user energy consumption value 306 and the predicted value are stored in storage 124.

[0114] At 730, determining aggregate usage parameters. In some embodiments, the current and predicted values stored at step 722 are used to calculate the aggregate usage parameters for both real time demand and predictive demand by summing the values, at the computing system 110, over a period of time (for example over a 24-hour period, over a 48-hour period, over a week, over a month, etc.) that are stored in storage 124, and then saving these calculated values in storage 124.

[0115] At 740, determining one or more energy generator setpoints. In some embodiments, both the real time and predictive values calculated in step 720 are retrieved from storage 124, and then the computing system 110 will sum the like values for one or more user connections to energy system 122. The summed individual values provide a total real time value and/or a total predictive value which are stored in storage 124. These values are compared by computing system 110, using proprietary algorithms, and one or more energy generator setpoints are determined for the energy system 122 and stored in storage 124.

[0116] Where a site has the ability to individually control supply via a dedicated inverter 302 to each monitored current transformer 306, then there may be a need to manage each inverter 302 individually via the set points calculated by computing system 110. At 750, one or more battery controller setpoints for controlling operation of the batteries 208 are determined. This is achieved by using the first set of values calculated in the in step 720 for the individual site, as well as the second set of values calculated in step 740. The first and second sets of values allow for one or more set points to be calculated by computing system 110, these calculated set points relating to the energy system 122 and/or the supply system 106 and/or the per user power supply 114. The set points are stored in storage 124.

[0117] As shown in **Figure 8**, providing the control parameters to the energy system 122 in order to effect control of one or more parts of the energy system 122 may include, at 810, applying one or more energy generator setpoints, and at 820, applying one or more battery controller setpoints. Optionally, at 830, per user power supply may be controlled.

[0118] **Figure 9** shows how received and processed status data is further processed and stored according to the method of Figure 5. At 910 per user energy consumption data is stored (including how much renewable energy and how much grid energy forms part of a user's energy consumption). At 920, battery status data (e.g. percent charge, charge rate, charging/discharging status, etc.) is stored and at 930 energy generator data (current kWh generation, cumulative energy generation, averaged energy generation per time period such as per hour or per day, etc.) is stored. At 940, aggregate energy consumption data relating to a particular site (e.g. one building) is stored. At 950, other user usage parameters are stored, such as average energy use, peak energy use, energy use of a period (e.g. over 24 hours), etc. At 960, aggregate usage parameters (relating to the site as a whole) are stored. At 970, the data stored is transmitted to offsite storage, for example cloud storage or data storage 124. Step 970 may form part of one or more of steps 910 to 960. In some embodiments all the data may be transmitted to the computing system 110 first, before any of the storage steps (steps 910-960) occur.

[0119] In alternative embodiments, the data may be stored locally in storage associated with the energy management system 104, in addition to or as an alternative to storing the data offsite (for example in data storage 124 or in cloud storage).

[0120] **Figure 10** shows an embodiment of a method 1000 of managing billing for the energy provision system 100. At 1002 status data and usage parameters are received by the computing system 110. At 1004 the received status data and usage parameters are applied to billing platform 120. At 1006, according to some embodiments, the usage parameters and billing data are provided to an energy software platform that supports the energy app accessible to the users 112, e.g. via a personal computing device such as a mobile smart phone.

[0121] ***Energy Software Platform and Energy App***

[0122] An energy software platform is supported by the computing system 110 and/or the energy management system 104. The energy software platform has access to the measured and processed data that relates to the operation of the energy provision system 100, and facilitates providing the measured and processed data to the users 112 via an energy app. In some embodiments, users can download an application (“app”) on a personal computing device (for example a portable device such as a tablet or smart phone), or log in via a web interface to view various details relating to their energy usage. The energy software platform also facilitates providing the measured and processed data to other users or stakeholders of the energy provision system 100, for example a building manager where the users 112 are tenants.

[0123] Referring to Figure 15 of the drawings, a user interface 1500 for an energy app is shown. In this embodiment, the user interface 1500 provides an overview of energy consumption related data for a building as a whole, including multiple users (also referred to as tenants). This user interface 1500 may, for example, be used by building managers. The user interface 1500 provides an overall view of the entire property's energy consumption. The top section 1520 shows each energy source that has been consumed: battery energy 1508, renewable energy 1506, and grid energy 1518, as well as showing the total energy consumption 1502.

[0124] The middle left section 1510 shows a percentage breakdown of energy supplied, and at 1512 the money saved by using renewable energy. Money saved is based on a number of input variables entered by the user. If no inputs are entered there is a prompt to action the user to provide inputs.

[0125] Middle right section 1514 is a graphic displaying the percentage of renewable energy supplied to the site compared to the electricity grid.

[0126] Across all these sections the user can toggle between all tenants or a specific tenant to drill down and get a more granular look. They can also look at usage over selected time periods.

[0127] The bottom section 1516 is a per tenant breakdown so the user (for example a building manager or owner) can see which tenants are consuming how much energy and what source of energy. This section also has time periods to see any trends over set periods of time.

[0128] Referring to Figure 16, another embodiment of a user interface 1600 is shown. This user interface 1600 would typically be used by a user that is a tenant, and shows electricity consumption of their tenancy.

[0129] The top section 1620 shows each energy source that has been consumed: battery energy 1614, renewable energy 1604, and grid energy 1606, as well as showing the total energy consumption 1602.

[0130] The middle left section 1612 shows a percentage breakdown of energy supplied (renewable versus grid energy), and at 1610 the money saved by using renewable energy is shown. Money saved is based on a number of input variables entered by the user. If no inputs are entered there is a prompt to action the user to provide inputs. Battery charge 1608 is also shown.

[0131] In some embodiments, the bottom section 1630 is used to display patterns and trends that enable the user to see how they compare against other matching tenants. Matching is based on common property data including apartment/office/warehouse floor area, usage type, room type (e.g., bedrooms/offices), installed appliances, etc.

[0132] ***Advantages and Benefits***

[0133] The exemplary embodiment of the energy provision system 100 described herein captures energy from the sun using solar panels. The energy management system 104 and the energy storage 103 are typically both located on site. The energy management system 104 constantly measures each user's electricity demand. The system 100 then precisely generates and distributes the exact amount of electricity demanded by all tenancies combined. The energy management system 104 actively makes energy supply adjustments within milliseconds to predictably mitigate grid export of renewable power, and simultaneously ensures optimal electricity energy storage for night time use. The energy management system 104 meters grid and renewable electricity usage of individual tenancies in real-time. Data is securely stored in the cloud. In addition, users can view real-time usage, energy-saving tips and usage costs on an app, e.g. a mobile app.

[0134] The system described herein can function as an urban situated, cloud connected, dynamic renewable power production and storage network that uses (typically low-set) multi-tenant buildings to generate, store and sell energy. The system includes advanced onboard energy control systems that, in a preferred embodiment, does not include export of renewable power to the grid. The system meters the supply of renewable power to each tenant onsite and invoices for their consumption. Advantageously, this can result in around 20% discount compared to energy retail costs. In a preferred embodiment, the system uses water based energy storage and can produce and supply up to 100% of most residential buildings' (and some commercial buildings') energy demand requirements over a twenty-four hour period.

[0135] The energy provision system described herein transforms the energy supplied from the power grid into an onsite backup energy supply. The large amount of stored energy at each site can be diverted to the power grid and act as a peaker plant if and when needed. When a number of energy provision systems as described herein are deployed throughout an urban region, they can remotely be controlled to supplement grid supply and inject energy into the power grid when and where it is needed most via a CT chamber and the onboard communications system.

[0136] The energy provision system described herein is disruptive and transformative in nature and could change the way we think about electricity in multi-tenant buildings. Presently, in multi-tenant buildings there exists no equitable method of sharing the roof space and/or energy generated from a renewable energy generation system amongst tenants and building owners or body corporates.

[0137] The energy provision system described herein aims to solve some of the challenges relating to renewable energy provision to multi-tenant buildings by creating a private, dynamic and metered renewable energy supply to each tenant of a multi-tenant building (output) that stems from at least one large-scale renewable energy generation system located on-site (input).

[0138] The energy provision system described herein systematically over-generates electricity to store inside benign vanadium flow energy storage systems to provide a safe, 24-hour renewable energy supply to multi-tenant buildings.

[0139] The tenants inside the multi-tenant site can be remotely isolated from the provided energy, e.g. for non-payment of electricity invoices and/or so the system can purge the stored energy it has accumulated during peak sun hours to the power grid (for example, at the request of the power grid at a commercially arranged per kWh rate.

[0140] Unique features of the systems described herein include that the energy usage of all tenancies within a building or a complex can be offset, not just community power, i.e., not just the power provided for shared or communal loads in a multi-tenant building or site (such as communal lighting, air conditioners, etc.). Furthermore, 90-100% of the total energy needs per tenancy can be supplied on demand; a single large, autonomous system can supply, meter and bill all tenants, not individual systems per tenants; and energy generation is precisely controlled to only enter the grid upon request and at agreed premium rates.

[0141] In some embodiments, the energy provision system described herein provides the following features:

[0142] Metering: The energy management system 104 continuously meters energy demand of all tenancies and continuously matches energy supply to the total site demand. The energy app provides real-time visibility on usage and charges for each tenant, property management organization and owner. This is achieved through cloud accumulation of real time data and provision to a range of mobile platforms.

[0143] Supply: A single installation supplies renewable energy to all tenants (plus community area demand) in the multi-tenant site. Multiple renewable energy sources can be added to the system as technology evolves (solar, wind, hydrogen etc.) Grid connectivity is maintained for backup and, upon instruction, renewable power is injected into the power grid. This reduces peak grid demand and the need to start up high cost peaker plant assets.

[0144] Storage: Surplus energy is diverted to batteries during the day to meet demand for evening use, through battery supply to the site. Energy is safely stored on site and the system does not export any electricity to the grid, removing regulatory limitations on large scale renewable energy supply.

[0145] Advantageously, according to some embodiments, the cloud-controlled urban renewable network generates energy where the users live and work. This mitigates line loss and maximises efficiency and profitability. The system is scalable across multiple properties and regions. All system and usage data are captured in the cloud, keeping customers connected from anywhere in the world. The system (via computing system 110) maintains 24/7 visibility and control over every powered site globally. Accordingly, regulatory bodies, building owners and customers can view current and historical aggregated and individual usage data. Upon request, each site can remotely supply electricity back to the grid from the on-site storage batteries at a predetermined premium rate. Controlled releases ensure energy is delivered when needed at times of peak grid load. The system does not allow energy to enter the grid unless specifically requested.

[0146] Advantageously, according to some embodiments, buildings that support the renewable energy provision system described herein generate sufficient energy to fill onsite batteries, energy retailers have real-time visibility on all battery storage levels and locations, retailers can request controlled release of energy to meet peak demand, peak demand can be scheduled for common trends and forecast peaks, and real-time controlled release can be triggered digitally upon request.

[0147] It will be understood to persons skilled in the art of the invention that many modifications may be made without departing from the spirit and scope of the invention.

[0148] In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

CLAIMS:

1. An energy management system for managing energy supply from a shared renewable energy source to a plurality of users sharing the renewable energy source, the energy management system including:

a data interface configured to receive energy parameters from a renewable energy system supplying energy;

a processor configured to:

process the energy parameters to determine energy use information of each of the plurality of users, the energy use information being indicative of individual user consumption; and

process the energy parameters to determine control parameters for the energy supply; and

wherein the data interface is further configured to provide the control parameters to the energy system so as to provide energy to the plurality of users from the single shared renewable energy source based on individual user consumption.

2. The energy management system of claim 1, wherein the processor processes the energy parameters to determine, based on the determined energy use information of the users, the control parameters for the energy supply.

3. The energy management system of any one of claims 1 to 2, further comprising a communication interface configured to communicate one or more of: the received and processed energy parameters to a computing system, and wherein the communication interface communicates the energy use information with a billing system.

4. A renewable energy system including:

the shared renewable energy source;

an energy storage connected to the shared renewable energy source and configured to store energy from the renewable energy source;

a supply system configured to supply energy from the shared renewable energy source and the energy storage to the plurality of users; and

the energy management system of any one of claims 1 to 3, the energy management system being configured to manage energy supply to the plurality of users by controlling at least one of: the energy source, the energy storage, and the supply system.

5. The renewable energy system of claim 4, wherein the energy management system is configured to communicate with a billing system to provide the billing system with the energy use information of individual users.

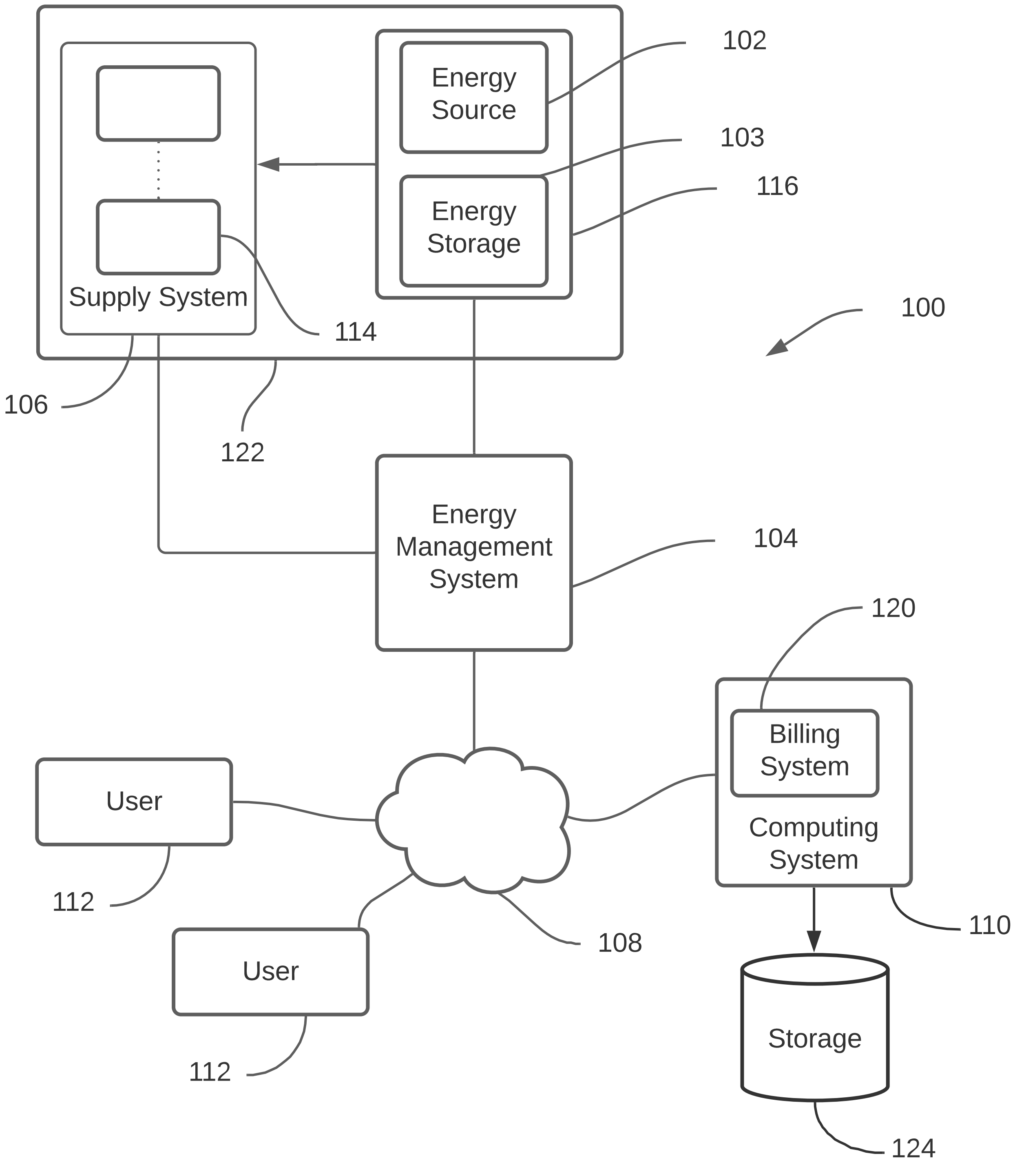

Energy Source
Energy Storage
Supply System
Energy Management System
User
User
Billing System
Computing System
Storage
100
102
103
104
106
108
110
112
112
114
116
120
122
124

Figure 1

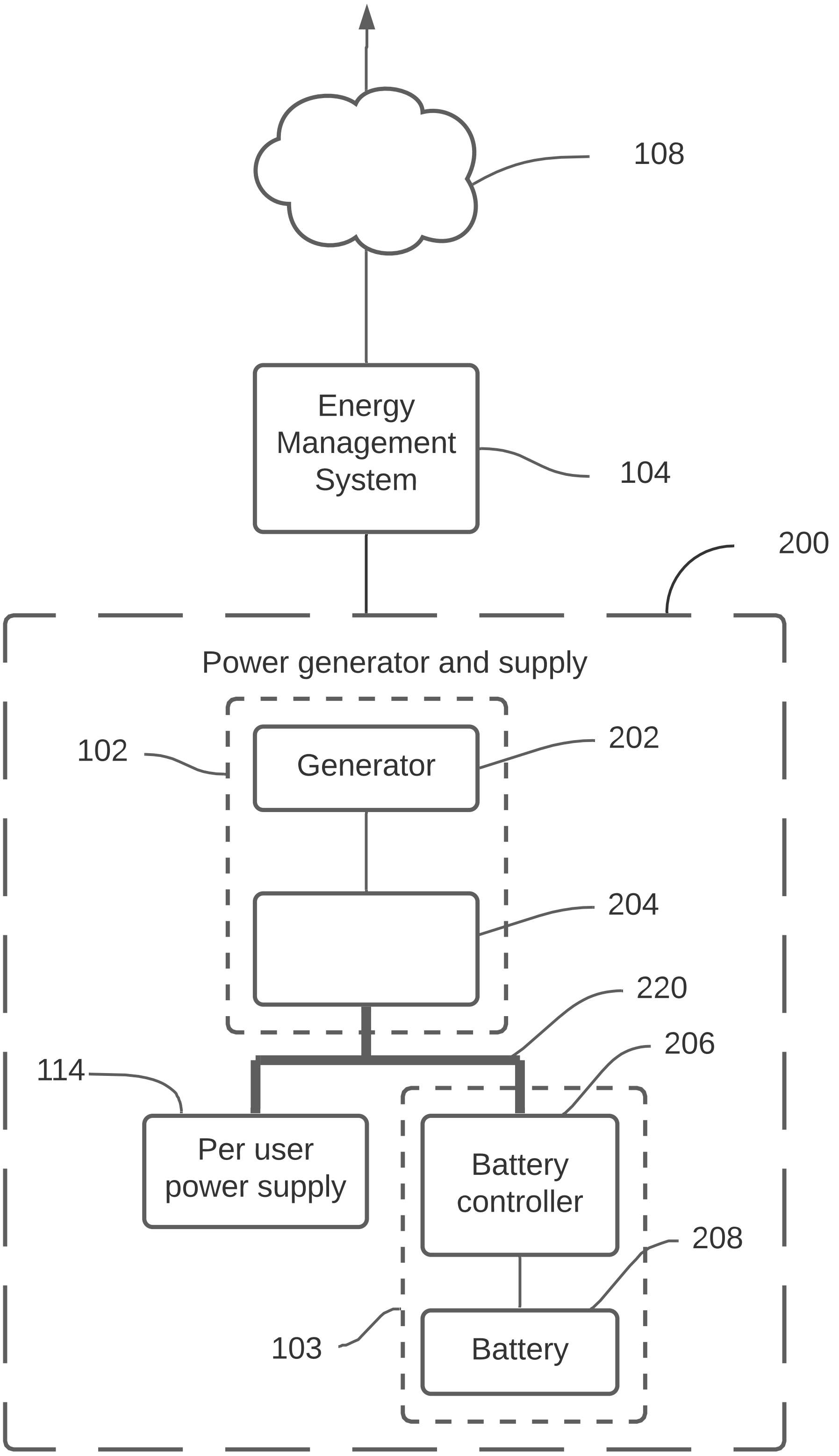

108
Energy Management System
104
200
Power generator and supply
102
Generator
202
204
220
206
114
Per user power supply
Battery controller
208
103
Battery

Figure 2

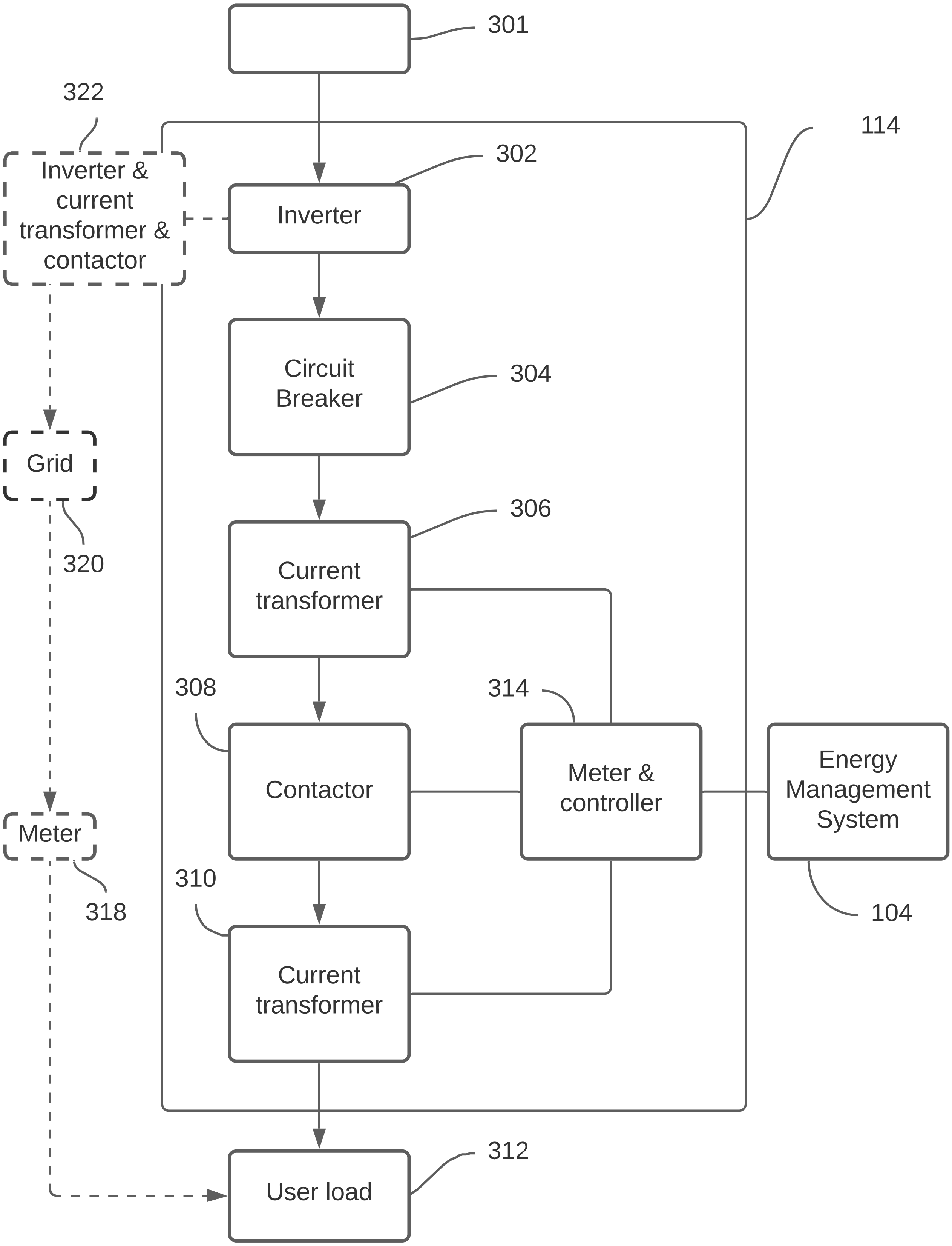

301
322
114
302
Inverter & current transformer & contactor
Inverter
Circuit Breaker
304
Grid
306
320
Current transformer
308
314
Contactor
Meter & controller
Energy Management System
Meter
310
318
104
Current transformer
312
User load

Figure 3

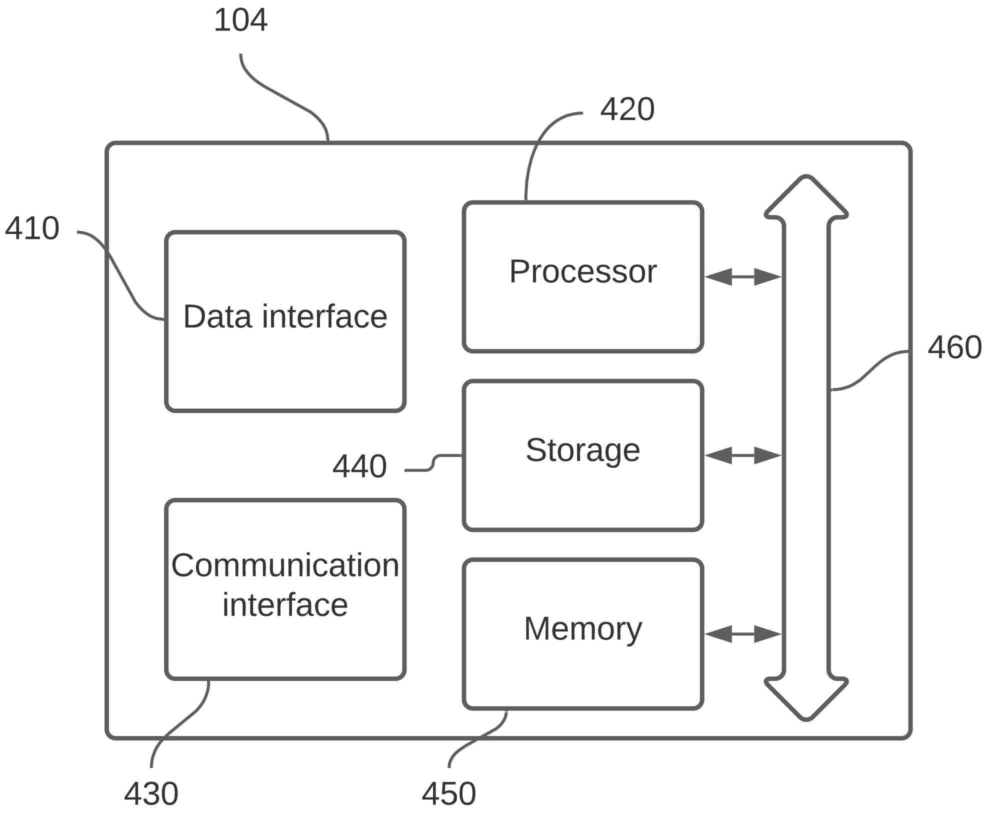

104
420
410
Processor
Data interface
460
Storage
440
Communication interface
Memory
430
450

Figure 4

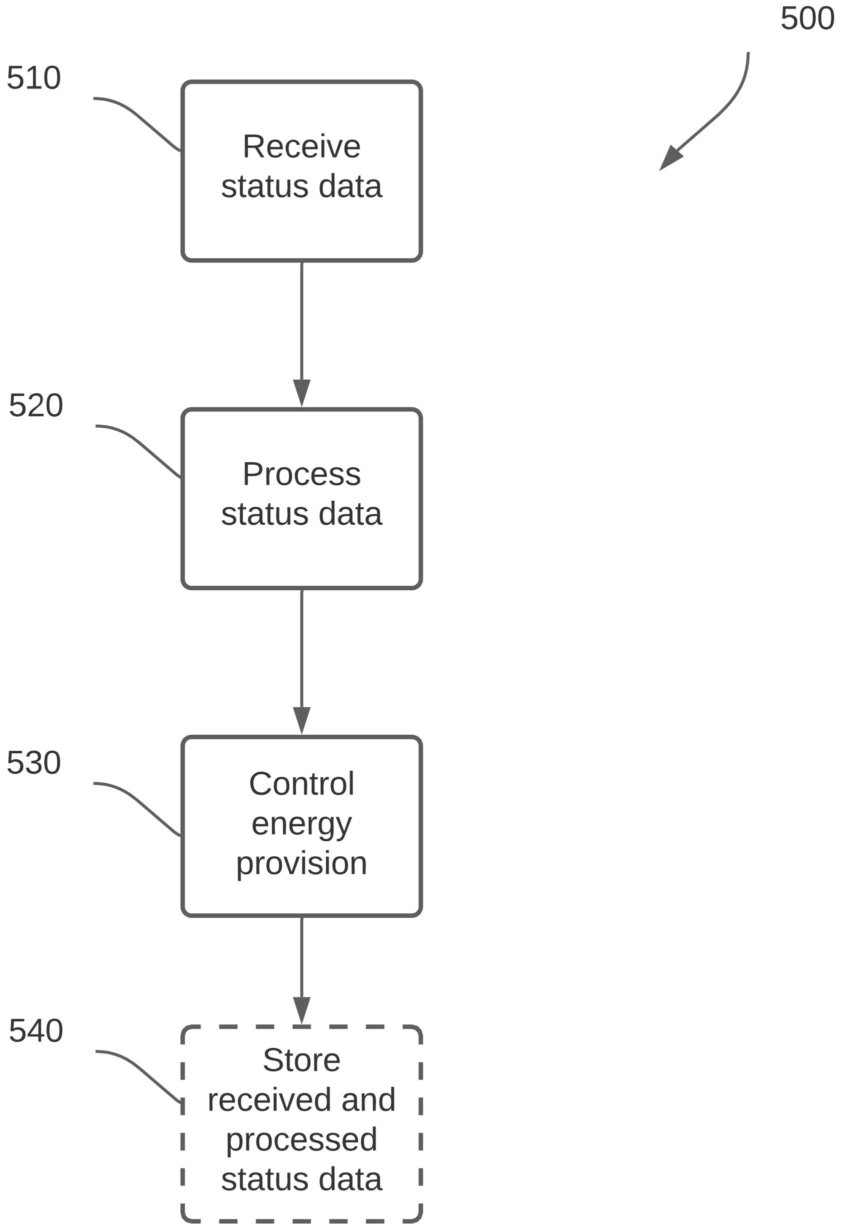

500
510
Receive status data
520
Process status data
530
Control energy provision
540
Store received and processed status data

Figure 5

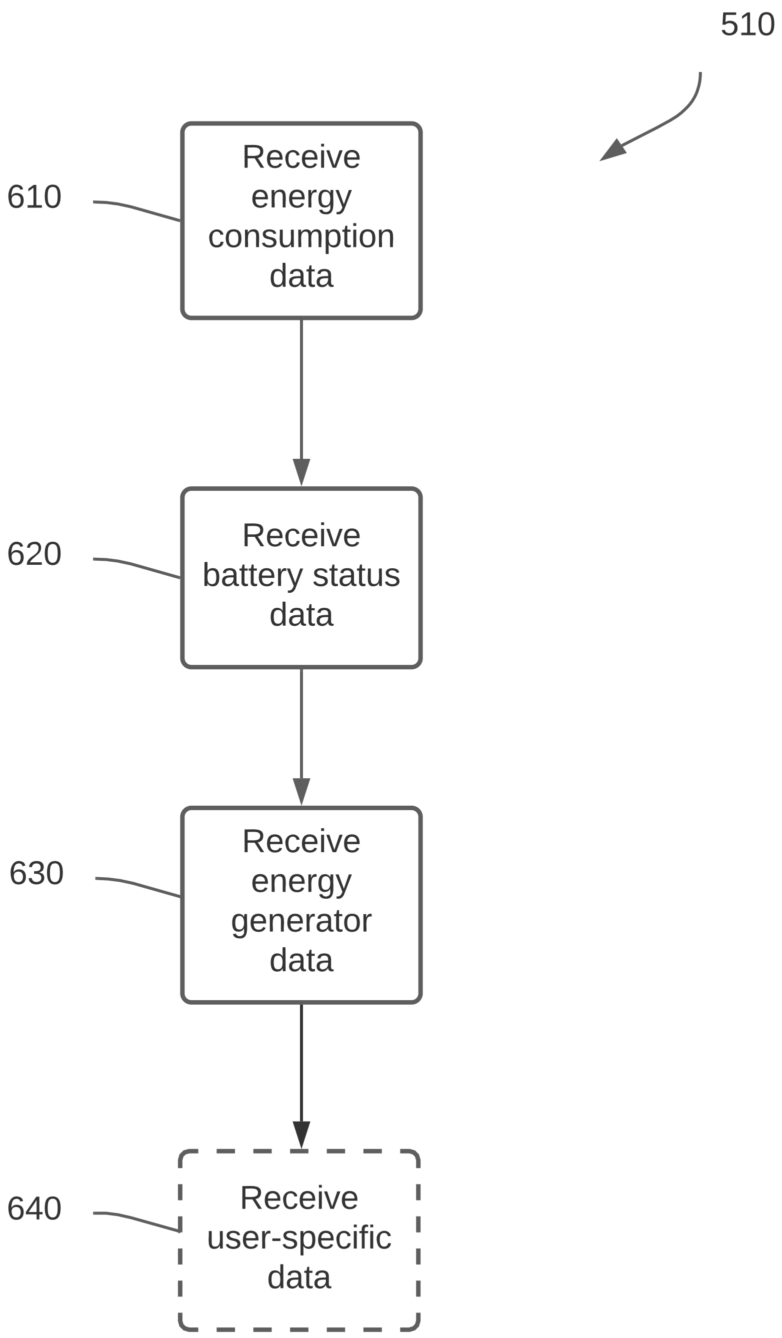

510
610
Receive energy consumption data
620
Receive battery status data
630
Receive energy generator data
640
Receive user-specific data

Figure 6

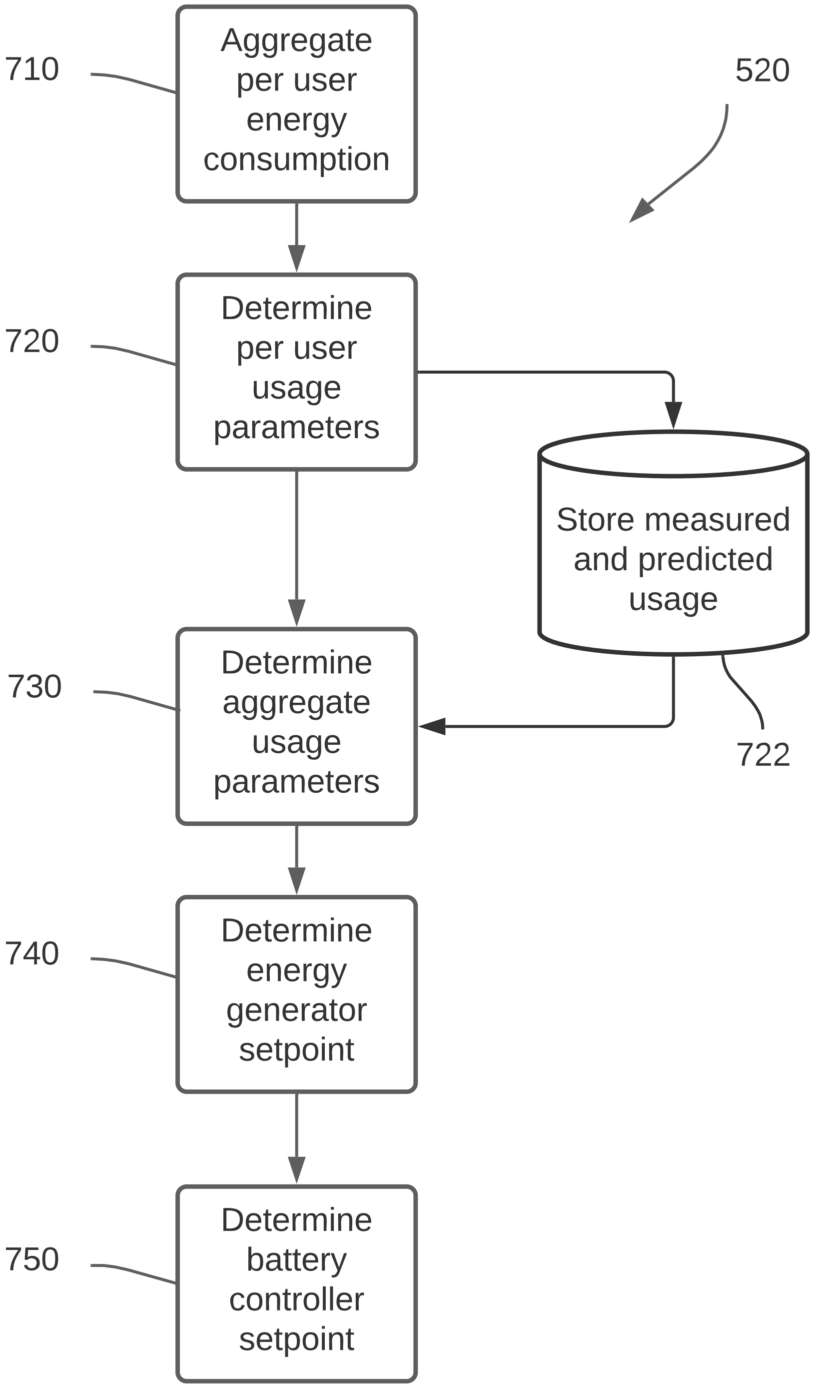

710
Aggregate per user energy consumption
520
720
Determine per user usage parameters
Store measured and predicted usage
730
Determine aggregate usage parameters
722
740
Determine energy generator setpoint
750
Determine battery controller setpoint

Figure 7

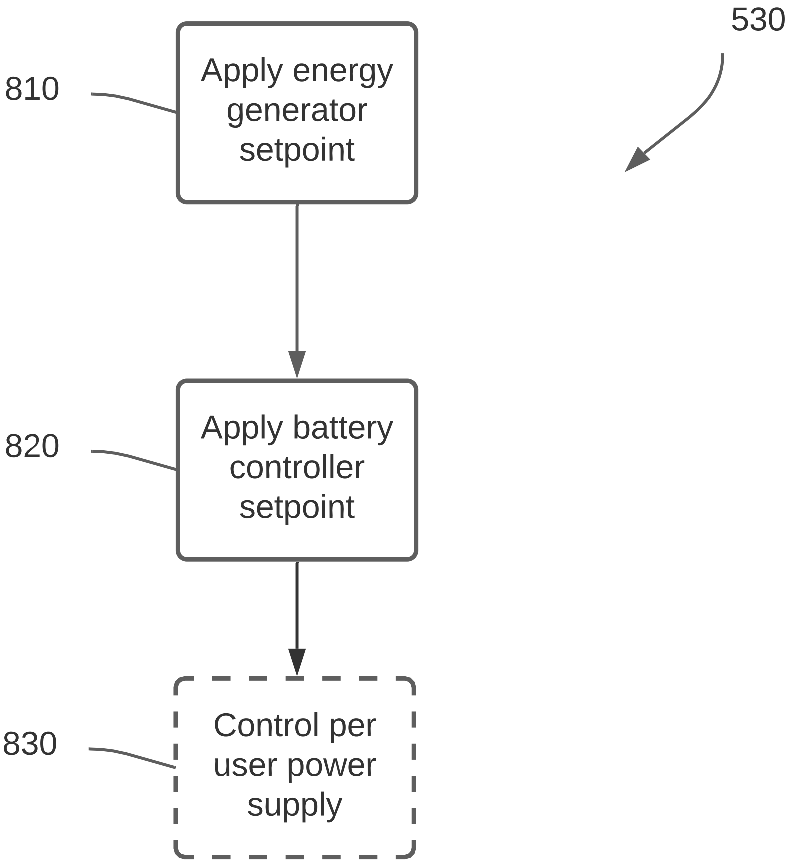

530
810
Apply energy generator setpoint
820
Apply battery controller setpoint
830
Control per user power supply

Figure 8

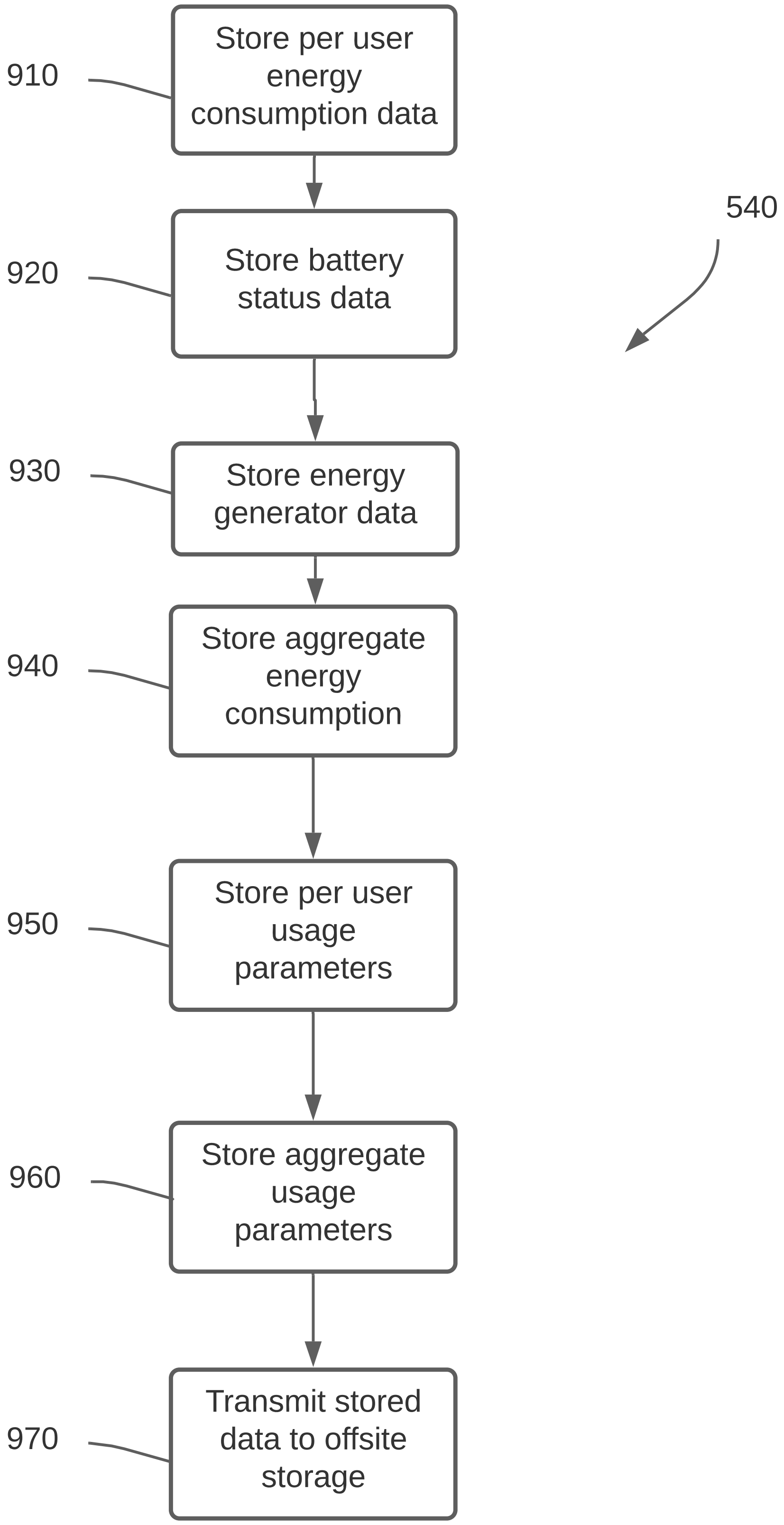

540
910
Store per user energy consumption data
920
Store battery status data
930
Store energy generator data
940
Store aggregate energy consumption
950
Store per user usage parameters
960
Store aggregate usage parameters
970
Transmit stored data to offsite storage

Figure 9

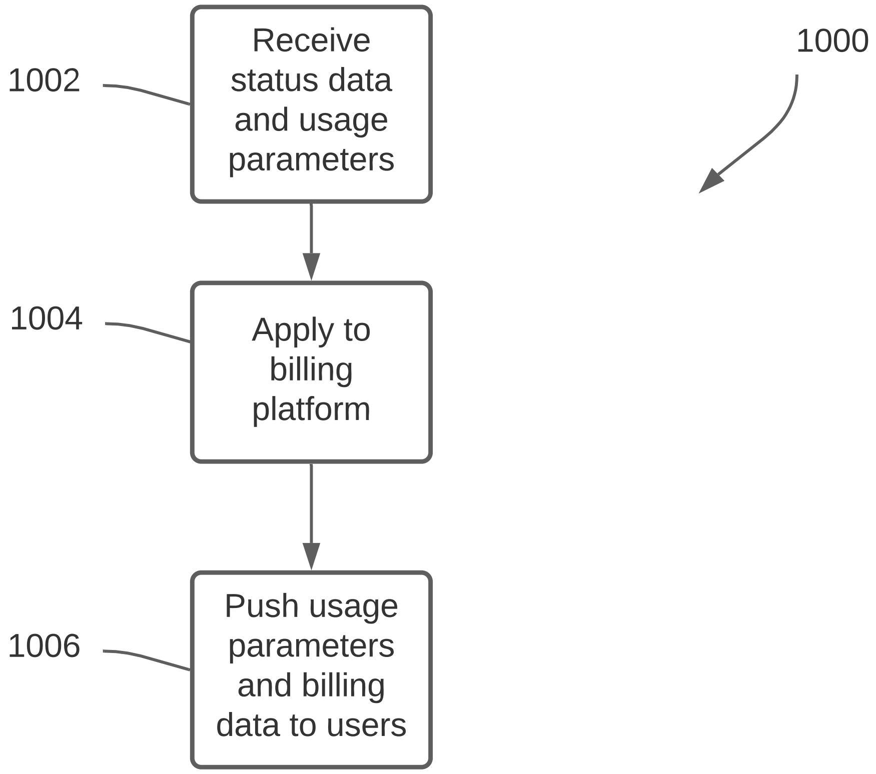

1000
1002
Receive status data and usage parameters
1004
Apply to billing platform
1006
Push usage parameters and billing data to users

Figure 10

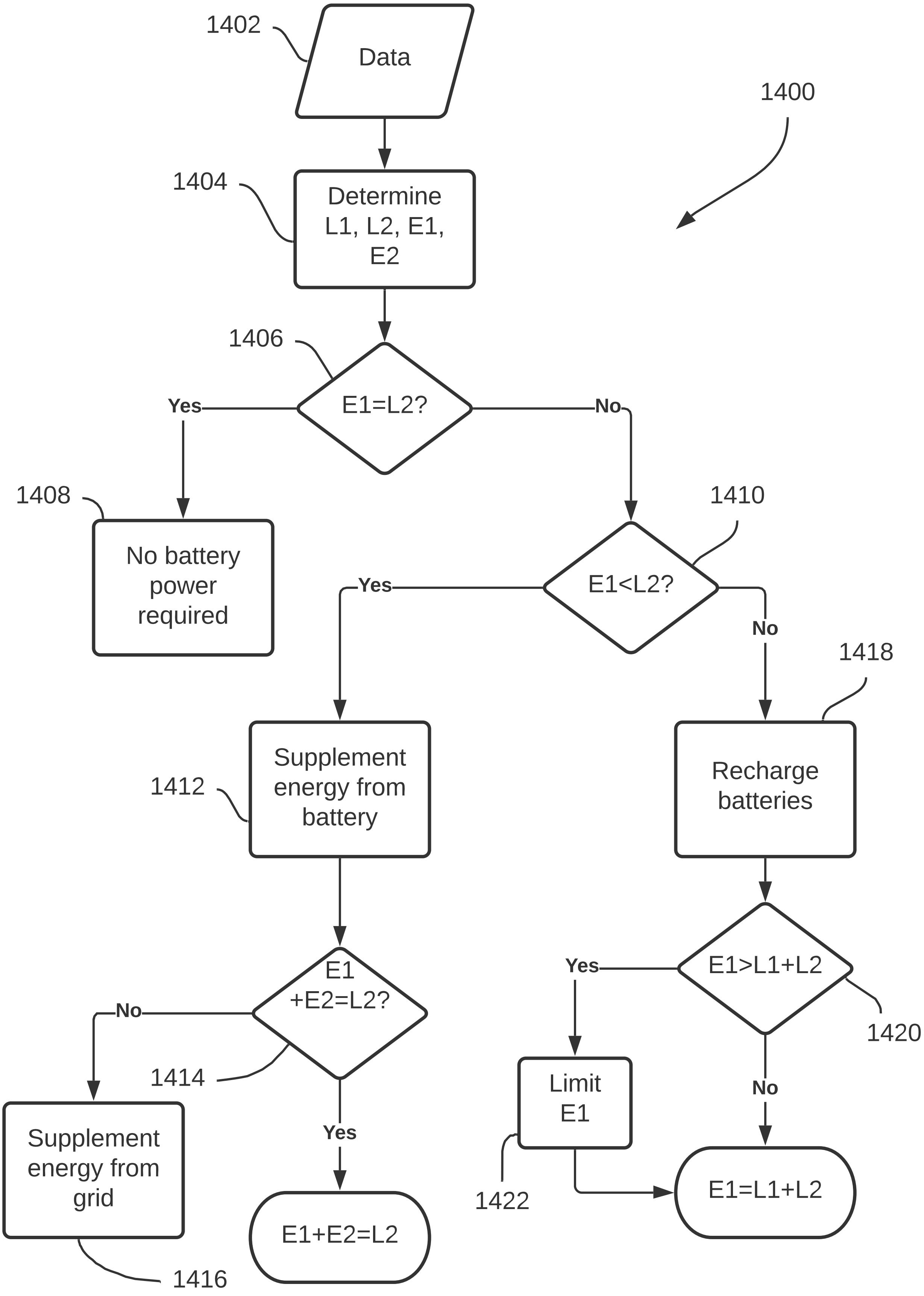

1402
Data
1400
1404
Determine L1, L2, E1, E2
1406
E1=L2?
Yes
No
1408
No battery power required
1410
E1<L2?
Yes
No
1418
1412
Supplement energy from battery
Recharge batteries
E1 +E2=L2?
No
1414
Yes
Supplement energy from grid
E1+E2=L2
1416
E1>L1+L2
Yes
1420
No
Limit E1
1422
E1=L1+L2

Figure 14

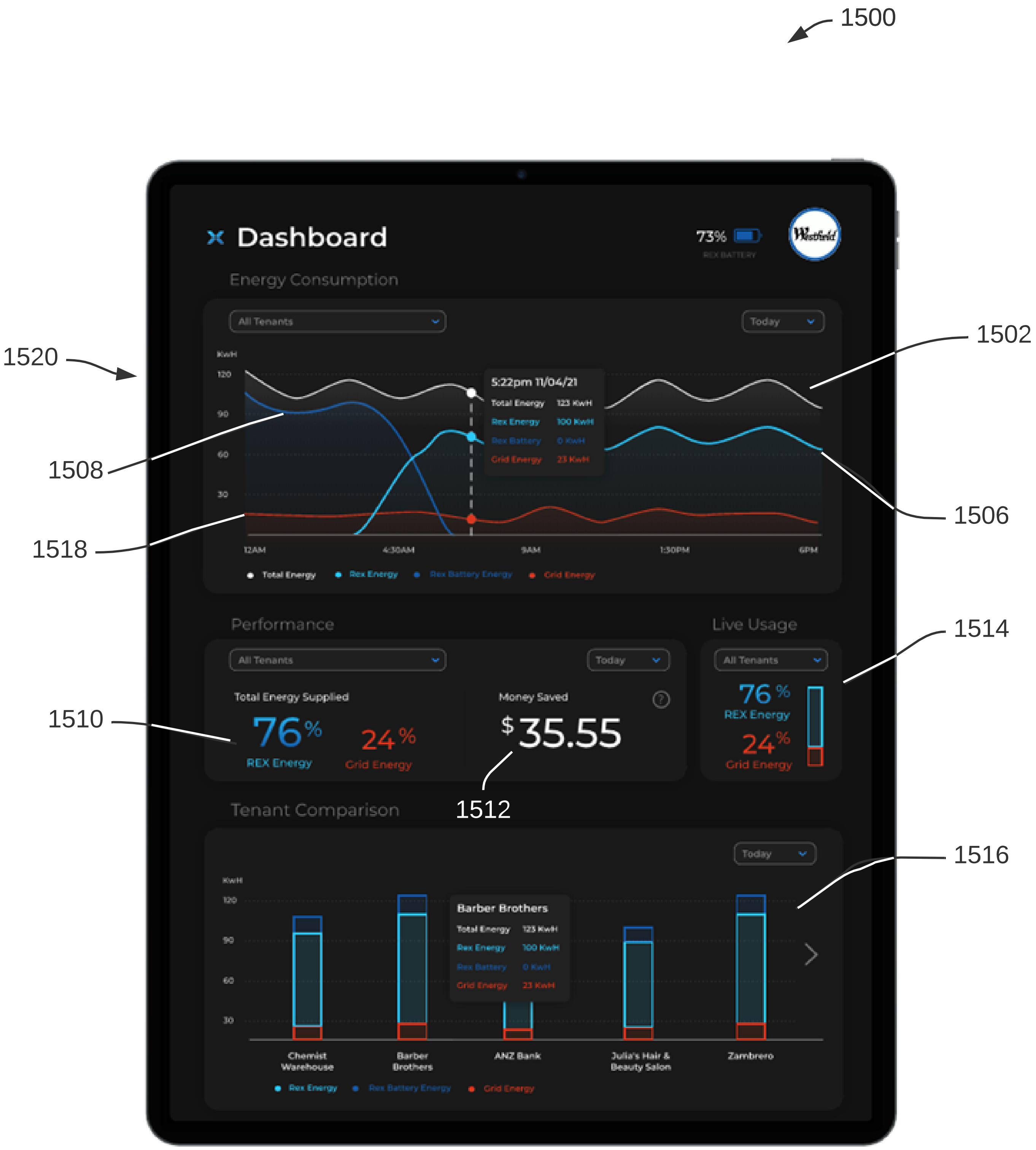
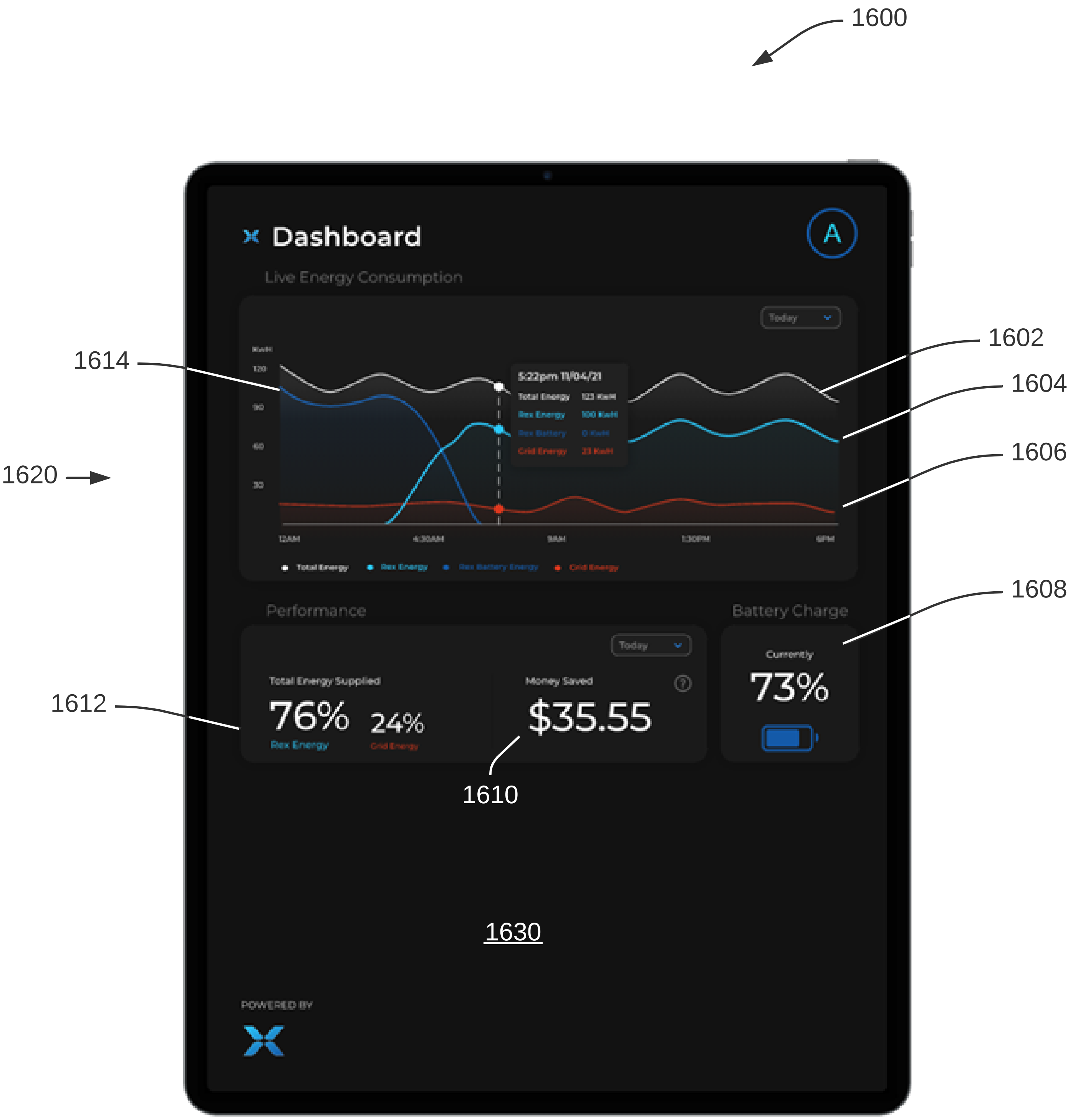

1500
Dashboard
73%
REX BATTERY
Westfield
Energy Consumption
All Tenants
Today
KwH
120
90
60
30
5:22pm 11/04/21
Total Energy 123 KwH
Rex Energy 100 KwH
Rex Battery 0 KwH
Grid Energy 23 KwH
12AM
4:30AM
9AM
1:30PM
6PM
● Total Energy
● Rex Energy
● Rex Battery Energy
● Grid Energy
1520
1502
1508
1506
1518
Performance
All Tenants
Today
Total Energy Supplied
76%
REX Energy
24%
Grid Energy
Money Saved
$35.55
Live Usage
All Tenants
76%
REX Energy
24%
Grid Energy
1514
1510
1512
Tenant Comparison
Today
KwH
120
90
60
30
Barber Brothers
Total Energy 123 KwH
Rex Energy 100 KwH
Rex Battery 0 KwH
Grid Energy 23 KwH
Chemist Warehouse
Barber Brothers
ANZ Bank
Julia's Hair & Beauty Salon
Zambrero
● Rex Energy
● Rex Battery Energy
● Grid Energy
1516

Figure 15



5:22pm 11/04/21
Total Energy 123 KwH
Rex Energy 100 KwH
Rex Battery 0 KwH
Grid Energy 23 KwH

Total Energy Supplied
76% Rex Energy
24% Grid Energy

Money Saved
$35.55

Currently
73%

Figure 16