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(54) Title: A POWER CONTROL DEVICE FOR AN ELECTRICAL INSTALLATION OF A BUILDING AND A METHOD OF POWER CONTROLLING AN ELECTRICAL INSTALLATION OF A BUILDING

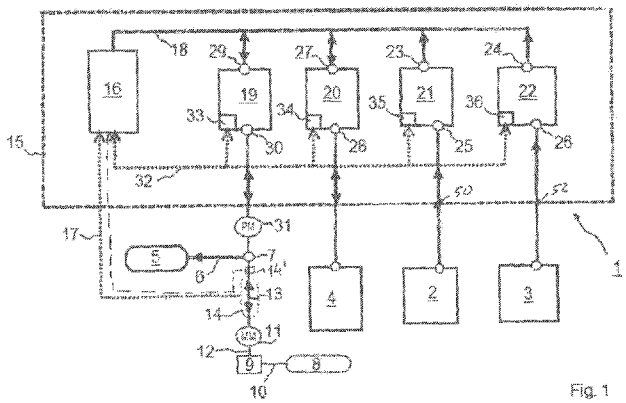

Fig. 1

(57) Abstract: A power control device for an electrical installation of a building, comprising: at least one power generation unit connector for connecting to at least one power generation unit for generating energy from renewable sources; an energy storage unit for storing energy and for supplying stored energy; an electrical load connector for connection to at least one electrical load of the electrical installation; a power grid connection unit for connecting the at least one electrical load to a power grid, for drawing energy from the power grid and for feeding energy into the power grid; a main meter for measuring the amount of energy drawn from the power grid and fed into the power grid; the electrical load connector being connected to the power grid connection unit through a junction, the power grid connection unit being connected to the junction by an electrical conductor; a power meter for measuring the sum of energy being supplied by the at least one power generation unit connector and the energy storage unit to the junction; the at least one power generation unit connector and the energy storage unit being connected via the power meter to the junction; a current sensor electromagnetically coupled to the electrical conductor at a sensing position between the main meter and the junction without direct electrical connection to the electrical conductor

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for creating a current sensor signal; and a power management unit connected to the current sensor for receiving the current sensor signal, the power management unit being adapted for controlling the energy flow between the at least one power generation unit connector, the energy storage unit, the electrical load connector and/or the power grid connection unit at least based on the current sensor signal.

Title: **A power control device for an electrical installation of a building and a method of power controlling an electrical installation of a building**

TECHNICAL FIELD

The invention generally relates to a power control device for an electrical installation of a building, such as a home or a commercial building, which obtains energy or power from both at least one power generation unit, such as a solar, wind or other fuel-less power source, and via a power grid connection unit another power source, typically a utility power grid.

BACKGROUND OF THE INVENTION

Such power control devices, for example ones that supply electrical energy to a household, as consumer unit (or "load unit"), are well known. When the power generation unit, such as a photovoltaic system generates a substantial amount of energy, for example when weather conditions are good, the household is supplied with sufficient electrical energy. When the photovoltaic system generates less energy than the household consumes, for example at night or when weather conditions are poor, the household needs to cover its energy requirements from the (public) power grid. For this purpose, the power control device has a grid connection unit by means of which the power control device may be connected to the power grid in order to draw this energy. This connection also permits the power control device to release energy that it generates to the power grid when the photovoltaic system generates more energy than is consumed by the household. The disadvantage of such a power control device is that during a period wherein the power generation unit generates more energy than required by the load the surplus energy is fed into the grid (for which only a low tariff will be paid in return by an operator of the

grid) while during a period wherein the power generation unit generates less energy than required by the load energy is drawn from the grid. This means a economical disadvantage for the client of the operator. More specifically, each flow of energy between the power control device and the power grid must be accounted for, which involves complicated calculation methods, inter alia.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a power control device which is simple in construction and easy to install. It is a further object of the invention to provide a power control device that causes the energy or electricity generated by a power generation unit to be utilised in an efficient and effective manner.

According to the invention at least one of these objects or at least part of one of these objects is achieved by providing a power control device according to claim 1. By using a current sensor electromagnetically coupled to the electrical conductor without direct electrical connection to the electrical conductor, the current sensor can in a simple way be used as part of a retrofit procedure with, for example, existing utility grid-connected solar power installations. Also the current sensor can in a simple way be used as part of a procedure with new utility grid-connected solar power installations. In addition by coupling the current sensor to the electrical conductor at a sensing position between the main meter and the junction it becomes very easy to control the flow of energy in an efficient and effective manner based on the current sensor signal created by the current sensor. Moreover because the optional energy storage unit can be used for storing energy and for supplying energy if the optional energy storage unit is present, the problem about the above referred to economical disadvantage may be solved.

A power control device which is simple in construction can be obtained when the at least one power generation unit is connected via the

power management unit to the power meter if the power meter is present and wherein the optional energy storage unit is connected via the power management unit to the power meter if the optional energy storage unit and the optional power meter are present. Also a power control device which is simple in construction can be obtained when the at least one power generation unit is connected via the power management unit to the junction if the optional power meter is not present and wherein the optional energy storage unit is connected via the power management unit to the junction if the optional energy storage unit is present and the optional power meter is not present.

An optimized supply of energy that matches requirements of the electrical installation using as less as possible energy from the power grid can be provided in an embodiment of a power control device according to the invention, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit, the electrical load connector and/or the power grid connection unit such as to try to regulate the electrical current through the electrical conductor to zero. In other words, the power grid connection unit regulates the electrical current through the electrical conductor towards zero and if possible to zero. It is noted that if in this application the energy flow from the power generation unit connector is mentioned this means, the energy flow of the power generation unit which is, in use, connected to the power generation unit connector.

If the energy flow supplied by the at least one power generation unit (or power generation unit connector) is larger than the demand of the load the surplus of energy flow is supplied to and stored in the energy storage unit (and not supplied into the power grid) because said current is regulated towards zero. In fact in that case said current is zero. If the energy flow supplied by the at least one power generation unit (or power generation unit connector) is larger than the demand of the load and the energy storage unit is full than the

surplus of energy (=the energy flow supplied by the at least one power generation unit (or power generation unit connector) minus the energy flow drawn by the load) is supplied to the power grid because said current is regulated towards zero. In fact in that case said current will not become zero but as small as possible. If the energy flow supplied by the at least one power generation unit (or power generation unit connector) is larger than the demand of the load and the required charging capacity of the energy storage unit is less than the surplus of energy flow generated by the at least one power generation unit (or power generation unit connector) which is not supplied to the load. Then the portion of the surplus of energy flow which can not be stored in the energy storage unit is supplied to the power grid because said current is regulated towards zero. In fact in that case said current will not become zero but as small as possible. If the energy flow supplied by the at least one power generation unit (or power generation unit connector) is smaller than the demand of the load the shortage of energy flow is supplied by the energy storage unit if available (and no energy flow is drawn from the power grid) because said current is regulated towards zero. In fact in that case said current is zero. If the energy flow supplied by the at least one power generation unit (or power generation unit connector) is smaller than the demand of the load and if the energy storage unit can only supply a portion of the energy flow which is additionally needed by the load or the energy storage unit is empty, than the shortage of energy flow is drawn from the power grid. In that case said current is not zero, but because the power generation unit tries to regulate the current to zero the energy drawn from the power grid is as small as possible.

Thus, in an embodiment of a power control device according to the invention in which this is possible, the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit and the electrical load connector such that the amount of energy drawn by the at least one electrical load is supplied solely by the

combination of the at least one power generation unit and the energy storage unit. In this way it is possible to provide energy to the at least one electrical load independent from the power grid in an efficient and a cheap way. Especially in this case it is further advantageous when the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit, the electrical load connector and/or the power grid connection unit such that the electrical current through the electrical conductor is regulated to zero, and the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit, the electrical load connector and/or the power grid connection unit such that a surplus of energy supplied by the at least one power generation unit with respect to the amount of energy drawn by the at least one electrical load is stored in the energy storage unit or a shortage of energy supplied by the at least one power generation unit with respect to the amount of energy drawn by the at least one electrical load is drawn from the energy storage unit. In this manner amounts of energy provided internally (by the at least one power generation unit and the energy storage unit), which amounts are sufficient to cover the demand by the at least electrical load and are kept in balance by storing or drawing energy from the energy storage unit.

If it is not possible for the power management unit to regulate the electrical current through the electrical conductor exactly to zero, then the power management unit will regulate this current as close as possible to zero, so that all the energy supplied by the at least one power generation unit and the energy storage unit is first used to cover the demand by the at least one electrical load and the remainder is drawn from the power grid via the power grid connection unit. In this case the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit, the electrical load connector and/or the power grid connection unit such that the electrical current through the electrical

conductor is regulated as close as possible to zero, and for controlling the energy flow between the at least one power generation unit, the energy storage unit, the power grid connection unit and the electrical load connector such that a shortage of energy supplied by the combination of the at least one power generation unit and the energy storage unit with respect to the amount of energy drawn by the at least one electrical load is drawn from the power grid connection unit.

In particular in case the current sensor is coupled to the electrical conductor during a retrofit operation it is advantageous to use an embodiment of the power control device according to the invention, wherein the power management unit is adapted for controlling an initial energy flow between the power grid connection unit and the electrical load connector when the current sensor is electromagnetically coupled to the electrical conductor for providing an indication of the current direction and/or value of the electrical current through the electrical conductor. In this manner it is possible to correctly define the values provided by the optional power meter if the power meter is present, and the main meter. In case the current sensor is a clip on sensor retrofit operation is extremely simple because the original wiring need not be interrupted or changed.

In accordance with the invention the power control is adapted for determining the amount of power submitted to the power grid via the power grid connection unit and lowering the amount of power supplied, in use, by the at least one power generation unit to the at least one power generation unit connector if the amount of power submitted to the power grid exceeds a predetermined value. By lowering the amount of power submitted to the power grid if this amount of power exceeds the predetermined value the change is lowered that peak values of the power in the power grid occur due to the power control device submitting electric energy into the grid. In this embodiment the power control device may, but need not, be provided with the optional energy storage unit.

The invention further relates to a method of power controlling an electrical installation of a building, the method using a power control device, comprising:

at least one power generation unit for generating energy from renewable sources;

an optional energy storage unit for storing energy and for supplying stored energy;

an optional power meter for measuring the energy being supplied by the at least one power generation unit and the energy being supplied by the optional energy storage unit if this unit is present;

an electrical load connector for connection to at least one electrical load of the electrical installation;

a power grid connection unit for connecting the electrical load connector to a power grid, for drawing energy from the power grid and for feeding energy into the power grid;

a main meter for measuring the amount of energy drawn from the power grid and fed into the power grid;

the electrical load connector being connectable to the power grid connection unit through a junction, the power grid connection unit being connected to the junction by an electrical conductor;

the at least one power generation unit and the optional energy storage unit if this unit is present being connected to the junction wherein the at least one power generation unit and the optional energy storage unit if this unit is present being connected via the power meter to the junction if the power meter is present;

a current sensor electromagnetically coupled to the electrical conductor at a sensing position between the main meter and the junction without direct electrical connection to the electrical conductor for creating a current sensor signal;

the method comprises the step of receiving by a power management unit connected to the current sensor the current sensor signal created by the current sensor, and the step of controlling by the power management unit the energy flow between the power generation unit, the optional energy storage unit if this unit is present, the electrical load connector and/or the power grid connection unit at least based on the current sensor signal. Preferably the method further comprises the step of adapting the power management unit such that it controls the energy flow between the at least one power generation unit, the optional energy storage unit if this unit is present, the electrical load connector and/or the power grid connection unit such as to try to regulate the electrical current through the electrical conductor to zero.

Further objects, features, effects, advantages and details of the invention are described with reference to examples shown in the drawings.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a schematic diagram illustrating a power control device for an electrical installation of a building in accordance with the invention.

DETAILED DESCRIPTION

FIG. 1 illustrates a simplified block diagram of a power control device 1 including at least one power generation unit, such as a solar panel 2 and a windmill 3. Although a windmill and a solar panel, i.e. a photovoltaic system, are described as an example the invention is not limited to power generation units generating energy by solar power or by wind energy, but such a unit can generate power equally well from biogas, geothermal energy or other renewable resources.

An energy storage unit 4 is present for storing electric energy and for providing electric energy. Such an energy storage unit 4 may for example

be formed by one or more supercaps, Li-ion batteries or any other energy storage means.

At least one electrical load 5 of an electrical installation of a building is connected via an electrical load connector 6 to a junction 7. Such an electrical load 5 may be formed by any or all electrical appliances which can be present in a household or a commercial building.

An AC power grid or utility grid 8 (not belonging to the power control device 1) is connected to a power grid connection unit 9 by a line 10. In this way energy can be drawn from or fed into the power grid 8. A main or electric consumption meter 11 is connected to the power grid connection unit 9 by a line 12 and measures the amount of energy drawn from and fed into the power grid 8. The main meter may be arranged for measuring the amount of energy drawn from the power grid and for measuring the amount of energy fed into the power grid. However in this example the main meter is arranged for measuring the amount of energy drawn from the power grid minus the amount of energy fed into the power grid, thus a net amount of energy is measured which is supplied to the power grid or drawn form the power grid. Electrical energy from the power grid 8 is supplied to the at least one electrical load 5 via the grid connection unit 9, the main meter 11 and the junction 7 and passes through an electrical conductor 13.

A current sensor 14 is positioned along electrical conductor 13 between junction 7 and the main meter 11 and is electromagnetically coupled to electrical conductor 13 without direct electrical connection to the electrical conductor 13. The current sensor 14 can, in one example, be a differential noncontact current sensor, such as a Rogowski coil having an open interior or AC Current transformers TT 100-SD or TT 50-SD from LEM. In the presently most preferred embodiment the current sensor 14 is a clip-on current sensor using magnetic inductivity to measure the direction of the AC current (and optionally the value of the current) flowing within the electrical conductor 13. Such clip-on sensors are known per se. Using this type of non-contact current

sensor provides several advantages. It makes retrofit operation simple because the original wiring need not be interrupted or changed; the current sensor can be simply clipped on the electrical conductor without disturbing the conductor. Other types of non-contact current sensors, such as other differential sensors or proportional sensors, including magnetic field current sensors, current transformers, and Hall effect sensors, can also be used in different embodiments of the invention. The current sensor 14 creates a current sensor signal representative of at least the direction of the current flowing through the electrical conductor 13 and, optionally after calibration, a signal representative of the value of the amount of current flowing through the electrical conductor 13.

The inventive power control device 1 also includes a power management unit 15 comprising a microprocessor or any other suitable control means 16 which is connected to the current sensor 14 by a current sensor signal line 17, which signal line 17 transports the current sensor signal from the current sensor 14 to the control means 16. In this example the power management unit 15 further comprises a bus 18 and a plurality of modules 19, 20, 21, 22 which are detachably connected with the bus 18 for mutually exchanging electrical energy between the modules via the bus 18.

Each module 21; 22 has a first connection 23; 24 which is, as shown in this example, operatively electrically connected with the bus 18 for supplying energy to the bus 18. Each module 21; 22 is further provided with a second connection 25; 26 which is operatively connected with the solar panel 2 and the windmill 3 via power generation unit connectors 50, 52 respectively, for drawing energy from the respective power generation unit via the second connection.

The module 20 of the power management unit 15 is provided with a first connection 27 which is, as shown in this example, operatively electrically connected with the bus 18 and a second connection 28 which is operatively electrically connected with the energy storage unit 4 for, as desired, supplying

energy to the bus via the first connection 27 and drawing energy from the energy storage unit 4 via the second connection 28 or drawing energy from the bus via the first connection 27 and supplying energy to the energy storage unit 4 via the second connection 28.

The module 19 of the power management unit 15 is provided with a first connection 29 which is, as shown in this example, operatively electrically connected with the bus 18 and a second connection 30 which is operatively electrically connected with the junction 7 via a power meter 31 for, as desired, drawing energy from the bus 18 via the first connection 29 and supplying energy to the at least one electrical load 5 via the second connection 30, the power meter 31 and the junction 7 and/or drawing energy from the power grid 8 and supplying energy to the at least one electrical load 5 via the power grid connection unit 9, the main meter 11 and the junction 7. The power meter 31 measures the amount of energy which is supplied from unit 19 towards the junction 7. In this example the voltage on the bus is a DC voltage wherein the module 19 transforms a DC current from the bus into an AC current through the power meter 31 and vice versa. The current supplied to the connections 25, 26, 28 is however in this example a DC current. In each of the examples discussed and in accordance with the invention the power meter is optional and may be deleted. In that case in the example the unit 14 is directly connected to the junction 7. Also in that case in the example the power management unit 15 is directly connected to the junction 7. The power meter 31 is in that case in the example replaced by a direct connection via a wire.

In this example, the control means 16 generates control signals on a line 32 connecting the control means 16 with each of the modules 19, 20, 21, 22 for respective control, such as activation or deactivation, of the modules. In this example each module 19; 20; 21; 22 is further provided with a local control unit 33; 34; 35; 36 which is connected to the control means 16.

The power management unit 15 is adapted for controlling the energy flow between the at least one power generation unit 2, 3, the energy storage

unit 4, the at least one electrical load 5 and the power grid connection unit 9 with the help of the control means 16, the local control units 33, 34, 35, 36 and at least based on the current sensor signal created by the current sensor 14.

The power management unit 15 controls the energy flows based on the current sensor signal such as to try to regulate the electrical current through the electrical conductor 13 to zero. Thus the power management unit 15 tries to control the energy flows such that the electrical current drawn from the power grid is low as possible, preferably zero.

In case internal energy (i.e. energy provided by the combination of the at least one power generation unit 2, 3 and the energy storage unit 4) is sufficient to cover the electrical demands of the at least one electrical load 5, the power management unit 15 is able to control the energy flows such that the current through the electrical conductor 13 is exactly zero. Preferably, the power management unit 15 controls the energy flows such that first the energy supplied by the power generation units 2, 3 is used to cover the demands of the at least one electrical load 5. If the power generation units 2, 3 produce more energy than the energy drawn by the at least one load 5, the surplus energy is supplied to or stored in the energy storage unit 4. Only in case the energy storage unit 4 is fully loaded and/or the required charging capacity of the storage unit is too small (so that the energy storage unit can not be loaded with the full surplus of energy flow) , then the power management unit 15 feeds the portion of the surplus of energy flow which can not be loaded into the energy storage unit 4 into the power grid. Than said current is not zero although it is tried by the power management unit to regulate said current to zero. If the power generation units 2, 3 produce not enough energy with respect to the energy drawn by the at least one load 5, the control of the power management unit 15 is such that the remaining energy is drawn from the energy storage unit 4 (than said current is not zero although it is tried by the power management unit to regulate said current to zero).

Only if the at least one power generation unit 2, 3 in combination with the energy storage unit 4 are unable to meet the demand of the at least one electrical load 5, the power management unit 15 is unable to regulate the electrical current through the electrical conductor 13 to exactly zero, but then regulates this electrical current such that it is as close as possible to zero. The power management unit 15 then resorts to the power grid 8 for drawing the remaining energy. Thus the power management unit 15 controls the energy flows such that first the internal energy (provided by the at least one power generation unit and the energy storage unit) is used to cover the demand of the electrical load and only if this is not sufficient the power grid is used, in this case the combination of internal and external energy (i.e. from the power grid) covers the electrical demand of the electrical installation of the building. A user of the system may pay a first tariff per kWH for the amount of energy drawn from the power grid minus the energy supplied to the power grid if the amount of energy drawn from the grid is larger than the amount of energy supplied to the power grid (this amount of energy is measured by the main meter 11). The user of the system may be paid a second tariff per kWH for the amount of energy supplied to the power grid minus the energy drawn from the power grid if the amount of energy supplied to the power grid is larger than the amount of energy drawn from the power grid (this amount of energy is measured by the main meter 11). The first tariff may be higher than the second tariff. In addition the user may be paid a third tariff for energy supplied from the power generation units towards the junction 7 as measured by the power meter 31. Therefore it is in that case also economically advantageous to the user that it is tried to regulate the current through the conductor 14 to zero as discussed above.

In case the current sensor 14 is coupled to the electrical conductor 13 as part of a retrofit operation the power management unit 15 is adapted for checking the correct operation of the current sensor 14 and optionally for calibrating the current sensor 14. This is achieved in that (immediately) after

the current sensor is fitted the power management unit 15 initiates an initial energy flow between the power grid connection unit 9 (i.e. coming from the power grid 8) and the at least one electrical load. This initial energy flow will make it possible to provide a correct indication of the direction of the electrical current flowing through the electrical conductor and/or an indication whether the current sensor is connected or not. In this way it is possible to correctly distinguish between electrical current coming from the at least one power generation unit 2, 3 and the energy storage unit 4 and electrical current coming from the power grid. Calibration of the current sensor is possible when the power management unit 15 initiates an initial energy flow of a predetermined value to flow through the electrical conductor. In this way it is not only possible to provide a correct indication of the direction of the electrical current flowing through the electrical conductor but also to calibrate the amount (or value) of said electrical current. In this manner it is furthermore possible to correctly define the values provided by the power meter 31 and the main meter 11 so that it is possible to exactly determine the amounts of energy drawn from and supplied to the power grid and the amount of energy supplied by the at least one power generation unit and the energy storage unit. The invention is not limited to the described embodiment. The regulation of the current towards or to zero can be arranged by detecting when the direction of the current changes and regulating such that a continuous changing of direction is detected, meaning that the current is regulated towards or to zero. It is also possible to measure the direction and the amplitude of the current for regulating the current towards or to zero. Thus it holds, according to an embodiment of the invention, that the power management unit is adapted for regulating the electrical current through the electrical conductor towards zero and if possible to zero by regulation of the magnitude of the energy flow to the energy storage unit wherein said magnitude has a positive sign if energy is stored in the energy storage unit and said magnitude has a negative sign if energy is supplied by the energy storage unit. Thus in this application

magnitude indicates the amplitude of the current and the direction of the current. Also it holds, according to an embodiment of the invention, that the electrical current through the electrical conductor is regulated to zero if the energy flow to the electrical load connector can be supplied solely by the energy storage unit and the power generation unit connector or if the energy flow supplied by the power generation unit connector can be supplied completely to the electrical load connector and the energy storage unit; and preferably in that the electrical conductor is regulated towards zero but does not reach zero if the energy flow drawn by the electrical load connector can not be supplied solely by the energy storage unit and the power generation unit connector so that a shortage energy flow is drawn from the power grid or the electrical conductor is regulated towards zero but does not reach zero if the energy flow supplied by the power generation unit connector cannot be supplied completely to the electrical load connector and the energy storage unit because the energy storage unit can not store the full surplus of energy flow so that the portion of the surplus of energy flow which can not be stored in the energy storage unit is supplied into the power grid.

The current sensor can also be positioned between the main meter 11 and the power grid connection unit 9 for measuring the same current. In the example the main meter is arranged for measuring the amount of energy drawn from the power grid minus the amount of energy fed into the power grid. It is also possible that the main meter is arranged for measuring separately the amount of energy drawn from the power grid and the amount of energy fed into the power grid. In the latter case it is possible that the main meter comprises a first meter and a second meter which are functionally and possibly physically separated from each other wherein the first meter is arranged for measuring the amount of energy drawn from the power grid and the second meter is arranged for measuring the amount of energy fed into the power grid.

In accordance with a special embodiment the power control device 1

is provided with a power sensor 14' connected to the power management unit 15 for determining the amount of power submitted to the power grid via the power grid connection unit. The power management unit 15 is arranged for lowering the amount of power supplied, in use, by the at least one power generation unit 2, 3 to the at least one power generation unit connector 50, 52 if the amount of power submitted to the power grid exceeds a predetermined value. In this way the chance may be lowered that a peak power is generated in the power grid 8 if the at least one power generation unit 2, 3 generates an high amount of power. Preferably the predetermined value is a fixed percentage from the maximum amount of power which can be generated by the at least one power generation unit 2, 3 which is, in use, connected to the at least one power generation unit connector 50, 52. For example if the maximum power of the unit 2 is 1kW, the predetermined value may be 70% of 1kW. It is however also possible that the predetermined value is another fixed value not related to the maximum amount of power of unit 2 and/or unit 3.

In this example the power control device is provided with a plurality of power generation unit connectors (50, 52) wherein the power control device is adapted for determining the amount of power submitted to the power grid via the power grid connection units and for lowering the amount of power supplied, in use, by at least one of the power generation units to at least one of the power generation unit connectors if the amount of power submitted to the power grid exceeds a predetermined value. Thus as a response to an amount of power which is submitted to the power grid exceeding the predetermined value for example the amount of power submitted by the solar panel 2 to the power control device and thereby to the power grid is lowered. Alternatively as a response to an amount of power which is submitted to the power grid exceeding the predetermined value, the amount of power submitted by the windmill 3 to the power control device and thereby to the power grid is lowered. However it is also possible that as a response to an amount of power which is submitted to the power grid exceeding the predetermined value, both

the amount of power submitted by the solar panel 2 to the power control device and thereby to the power grid is lowered as well as the amount of power submitted by the windmill 3 to the power control device and thereby to the power grid is lowered. Thus in that case it holds that the power control device is adapted for lowering the amount of power supplied by each of a plurality of power generation units which are, in use, connected to a plurality of power generation unit connectors of the plurality of power generation unit connectors if the amount of power submitted to the power grid exceeds the predetermined value.

Preferably the predetermined value is a fixed percentage from the maximum amount of power which can be generated in combination by the plurality of power generation units which are, in use, connected to the plurality of power generation unit connectors. For example if the solar panel 2 can generate a maximum power of 2kW and the windmill 3 can generate a maximum power of 1kW the total power which can be generated is 3kW. The predetermined value can for example be 70% of 3kW. It may however also be another fixed value such as 2.5 kW. Preferably the power control device is adapted so that if the power control device lowers the amount of power submitted to the power grid, this amount of power is lowered to the predetermined value.

In this embodiment the power sensor 14' is connected to control means 16 wherein the control means 16 controls the module 21 via line 32 for lowering the amount of power submitted by the power generation unit 2 to the power control device 1 and/or the control means 16 controls the module 22 via line 32 for lowering the amount of power submitted by the power generation unit 3 to the power control device respectively. Also according to a special embodiment the power sensor 14 'is formed by the current sensor 14. Thus in figure 1 the additional power sensor 14' may be deleted wherein the sensor 14 will function as the power sensor. It is noted that the current which is measured by means of the current sensor 14 is a measure of the power

submitted to the grid if power is submitted to the grid 8. In the system of figure 1 the energy storage unit may be deleted. In that case the sensor 14 can still be used for measuring the power submitted to the grid and for lowering – as discussed above- the amount of power supplied, in use, by the at least one power generation unit 2, 3 to the at least one power generation unit connector 50, 52 if the amount of power submitted to the power grid exceeds a predetermined value. If the energy storage unit 4 is deleted the module 20 may also be deleted.

Claims

1. A power control device for an electrical installation of a building, comprising:

at least one power generation unit connector for connecting to at least one power generation unit for generating energy from renewable sources;

an optional energy storage unit for storing energy and for supplying stored energy;

an electrical load connector for connection to at least one electrical load of the electrical installation;

a power grid connection unit for connecting the at least one electrical load to a power grid, for drawing energy from the power grid and for feeding energy into the power grid;

a main meter for measuring the amount of energy drawn from the power grid and fed into the power grid;

the electrical load connector being connected to the power grid connection unit through a junction, the power grid connection unit being connected to the junction by an electrical conductor;

an optional power meter for measuring the energy being supplied by the at least one power generation unit connector to the junction if the optional energy storage unit is not present and for measuring the sum of energy supplied by the at least one power generation unit connector and the optional energy storage unit to the junction if the optional energy storage unit is present;

the at least one power generation unit connector being connected to the junction wherein the at least one power generation unit connector is connected to the junction via the power meter if the power meter is present; and

the optional energy storage unit being connected to the junction if the optional energy storage unit is present wherein the optional energy storage unit is connected to the junction via the power meter if the optional energy storage unit and the optional power meter are present ;

a current sensor electromagnetically coupled to the electrical conductor at a sensing position between the main meter and the junction without direct electrical connection to the electrical conductor for creating a current sensor signal; and

a power management unit connected to the current sensor for receiving the current sensor signal, the power management unit being adapted for controlling the energy flow between the at least one power generation unit connector, the optional energy storage unit if the optional energy storage unit is present, the electrical load connector and/or the power grid connection unit at least based on the current sensor signal.

2. The power control device according to claim 1, wherein the at least one power generation unit connector is connected via the power management unit to the power meter if the power meter is present
and wherein the energy storage unit is connected via the power management unit to the power meter if the optional energy storage unit and the optonal power meter are present; or
wherein the at least one power generation unit is connected via the power management unit to the junction if the optional power meter is not present and wherein the optional energy storage unit is connected via the power management unit to the junction if the optional energy storage unit is present and the optional power meter is not present.

3. The power control device according to claim 1 or 2, wherein the optional energy storage unit is present and/or wherein the optional power meter is present.

4. The power control device according to claim 3, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit connector, the energy storage unit, the electrical load connector and/or the power grid connection unit such as to try to regulate the electrical current through the electrical conductor to zero, wherein preferably said current is an AC current.

5. The power control device according to claim 4, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit connector, the energy storage unit and the electrical load connector such that the amount of energy drawn by the at least one electrical load is supplied solely by the combination of the at least one power generation unit connector and the energy storage unit.

6. The power control device according to any preceding claim 3-5, characterised in that the power management unit is adapted for regulating the electrical current through the electrical conductor towards zero and if possible to zero by regulation of the magnitude of the energy flow to the energy storage unit wherein said magnitude has a positive sign if energy is stored in the energy storage unit and said magnitude has a negative sign if energy is supplied by the energy storage unit.

7. The power control device according to claim 6, characterised in that the electrical current through the electrical conductor is regulated to zero if the energy flow to the electrical load connector can be supplied solely by the energy storage unit and the power generation unit connector or if the energy flow supplied by the power generation unit connector can be supplied completely to the electrical load connector and the energy storage unit; and preferably in that the electrical conductor is regulated towards zero but does not reach zero

if the energy flow drawn by the electrical load connector can not be supplied solely by the energy storage unit and the power generation unit connector so that a shortage energy flow is drawn from the power grid or the electrical conductor is regulated towards zero but does not reach zero if the energy flow supplied by the power generation unit connector cannot be supplied completely to the electrical load connector and the energy storage unit because the energy storage unit can not store the full surplus of energy flow so that the portion of the surplus of energy flow which can not be stored in the energy storage unit is supplied into the power grid.

8. The power control device according to any preceding claim 3-7, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit connector, the energy storage unit, the electrical load connector and/or the power grid connection unit such that the electrical current through the electrical conductor is regulated to zero, and wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit connector, the energy storage unit, the electrical load connector and/or the power grid connection unit such that a surplus of energy supplied by the at least one power generation unit connector with respect to the amount of energy drawn by the at least one electrical load is stored in the energy storage unit or a shortage of energy supplied by the at least one power generation unit connector with respect to the amount of energy drawn by the at least one electrical load is drawn from the energy storage unit.

9. The power control device according to any preceding claim 3-8, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit connector, the energy storage unit, the electrical load connector and/or the power grid connection unit such that the electrical current through the electrical conductor is regulated as close

as possible to zero, and wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit connector, the energy storage unit, the power grid connection unit and the electrical connector load such that a shortage of energy supplied by the combination of the at least one power generation unit connector and the energy storage unit with respect to the amount of energy drawn by the at least one electrical load is drawn from the power grid connection unit.

10. The power control device according to any preceding claim 3-9, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit connector, the energy storage unit, the electrical load connector and/or the power grid connection unit such that the electrical current through the electrical conductor is regulated as close as possible to zero, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit connector, the energy storage unit, the power grid connection unit and the electrical connector load such that a surplus of energy supplied by the at least one power generation unit connector and which is not drawn by electrical load is supplied as much as possible to the energy storage unit wherein a portion of the surplus of energy which can not be stored into the electrical storage unit is supplied to the power grid.

11. The power control device according to any one of the preceding claims 3-10, wherein the power management unit is adapted for controlling an initial energy flow between the power grid connection unit and the electrical load connector when the current sensor is electromagnetically coupled to the electrical conductor for providing an indication of the current direction and/or value of the electrical current through the electrical conductor wherein preferably said current is an AC current.

12. The power control device according to any one of the preceding claims, wherein the current sensor is a clip on sensor.

13. The power control device according to any one of the preceding claims, wherein the main meter is arranged for measuring the amount of energy drawn from the power grid and measuring the amount of energy fed into the power grid and/or wherein the main meter is arranged for measuring the amount of energy drawn from the power grid minus the amount of energy fed into the power grid or wherein the main meter comprises a first meter and a second meter which are functionally and possibly physically separated from each other wherein the first meter is arranged for measuring the amount of energy drawn from the power grid and the second meter is arranged for measuring the amount of energy fed into the power grid.

14. A power control device according to any preceding claim, characterised in that the power control device further comprises a power generation unit connected to the power generation unit connector.

15. A power control device according to claims 14, characterised in that, the power meter is arranged for measuring energy being supplied by the at least one power generation unit to the junction if the optional energy storage unit is not present or the sum of energy being supplied by the at least one power generation unit and the optional energy storage unit to the junction if the optional energy storage unit is present;

the at least one power generation unit being connected via the power meter to the junction if the optional energy storage unit is not present or the at least one power generation unit and the energy storage unit being connected via the power meter to the junction if the optional energy storage unit is present;

and

the power management unit being connected to the current sensor for receiving the current sensor signal, the power management unit being adapted for controlling the energy flow between the at least one power generation unit, the optional energy storage unit if the optional energy storage unit is present, the electrical load connector and/or the power grid connection unit at least based on the current sensor signal.

16. The power control device according to claim 15, wherein the at least one power generation unit is connected via the power management unit to the power meter and the energy storage unit is connected via the power management unit to the power meter if the optional energy storage unit is present.

17. The power control device according to claim 3 and claim 14 or 15, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit, the electrical load connector and/or the power grid connection unit such as to try to regulate the electrical current through the electrical conductor to zero wherein preferably said current is an AC current.

18. The power control device according to claim 17, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit and the electrical load connector such that the amount of energy drawn by the at least one electrical load is supplied solely by the combination of the at least one power generation unit and the energy storage unit.

19. The power control device according claim 3 and any preceding claim 15-18, characterised in that the power management unit is adapted for regulating the electrical current through the electrical conductor towards zero

and if possible to zero by regulation of the magnitude of the energy flow to the energy storage unit wherein said magnitude has a positive sign if energy is stored in the energy storage unit and said magnitude has a negative sign if energy is supplied by the energy storage unit.

20. The power control device according to claim 19, characterised in that the electrical current through the electrical conductor is regulated to zero if the energy flow to the electrical load connector can be supplied solely by the energy storage unit and the power generation unit or if the energy flow supplied by the power generation unit can be supplied completely to the electrical load connector and the energy storage unit; and preferably in that the electrical conductor is regulated towards zero but does not reach zero if the energy flow drawn by the electrical load connector can not be supplied solely by the energy storage unit and the power generation unit so that a shortage of energy is drawn from the power grid or wherein preferably the electrical conductor is regulated towards zero but does not reach zero if the energy flow supplied by the power generation unit can not be supplied completely to the electrical load connector and the energy storage unit because the energy storage unit can not store the full surplus of energy flow so that the portion of the surplus of energy flow which can not be stored in the energy storage unit is supplied into the power grid.

21. The power control device according to claim 3 and any preceding claim 15-20, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit, the electrical load connector and/or the power grid connection unit such that the electrical current through the electrical conductor is regulated to zero, and wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit, the electrical load connector and/or the power grid

connection unit such that a surplus of energy supplied by the at least one power generation unit with respect to the amount of energy drawn by the at least one electrical load is stored in the energy storage unit or a shortage of energy supplied by the at least one power generation unit with respect to the amount of energy drawn by the at least one electrical load is drawn from the energy storage unit.

22. The power control device according to claim 3 and any preceding claim 15-21, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit, the electrical load connector and/or the power grid connection unit such that the electrical current through the electrical conductor is regulated as close as possible to zero, and wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit, the power grid connection unit and the electrical connector load such that a shortage of energy supplied by the combination of the at least one power generation unit and the energy storage unit with respect to the amount of energy drawn by the at least one electrical load is drawn from the power grid connection unit.

23. The power control device according to claim 3 and any preceding claim 15-22, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit, the electrical load connector and/or the power grid connection unit such that the electrical current through the electrical conductor is regulated as close as possible to zero, wherein the power management unit is adapted for controlling the energy flow between the at least one power generation unit, the energy storage unit, the power grid connection unit and the electrical connector load such that a surplus of energy flow supplied by the at least one power generation unit and which is not drawn by electrical load is

supplied as much as possible to the energy storage unit wherein a portion of the surplus of energy flow which can not be stored into the electrical storage unit is supplied to the power grid.

24. The power control device according to any one of the preceding claims 15-23, wherein the power management unit is adapted for controlling an initial energy flow between the power grid connection unit and the electrical load connector when the current sensor is electromagnetically coupled to the electrical conductor for providing an indication of the current direction and/or value of the electrical current through the electrical conductor wherein preferably said current is an AC current.

25. The power control device according to any preceding claim, wherein the power control device is adapted for determining the amount of power submitted to the power grid via the power grid connection unit and lowering the amount of power supplied, in use, by the at least one power generation unit to the at least one power generation unit connector if the amount of power submitted to the power grid exceeds a predetermined value.

26. The power control device according to claim 25, wherein the predetermined value is a fixed percentage from the maximum amount of power which can be generated by the at least one power generation unit which is, in use, connected to the at least one power generation unit connector.

27. The power control device according to any preceding claim, wherein the power control device is provided with a plurality of power generation unit connectors wherein the power control device is adapted for determining the amount of power submitted to the power grid via the power grid connection units and for lowering the amount of power supplied, in use, by at least one of the power generation units to at least one of the power generation unit

connectors if the amount of power submitted to the power grid exceeds a predetermined value.

28. The power control device according to claim 27, wherein the power control device is adapted for lowering the amount of power supplied by each of a plurality of power generation units which are, in use, connected to a plurality of power generation unit connectors of the plurality of power generation unit connectors if the amount of power submitted to the power grid exceeds the predetermined value.

29. The power control device according to claim 27 or 28, wherein the predetermined value is a fixed percentage from the maximum amount of power which can be generated in combination by the plurality of power generation units which are, in use, connected to the plurality of power generation unit connectors.

30. The power control device according to any preceding claim 25-29, wherein the power control device is adapted so that if the power control device lowers the amount of power submitted to the power grid, this amount of power is lowered to the predetermined value.

31. The power control device according to any preceding claim 25-30, wherein the power control device is provided with a power sensor connected to the power management unit for determining the amount of power submitted to the power grid via the power grind connection unit wherein the power management unit is arranged for said lowering of the power and wherein preferably the power sensor is formed by the current sensor.

32. The power control device according to any preceding claim, wherein

the power control device comprises at least one power grid connected to the power grid connection unit.

33. A method of power controlling an electrical installation of a building, the method using a power control device, comprising:

at least one power generation unit for generating energy from renewable sources;

an optional energy storage unit for storing energy and for supplying stored energy;

an electrical load connector for connection to at least one electrical load of the electrical installation;

a power grid connection unit for connecting the electrical load connector to a power grid, for drawing energy from the power grid and for feeding energy into the power grid;

a main meter for measuring the amount of energy drawn from the power grid and fed into the power grid;

the electrical load connector being connectable to the power grid connection unit through a junction, the power grid connection unit being connected to the junction by an electrical conductor;

an optional power meter for measuring the energy being supplied by the at least one power generation unit if the optional energy storage unit is not present and for measuring the sum of energy supplied by the at least one power generation unit and the optional energy storage unit to the junction if the optional power storage unit is present;

the at least one power generation unit being connected via the power meter to the junction if the power meter is present, and the energy storage unit being connected via the power meter to the junction if the optional energy power storage unit and the optional power meter are present; or

the at least one power generation unit being connected to the junction if the power meter is not present, and the optional energy storage unit

being connected to the junction if the optional energy power storage unit is present and the optional power meter is not present;

a current sensor electromagnetically coupled to the electrical conductor at a sensing position between the main meter and the junction without direct electrical connection to the electrical conductor for creating a current sensor signal;

the method comprises the step of receiving by a power management unit connected to the current sensor the current sensor signal created by the current sensor, and the step of controlling by the power management unit the energy flow between the power generation unit, the optional energy storage unit if the optional energy storage unit is present, the electrical load connector and/or the power grid connection unit at least based on the current sensor signal.

34. The method according to claim 33, wherein the optional energy storage unit is present and/or the optional power meter is present.

35. The method according to claim 34, wherein the method comprises the step of adapting the power management unit such that it controls the energy flow between the at least one power generation unit, the energy storage unit, the electrical load connector and/or the power grid connection unit such as to try to regulate the electrical current through the electrical conductor to zero wherein preferably said current is an AC current, preferably wherein said trying comprises regulating the current toward zero, if possible to zero.

36. The method according to any claim 33-35, wherein the method comprises the step of electromagnetically coupling the current sensor to the electrical conductor, and thereafter the step of providing by means of the power management unit an initial energy flow between the power grid connection unit and the at load connector and of providing an indication of the

current direction and/or value of the electrical current through the electrical conductor during the initial energy flow wherein preferably said current is an AC current..

37. The method according to any claim 33-36, wherein the main meter is arranged for measuring the amount of energy drawn from the power grid and measuring the amount of energy fed into the power grid and/or wherein the main meter is arranged for measuring the amount of energy drawn from the power grid minus the amount of energy fed into the power grid or wherein the main meter comprises a first meter and a second meter which are functionally and possibly physically separated from each other wherein the first meter is arranged for measuring the amount of energy drawn from the power grid and the second meter is arranged for measuring the amount of energy fed into the power grid.

38. The method according to any claim 33-37, wherein the amount of power submitted to the power grid via the power grid connection unit is determined and the amount of power supplied, in use, by the at least one power generation unit to the at least one power generation unit connector is lowered if the amount of power submitted to the power grid exceeds a predetermined value, wherein preferably the amount of power submitted to the power grid via the power grid connection unit is determined by means of the current sensor.

39. The method according to any claim 33-38, wherein the power control device is provided with a plurality of power generation units wherein the amount of power submitted to the power grid via the power grid connection unit is determined and the amount of power supplied, in use, by at least one of the power generation units is lowered if the amount of power submitted to the power grid exceeds a predetermined value.

40. The method according to claim 38 or 39, wherein the amount of power is lowered to the predetermined value if the amount of power submitted to the power grid exceeds the predetermined value.

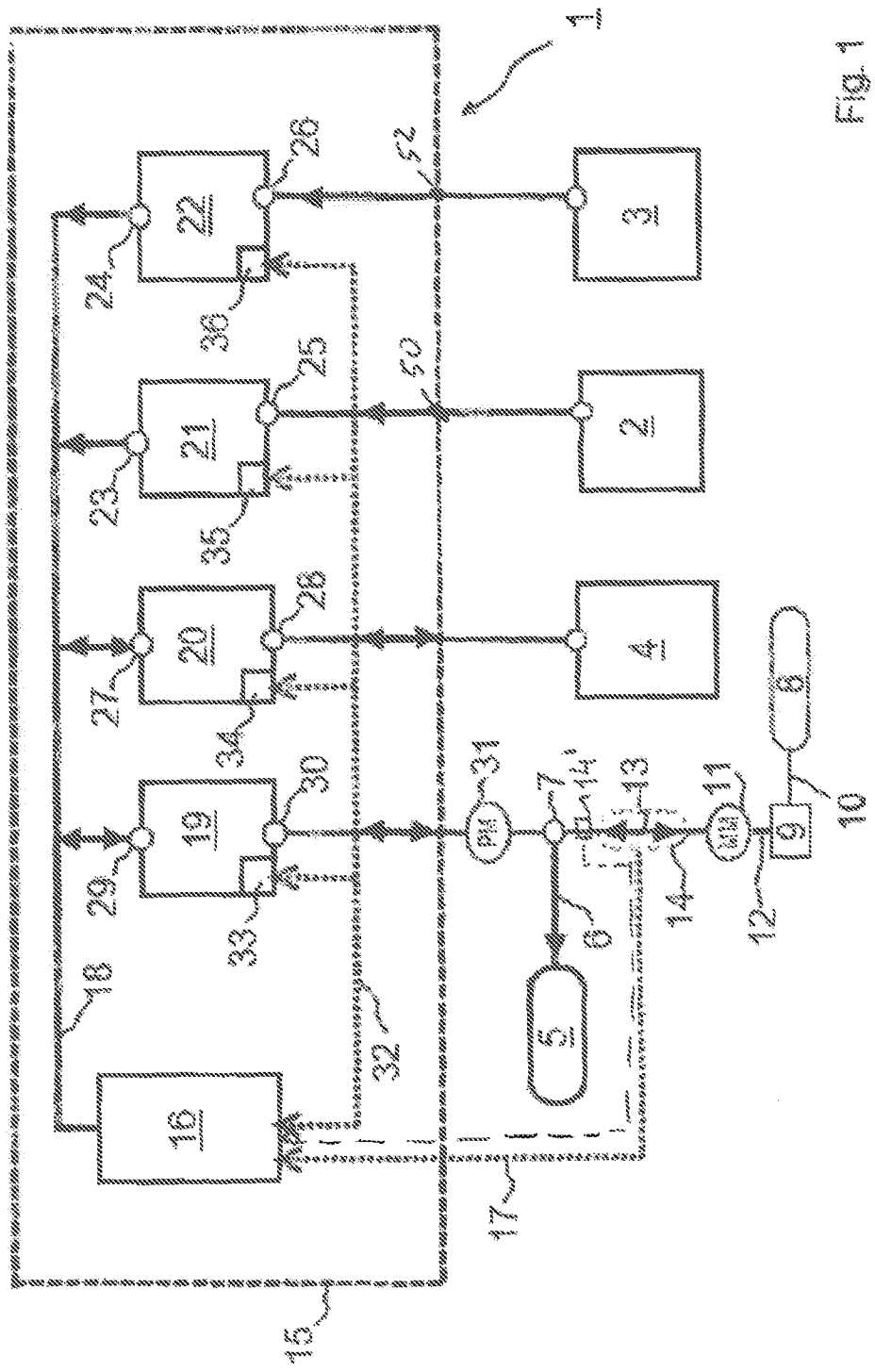
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Fig. 1