

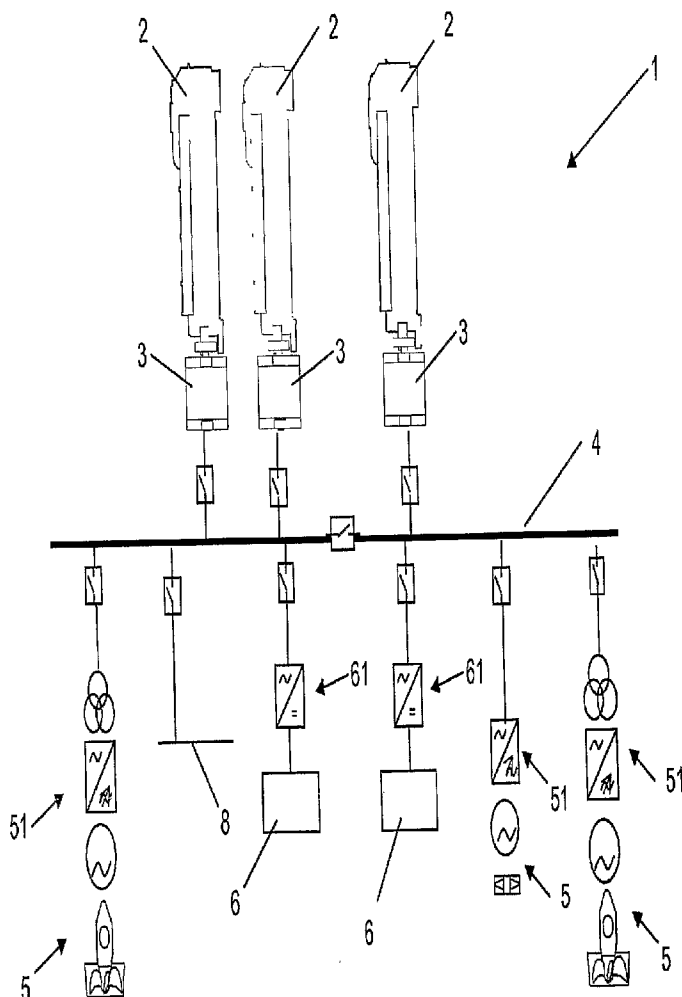


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(19) **United States**(12) **Patent Application Publication**
Levander et al.(10) **Pub. No.: US 2012/0028516 A1**(43) **Pub. Date: Feb. 2, 2012**(54) **ARRANGEMENT AND METHOD FOR
IMPROVING LOAD RESPONSE IN A MARINE
VESSEL****Publication Classification**(51) **Int. Cl.**
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(57) **ABSTRACT**(76) **Inventors:** **Oskar Levander**, Lansiturunmaa
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Noel Dunstan, Ulsteinvik (NO)(21) **Appl. No.:** **12/673,442**(22) **PCT Filed:** **Aug. 20, 2008**(86) **PCT No.:** **PCT/FI08/50468**§ 371 (c)(1),
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The invention relates to an arrangement for improving load response in a marine vessel, which vessel comprises a propulsion system (1) including an internal combustion engine (2), a generator (3), a main switchboard (4), and an electric propulsion unit (5). A power bank (6) is connected to the main switchboard (4), whereby the power bank (6) is arranged to store additional electric energy supplied by the generator (3) by way of the main switchboard (4). The additional energy stored in the power bank (6) is arranged to be used together with the electric energy supplied by the generator (3) in order to increase the load response to the electric propulsion unit (5) at a given time.



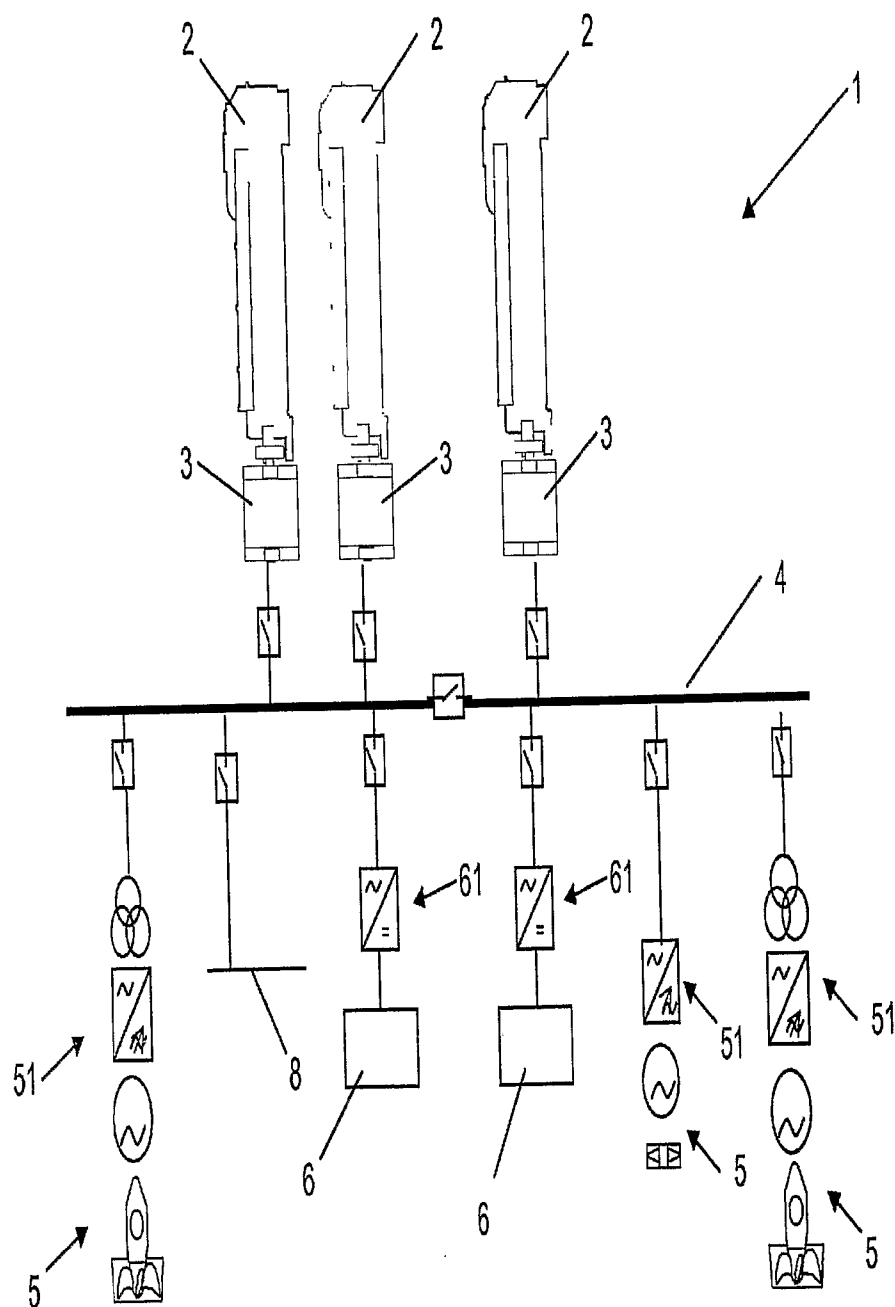


Fig. 1

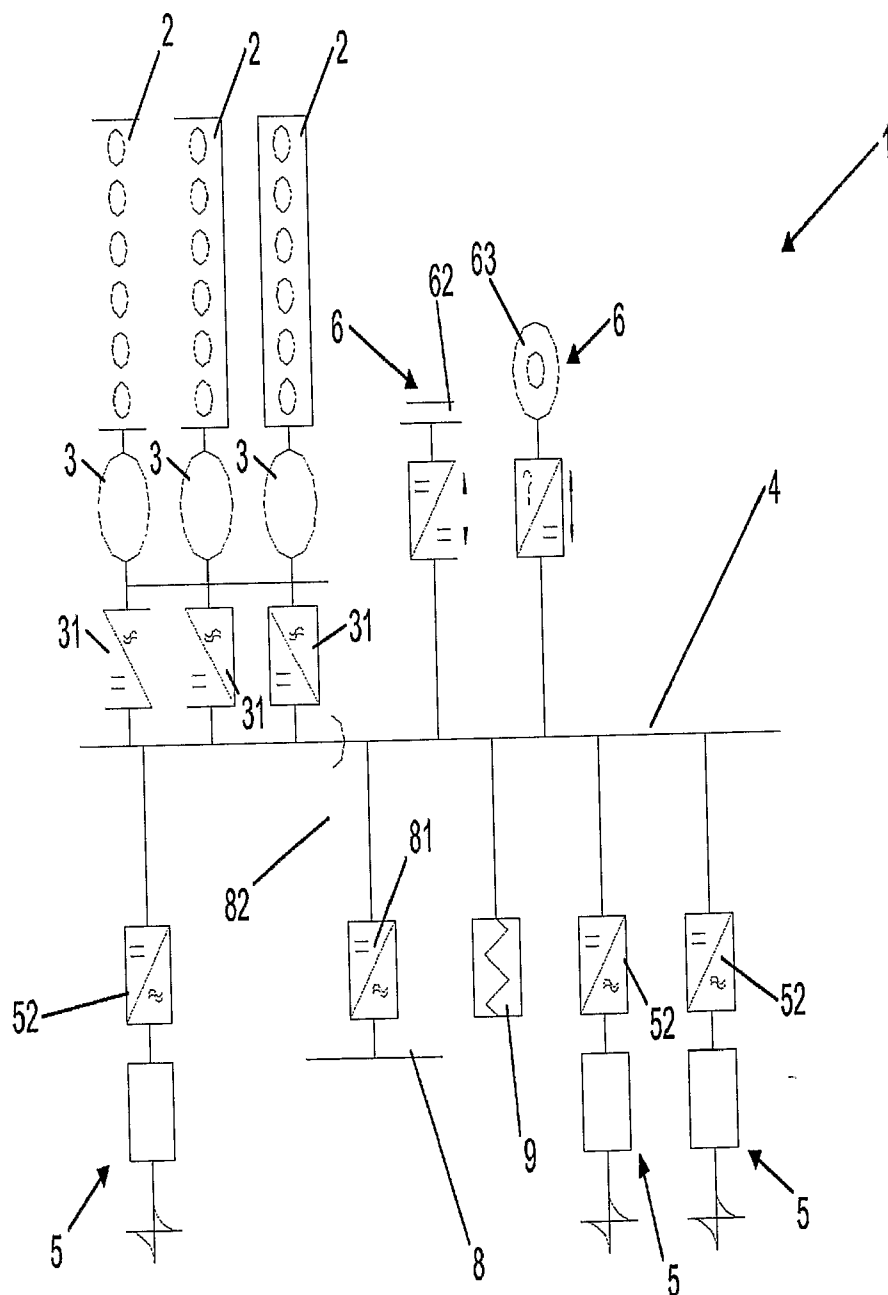


Fig. 2

ARRANGEMENT AND METHOD FOR IMPROVING LOAD RESPONSE IN A MARINE VESSEL

TECHNICAL FIELD

[0001] The invention relates to an arrangement for improving load response in a marine vessel, which vessel comprises a propulsion system including an internal combustion engine, a generator, a main switchboard, and an electric propulsion unit according to the preamble of claim 1. The invention also relates to a method according to the preamble of claim 7.

BACKGROUND ART

[0002] A conventional way to increase load with a diesel engine has been to increase supply of the fuel to the cylinder. Due to the turbocharger lag, the engine will be running at low air to fuel ratio some time, but the load of the engine is increasing. With a dual-fuel engine in "diesel mode", the engine is working with this principle, but in "gas mode" the engine is run according to a so-called otto-cycle. In gas mode (otto-cycle) increasing the amount of fuel in a short period to increase load would lead to pre-ignition (knocking), which is an undesirable situation for the engine.

[0003] As the awareness of the environment is increasing, gas engines are becoming more common for power production also in marine applications due to their lower emission levels.

[0004] In special vessel types, such as tugboats, the load response of the engine is a critical issue.

[0005] An object of the present invention is to provide an arrangement for improving load response in a marine vessel, which arrangement avoids the problems encountered in connection with prior art and which provides a simple and reliable solution. These objects are attained by an arrangement according to claim 1 and a method according to claim 7.

SUMMARY OF THE INVENTION

[0006] The basic idea of the invention is to provide an environmentally sound way to deliver a high load response in marine vessels. This is achieved by having a power bank connected to the main switchboard on the marine vessel. The power bank is arranged to store additional energy provided by the internal combustion engine generator combination by way of the main switchboard. For increasing load response, the additional energy stored in the power bank together with the electric energy delivered by the generator are supplied to the electric propulsion unit of the marine vessel in order to meet high load response demand at given times.

[0007] The electric propulsion units provide the entire propulsive power, whereby the entire power of the motors can be used for instantaneous load change.

[0008] The marine vessel may further comprise other energy consumers, such as hotel load. In this case the additional energy stored in the power bank is advantageously arranged to be used together with the electric energy supplied by the generator also for powering said other energy consumers in order to increase the load response of said other energy consumers at a given time.

[0009] In view of environmental aspects, the internal combustion engine is advantageously arranged to primarily use gas as fuel. Consequently, if the internal combustion engine is a dual-fuel engine, the dual-fuel engine is preferably arranged

to be driven in a gas mode. Dual fuel engines are less responsive than similar diesel fuelled engines.

[0010] Dual-fuel engines driven in diesel mode and diesel engines, however, are also widely used in applications where load response is critical. The present invention may also advantageously be applied to dual-fuel engines driven in diesel mode as well as diesel engines. Diesel driven engines are also going to longer load response times as the mean effective pressure increases (corresponds to engine output and efficiency).

[0011] A further advantage with the present invention is that the power bank may also be used to cover total electric load in port operation. The power bank can be used to assist propulsion in load transients or it can be used as a primary source of energy for other consumers, e.g. hotel load. This means that in an emission sensitive area, like a port, the marine vessel can be operated without running the engines.

[0012] The power bank is advantageously a battery, a capacitor, a flywheel generator or any combination of these.

[0013] The preferable embodiments of the method according to the invention are given in claims 8-12.

BRIEF DESCRIPTION OF DRAWINGS

[0014] In the following the invention will be described, by way of example only, with reference to the accompanying schematic drawings, in which

[0015] FIG. 1 illustrates a first embodiment of an arrangement according to the present invention, and

[0016] FIG. 2 illustrates a second embodiment of an arrangement according to the present invention.

DETAILED DESCRIPTION

[0017] FIG. 1 shows a general layout of a propulsion system 1 of a marine vessel in a first embodiment of an arrangement according to the present invention. The propulsion system includes, in this embodiment, three so-called gensets, i.e. three internal combustion engines 2 with three respective generators 3. The generators 3 are coupled to a main switchboard (AC) 4. The propulsion system 1 also includes three electric propulsion units 5. Two of the electric propulsion units are shown as azimuthing thrusters and one as a tunnel thruster. The number and type of electric propulsion units may of course vary depending on the type of marine vessel. Variable speed drive of the electric propulsion units 5 is normally achieved by using converters (AC-DC-AC) 51 between the electric propulsion units 5 and the main switchboard (AC) 4.

[0018] The arrangement according to the invention further includes two power banks (DC) 6, which are connected to the main switchboard (AC) 4 through respective inverters (DC-AC) 61. The power bank could be a battery, a capacitor, a fly-wheel generator or any combination of these.

[0019] Reference numeral 8 indicates an additional energy consumer, such as hotel load, which also is connected to the main switchboard 4.

[0020] In a marine vessel comprising a propulsion system as described above, the internal combustion engines 2 drive the generators 3 which deliver electric energy to the main switchboard (AC) 4. The electric energy is then supplied to the electric propulsion units 5 by way of the main switchboard 4 and the converters (AC-DC-AC) 51 for driving the same. At the same time, the power banks 6 may be loaded by electric

energy supplied through the main switchboard (AC) **4** and the inverters (DC-AC) **61** for storage.

[0021] When there is a demand for sudden load increase in view of required output power, which is greater than what the generator conventionally can supply, electric energy can be delivered from both the generators **3** and the power banks **6** in order to supply a greater load response to one or more of the electric propulsion units **5**.

[0022] The electric propulsion units provide the entire propulsive power, whereby the entire power of the units can be used for instantaneous load change.

[0023] In an arrangement according to the invention, the power required by the master of the marine vessel is taken from the bridge control instrumentation integrated into an automation system. The automation system assesses the status of the engine load currently being delivered and the current state of the power bank charge. The engine load delivered is in turn assessed by the automation system by sampling the power, i.e. the electric energy being produced at the generator (s). The state of charge of the power bank is assessed by the electronics in the automation system.

[0024] These two points of system information are important to calculate how the power requirement is to be achieved.

[0025] Changing engine loads requires that a protocol is followed. This protocol is integrated into the automation system. Given the state of engine load, the engine is taken through load steps to achieve the required output power by the automation system. Given the time to perform this load step, the automation system determines the optimal procedure for discharging the power bank(s) to enhance the load response. The automation system considers the current state of charge of the power bank(s) to ensure the power bank(s) is discharged to sufficiently cover the difference of required power to current engine power.

[0026] Control of the extent of discharge is also exercised by the automation system to ensure the power bank(s) is not discharged to the detriment of the power bank life.

[0027] If there is a demand for sudden load increase for the other energy consumer **8**, it can be met in the same way both from the generators **3** and the power banks **6** by a combined supply of electric energy as described above.

[0028] The invention is particularly advantageous using internal combustion engines primarily using gas as fuel. In the case of a dual fuel engine, the dual fuel engine is preferably driven in gas mode. Load response in gas operation is inferior in view of diesel operation, but on the other hand gas operation is clearly more environmental friendly than diesel operation. The increased load response capacity provided by the power bank set-up may thus be used to raise the load response level in gas operation to at least an equal level, or even a higher level than the load response level in diesel operation.

[0029] Dual-fuel engines driven in diesel mode and diesel engines, however, are also widely used in applications where load response is critical. The present invention may also advantageously be applied to dual-fuel engines driven in diesel mode as well as diesel engines. Diesel driven engines are also going to longer load response times as the mean effective pressure increases (corresponds to engine output and efficiency).

[0030] FIG. 2 shows a general layout of a propulsion system **1** of a marine vessel in a second embodiment of an arrangement according to the present invention. The propulsion system includes, in this embodiment, three so-called

gensets, i.e. three internal combustion engines **2** with three respective generators **3**. The generators **3** are coupled to a main switchboard (DC) **4** through respective rectifiers (AC-DC) **31**. The propulsion system **1** also includes three electric propulsion units **5**. Two of the electric propulsion units could e.g. be azimuthing thrusters and one e.g. a tunnel thruster. The number and type of electric propulsion units may of course vary depending on the type of marine vessel. The electric propulsion units **5** are connected to the main switchboard (DC) **4** through respective inverters (DC-AC) **52**.

[0031] The arrangement according to the invention further includes two power banks (DC) **6**, which are connected to the main switchboard (DC) **4**. In this embodiment one of the power banks **6** is a battery **62**, i.e. a chemical storage, and the other power bank is a flywheel **63**, i.e. a mechanical storage. Alternatively, the power bank could be a capacitor, on any combination of these.

[0032] Reference numeral **8** indicates an additional energy consumer, such as hotel load, which also is connected to the main switchboard (DC) **4** through an inverter (DC-AC) **81**. Said energy consumer **8** may also be connected to an ACbus between the generators **3** and the respective rectifiers (AC-DC) **31** as shown by connection **82**. Thus, energy could be delivered directly to said energy consumer **8** from the generators **3**.

[0033] Reference numeral **9** indicates a surplus load heat discharge, for dumping reverse power in situations where propulsion load is negative, i.e. when a propeller is turning the electric propulsion unit.

[0034] In a marine vessel comprising a propulsion system as described above, the internal combustion engines **2** drive the generators **3** which deliver electric energy to the main switchboard (DC) **4** through the rectifiers (AC-DC) **31**. The electric energy is then supplied to the electric propulsion units **5** by way of the main switchboard **4** and the inverters (DC-AC) **52** for driving the same. At the same time, the power banks **6** may be loaded by electric energy supplied through the main switchboard (DC) **4** for storage.

[0035] When there is a demand for sudden load increase in view of required output power, which is greater than what the generator conventionally can supply, electric energy can be delivered from both the generators **3** and the power banks **6** in order to supply a greater load response to one or more of the electric propulsion units **5**.

[0036] The electric propulsion units provide the entire propulsive power, whereby the entire power of the motors can be used for instantaneous load change.

[0037] In an arrangement according to the invention, the power required by the master of the marine vessel is taken from the bridge control instrumentation integrated into an automation system. The automation system assesses the status of the engine load currently being delivered and the current state of the power bank charge. The engine load delivered is in turn assessed by the automation system by sampling the power, i.e. the electric energy being produced at the generator (s). The state of charge of the power bank is assessed by the electronics in the automation system.

[0038] These two points of system information are important to calculate how the power requirement is to be achieved.

[0039] Changing engine loads requires that a protocol is followed. This protocol is integrated into the automation system. Given the state of engine load, the engine is taken through load steps to achieve the required output power by the automation system. Given the time to perform this load step,

the automation system determines the optimal procedure for discharging the power bank(s) to enhance the load response. The automation system considers the current state of charge of the power bank(s) to ensure the power bank(s) is discharged to sufficiently cover the difference of required power to current engine power.

[0040] Control of the extent of discharge is also exercised by the automation system to ensure the power bank(s) is not discharged to the detriment of the power bank life.

[0041] If there is a demand for sudden load increase for the other energy consumer 8, it can be met in the same way both from the generators 3 and the power banks 6 by a combined supply of electric energy as described above.

[0042] In this embodiment the main switchboard 4 is a DC switchboard, which makes it easier to connect a DC-type power bank 6. In the power chain from power bank to electric propulsion unit, this further means that a rectifier may be eliminated. Consequently, this provides for a simple system with reduced transmission losses.

[0043] The invention is particularly advantageous using internal combustion engines primarily using gas as fuel. In the case of a dual fuel engine, the dual fuel engine is preferably driven in gas mode. Load response in gas operation is inferior in view of diesel operation, but on the other hand gas operation is clearly more environmental friendly than diesel operation. The increased load response capacity provided by the power bank set-up, may thus be used to raise the load response level in gas operation to at least an equal level, or even a higher level than the load response level in diesel operation.

[0044] Dual-fuel engines driven in diesel mode and diesel engines, however, are also widely used in applications where load response is critical. The present invention may also advantageously be applied to dual-fuel engines driven in diesel mode as well as diesel engines. Diesel driven engines are also going to longer load response times as the mean effective pressure increases (corresponds to engine output and efficiency).

[0045] The two embodiments described above are just examples and clearly show that many variations with varying components are possible in carrying out the present invention.

[0046] The description and drawings are only intended to clarify the basic idea of the invention. The invention may vary within the scope of the ensuing claims.

1-12. (canceled)

13. An arrangement for improving load response in a marine vessel, which marine vessel comprises a propulsion system including an internal combustion engine, a generator driven by the internal combustion engine, a main switch-

board, a power bank connected to the main switchboard, and an electric propulsion unit, in which arrangement the power bank is arranged to store additional electric energy supplied by the generator by way of the main switchboard, wherein the internal combustion engine is arranged to primarily use gas as fuel or that the internal combustion engine is a dual-fuel engine, and in that the additional energy stored in the power bank is arranged to be used together with the electric energy supplied by the generator in order to increase the load response to the electric propulsion unit at a given time.

14. The arrangement according to claim 13, wherein the marine vessel further comprises other energy consumers, such as hotel load, and in that the additional energy stored in the power bank is arranged to be used together with the electric energy supplied by the generator in order to increase the load response to said other energy consumers at a given time.

15. The arrangement according to claim 13, wherein the power bank is a battery, a capacitor, a flywheel generator or any combination of these.

16. A method for improving load response in a marine vessel, which marine vessel comprises a propulsion system including an internal combustion engine, a generator, a main switchboard, a power bank connected to the main switchboard, and an electric propulsion unit, in which method the internal combustion engine drives the generator and the generator supplies electric energy for driving the electric propulsion unit, whereby the generator further supplies additional electric energy to the power bank by way of the main switchboard, wherein the method employs an internal combustion engine primarily using gas as fuel or that the method employs an internal combustion engine in the form of a dual-fuel engine, and in that the additional electric energy stored in the power bank is supplied to the electric propulsion unit together with the electric energy supplied by the generator in order to increase the load response to the electric propulsion unit at a given time.

17. The method according to claim 16, wherein marine vessel further comprises another energy consumer, such as hotel load, and in that the additional energy stored in the power bank is supplied to said other energy consumer together with the electric energy supplied by the generator in order to increase the load response to said other energy consumers at a given time.

18. The method according to claim 16, wherein a battery, a capacitor, a flywheel generator, or any combination of these is employed as the power bank.

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