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(54) **MODULAR REGENERATIVE FUEL CELL SYSTEM**

MODULARES REGENERATIVES BRENNSTOFFZELLENSYSTEM

SYSTEME DE PILE A COMBUSTIBLE REGENERATIF MODULAIRE

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- **PATENT ABSTRACTS OF JAPAN vol. 018, no. 687 (E-1651), 26 December 1994 (1994-12-26) & JP 06 276701 A (KANSAI ELECTRIC POWER CO INC: THE; others: 01), 30 September 1994 (1994-09-30)**
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Description

RELATED APPLICATION

[0001] This application claims priority from U.S. Provisional Patent Application Serial No. 60/667,392, filed March 31, 2005.

FIELD OF THE INVENTION

[0002] The present invention generally relates to a power generation and energy storage system, and more particularly relates to a modular regenerative fuel cell system.

BACKGROUND AND SUMMARY OF THE INVENTION

[0003] Regenerative fuel cell systems in which one or more electrochemical cells are utilized to both electrolyze water to produce hydrogen and oxygen, and to produce electricity by converting hydrogen and oxygen back into water, are known. These systems, which may be used with either renewable or non-renewable, grid connected or off-grid power sources, offer a means for storing energy to be used during periods when primary power from one of these sources is unavailable, and are constructed as either unitary or modular structures, with the modular design allowing for flexibility in, among other things, shipping, installation, power output, run time, recharge time and system modification (*e.g.*, upgrading, increasing capacity).

[0004] The system architecture for the modular regenerative fuel cell systems, which is best shown in FIG. 1, place hydrogen generation, hydrogen storage, and fuel cell power generating functions in separate modules. These modular systems, which are packaged as either floor mounted or rack mounted systems, employ electrolysis cell subsystems 1, fuel cell subsystems 2, as well as hydrogen storage subsystems 3, with each electrolysis and fuel cell subsystem including a cell stack and associated fluid systems and power conditioning. During charge operation, water is introduced to the electrolysis cell subsystem 1, where it is electrolyzed to form hydrogen gas and oxygen according to the reaction $2H_2O \rightarrow 2H_2 + O_2$. The hydrogen gas produced in electrolysis cell subsystem 1 is stored in the hydrogen storage subsystem 3, while the oxygen may be either vented to ambient air or stored. During power generation operation, the hydrogen gas stored in subsystem 3 flows to the fuel cell subsystem 2, where it reacts with oxygen supplied from either the air or storage to generate electricity and to yield product water.

[0005] For applications requiring additional electrolysis or power capability, complete subsystems are added to these prior art modular regenerative fuel cell systems. Such an approach, however, may result in sub-optimal matching of either charge or discharge capability and in redundant equipment. One such approach is described in U.S. Patent Application Publication No. 2003/215680 A1 (now U.S. Patent No. 7,083,875). This reference relates to a modular power system having separately removable electrolysis and power modules, each with a separate set of connection ports. As shown in FIG. 1, the modular power system (MPS) 100 has an electrolyzer module (ELM) 200, a power module (PWM) 300, a water storage module (WSM) 400, a hydrogen storage module (HSM) 500 and a controller module (CTM) 600. The electrolyzer module (ELM) 200 and the power module (PWM) 300, which are in direct fluid communication with the water storage module (WSM) 400 and the hydrogen storage module (HSM) 500, contain major fluid systems. For example, power module (PWM) 300 contains, among other things, at least one hydrogen valve, at least one hydrogen pressure regulator, at least two fans, an air compressor, and a liquid to air heat exchanger.

[0006] By way of the present invention. It has been discovered that partitioning the electrolysis cell and fuel cell subsystems into separate stack and fluid modules allows a user to specifically and effectively tailor the system to the demands of a particular application.

[0007] The present invention therefore generally provides a modular, regenerative fuel cell system that comprises a plurality of reversible or dedicated electrochemical cell stack modules, wherein each such module is devoid of major fluid systems.

[0008] Aspects of the invention are specified in the independent claims.

[0009] Preferred features are specified in the dependent claims.

[0010] Other features and advantages of the invention will be apparent to one of ordinary skill from the following detailed description and drawings. Unless otherwise defined, all technical and scientific terms used herein, have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. In case of conflict, the present specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

BRIEF DESCRIPIION OF THE DRAWINGS

[0011] in the course of the description which follows, reference is made to the drawings, in which:

FIG. 1 is a schematic diagram of a prior art, modular, regenerative fuel cell system;

FIG. 2 is a block schematic diagram of a more preferred embodiment of the modular, regenerative fuel cell system of the present invention; and

FIG. 3 is a block schematic flow diagram of the more preferred embodiment of the modular regenerative fuel cell system shown in FIG. 2.

BEST MODE FOR CARRYING OUT THE INVENTION

[0012] The preferred modular regenerative fuel cell system of the present invention offers a variety of modules, each directed toward a different system function. As such, the inventive system allows a user to specifically and effectively tailor the system to the demands of a particular application. If additional electrolysis capability and/or additional power are needed, only electrolysis cell stack modules and/or fuel cell stack modules are added to the system. The use of unnecessary or duplicative support equipment is avoided rendering the system more cost effective and efficient. Moreover, the inventive system offers a number of packaging options including a wall mounting packaging option in addition to floor and rack mounting options.

[0013] Referring now to FIG. 2, a more preferred embodiment of the modular regenerative fuel cell system of the present invention is shown generally at 10. System 10, which is rack-mounted, basically comprises:

(a) electrolysis cell stack modules 12, each in fluid communication with an electrolysis cell fluid module 16, and in electrical communication with power means 24 and control means 26, each being adapted to convert water, water vapor, or an aqueous solution into at least a hydrogen gas;
(b) a hydrogen gas storage tank 14;
(c) an electrolysis cell fluid module 16 in fluid communication with (i) a source of water, water vapor, or aqueous solution (not shown), (ii) the electrolysis cell stack modules 12, and (iii) the hydrogen gas storage tank 14, and in electrical communication with the power means 24 and control means 26, for providing water, water vapor, or an aqueous solution to the electrolysis cell stack modules 12 and for delivering hydrogen gas generated by the electrolysis cell stack modules 12 to the hydrogen gas storage tank 14;
(d) fuel cell stack modules 18, each in fluid communication with a fuel cell fluid module 20, and in electrical communication with power means 24, control means 26, and an external load or power grid (not shown), each being adapted to extract chemical energy from hydrogen gas and air or oxygen and convert the extracted chemical energy into electrical power;
(e) a fuel cell fluid module 20 in fluid communication with (i) the hydrogen gas storage tank 14, (ii) a source of air or oxygen (not shown), and (iii) the fuel cell stack modules 18, and in electrical communication with power means 24 and control means 26, for providing hydrogen gas and air or oxygen to the fuel cell stack modules 18;
(f) one or more batteries 22;
(g) power means 24 for (i) receiving power from an energy source (*e.g.*, a generator system, photovoltaics, wind turbine or any other conventional or newly developed source) (not shown), (ii) optionally charging the one or more batteries 22, (iii) providing power to the electrolysis cell fluid module 16, the electrolysis cell stack modules 12, and the fuel cell fluid module 20, and (iv) converting variable power from the fuel cell stack modules 18 to constant or relatively constant voltages and/or for inverting direct currents to alternating currents;
(h) monitoring means (not shown) for monitoring information regarding all aspects of the modular regenerative fuel cell system 10 and for communicating such information to the control means 26; and
(i) control means 26 for receiving information from the monitoring means and for controlling all aspects of the modular regenerative fuel cell system 10, thereby assuring continuous, uninterrupted system operation.

[0014] System 10 contains a number of individual electrochemical cells arranged in stacks, with the working fluids directed through the cells via input and output conduits formed within each stack structure. As noted above, these cell stacks are preferably dedicated cell stacks that are used within system 10 to either electrolyze water (or an aqueous solution) to produce hydrogen and oxygen (electrolysis cell stack modules 12), or to produce electricity by converting hydrogen and oxygen back into water (fuel cell stack modules 18), as needed. These cell stacks, however, may also be reversible cell stacks that serve to both electrolyze water (or an aqueous solution) and produce electricity.

[0015] The one or more electrolysis cell stack modules 12 are in fluid communication with one or more electrolysis cell fluid modules 16, and in electrical communication with power means 24 and control means 26, while the one or more fuel cell stack modules 18 are in fluid communication with one or more fuel cell fluid modules 20, and in electrical communication with power means 24, an external load or power grind, and control means 26.

[0016] As is well known to those skilled in the art, electrolysis cells and fuel cells are basically energy conversion devices and include liquid electrolyte cells and solid, liquid, or membrane electrolyte cells. Electrolysis and fuel cells are structurally similar, but are utilized to effect different half-cell reactions.

[0017] In a preferred embodiment, the cell stack modules employed within system 10 contain membrane electrolysis cells and membrane fuel cells that generally comprise an anode, a cathode, an ion exchange membrane disposed there between, for providing ion exchange between the cathode and the anode electrodes, an anode chamber and a cathode chamber. In order to assure that half-cell reactions that take place at the anode and cathode move forward at useful rates, catalyst materials may be incorporated into these cells.

[0018] As alluded to above, preferred membrane electrochemical cells of system 10 are selected from the

group of PEM cells and solid oxide cells.

[0019] The electrolysis cell stack module(s) 12 preferably has the ability to self pressurize. In specific regard to PEM and solid oxide cell stack modules, hydrogen pressurization may be achieved by, for example, electrochemical pumping of hydrogen ions across the membranes to the cathodes where hydrogen gas evolves until a pre-set pressure limit is reached, while oxygen pressurization may be achieved by back pressuring the oxygen gas evolving at the anodes. As will be readily appreciated by those skilled in the art, such pressurization processes may be used in both dedicated and reversible cells and cell stacks.

[0020] The electrolysis cell stack module(s) 12 of the present invention may produce hydrogen gas at rates ranging from less than about 0.1 standard cubic feet per hour (SCFH) (0.05 standard liters per minute (SLPM)) to more than about 30,000 SCFH (14,160 SLPM).

[0021] Power generated by the fuel cell stack module (s) 18 of the present invention may range from less than several watts to over 1000 kilowatts.

[0022] The electrolysis cell fluid module(s) 16 of system 10 is in fluid communication with (i) a source of water, water vapor, or aqueous solution, (ii) the electrolysis cell stack module(s) 12; and (iii) hydrogen gas storage means (*e.g.*, the hydrogen gas storage tank 14, and is in electrical communication with power means 24 and control means 26. Fluid module(s) 16 provides liquid or vapor phase water (or aqueous solution) to the electrolysis cell stack module(s) 12, receives product gases and waste heat from the electrolysis cell stack module(s) 12 that are generated during electrolysis, separates the hydrogen gas from the oxygen gas and waste heat, and then directs the separated hydrogen gas to the hydrogen gas storage means (*e.g.*, the hydrogen gas storage tank 14). Each such fluid module 16 basically comprises one or more pumps, valves, regulators, water/gas phase separation devices, and temperature, pressure and hydrogen sensors.

[0023] The fuel cell fluid module(s) 20 of system 10 is in fluid communication with (i) the hydrogen gas storage means (*e.g.*, the hydrogen gas storage tank 14), (ii) a source of air or oxygen, and (iii) fuel cell stack module(s) 18, and is in electrical communication with power means 24, and control means 26. Fluid module(s) 20 provides humidified hydrogen gas and air or oxygen to the fuel cell stack module(s) 18, and receives product water from the fuel cell stack module(s) 18. Each such fluid module 18 basically comprises hydrogen and air/oxygen fluid manifolds, a thermal control device, water management means, valves, regulators and safety and control sensors.

[0024] Fluid and electrical connections within system 10 are not limited and may be effected using conventional materials and connection means.

[0025] Power means 24, which includes power regulating and/or power inverting means, receives DC or AC voltage from an energy source such as a generator system, photovoltaics, wind turbine or any other conventional or newly developed source and optionally converts a portion of the power to voltage for charging one or more batteries 22. Power means 24 may be used alone or in combination with the battery(ies) 22 to power the one or more electrolysis cell stack modules 12, the one or more electrolysis cell fluid modules 16, and the one or more fuel cell fluid modules 20. Alternatively, the electrolysis cell stack modules 12 may be connected directly to the battery(ies) 22. Power means 24 also receives DC voltage generated by the one or more fuel cell stack modules 18, which may also be used to charge the one or more batteries 22.

[0026] The fuel cell stack module(s) 18 will typically produce direct current at a voltage which varies according to the number of cells in the stack and the operating conditions of the cells. Applications for the power generated by these fuel cell stacks may demand constant voltage, or alternating current at a constant voltage and frequency similar to a municipal power grid, etc. Power means 24 accommodates such demands.

[0027] Technologies for converting variable direct current voltages to constant or relatively constant voltages are well known, as are technologies for inverting direct currents to alternating currents. As demonstrated by U.S. Patent No. 6,581,015, suitable power conditioner topologies for fuel cells are also well known,

[0028] In a preferred embodiment, power means 24 comprises either a charge controller with optional maximum power point tracker (MPPT) and/or inverting capability, or an inverter with optional charging capability. In one such preferred embodiment, power means 24 is a DC to AC inverter/charger. Suitable inverter/chargers, which combine an inverter, battery charger and transfer switch in one package, are available from (1) Xantrex International SRL and Xantrex Technology BVI, Inc., Suite No. 3, Stafford House, The Garrison, St. Michael, Barbados, under the trade designation XANTREX SW Plus inverter/charger, and from (2) Outback Power Systems, Inc., 19009 62nd Avenue, Arlington, WA 98223, USA.

[0029] Control means 26 basically comprises at least system controller, which is programmed to oversee status, transactions, and processes of system 10. Specifically with respect to controlling the production of hydrogen gas by the one or more electrolysis cell stack modules 12, the system controller(s) enables, monitors, adjusts, and disables all aspects of the connections between: (i) power means 24 (e.g., a charge controller, or inverter), the electrolysis cell stack module(s) 12, and the electrolysis cell fluid module(s) 16; and (ii) the electrolysis cell fluid module(s) 16, the source of water, water vapor, or aqueous solution, the electrolysis cell stack module(s) 12, and the hydrogen gas storage means 14. Similarly, with respect to controlling the production of electrical power, the system controller(s) enables, monitors, adjusts, and disables all aspects of the connections between: (i) power means 24, the fuel cell fluid module(s)

20, and the fuel cell stack module(s) 18; and (ii) the fuel cell fluid module(s) 20, the hydrogen gas storage means 14, the source of air or oxygen, and the fuel cell stack module(s) 18. The system controller(s) will detect normal variations in module, stack, or subsystem performance and will automatically provide direct or indirect compensation for any such variation, thereby balancing old and new modules, as well as, modules having different technology, manufacturers, level/status, or the like.

[0030] The system controller also manages the modular replacement of components within the regenerative fuel cell system 10, and can be reconfigured for modular replacement of components and connection and disconnection of external service ports. The system controller can also control the operating mode of system 10 and place system 10 in a maintenance mode where the modular replacement is plug-and-play, to allow continuous operation.

[0031] The system controller may be a single controller that controls all the operations of system 10. Alternatively, multiple controllers may be provided to control different aspects of system 10 operation.

[0032] Monitoring means, which basically comprises monitoring instrumentation and a communication system, monitors information regarding aspects of the modular regenerative fuel cell system 10 and transmits the information to the control means 26 (*e.g.*, the system controller(s)), which enables/disables or adjusts all aspects of the connections within system 10 in response thereto, thereby assuring continuous, uninterrupted operation.

[0033] Monitoring instrumentation is mounted on the functional modules of system 10 and elsewhere and provides information to the system controller(s) regarding particular attributes of the cell stacks and fluid modules and storage means including but not limited to the functional status, output, and/or fuel levels. This information may be routed via the communication system to an Internet site or other specific destination. The communication system is not limited and may be comprised of any number of analog or digital devices such as a personal computer, a local area network (LAN), or a relay station for wireless communication. The electrical output of the fuel cell stack module(s) 18 may be used to power such a system from a remote location, circumventing the need for an additional power supply to maintain the transmission of information on the status of system 10.

[0034] In a preferred embodiment, the communication system is a high-speed LAN, with each component of system 10 interfacing itself with the LAN through a wired or wireless LAN interface.

[0035] In another preferred embodiment, the communication system employs Radio Frequency Identification (RFID) tags that uniquely identify the components of system 10 and communicate with the system controller.

[0036] In operation, and as best shown in FIG. 3, power means 24, in the form of an inverter/charger 28, receives power from energy source 30. Upon receiving a signal from the control means 26, inverter/charger 28 will switch to charger operation to replenish battery 22. Although not shown, system 10 may also be operated without inverter/charger 28, powered only by the voltage level of battery 22.

[0037] When hydrogen levels in storage tanks 14 drop below a pre-set value, system controller 32 will direct voltage from inverter/charger 28 and/or battery 22, to electrolysis cell fluid module 16 and electrolysis cell stack modules 12, while at the same time directing water (or aqueous solution) from fluid module 16 to stack modules 12. If liquid feed water is used, system controller 32 will direct the gases and waste heat generated by the stack modules 12 along with liquid water to the fluid module 16, where the hydrogen gas will be separated out and directed to the hydrogen storage tanks 14 until a pre-set pressure limit or other control limit is reached. Waste heat may be recovered and used to provide local heating or thermal loads. If vapor phase feed water is used, system controller 32 will direct the hydrogen gas generated by the stack modules 12 directly to the hydrogen storage tanks 14 until the pre-set limit is reached.

[0038] When electrical power is needed, system controller 32 will direct the hydrogen gas to the fuel cell fluid module 20 for distribution to the fuel cell stack modules 18. The system controller 32 will also simultaneously direct air or oxygen to the fuel cell stack modules 18.

[0039] The power generated by the fuel cell stack modules 18 is directed by the system controller 32 to the inverter/charger 28. The inverter/charger 28 may convert variable DC voltages from the fuel cell stack modules 18 to constant or relatively constant voltages and/or invert direct currents to alternating currents, before supplying same to an external load or power grid.

[0040] Waste heat generated as a result of fuel cell power production may be vented to the atmosphere, or used to provide local heating or thermal loads.

[0041] As noted above, system 10 offers flexibility in terms of system configuration or arrangement. More specifically, the components employed in system 10 can be combined in various configurations to meet the particular needs of an installation and may be, for example, rack-mounted, wall-mounted, or floor mounted.

[0042] In a preferred embodiment, the components or modules employed in system 10 are wall-mounted. As will be readily appreciated by one skilled in the art, configuring system 10 as a set of wall-mounted modules connected by standard cables and connectors provides a number of advantages including, but not limited to, the ability to ship the system by way of conventional carriers, providing for easy setup and installation of the modules by one person and in the same manner as other solar/wind components, as well as the ability to readily access each module for repair or maintenance.

[0043] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of

the present invention should not be limited by any of the exemplary embodiments.

[0044] Having thus described the invention, what is claimed is:

Claims

1. A modular, regenerative fuel cell system that comprises:

(a) one or more reversible fuel cell stack modules, each in fluid communication with at least one fluid module, and in electrical communication with a power source, an external load or power grid, and control means, and each being adapted to convert water, water vapor, or an aqueous solution into at least a hydrogen gas, and to extract chemical energy from hydrogen gas and air or oxygen and convert that extracted chemical energy into electrical power;
(b) one or more fluid modules in fluid communication with (i) a source of water, water vapor, or aqueous solution, (ii) means for storing hydrogen gas, (iii) a source of air or oxygen, and (iv) the one or more reversible fuel cell stack modules, and in electrical communication with a power source and control means, for providing water, water vapor, or aqueous solution, hydrogen gas, and air or oxygen to the one or more reversible fuel call stack modules, and for delivering hydrogen gas generated by the one or more reversible fuel cell stack modules to the means for storing hydrogen gas;
(c) a power source;
(d) control means; and
(e) means for storing hydrogen gas.

2. A modular, regenerative fuel cell system that comprises:

(a) one or more electrolysis cell fluid modules in fluid communication with (i) a source of water, water vapor, or aqueous solution, (ii) one or more electrolysis cell stack modules, and (iii) means for storing hydrogen gas, and in electrical communication with a power source and control means, for providing water, water vapor, or an aqueous solution to the one or more electrolysis cell stack modules and for delivering hydrogen gas generated by the one or more electrolysis cell stack modules to the means for storing hydrogen gas;
(b) one or more electrolysis cell stack modules, each in fluid communication with at least one electrolysis cell fluid module, and in electrical communication with the power source and the control means, each being adapted to convert water, water vapor, or an aqueous solution into at least a hydrogen gas;
(c) one or more fuel cell fluid modules in fluid communication with (i) the means for storing hydrogen gas, (ii) a source of air or oxygen, and (iii) the one or more fuel cell stack modules, and in electrical communication with the power source and the control means, for providing hydrogen gas and air or oxygen to the one or more fuel cell stack modules;
(d) one or more fuel cell stack modules, each in fluid communication with at least one fuel cell fluid module, and in electrical communication with the power source, an external load or power grid, and the control means, and each being adapted to extract chemical energy from the hydrogen gas and air or oxygen and converting the extracted chemical energy into electrical power;
(e) a power source;
(f) control means; and
(g) means for storing hydrogen gas.

3. The modular, regenerative fuel cell system of claim 2, wherein the power source comprises one or more batteries.

4. The modular, regenerative fuel cell system of claim 2, wherein the power source comprises means for (i) receiving power from an energy source, (ii) providing power to the one or more electrolysis cell fluid modules, the one or more electrolysis cell stack modules, and the one or more fuel cell fluid modules, and (iii) converting variable power from the one or more fuel cell stack modules to constant or relatively constant voltages and/or inverting direct currents to alternating currents.

5. The modular, regenerative fuel cell system of claim 2, wherein the power source comprises: one or more batteries; and means for (i) receiving power from an energy source, (ii) optionally, charging the one or more batteries, (iii) providing power to the one or more electrolysis cell fluid modules, the one or more electrolysis cell stack modules, and the one or more fuel cell fluid modules, and (iv) converting variable power from the one or more fuel cell stack modules to constant or relatively constant voltages and/or inverting direct currents to alternating currents.

6. The modular, regenerative fuel cell system of claim 2, which further comprises: monitoring means for monitoring information regarding all aspects of the modular regenerative fuel cell system and for communicating the information to the control means.

7. The modular, regenerative fuel cell system of claim 2, wherein the system is selected from the group of

modular, regenerative Proton Exchange membrane fuel cell systems, modular, regenerative Solid Oxide fuel cell systems, modular regenerative Alkaline fuel cell systems, modular regenerative Phosphoric Acid fuel cell systems, modular hydrogen-halogen fuel cell systems, and combinations thereof.

8. The modular, regenerative fuel cell system of claim 1, that comprises;

(a) a hydrogen gas storage tank;
(b) reversible fuel cell stack modules, each in fluid communication with a fluid module, and in electrical communication with power means, an external load or power grid, and control means, each being adapted to convert water, water vapor, or an aqueous solution into at least a hydrogen gas, and to extract chemical energy from hydrogen gas and air or oxygen and convert the extracted chemical energy into electrical power;
(c) a fluid module in fluid communication with (i) a source of water, water vapor, or aqueous solution, (ii) means for storing hydrogen gas, (iii) a source of air or oxygen, and (iv) the reversible fuel cell stack modules, and in electrical communication with the power means and the control means, for providing water, water vapor, or aqueous solution, hydrogen gas, and air or oxygen to the reversible fuel cell stack modules;
(d) one or more batteries;
(e) power means for (i) receiving power from an energy source, (ii) optionally, charging the one or more batteries, (iii) providing power to the fluid module, and (iv) converting variable power from the reversible fuel cell stack modules to constant or relatively constant voltages and/or for inverting direct currents to alternating currents;
(f) monitoring means for monitoring information regarding all aspects of the modular regenerative fuel cell system and for communicating the information to the control means; and
(g) control means for receiving information from the monitoring means and for controlling all aspects of the modular regenerative fuel cell system, thereby assuring continuous, uninterrupted system operation.

9. The modular, regenerative fuel cell system of claim 2, that comprises:

(a) electrolysis cell stack modules, each in fluid communication with an electrolysis cell fluid module, and in electrical communication with power means and control means, each being adapted to convert water or an aqueous solution into at least a hydrogen gas;
(b) a hydrogen gas storage tank
(c) an electrolysis cell fluid module in fluid communication with (i) a source of water, water vapor, or aqueous solution, (ii) the electrolysis cell stack modules, and (iii) the hydrogen gas storage tank, and in electrical communication with the power means and the control means, for providing water, water vapor, or an aqueous solution to the electrolysis cell stack modules and for delivering hydrogen gas generated by the electrolysis cell stack modules to the hydrogen gas storage tank;
(d) fuel cell stack modules, each in fluid communication with a fuel cell fluid module, and in electrical communication with the power means, an external load or power grid, and the control means, each being adapted to extract chemical energy from hydrogen gas and air or oxygen and converting the extracted chemical energy into electrical power;
(e) a fuel cell fluid module in fluid communication with (i) the hydrogen gas storage tank, (ii) a source of air or oxygen, and (iii) the fuel cell stack modules, and in electrical communication with power means and the control means, for providing hydrogen gas and air or oxygen to the fuel cell stack modules;
(f) one or more batteries;
(g) power means for (i) receiving power from an energy source, (ii) optionally, charging the one or more batteries, (iii) providing power to the electrolysis cell fluid module, the electrolysis cell stack modules, and the fuel cell fluid module, and (iv) converting variable power from the fuel call stack modules to constant or relatively constant voltages and/or for inverting direct currents to alternating currents;
(h) monitoring means for monitoring information regarding all aspects of the modular regenerative fuel cell system and for communicating the information to the control means; and
(i) control means for receiving information from the monitoring means and for controlling all aspects of the modular regenerative fuel cell system, thereby assuring continuous, uninterrupted system operation.

10. The modular, regenerative fuel cell system of claim 9, wherein the cell stack modules contain membrane electrolysis cells and membrane fuel cells that each comprise an anode, a cathode, an ion exchange membrane disposed between the anode and the cathode, an anode chamber and a cathode chamber.

11. The modular, regenerative fuel cell system of claim 9, wherein the electrotype cell stack modules are self-pressurizing electrolysis cell stack modules.

12. The modular, regenerative fuel cell system of claim 9, wherein the power means comprises a charge

controller with optional maximum power point tracker and/or inverting capability.

13. The modular, regenerative fuel cell system of claim 9, wherein the power means comprises an inverter with optional charging capability.

14. The modular, regenerative fuel cell system of claim 13, wherein the power means comprises a direct current to alternating current inverter/charger.

15. The modular, regenerative fuel cell system of claim 9, wherein the monitoring means comprises monitoring instrumentation, and a communication system.

16. The modular, regenerative fuel cell system of claim 15, wherein the communication system is a high-speed local area network or LAN, and wherein the modular, regenerative fuel cell system interfaces with the LAN network through a wired or wireless LAN interface.

17. The modular, regenerative fuel cell system of claim 15, wherein the communication system comprises Radio Frequency identification tags.

18. The modular, regenerative fuel cell system of claim 9, wherein the modules are wall-mounted modules.

Patentansprüche

1. Ein modulares regeneratives Brennstoffzellensystem, das umfasst:

(a) ein oder mehrere reversible Brennstoffzellen-Stackmodule, wobei jedes in flüssiger Kommunikation mit mindestens einem Fluidmodul und in elektrischer Kommunikation mit einer Stromquelle ist, ein externes Ladungs- oder Stromnetz, und Steuermittel, wobei jedes angepasst ist, um Wasser, Wasserdampf oder eine wässrige Lösung in mindestens ein Wasserstoffgas umzuwandeln, und um chemische Energie aus Wasserstoffgas und Luft oder Sauerstoff zu gewinnen und die gewonnene chemische Energie in elektrische Kraft umzuwandeln;
(b) ein oder mehrere Fluidmodule in flüssiger Kommunikation mit (i) einer Quelle aus Wasser, Wasserdampf oder wässriger Lösung, (ii) Mittel zur Speicherung von Wasserstoffgas, (iii) einer Luft- oder Sauerstoffquelle und (iv) mit den ein oder mehreren reversiblen Brennstoffzellen-Stackmodulen, und in elektrischer Kommunikation mit einer Stromquelle und Steuermittel zur Bereitstellung von Wasser, Wasserdampf oder wässriger Lösung, Wasserstoffgas und Luft oder Sauerstoff für die ein oder mehreren reversiblen Brennstoffzellen-Stackmodule, und zur Bereitstellung von Wasserstoffgas, das durch die ein oder mehreren reversiblen Brennstoffzellen-Stackmodule hergestellt wurde, zu den Mitteln zur Speicherung des Wasserstoffgases;
(c) eine Stromquelle;
(d) Kontrollmittel; und
(e) Mittel zur Speicherung von Wasserstoffgas.

2. Ein modulares regeneratives Brennstoffzellensystem, das umfasst:

(a) ein oder mehrere Elektrolysezellen-Fluidmodule in flüssiger Kommunikation mit (i) einer Quelle von Wasser, Wasserdampf oder wässriger Lösung, (ii) ein oder mehrere Elektrolysezellen-Stackmodule, und (iii) Mittel zur Speicherung von Wasserstoffgas, und in elektrischer Kommunikation mit einer Stromquelle und Steuermittel zur Bereitstellung von Wasser, Wasserdampf oder einer wässrigen Lösung für die ein oder mehreren Elektrolysezellen-Stackmodule und zur Lieferung von Wasserstoffgas generiert durch die ein oder mehreren Elektrolysezellen-Stackmodule zu den Mitteln zur Speicherung von Wasserstoffgas;
(b) ein oder mehrere Elektrolysezellen-Stackmodule, wobei jedes in flüssiger Kommunikation mit zumindest einem Elektrolysezellen-Fluidmodul und in elektrischer Kommunikation mit der Stromquelle und dem Steuermittel ist, wobei jedes angepasst ist, um Wasser, Wasserdampf oder eine wässrige Lösung in zumindest ein Wasserstoffgas umzuwandeln;
(c) ein oder mehrere Brennstoffzellen-Fluidmodule in flüssiger Kommunikation mit (i) den Mitteln zur Speicherung von Wasserstoffgas, (ii) einer Luft- oder Sauerstoffquelle, und (iii) den ein oder mehreren Brennstoffzellen-Stackmodulen, und in elektrischer Kommunikation mit der Stromquelle und dem Steuermittel zur Bereitstellung von Wasserstoffgas und Luft oder Sauerstoff für die ein oder mehreren Brennstoffzellen-Stackmodule;
(d) ein oder mehrere Brennstoffzellen-Stackmodule, wobei jedes in flüssiger Kommunikation mit mindestens einem Brennstoffzellen-Fluidmodul und in elektrischer Kommunikation mit der Stromquelle, einem externen Ladungs- oder Stromnetz und dem Steuermittel ist, und wobei jedes angepasst ist, um chemische Energie aus dem Wasserstoffgas und der Luft oder Sauerstoff zu gewinnen und die gewonnene chemische Energie in elektrischen Strom umzuwandeln:
(e) eine Stromquelle;
(f) Steuermittel, und

(g) Mittel zur Speicherung von Wasserstoffgas.

3. Modulares regeneratives Brennstoffzellensystem nach Anspruch 2, wobei die Stromquelle ein oder mehrere Batterien umfasst.

4. Modulares regeneratives Brennstoffzellensystem nach Anspruch 2, wobei die Stromquelle Mittel umfasst zum (i) Empfangen von Strom aus einer Energiequelle, (ii) Bereitstellen von Strom für das eine oder die mehreren Elektrolysezellen-Fluidmodule, die ein oder mehreren Elektrolysezellen-Stackmodule und die einen oder mehreren Brennstoffzellen-Fluidmodule, und (iii) Umwandeln von variablen Strom von dem einen oder mehreren Brennstoffzellen-Stackmodulen in konstante oder relativ konstante Spannung und / oder Invertieren von Gleichströmen in Wechselströme.

5. Modulares, regeneratives Brennstoffzellensysten nach Anspruch 2, wobei die Stromquelle umfasst: ein oder mehrere Batterien; und Mittel zum (i) Empfangen von Strom aus einer Energiequelle, (ii) optionales Aufladen der ein oder mehreren Batterien, (iii) Bereitstellen von Strom für die ein oder mehreren Elektrolysezellen-Fluidmodule, die ein oder mehreren Elektrolysezellen-Stackmodule und die ein oder mehreren Brennstoffzellen-Fluidmodule, und (iv) Umwandeln von variablen Strom von dem einen oder mehreren Brennstoffzellen-Stackmodulen in konstante oder relativ konstante Spannung und / oder Invertieren von Gleichströmen in Wechselströme.

6. Modulares regeneratives Brennstoffzellensystem nach Anspruch 2, welches des Weiteren umfasst: Überwachungsmittel zum Überwachen von Informationen betreffend alle Aspekte des modularen regenerativen Brennstoffzellensystems und zum Kommunizieren der Information an das Steuermittel.

7. Modulares regeneratives Brennstoffzellensystem nach Anspruch 2, wobei das System ausgewählt ist aus der Gruppe von modularen, regenerativen Protonenaustauschmembran-Brennstoffzellensystemen, modularen, regenerativen Festoxiden-Brennstoffzellensystemen, modularen regenerativen alkalischen Brennstoffzellensystemen, modularen regenerativen Phosphorsäure-Brennstoffzellensystemen, modularen Wasserstoff-Halogen-Brennstoffzellensystemen und Kombinationen davon.

8. Modulares regeneratives Brennstoffzellensystem nach Anspruch 1, das umfasst:

(a) einen Speichertank für Wasserstoffgas;
(b) reversible Brennstoffzellen-Stackmodule, wobei jedes in flüssiger Kommunikation mit einem Fluidmodul und in elektrischer Kommunikation mit Strommitteln ist, ein externes Ladungs- oder Stromnetz, und Steuermittel, wobei jedes angepasst ist, um Wasser, Wasserdampf oder eine wässrige Lösung in zumindest ein Wasserstoffgas umzuwandeln, und chemische Energie aus Wasserstoffgas und Luft oder Sauerstoff zu gewinnen und die gewonnene chemische Energie in elektrischen Strom umzuwandeln;
(c) ein Fluidmodul in flüssiger Kommunikation mit (i) einer Quelle von Wasser, Wasserdampf oder wässriger Lösung, (ii) Mitteln zur Speicherung von Wasserstoffgas, (iii) einer Luft- oder Sauerstoffquelle, und (iv) mit den reversiblen Brennstoffzellen-Stackmodulen und in elektrischer Kommunikation mit dem Strommittel und dem Steuermittel zur Bereitstellung von Wasser, Wasserdampf oder wässriger Lösung, Wasserstoffgas und Luft oder Sauerstoff für die reversiblen Brennstoffzellen-Stackmodule;
(d) ein oder mehrere Batterien;
(e) Strommittel zur (i) Aufnahme von Strom von einer Energiequelle, (ii) optionales Aufladen der ein oder mehreren Batterien, (iii) Bereitstellen von Strom für die Fluidmodule und (iv) Umwandeln von variablen Strom von den reversiblen Brennstoffzellen-Stackmodulen in konstante oder relativ konstante Spannung und / oder zum Invertieren von Gleichströmen in Wechselströme;
(f) Überwachungsmittel zum Überwachen von Informationen betreffend alle Aspekte des modularen regenerativen Brennstoffzellensystems und zur Kommunikation der Information an das Steuermittel; und
(g) Steuermittel zum Empfangen der Information von dem Überwachungsmittel und zur Steuerung von allen Aspekten des modularen regenerativen Brennstoffzellensystems, um somit eine kontinuierliche, ununterbrochene Systembedienung zu gewährleisten.

9. Modulares regeneratives Brennstoffzellensystem nach Anspruch 2, das umfasst:

(a) Elektrolysezellen-Stackmodule, wobei jedes in flüssiger Kommunikation mit einem Elektrolysezellen-Fluidmodul und in elektrischer Kommunikation mit Strommitteln und Kontrollmitteln ist, wobei jedes angepasst ist, um Wasser oder eine wässrige Lösung zumindest in ein Wasserstoffgas umzuwandeln;
(b) einen Speichertank für Wasserstoffgas,
(c) ein Elektrolysezellen-Fluidmodul in flüssiger Kommunikation mit (i) einer Quelle von Wasser, Wasserdampf oder wässriger Lösung, (ii) mit den Elektrolysezellen-Stackmodulen und (iii)

mit dem Speichertank für Wasserstoffgas, und in elektrischer Kommunikation mit dem Strommittel und dem Steuermittel zur Bereitstellung von Wasser, Wasserdampf oder einer wässrigen Lösung für die Elektrolysezellen-Stackmodule und zur Bereitstellung von Wasserstoffgas generiert durch die Elektrolysezellen-Stackmodule für den Wasserstoffgasspeichertank;
(d) Brennstoffzellen-Stackmodule, wobei jedes in flüssiger Kommunikation mit einem Brennstoffzellen-Fluidmodul und in elektrischer Kommunikation mit dem Strommittel, einem externen Ladungs- oder Stromnetz und dem Steuermittel ist, wobei jedes angepasst ist, um chemische Energie aus Wasserstoffgas und Luft oder Sauerstoff zu gewinnen und die gewonnene chemische Energie in elektrischen Strom umzuwandeln;
(e) Ein Brennstoffzellen-Fluidmodul in flüssiger Kommunikation mit (i) dem Wasserstoffgasspeichertank, (ii) einer Luft- oder Sauerstoffquelle und (iii) mit den Brennstoffzellen-Stackmodulen, und in elektrischer Kommunikation mit Strommitteln und dem Steuermittel zur Bereitstellung von Wasserstoffgas und Luft oder Sauerstoff für die Brennstoffzellen-Stackmodule;
(f) ein oder mehrere Batterien;
(g) Strommittel zur (i) Aufnahme von Strom aus einer Energiequelle, (ii) optionales Aufladen der ein oder mehreren Batterien, (iii) Bereitstellen von Strom für das Elektrolysezellen-Fluidmodul, die Elektrolysezellen-Stackmodule und das Brennstoffzellen-Fluidmodul, und (iv) Umwandeln von variablen Stroms von den Brennstoffzellen-Stackmodulen in konstante oder relativ konstante Spannung und / oder zum Invertieren von Gleichströmen in Wechselströme;
(h) Überwachungsmittel zur Überwachung von Informationen betreffend alle Aspekte des modularen regenerativen Brennstoffzellensystems und zur Kommunikation der Information an das Steuermittel; und
(i) Steuermittel zum Empfangen der Information von dem Überwachungsmittel und zur Steuerung aller Aspekte des modularen regenerativen Brennstoffzellensystems, um eine kontinuierliche ununterbrochene Systembedienung zu gewährleisten.

10. Modulares regeneratives Brennstoffzellensystem nach Anspruch 9, wobei die Zellen-Stackmodule Membranelektrolysezellen und Membranbrennstoffzellen enthalten, wobei jedes eine Anode, eine Katode, eine zwischen der Anode und der Katode angeordnete lonenaustauschmembran, eine Anodenkammer und eine Katodenkammer umfasst.

11. Modulares regeneratives Brennstoffzellensystem nach Anspruch 9, wobei die Elektrolysezellen-Stackmodule sich selbst unter Druck setzende Elektrolysezellen-Stackmodule sind.

12. Modulares regeneratives Brennstoffzellensystem nach Anspruch 9, wobei das Strommittel eine Ladungssteuerung mit optionalen maximalen Power-Point-Trakker-Tracker und / oder invertierender Fähigkeit umfasst.

13. Modulares regeneratives Brennstoffzellensystem nach Anspruch 9, wobei das Strommittel einen Inverter mit optionaler Ladungsfähigkeit umfasst.

14. Modulares regeneratives Brennstoffzellensystem nach Anspruch 13, wobei das Strommittel einen Gleichstrom-zu-Wechselstrominverter / Ladegerät umfasst,

15. Modulares regeneratives Brennstoffzellensystem nach Anspruch 9, wobei das Überwachungsmittel Überwachungsinstrumente und ein Kommunikationssystem umfasst.

16. Modulares regeneratives Brennstoffzellensystem nach Anspruch 15, wobei das Kommunikationssystem ein hochgeschwindigkeits-örtliches Netzwerk oder LAN ist, und wobei das modulare regenerative Brennstoffzellensystem eine Schnittstelle mit dem LAN-Netzwerk durch eine verdrahtete oder drahtlose LAN-Schnittstelle aufweist.

17. Modulares regeneratives Brennstoffzellensystem nach Anspruch 15, wobei das Kommunikationssystem Tags zur Identifizierung von Radiofrequenzen umfasst.

18. Modulares regeneratives Brennstoffsystem nach Anspruch 9, wobei die Module an der Wand befestigte Module sind.

Revendications

1. Système modulaire et régénérable de piles à combustible qui comprend :

(a) un ou plusieurs modules d'empilage de piles à combustible réversibles, chacun en communication fluidique avec au moins un module de fluide, et en communication électrique avec une source d'énergie, une charge externe ou un réseau électrique, et des moyens de commande, et chacun étant adapté pour convertir de l'eau, de la vapeur d'eau, ou une solution aqueuse en au moins un hydrogène gazeux, et pour extraire de l'énergie chimique à partir d'hydrogène gazeux et d'air ou d'oxygène et convertir l'énergie

chimique extraite en énergie électrique ;
(b) un ou plusieurs modules de fluide en communication fluidique avec (i) une source d'eau, de vapeur d'eau ou de solution aqueuse, (ii) des moyens pour stocker de l'hydrogène gazeux, (iii) une source d'air ou d'oxygène, et (iv) le ou les modules d'empilage de piles à combustible réversibles, et en communication électrique avec une source d'énergie et des moyens de commande, pour fournir de l'eau, de la vapeur d'eau, ou une solution aqueuse, de l'hydrogène gazeux et de l'air ou de l'oxygène au ou aux modules d'empilage de piles à combustible réversibles, et pour distribuer l'hydrogène gazeux généré par le ou les modules d'empilage de piles à combustible réversibles aux moyens pour stocker de l'hydrogène gazeux ;
(c) une source d' énergie ;
(d) des moyens de commande ; et
(e) des moyens pour stocker de l'hydrogène gazeux.

2. Système modulaire et régénérable de piles à combustible qui comprend :

(a) un ou plusieurs modules de fluide de cellules d'électrolyse en communication fluidique avec (i) une source d'eau, de vapeur d'eau ou de solution aqueuse, (ii) un ou plusieurs modules d'empilage de cellules d'électrolyse, et (iii) des moyens pour stocker de l'hydrogène gazeux, et en communication électrique avec une source d'énergie et des moyens de commande, pour fournir de l'eau, de la vapeur d'eau, ou une solution aqueuse au ou aux modules d'empilage de cellules d'électrolyse et pour distribuer l'hydrogène gazeux généré par le ou les modules d'empilage de cellules d'électrolyse aux moyens pour stocker de l'hydrogène gazeux ;
(b) un ou plusieurs modules d'empilage de cellules d'électrolyse, chacun en communication fluidique avec au moins un module de fluide de cellules d'électrolyse, et en communication électrique avec la source d'énergie et les moyens de commande, chacun étant adapté pour convertir de l'eau, de la vapeur d'eau, ou une solution aqueuse en au moins un hydrogène gazeux ;
(c) un ou plusieurs modules de fluide de cellules d'électrolyse en communication fluidique avec (i) les moyens pour stocker de l'hydrogène gazeux, (ii) une source d'air ou d'oxygène, et (iii) le ou les modules d'empilage de piles à combustible, et en communication électrique avec la source d'énergie et les moyens de commande, pour fournir de l'hydrogène gazeux et de l'air ou de l'oxygène au ou aux modules d'empilage de piles à combustible ;
(d) un ou plusieurs modules d'empilage de piles à combustible, chacun en communication fluidique avec au moins un module de fluide de piles à combustible, et en communication électrique avec la source d'énergie, une charge externe ou un réseau électrique, et les moyens de commande, et chacun étant adapté pour extraire de l'énergie chimique à partir de l'hydrogène gazeux et de l'air ou de l'oxygène et convertir l'énergie chimique extraite en énergie électrique ;
(e) une source d' énergie ;
(f) des moyens de commande ; et
(g) des moyens pour stocker de l'hydrogène gazeux.

3. Système modulaire et régénérable de piles à combustible selon la revendication 2, dans lequel la source d'énergie comprend une ou plusieurs batteries.

4. Système modulaire et régénérable de piles à combustible selon la revendication 2, dans lequel la source d'énergie comprend des moyens pour (i) recevoir de l'énergie à partir d'une source d'énergie, (ii) fournir de l'énergie au ou aux modules de fluide de cellules d'électrolyse, au ou aux modules d'empilage de cellules d'électrolyse, et au ou aux modules de fluide de cellules d'électrolyse, et (iii) convertir de l'énergie variable à partir du ou des modules d'empilage de piles à combustible en tensions constantes ou relativement constantes et/ou inverser des courants continus en courants alternatifs.

5. Système modulaire et régénérable de piles à combustible selon la revendication 2, dans lequel la source d'énergie comprend : une ou plusieurs batteries ; et des moyens pour (i) recevoir de l'énergie à partir d'une source d'énergie, (ii) facultativement, charger la ou les batteries, (iii) fournir de l'énergie au ou aux modules de fluide de cellules d'électrolyse, au ou aux modules d'empilage de cellules d'électrolyse, et au ou aux modules de fluide de cellules d'électrolyse, et (iv) convertir de l'énergie variable à partir du ou des modules d'empilage de piles à combustible en tensions constantes ou relativement constantes et/ou inverser des courants continus en courants alternatifs.

6. Système modulaire et régénérable de piles à combustible selon la revendication 2, qui comprend en outre : des moyens de surveillance pour surveiller des informations concernant tous les aspects du système modulaire et régénérable de piles à combustible et pour communiquer les informations aux moyens de commande.

7. Système modulaire et régénérable de piles à combustible selon la revendication 2, dans lequel le sys-

tème est sélectionné parmi le groupe de systèmes modulaires et régénérables de piles à combustible à membrane échangeuse de protons, systèmes modulaires et régénérables de piles à combustible à oxyde solide, systèmes modulaires et régénérables de piles à combustible alcalines, systèmes modulaires et régénérables de piles à combustible à acide phosphorique, systèmes modulaires de piles à combustible à hydrogène-halogène, et des associations de ceux-ci

8. Système modulaire et régénérable de piles à combustible selon la revendication 1, qui comprend :

(a) un réservoir de stockage d'hydrogène gazeux ;
(b) des modules d'empilage de piles à combustible réversibles, chacun en communication fluidique avec un module de fluide, et en communication électrique avec des moyens d'énergie, une charge externe ou un réseau électrique, et des moyens de commande, chacun étant adapté pour convertir de l'eau, de la vapeur d'eau, ou une solution aqueuse en au moins un hydrogène gazeux, et pour extraire de l'énergie chimique à partir d'hydrogène gazeux et d'air ou d'oxygène et convertir l'énergie chimique extraite en énergie électrique ;
(c) un module de fluide en communication fluidique avec (i) une source d'eau, de vapeur d'eau ou de solution aqueuse, (ii) des moyens pour stocker de l'hydrogène gazeux, (iii) une source d'air ou d'oxygène, et (iv) les modules d'empilage de piles à combustible réversibles, et en communication électrique avec les moyens d'énergie et les moyens de commande, pour fournir de l'eau, de la vapeur d'eau, ou une solution aqueuse, de l'hydrogène gazeux et de l'air ou de l'oxygène aux modules d'empilage de piles à combustible réversibles ;
(d) une ou plusieurs batteries ;
(e) des moyens d'énergie pour (i) recevoir de l'énergie à partir d'une source d'énergie, (ii) facultativement, charger la ou les batteries, (iii) fournir de l'énergie au module de fluide, et (iv) convertir de l'énergie variable à partir des modules d'empilage de piles à combustible réversibles en tensions constantes ou relativement constantes et/ou pour inverser des courants continus en courants alternatifs ;
(f) des moyens de surveillance pour surveiller des informations concernant tous les aspects du système modulaire et régénérable de piles à combustible et pour communiquer les informations aux moyens de commande ; et
(g) des moyens de commande pour recevoir des informations à partir des moyens de surveillance et pour commander tous les aspects du système modulaire et régénérable de piles à combustible, garantissant ainsi un fonctionnement de système continu ininterrompu.

9. Système modulaire et régénérable de piles à combustible selon la revendication 2, qui comprend :

(a) des modules d'empilage de cellules d'électrolyse, chacun en communication fluidique avec un module de fluide de cellules d'électrolyse, et en communication électrique avec des moyens d'énergie et des moyens de commande, chacun étant adapté pour convertir de l'eau ou une solution aqueuse en au moins un hydrogène gazeux ;
(b) un réservoir de stockage d'hydrogène gazeux ;
(c) un module de fluide de cellules d'électrolyse en communication fluidique avec (i) une source d'eau, de vapeur d'eau ou de solution aqueuse, (ii) les modules d'empilage de cellules d'électrolyse, et (iii) le réservoir de stockage d'hydrogène gazeux, et en communication électrique avec les moyens d'énergie et les moyens de commande, pour fournir de l'eau, de la vapeur d'eau, ou une solution aqueuse aux modules d'empilage de cellules d'électrolyse et pour distribuer l'hydrogène gazeux généré par les modules d'empilage de cellules d'électrolyse au réservoir de stockage d'hydrogène gazeux ;
(d) des modules d'empilage de piles à combustible, chacun en communication fluidique avec un module de fluide de piles à combustible, et en communication électrique avec les moyens d'énergie, une charge externe ou un réseau électrique, et les moyens de commande, chacun étant adapté pour extraire de l'énergie chimique à partir d'hydrogène gazeux et d'air ou d'oxygène et convertir l'énergie chimique extraite en énergie électrique ;
(e) un module de fluide de piles à combustible en communication fluidique avec (i) le réservoir de stockage d'hydrogène gazeux, (ii) une source d'air ou d'oxygène, et (iii) les modules d'empilage de piles à combustible, et en communication électrique avec des moyens d'énergie et les moyens de commande, pour fournir de l'hydrogène gazeux et d'air ou d'oxygène aux modules d'empilage de piles à combustible ;
(f) une ou plusieurs batteries ;
(g) des moyens d'énergie pour (i) recevoir de l'énergie à partir d'une source d'énergie, (ii) facultativement, charger la ou les batteries, (iii) fournir de l'énergie au module de fluide de piles d'électrolyse, les modules d'empilage de cellules d'électrolyse, et un module de fluide de piles à combustible, et (iv) convertir de l'énergie variable à partir des modules d'empilage de piles

à combustible en tensions constantes ou relativement constantes et/ou pour inverser des courants continus en courants alternatifs ;
(h) des moyens de surveillance pour surveiller des informations concernant tous les aspects du système modulaire et régénérable de piles à combustible et pour communiquer les informations aux moyens de commande ; et
(i) des moyens de commande pour recevoir des informations à partir des moyens de surveillance et pour commander tous les aspects du système modulaire et régénérable de piles à combustible, garantissant ainsi un fonctionnement de système continu ininterrompu.

10. Système modulaire et régénérable de piles à combustible selon la revendication 9, dans lequel les modules d'empilage de cellules contiennent des cellules d'électrolyse à membrane et des piles à combustible à membrane qui comprennent chacune une anode, une cathode, une membrane échangeuse d'ions disposée entre l'anode et la cathode, une chambre d'anode et une chambre de cathode.

11. Système modulaire et régénérable de piles à combustible selon la revendication 9, dans lequel les modules d'empilage de cellules d'électrolyse sont des modules d'empilage de cellules d'électrolyse à mise sous pression automatique.

12. Système modulaire et régénérable de piles à combustible selon la revendication 9, dans lequel les moyens d'énergie comprennent un dispositif de commande de charge avec un dispositif de conversion optimale d'énergie et/ou une capacité d'inversion facultatifs.

13. Système modulaire et régénérable de piles à combustible selon la revendication 9, dans lequel les moyens d'énergie comprennent un onduleur avec une capacité de chargeur facultative.

14. Système modulaire et régénérable de piles à combustible selon la revendication 13, dans lequel les moyens d'énergie comprennent un onduleur de courant continu en courant alternatif/un chargeur.

15. Système modulaire et régénérable de piles à combustible selon la revendication 9, dans lequel les moyens de surveillance comprennent une instrumentation de surveillance, et un système de communication.

16. Système modulaire et régénérable de piles à combustible selon la revendication 15, dans lequel le système de communication est un réseau local à grande vitesse ou LAN, et dans lequel le système modulaire et régénérable de piles à combustible réalise une interface avec le réseau LAN par l'intermédiaire d'une interface LAN avec ou sans fil.

17. Système modulaire et régénérable de piles à combustible selon la revendication 15, dans lequel le système de communication comprend des étiquettes d'identification par radiofréquence.

18. Système modulaire et régénérable de piles à combustible selon la revendication 9, dans lequel les modules sont des modules montés sur mur.

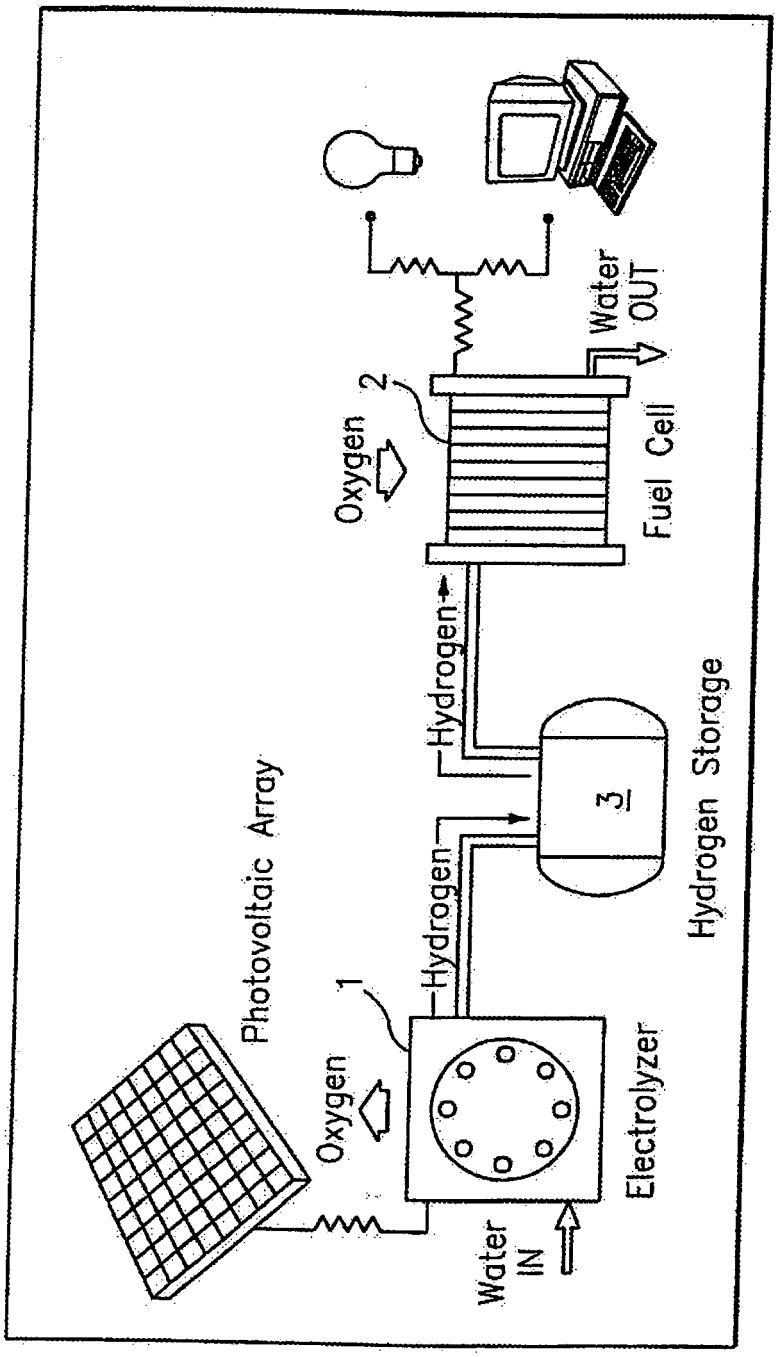

FIG. 1
(PRIOR ART)

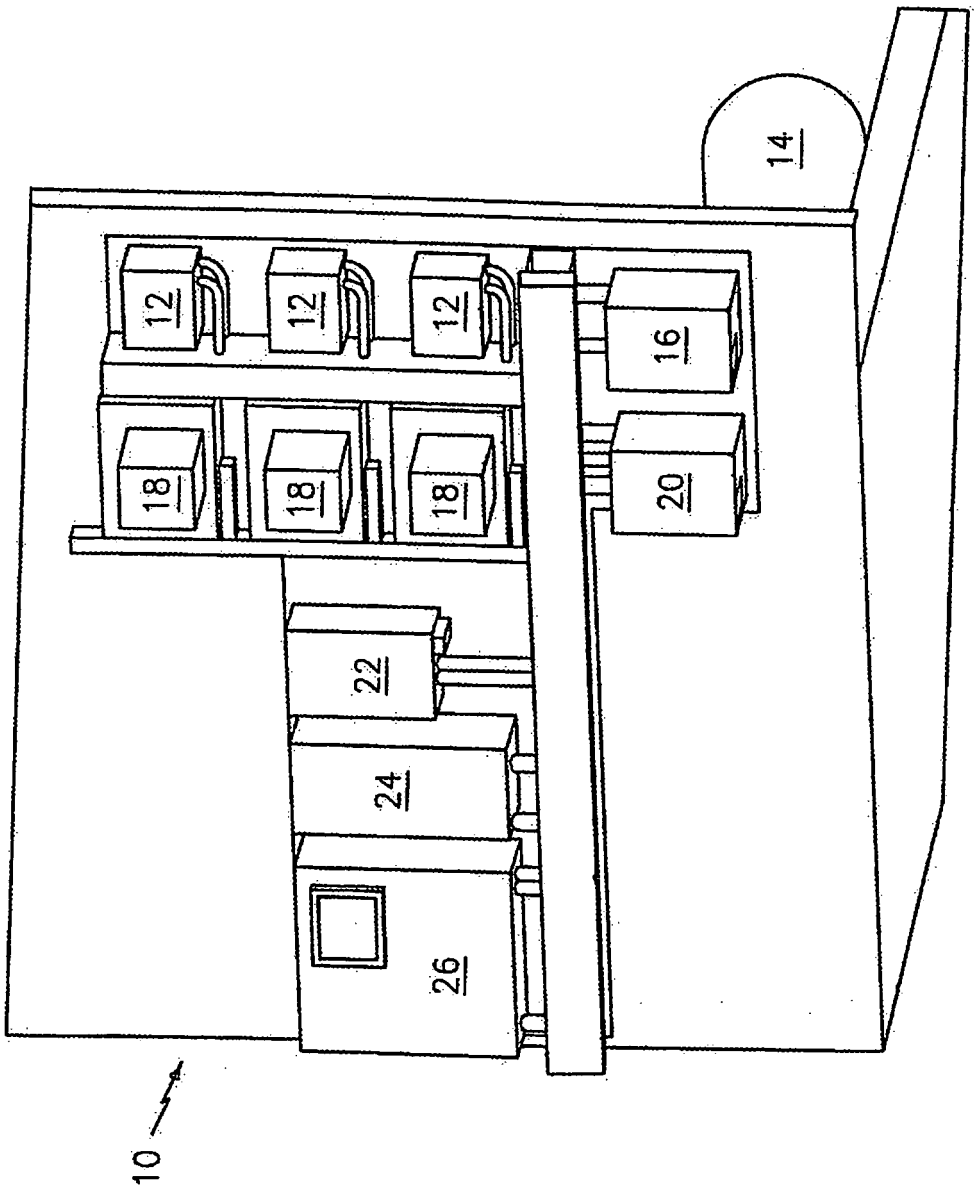

FIG. 2

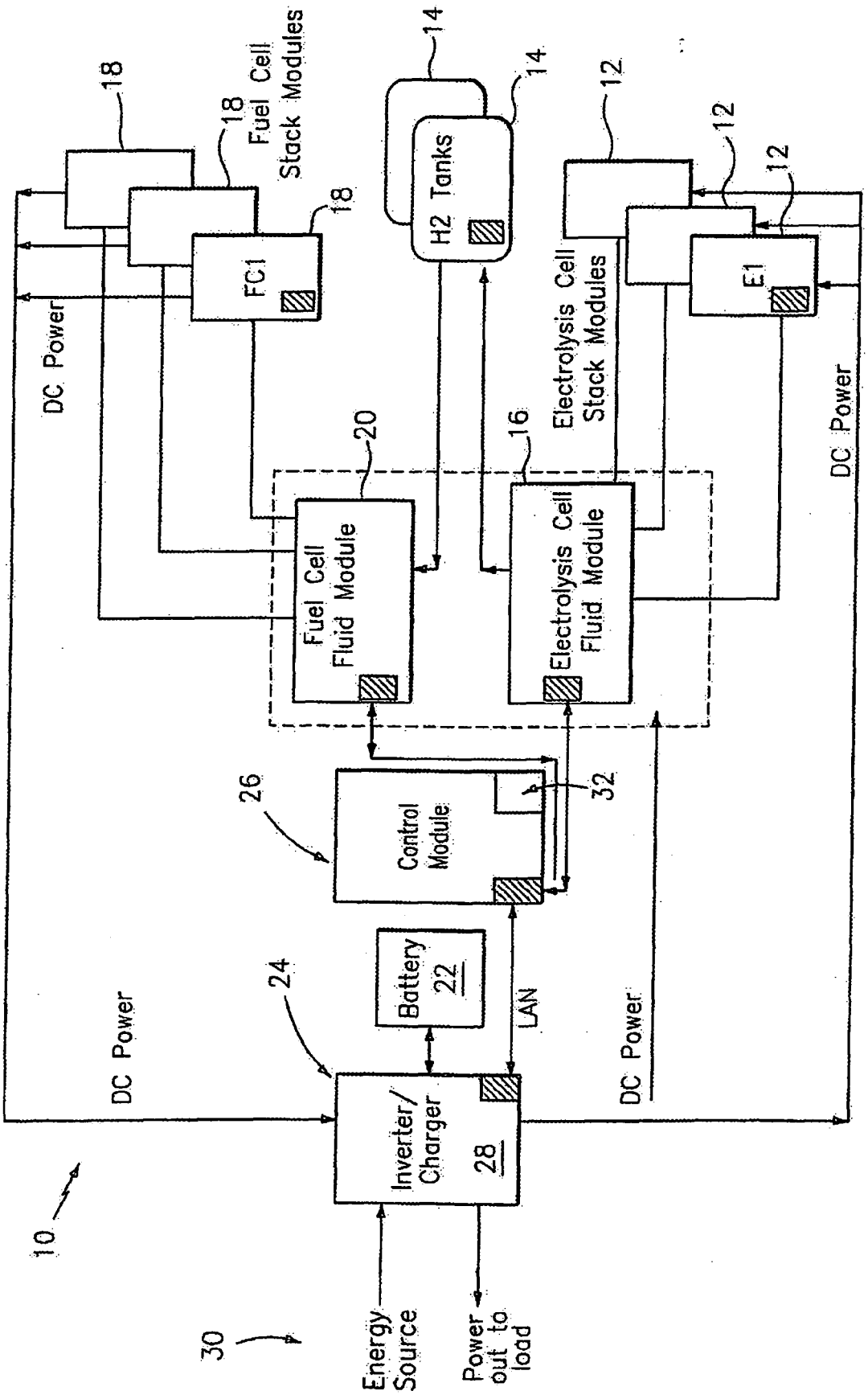
18
18
Fuel Cell
Stack Modules
18
FC1
14
14
H2 Tanks
12
12
12
E1
Electrolysis Cell
Stack Modules
DC Power
DC Power
20
Fuel Cell
Fluid Module
16
Electrolysis Cell
Fluid Module
26
Control
Module
32
24
Battery
22
LAN
DC Power
DC Power
Inverter/
Charger
28
10
30
Energy
Source
Power
out to
load

FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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