

POWER GENERATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention generally relates to a system for supplying electrical power to a remote subsea installation. More specifically, in one illustrative example, the invention relates to method and system for generating electrical power locally for an autonomous subsea installation such as a Christmas tree. The subsea installation being connected to a second installation by a fluid supply line or flowline, where said second installation being arranged to supply pressurized fluid through the fluid supply line to the subsea installation.

2. Description of the related art

The production from a subsea well is controlled by a number of valves that are assembled into a unitary structure generally referred to as a Christmas tree. The actuation of the valves is normally dependent upon hydraulic fluid to power hydraulic actuators that operate the valves. Hydraulic fluid is normally supplied through an umbilical running from a remote station located on a vessel or platform at the surface. Less commonly, the hydraulic umbilical may be run from a land-based station. Usually the actuators are controlled by pilot-operated control valves housed in a control module located at or near the subsea installation. The control valves direct the supply of fluid to each actuator, as required for each particular operation. The pilot valves may be electrically actuated, such as by solenoids. Such a system is commonly referred to as an electro-hydraulic system.

In order to control a subsea well, a connection must be established between the well and a monitoring and control station. The monitoring and control station may be located in a platform or floating vessel near the subsea installation, or alternatively in a more remote land station. The connection between the control station and the subsea installation is usually established by installing an umbilical between the two points. The umbilical must include hydraulic lines for supplying hydraulic fluid to the various hydraulic actuators located on or near the well. The umbilical may also include electrical lines for supplying electric power and also for communicating control signals to and/or from the various monitoring and control devices located on or near the well. The typical umbilical is a very complicated and expensive item. The umbilical can cost several thousand U.S. dollars per meter of length, and may be thousands of meters long.

Exploitation of oil and gas moves further and further offshore and in increasingly deeper waters. Aside from the increased costs of longer umbilicals, there is also a problem with response times for the hydraulic equipment, which increases with

increasing distance. Another problem is that in the longer hydraulic supply lines the energy losses becomes very high because of friction. At one point, it will become necessary to install costly boosters and/or accumulators subsea to achieve necessary response times. This adds to the complexity (and cost) of the subsea installation.

It has been proposed to install electric actuators on subsea installations. For many years, electric valve actuators have been preferred in land based industries, because electric actuators are more compact than hydraulic actuators. Furthermore, most of the components of a typical electric actuator, such as the electric motor and/or gearbox, are readily available items that can be easily and inexpensively procured from many manufacturers. In some applications, electric actuators are seen as a good alternative to hydraulic actuators because the ambient pressure does not affect the required operating force of an electrically operated valve. However, the stringent requirements for failsafe operations have prohibited use of electric actuators, because such devices must incorporate mechanical springs as a failsafe device. Such actuators therefore tend to be just as large and bulky as the hydraulic actuators they are intended to replace and in addition consumes much power to operate.

Typically, existing subsea electric actuators are powered from a remote location through a subsea cable, in order to ensure a sufficient and reliable supply of electric power. It is usually required that the power supply be sufficient to operate all the valves simultaneously. If the distance between the land station and the subsea installation is very large, even such a cable becomes very costly. Also, hydrocarbons have been found in the Arctic, where ice prohibits the use of a floating production unit or even access to the well for most of the year. Also at times it may be desirable to locate a single well a distance from the main installation without having to invest in costly supply or communication lines. A typical example of such a well may be a water injection well.

It would therefore be of great interest to be able to locate a subsea installation at a remote locale and be able to operate the well as autonomously as possible, the installation having its own power supply and intelligent control system. One method is disclosed in WO 9723708 which describes a subsea installation having a turbine that is rotated by sea currents to generate power for the operation of a subsea device. It will be obvious that such a system will be able to provide only a limited amount of power, and be at mercy of the prevailing sea currents and is therefore not controllable. Another problem is that the electricity that can be generated would not be sufficient to operate all the valves in a larger installation.

Batteries have recently been developed which can store enough power to operate all valves in a subsea installation, if necessary simultaneously, thus enabling power for the electric actuators to be stored in locally installed batteries. An added advantage

is that the operation of such actuators will be independent of the water depth of the system. The need for pilot valves will also be eliminated, since the actuators may be directly controlled electrically. Thus, there will also be potentially large savings on umbilical cost since the hydraulic lines can be removed.

All-electric subsea systems require a more sophisticated control system than electro-hydraulic systems. The control system must control the charging of the batteries and monitor their status. The control system should also monitor the status and position of each valve so that at any time an operator can access this information and intervene if necessary. Furthermore, the control system must implement the failsafe function and close all valves if required.

The present invention is directed to a method and an apparatus for solving, or at least reducing the effects of, some or all of the aforementioned problems by establishing a reliable power supply and a control system that ensures that the actuators are operable at all times.

SUMMARY OF THE INVENTION

In general, the present invention is directed to a system and method for supplying electric energy at a subsea installation as defined in the independent claims and more specifically an electrical power generation system for a subsea installation, and various methods of operating same. Preferred embodiment are given in the dependent claims.

One aspect of the present invention provides a system for supplying electrical power to a subsea installation in a remote location, said subsea installation comprising at least one electrically operated component, a fluid supply line extending from said subsea installation to a second installation, said second installation comprising a pump arranged to supply pressurized fluid through said supply line to said subsea installation, said subsea installation comprising means for operationally injecting said pressurised fluid into a well or a fluid produced by a well, at a specific pressure at least equivalent to the well pressure or pressure of the produced fluid; in which the system comprises electrical generating means comprising a turbine which in use is operatively connected to said fluid supply line at said subsea installation, said turbine in use generating electrical power output from said pressurized fluid flowing through said fluid supply line, to power the at least one electrically operated component on the subsea installation, the pump at the second installation being operated to deliver a fluid at a pressure above said specific pressure at said subsea installation, the surplus being available for generating electric energy.

An alternate aspect of the present invention provides a method for supplying energy to a subsea installation at a remote location, which subsea installation comprises at least one electrically operated component and having at least one fluid supply line connecting said subsea installation with a second installation, for transfer of a supply fluid from said second installation to said remote subsea installation for injection into a well or a fluid produced by a well, said method comprising: providing electrical generating means comprising a turbine operatively connected to said fluid supply line at said subsea location, adding energy to said supply fluid at said second installation by pressurizing said fluid to a level higher than what is necessary to inject the fluid into a well or into a fluid produced by a well, transporting said fluid to said remote subsea installation, at the remote subsea installation, extracting the excess energy in the fluid in the fluid supply line by operating the turbine to generate electric energy to operate the at least one electrically operated component.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals identify like elements, and in which:

Fig. 1 shows an exemplary embodiment of the invention;

Fig. 2 shows a schematic of a subsea installation according an exemplary embodiment of the invention;

Fig. 3 shows an exemplary embodiment generator bypass loop;

Fig. 4 shows a detailed view of an exemplary embodiment turbine; and

Fig. 5 shows an exemplary embodiment algorithm for monitoring the flow direction in the flowline and responding thereto.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

Illustrative embodiments of the invention are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

The present invention will now be described with reference to the attached figures. The words and phrases used herein should be understood and interpreted to have a meaning consistent with the understanding of those words and phrases by those skilled in the relevant art. No special definition of a term or phrase, *i.e.*, a definition that is different from the ordinary and customary meaning as understood by those skilled in the art, is intended to be implied by consistent usage of the term or phrase herein. To the extent that a term or phrase is intended to have a special meaning, *i.e.*, a meaning other than that understood by skilled artisans, such a

special definition will be expressly set forth in the specification in a definitional manner that directly and unequivocally provides the special definition for the term or phrase.

Referring to Fig. 1, in an exemplary embodiment of the invention a subsea installation 1 is located on the seabed 2. The installation 1 includes a Christmas tree 11 mounted on a wellhead 12, the wellhead being the uppermost part of a well that extends down into the sea floor to a subterranean hydrocarbon formation. The Christmas tree 11 has at least one electrically operated device such as electric actuator 13 for actuating at least one flow control valve (not shown). An electrically operated control module 14 is attached to the Christmas tree 11. The control module 14 houses electronic equipment for receiving and transmitting control and/or telemetry signals 19. The control module 14 also houses one or more electric power storage devices 22, 23 (in Fig. 2), such as batteries, which provide power to the electric actuators and/or other electrical devices on the Christmas tree 11 or wellhead 12. A cable 15 extends from the control module 14 to actuator 13. Other equipment, such as various electrically operated sensors, may also be connected to the control module 14. The Christmas tree 11 may also include a remotely operated vehicle (ROV) panel (not shown) to allow manual actuation of the valves by an ROV, as is well known in the art. A vessel 3, such as a floating processing unit (FPU) is located on the surface 4 of the water. A fluid supply line or flowline 5 extends from the vessel 3 to the Christmas tree 11. A local power generating system 30 is operatively connected to the flowline 5. A cable 31 connects the generating system 30 with the control module 14.

A hydro-acoustic communication unit 16 is attached to the Christmas tree 11 and is connected to the control module 14 via cable 17. The communication unit 16 includes a first antenna 18, an acoustic transmitter (not shown), and an acoustic receiver (not shown). The vessel 3 further includes a second antenna 20 for receiving and transmitting acoustic control and telemetry signals 19 to and from the antenna 18 on the Christmas tree 11. In other embodiments, different communication methods may be employed, such as radio waves. In other embodiments the antenna 18 may be deployed on a buoy (not shown) floating on the surface 4. The buoy could then be linked to a remote station via a satellite link, cable, radio, or other suitable communication means.

In the instant exemplary embodiment, the Christmas tree 11 is a water injection tree. Water is pumped from the vessel 3, through flowline 5, and to the subsea installation 1 where it is injected into the formation. Alternatively, the flowline 5 may extend from a processing or separation unit (not shown) located remotely from the well. The processing or separation unit processes the fluid produced from other wells in the formation, and separates the produced water from the hydrocarbons.

The processing or separation unit may be located subsea, on a vessel or platform, or on land.

Fig. 2 shows a schematic of the Christmas tree 11 connected to the wellhead 12. The subsea well is completed in the usual manner by first drilling a hole and installing a conductor pipe, then installing a wellhead and a series of concentric casing strings anchored in the wellhead. Lastly the tubing string and tubing hanger are installed in the well and the Christmas tree 11 is connected to the wellhead 12. In Fig. 2, 41 denotes the production flow passage, which communicates with the flow bore of the production tubing string. 42 denotes the annulus passage, which communicates with the annular space between the tubing and the innermost casing string. 43 denotes the production outlet, from which produced fluids would normally exit in a producing well. In a water injection well, such as in the instant embodiment, the production outlet 43 is used to inject water into the well. The production outlet 42 is connected to flowline 5. The reference number 44 denotes a crossover passage, which links the annulus passage 42 and the production flow passage 41.

A master production valve 45 is located in the production flow passage 41, and a master annulus valve 46 is located in the annulus passage 42. A crossover valve 47 controls fluid flow through the crossover passage 44. A production wing valve 50 is located in production outlet 43. A choke valve 48 controls the pressure in the production outlet 43. The power generating system 30 comprises a turbine 60 (not indicated on fig. 2), which is located in the flow path of production outlet 43, in a manner that is described more fully below.

Valves 45, 46, 47, 48 and 50 are each operated by an electric actuator. In one illustrative embodiment, each electric actuator (not shown) includes an electric motor, a gearbox, and a driveshaft, which is connected to its respective valve spindle via a standard API interface. In an exemplary embodiment, the electric motor may be a brushless type DC motor and the gearbox may be a planetary gearbox. Examples of a suitable motor 185 and gearbox 175 combination include a model named TPM 050 sold by the German company Wittenstein. Each electric actuator has an associated motor controller (not shown) for receiving and sending signals from the control module 14 and modulating power to the motor upon receiving the appropriate commands from the control module 14. Each electric actuator is housed in a removable unit (not shown). The standard API interface makes it possible to remove the actuator in an emergency, and to actuate the valve spindle directly with an ROV or a diver.

Workover valves 51 and 52 are also located in the Christmas tree. These additional valves may be operated by hydraulic actuators (not shown), and are used for access to the well during workover situations. During workover an umbilical (not shown)

will be used to supply hydraulic fluid to any remaining hydraulic actuators and to wellhead connector 53. The workover umbilical is connected to a workover unit 54 as shown.

A number of sensors are located in the subsea installation to monitor various parameters of the system. A pressure/temperature (PT) sensor 56 is located in the annulus passage 42. Another PT sensor 58 is located in the production outlet 43 upstream water injection flow of the choke 48. A third PT sensor 57 is located in the production outlet 43 downstream water injection flow of the choke. Sensors 57 and 58 are used to monitor the pressure of the injection fluid as it is pumped into the well. This information is used to regulate the choke 48 to achieve the desired injection pressure.

The control module 14 houses a processing unit 21, which includes electronics to receive and transmit signals to the various devices in the system, and to the hydro-acoustic antenna 18. The electronics in processing unit 21 also direct electric power as required to the various devices, including the electric valve actuators. The exemplary control module 14 also houses at least two batteries 22, 23 for redundancy. The processing unit controls the operation of the electric actuators (not shown) and the turbine 60 (in Fig. 4), monitors the charge of the batteries 22, 23 via a charge sensor (not shown), and handles communication signals both internally and externally of the system. An acoustic communication unit 16 includes the antenna 18, and provides communication with the receiving antenna 20 (in Fig. 1) at the surface vessel, platform, or remote station.

In other embodiments, the electric actuators (not shown) may be equipped with mechanical failsafe springs (not shown), to provide a failsafe closed capability. For example, referring to Fig. 2 the wing valve 50 is depicted with a failsafe spring. In the instant exemplary embodiment the failsafe springs are omitted from the other electric actuators. The processing unit 21 can be used, as long as electrical power is available, to provide failsafe closed functionality. Without electrical power the electric actuators will have a fail "as is" functionality.

Referring to Figs. 3 and 4, in a first exemplary embodiment the power generating system 30 includes a turbine 60 installed closed pipe loop 32, which is coupled to control valve 38 via flanges 33 and 34. The turbine 60 is operatively connected to flowline 5, and valve 38 regulates the flow of fluid from flowline 5 to the turbine 60. The valve 38 may be operated by an electric actuator (not shown), which may be controlled by the control module 14 (in Fig. 2). With this arrangement a controlled amount of fluid may be supplied through the pipe loop 32 as needed, to provide electricity to charge the batteries 22, 23 (in Fig. 2). Valve 38 may be positioned in a first position such that fluid flowing through the flowline 5 is

directed through the pipe loop 32. Valve 38 may also be positioned in a second position such that flow through flowline 5 bypasses the pipe loop 32 entirely.

The turbine 60 is shown in greater detail in Fig. 4. The turbine 60 includes a plurality of turbine blades 36 extending between a central shaft 39 and an outer ring 35. The blades 36 are distributed evenly around the shaft 39. The turbine 60 is rotated by the flow of fluid through pipe loop 32. A number of rotating permanent magnets 37 are mounted on the outer diameter of ring 35 to form rotor windings. Additional stationary permanent magnets 40 are fixedly mounted in a ring arrangement around the permanent magnets 37 to form stator windings. As is well known in the art, rotation of the rotor inside the stator will cause relative movement between the rotating and stationary magnets, thus creating a current and generating electric power. The windings in the stator are arranged to produce a three-phase AC power output or signal in a known manner.

In a preferred embodiment, the turbine is installed directly into the flow line and there is no control valve. The turbine will in this case rotate all the time, whether under load or not. This enables the turbine to be used for measurements that will monitor the state of the system, as will be explained in more detail below.

The system includes sensors (not shown) for sensing the speed and direction of rotation of the turbine 60. Normally, voltage and current meters or sensors are also provided to enable calculation of generator output. The AC output can be expressed as three temporally offset sinusoidal curves or phases (A, B, and C). The time between the peaks of adjacent phases (e.g., A and B) determines the frequency and thereby the rotational speed of the turbine 60. A speed sensor is thus provided for sensing this frequency. The rotational direction of the turbine 60 can be determined from the sequence of the three phases. A change in the sequence of the phases (for example from ABC to BAC) will indicate a change in the direction of rotation of the turbine 60. A direction sensor is also provided for sensing the sequence of at least two of the three phases of the three-phase AC signal. The sensors for sensing the frequency and phase sequence of the power output may comprise calculation routines within the processing unit 21 of the control module 14 (see fig. 2).

During normal operations, the turbine 60 is running free or with a very small electrical load. In this configuration, the rotational speed and direction may be constantly monitored. From the rotational speed, the flowrate Q can be determined, thus allowing the detection of interruptions in the flow. When the turbine 60 is running under electrical load, the rotational speed may be compared to the current being produced by the generator. This enables the efficiency and/or performance of the turbine 60 to be monitored. Parameter measurements in a predetermined range may give an indication that the turbine 60 is failing and should be replaced. Another way to measure the performance of the turbine 60 is to measure the drop in

rotational speed when the turbine 60 is placed under electrical load. For the particular turbine 60 used, the relationship between current output and the slowing of the turbine 60 under load will be known. If the slowing of the turbine 60 and/or the current output should deviate from this known relationship, it may be an indication that the turbine 60 is failing. Comparing the speed of the turbine 60 and the current generated will also give an indication of the efficiency of the turbine 60. A change in these readings over time may give an early warning of turbine 60 failure so that the turbine 60 can be replaced with a minimum of system downtime.

Measuring the rotational speed will also measure the flow, since the flow rate is proportional to the number of revolutions per minute of the turbine 60. Such measurements may be compared with the flow rate measured at the pumping station, in order to determine if there are leaks any leaks present in the system.

When the turbine 60 is placed under electrical load, a pressure drop will be measured in pressure sensor 58 (see fig. 2). This pressure drop will be proportional to the power output according to the formula $P = \Delta p \times Q$ (where P is the power output, Δp is the pressure drop, and Q is flow rate). This can be compared to the power output measured from the turbine 60, in order to give an indication of possible turbine 60 failure.

In an injection well it is very important to sense the flow direction, since a reversal in flow direction indicates that the well may have become unstable and/or water is flowing out of the well. When this occurs, the flow control valves (45 and 46) should be closed immediately to avoid problems with the well. An algorithm for accomplishing this is shown diagrammatically in Fig. 5. The flow direction can be measured in two ways. First, on the left hand side of Fig. 5 the direction of rotation of the turbine 60 is measured. A reversal of direction indicates that the flow is in the wrong direction and the master valve 45 should be closed. However, it is possible that this reading could be faulty, for example because of a fault in the turbine 60. To confirm that the flow direction has actually changed, the pressure drop across the choke is also measured, as shown on the right hand side of Fig. 5. If the pressure drop is positive across the choke, a faulty turbine 60 unit is indicated, and the remote control station is notified. If the pressure drop across the choke is negative, this confirms that fluid is flowing out of the well. In this case the master valve 45 should be closed automatically.

Referring again to Fig. 2, water is supplied through the flowline 5 to main passages 43 and 41. The master valve 45 and wing valve 50 are held in the open position, allowing water to be pumped down the well and into the formation. The control module 14 monitors the various parameters at the well, including the charge level on the batteries 22,23, and sends this information to a remote control station (not shown) on the vessel 3 (in Fig. 1) or on land. When the control module 14 senses

that the charge level on the batteries 22,23 is below a first predetermined value, a signal is sent to engage (in an electrical sense) the turbine 60. In the engaged state, the turbine 60 generates electrical power. The electricity generated by the turbine 60 is sent through cable 31 to recharge the batteries 22, 23. When the control system senses that the charge level on the batteries 22, 23 is above a second predetermined value, a signal is sent to disengage the turbine 60, *i.e.*, to remove the electrical load from the turbine 60, and the turbine 60 is allowed to return to its free-running state. In the electrically disengaged state, the turbine 60 generates little or no electrical power.

In the embodiment described above, the flowline is a water injection flowline. However, other fluids may be supplied to the Christmas tree that can be utilized for the same purpose, e.g. extracting energy. Such fluids may include, but not restricted to, chemicals such as scale or hydrate inhibitors, methanol or MEG. The fluid transferred may in one embodiment not be used to anything at the subsea installation but just be used for the transfer of energy to the subsea installation.

The downhole safety valve (not shown) may be a simple single-acting valve, for example a flapper valve. This type of valve will remain open as long as fluid is flowing into the well, but will close automatically when the fluid flow stops or reverses, thus closing off the well. In some countries there is a requirement to have a surface controlled subsurface safety valve (SCSSV). In this case a valve such as that described in Norwegian Patent Specification No. 313 209 can be used. Since this valve can be controlled from the outside of the Christmas tree, an electric actuator may be used. The safety control valve may also be manually closed, using an ROV if necessary.

Although the invention is described in conjunction with a water injection well, it should be understood that a similar system may be used for a producing well or a manifold system, without departing from the true spirit and scope of the invention. For example, the power generating system 30 could be operatively coupled to the methanol or other chemical injection flowline to the well, and the fluid pressurized above what is needed for its function, thus the excess energy in the flow is utilized to rotate the turbine 60.

In general, the present invention is directed to an electrical power generation system, and various methods of operating same. In one illustrative embodiment, the system comprises at least one flowline, a turbine operatively connected to the flowline, the turbine being rotatable by fluid flowing through the flowline, and the turbine generating the electrical power output when the turbine is rotated.

In one illustrative embodiment, the method comprises operatively connecting a turbine to the flowline and directing a flow of fluid through the turbine to thereby generate the electrical power output.

The particular embodiments disclosed above are illustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. For example, the process steps set forth above may be performed in a different order. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

CLAIMS

1. A system for supplying electrical power to a subsea installation in a remote location, said subsea installation comprising at least one electrically operated component, a fluid supply line extending from said subsea installation to a second installation, said second installation comprising a pump arranged to supply pressurized fluid through said supply line to said subsea installation, said subsea installation comprising means for operationally injecting said pressurised fluid into a well or a fluid produced by a well, at a specific pressure at least equivalent to the well pressure or pressure of the produced fluid; in which the system comprises electrical generating means comprising a turbine which in use is operatively connected to said fluid supply line at said subsea installation, said turbine in use generating electrical power output from said pressurized fluid flowing through said fluid supply line, to power the at least one electrically operated component on the subsea installation, the pump at the second installation being operated to deliver a fluid at a pressure above said specific pressure at said subsea installation, the surplus being available for generating electric energy.
2. The system of claim 1, wherein said supply line is a chemical supply line.
3. The system of claim 1, wherein said subsea installation is a water injection well and said fluid supply line is a water injection flowline, for water to be injected into the well.
4. The system of claim 1, wherein said subsea installation is a gas producing well and said fluid supply line is for a hydrate inhibiting fluid.
5. The system of any preceding claim, wherein said at least one electrically operated component comprises an electrically powered valve actuator.
6. The system of any preceding claim, wherein said at least one electrically operated component comprises a control module.
7. The system of any preceding claim, further comprising at least one electrical power storage device, said electrical power output being supplied to said at least one electrical power storage device.
8. The system of claim 7, wherein said at least one electrical power storage device comprises a battery.
9. The system of claim 7 or 8, further comprising at least one electrically operated component powered by said at least one electrical power storage device.

10. The system of any preceding claim, further comprising a control module for controlling said turbine.

11. The system of claim 10, wherein said control module causes said turbine to selectively be in at least a first state wherein said turbine generates electrical power, and a second state wherein said turbine does not generate electrical power.

12. The system of claim 11, further comprising:
at least one charge sensor for sensing the charge level of said battery, said charge level determining the selection of said first and second states of said turbine by said control module.

13. The system of any preceding claim, wherein said turbine comprises:
a rotary member comprising a plurality of blades and at least one rotating magnet; and
a fixed housing comprising at least one stationary winding, wherein rotation of said rotary member causes relative movement between said at least one rotating magnet and said at least one stationary winding, said relative motion generating said electrical power output.

14. The system of any preceding claim, further comprising at least one speed sensor for sensing a rotational speed of said turbine.

15. The system of claim 14, wherein said electrical power output comprises an AC signal having a frequency which is proportional to said rotational speed of said turbine, and said at least one speed sensor comprises a frequency sensor for sensing said frequency.

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16. The system of claim 14 or 15, further comprising:
at least one current sensor for sensing a current produced by said turbine;
a control unit for determining an efficiency of said turbine, said determination of said efficiency being based upon said rotational speed and said current.

17. The system of any of claims 14 - 16, further comprising a control module for determining a flow rate of fluid flowing through said turbine, said determination of said flow rate being based upon said rotational speed sensed by said speed sensor.

18. The system of any preceding claim, further comprising at least one direction sensor for sensing the direction of rotation of said turbine.

19. The system of claim 18, wherein said electrical power output comprises a three-phase AC signal, and said at least one direction sensor comprises a phase sequence sensor for sensing the sequence of at least two phases of said three-phase AC signal.

5 20. The system of any preceding claim, further comprising a closed flow loop in fluid communication with said fluid supply line, said turbine being positioned in said closed flow loop.

21. The system of claim 20, further comprising at least one control valve for regulating a flow of said fluid to said turbine.

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22. The system of claim 21, wherein said at least one control valve comprises at least a first position in which at least a part of said fluid flowing through said fluid supply line is directed through said turbine, and a second position in which fluid flowing through said fluid supply line bypasses said turbine.

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23. The system of any preceding claim, further comprising a communication unit for communicating with a control station located remotely from said subsea installation.

20 24. The system of claim 23, wherein said communication unit comprises at least one acoustic transmitter.

25. The system of claim 23 or 24, wherein said communication unit comprises at least one acoustic receiver.

25 26. The system of any preceding claim, wherein said second installation comprises a landbased installation, or a floating installation, or a fixed offshore installation.

27. A method for supplying energy to a subsea installation at a remote location, which subsea installation comprises at least one electrically operated component and having at least one fluid supply line connecting said subsea installation with a second installation, for transfer of a supply fluid from said second installation to said remote subsea installation for injection into a well or a fluid produced by a well, said method comprising:

providing electrical generating means comprising a turbine operatively connected to said fluid supply line at said subsea location,

adding energy to said supply fluid at said second installation by pressurizing said fluid to a level higher than what is necessary to inject the fluid into a well or into a fluid produced by a well,

transporting said fluid to said remote subsea installation,

at the remote subsea installation, extracting the excess energy in the fluid in the fluid supply line by operating the turbine to generate electric energy to operate the at least one electrically operated component.

28. The method of claim 27, wherein said supply fluid is used as water injection fluid.

29. The method of claim 27, wherein said supply fluid is used for chemical treatment.

30. The method of any one of claims 27 - 29, further comprising operatively connecting a turbine to said fluid supply line; and directing at least part of said flow of supply fluid through said turbine to thereby generate said electrical energy.

31. The method of claim 30, further comprising sensing a rotational speed of said turbine.

32. The method of claim 31, further comprising:
sensing a current produced by said turbine; and
determining an efficiency of said turbine, said determination of said efficiency being based upon said rotational speed and said current.

33. The method of claim 31 or 32, further comprising determining a flow rate of said fluid flowing through said turbine, said determination of said flow rate being based upon said rotational speed.

34. The method of any of claims 30 - 33, further comprising sensing a direction of rotation of said turbine.

35. The method of any of claims 27 - 34, further comprising:
connecting a choke valve to said fluid supply line;
sensing a first pressure in said fluid supply line on one side of said choke valve; and
sensing a second pressure in said fluid supply line on the other side of said choke valve.

36. The method of claim 35, further comprising determining a flow direction of fluid flowing through said choke valve, said determination of said flow direction being based upon said first and second pressures.

37. The method of claim 36, further comprising:
connecting a master valve to said fluid supply line; and
controlling said master valve in response to said flow direction.

38. The method of any of claims 27 - 37, further comprising supplying said electrical power output to at least one electrical power storage device.

39. The method of claim 38, further comprising powering at least one of said electrically operated components with said at least one electrical power storage device.

40. The method of claim 30 and 38, further comprising:
5 sensing a charge level of said at least one electrical power storage device; and
when said charge level is below a first predetermined value, causing said turbine to be in a first state wherein said turbine generates electrical power.

41. The method of claim 40, further comprising:
10 when said charge level is above a second predetermined value, causing said turbine to be in a second state wherein said turbine does not generate electrical power.

42. The method of any of claims 27 - 41, further comprising:
locating a control station remotely from said subsea installation; and
15 communicating acoustically between said subsea installation and said control station.

43. The method of any of claims 27 - 42, further comprising at the second installation adding energy to said supply fluid in an amount sufficient to power the turbine to provide sufficient electrical energy for operation of the electrically operated component.

