THE CONCEPT OF RENEWABLE ENERGY AND THE STORAGE OF WIND ENERGY

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Abstract

The terms winds energy or power describes by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy into the mechanical power that power can be transferred into the turbine stations that can store and that produce electricity that we used in our homes. A wind energy generating and storage can have plurality of direct compression wind turbine stations. A storage device is coupled to at least a portion of the wind turbine stations. At least a first compressor is coupled to the storage device to compress air. At least one expander is configured to release compressed air from the storage device. The system has a top-of-tower power to weight ratio greater than 1 megawatt/10 tons excluding the blades and rotor.

Introduction

Considerable amount of installation of the renewable energies to the power network arises lots of issues since the most of the renewable energies are intermittent . This paper describes a generally to a wind energy and storage system, and more particularly to a wind energy and storage system that has top-of-turbine power to weight ratio greater than 1 megawatt/15 tons.From its commercial beginnings more than twenty years ago, wind energy has achieved rapid growth as a technology for the generation of electricity. The current generation of wind technology is considered mature enough by many of the world's largest economies to allow development of significant electrical power generation. As of the end of 2016 more than 4,86,790 MW of wind power capacity had been installed worldwide, with annual industry growth rates of greater than 12.5% compared to the previous year. Ten years after that, wind power could be supplying up to 19 percent of the world's electricity avoiding more than three billion tons of co2 by a year. By 2050, 25-30 percent of global power could come from harnessing the wind.

Wind energy as a power sector has been growing exceptionally, especially in the last year. Total generation of the world has increased by 17.4% to amount to 841 terawatt hours in 2015. The reason that countries are stressing on wind energy these days is that it is healthier for the environment. The objectives that several nations have set for themselves in relation to climate can only be achieved if electricity is generated in a green way. Producing it with the help of renewable resources is an effective method and wind energy tops the list as an example.

Transmission and market access constraints can significantly affect the cost of wind energy. Varying and relatively unpredictable wind speeds affect the hour to hour output of wind plants, and thus the ability of power aggregators to purchase wind power, Such that costly and/or burdensome requirements can be imposed upon the deliverer of such varying energy. Congestion costs are the costs imposed on generators and customers to reflect the economic realities of congested power lines or “Bottlenecks.” Additionally, interconnection costs based upon peak usage are spread over relatively fewer KWHS from intermittent technologies such as wind power as compared to other technologies. Power from existing and proposed offshore wind plants is usually delivered to the onshore loads after stepping up the Voltage for delivery through Submarine high Voltage cables. The cost of such cables increases with the distance from shore. Alternatives to the high cost of submarine cables are currently being contemplated. As in the case of land based wind plants with distant markets, there will be greatly increased costs as the offshore wind power facility moves farther from the shore and the load centers. In fact, the increase in costs over longer distance may be expected to be significantly higher in the case of offshore wind plants. It would thus be advisable to develop alternative technologies allowing for the transmission of distant offshore energy Such as produced by wind power.

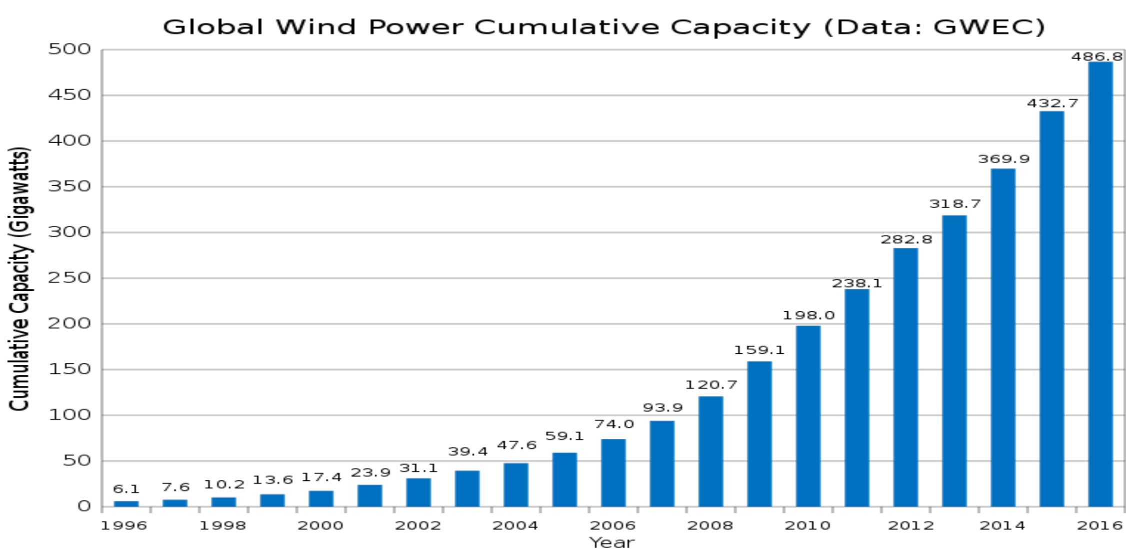

Figure 1. The above graph shows Global Growth of installed capacity, this was shown by GWEC, Global wind report annual market update 2011.

Summary

Accordingly, an object of the present research is to provide an improved wind energy and storage system. Another object of the present research is to provide a wind energy and storage system that includes direct compression wind turbines, where the rotor is directly connected to one or more compressors .Yet another object of the present research is to provide a wind energy and storage system that includes direct compression wind turbines that dispatches electrical energy to a production facility. Another object of the present research is to provide a wind energy and storage system that has a top-of turbine power to weight ratio greater than 1 megawatt/15 tons. These and other objects of the present research are achieved in a wind energy generating and storage system that has a plurality of direct compression wind turbine stations. A storage device is coupled to at least a portion of the wind turbine stations. At least a first compressor is coupled to the storage device to compress air. At least one expander is configured to release compressed air from the storage device. A generator is configured to convert com pressed air energy into electrical energy. The direct compression wind turbine system has a top of tower power to weight ratio greater than 1 megawatt/10 tons excluding blades and rotor.

Detailed description

A plurality of direct compression wind turbine stations 12 are provided. An inter cooler 13 can be included. Direct compression is direct rotational motion of a shaft or a rotor coupled to one or more compressors 16. A storage device 14 is coupled to at least a portion of the wind turbine stations 12. At least a first toroidal intersecting vane compressor 16 is coupled to the storage device to compress or liquefy air. The compressor 16 has a fluid intake opening and a fluid exhaust opening. Rotation of a turbine 18 drives the compressor 16. At least one expander 20 is configured to release compressed or liquid air from the storage device 14. A generator 22 is configured to convert the compressed or liquid air energy into electrical energy. 0019. In various embodiments, the compressor 16 operates at a pressure of about, 10 to 100 atmospheres at the fluid exhaust opening, 20 to 100 atmospheres, 10 to 80 atmospheres and the like. In various embodiments, the compressor has a minimum operating pressure for power storage of at least 20 atmospheres, has a peak pressure to low pressure ratio of about 10/1, has a peak pressure to low pressure ratio of about 5/1 and the like. In one embodiment the system 10 has a top of tower power to weight ratio greater than 1 megawatt/10 tons excluding blades and rotor. 0021. The compressor 16 is much lighter, and therefore less expensive than the generator 22 and gearbox it replaces. The best power-to-weight machine in current wide scale commercial use is the Vestas 3 MW machine, which has a nacelle weight of 64 tons. In another embodiment, illustrated in FIG. 1(b) a first multi-stage compressor 16 is coupled to the storage device 14 to compress air. In another embodiment, a pres Sure of compressed air in the storage device 14 is greater than 8 bar. The cost efficiency of storing compressed air in pipe changes dramatically with high pressure pipe and high pressure compressors 16. For relatively little extra cost, storage can increase an order of magnitude. 80 bar air holds ten times the energy storage of 8 barr air

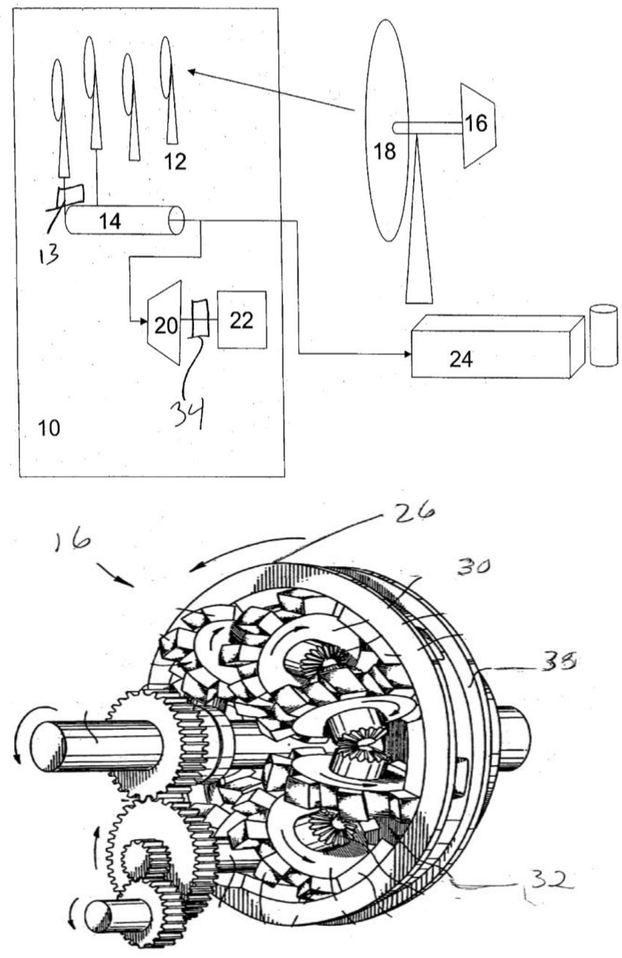

FIG. 2

Figure 2: One embodiment of the present invention is a wind energy generating and storage

In one embodiment of the present invention, a method of production collects and stores wind energy from a plurality of direct compression wind turbine stations 12. Air is compressed or liquefied air is formed from the wind energy utilizing a toroidal intersecting Vane compressor 16. An expander 20 is used to release compressed or liquid air. An absorber is introduced to the compressed or liquid air for pressure Swing absorption. The absorber is used for air separation into oxygen or nitrogen, argon, and other air products. In one embodiment, the absorber absorbs at a higher pressure and desorbs at a lower pressure. 0024. In one embodiment, at least a portion of the electrical energy, vacuum pressure, compressed air, heat from compression and liquid air or another compressed fluid from the system 10 is dispatchable to a production facility 24. 0.025 Suitable production facilities 24 include but are not limited to an aluminium production facility, a fertilizer, ammonia, or urea production facility, a liquid air product production facility that can be used in manufacturing liquid air, liquid oxygen, liquid nitrogen, and other liquid air products, a fresh water from desalination production facility, a ferrosilicon production facility, an electricity intensive

Figure 3: Wind Mills

chemical process or manufacturing facility, a tire recycling plant, coal burning facility, biomass burning facility, medical facility, cryogenic cooling process, or any plant that gasifies liquid oxygen, nitrogen, argon, CO. , an ethanol production facility, a food processing facility. Examples of food processing facilities include but are not limited to, dairy or meat processing facilities. In one embodiment, electricity provided by the system 10 is used to electrolyze water at the production facility 24. In another embodiment, the system 10 is con figured to provide pressure used at the production facility 24 to drive a reverse or forward osmosis process. In another embodiment, the system 10 is configured to provide at least one of vacuum or heat to drive a distillation process at the production facility 24. In one embodiment, the compressor 16 compresses fluid that is evaporating from fluid in a distillation process. In another embodiment, compressed fluid that is evaporating from a distillation process is returned to exchange its heat with liquid in an evaporation or distillation process. The production or processing facility 24 can be co-located with the system 10. In one embodiment, the system 10 is configured to receive waste heat from the production facility 24 and utilize at least a portion of the waste heat to provide the electrical energy that is dispatched to the production facility 24. By way of illustration, and, without limitation, the system 10 provides electricity for the reduction of carbon dioxide or water and can pressurize carbon dioxide to provide power to electrolyze the carbon dioxide to separate carbon from oxygen. The system 10 can be used to pressurize carbon dioxide and water to a Supercritical state and provide power for reaction of these components to methanol. Hydrogen can be introduced to the carbon to create hydrocarbon fuels. The oxygen can be utilized to oxy-fire coal, process iron ore, burncol, process iron ore and the like. The system 10 can be used to provide a vacuum directly to the production facility 24. This could assist, for example, in the production of products at low temperature distillation facilities, such as fresh water at desalination plants. By way of illustration, and without limitation, as shown in FIG. 2 the toroidal intersecting vane compressor 16 includes a Supporting structure 26, a first and second intersecting rotors 28 and 30 rotatably mounted in the supporting structure 26. The first rotor 28 has a plurality of primary vanes positioned in spaced relationship on a radially inner peripheral surface of the first rotor 28. The radially inner peripheral surface of the first rotor 28 and a radially inner peripheral Surface of each of the primary vanes can be transversely concave, with spaces between the primary Vanes and the inside Surface to define a plurality of primary chambers 32. The second rotor 30 has a plurality of secondary Vanes positioned in spaced relationship on a radially outer peripheral surface of the second rotor. The radially outer peripheral surface of the second rotor 30 and a radially outer peripheral Surface of each of the secondary vanes can be transversely convex. Spaces between the secondary Vanes and the inside Surface define a plurality of secondary chambers 32.

A first axis of rotation of the first rotor 28 and a second axis of rotation of the second rotor 30 are arranged so that the axes of rotation do not intersect. The first rotor 28,second rotor 30, primary vanes and secondary Vanes are arranged so that the primary Vanes and the secondary vanes intersect at only one location during their rotation. The toroidal intersecting vane compressor 16 can be self-synchronizing. In one embodiment, the turbine 18 is configured to power the compressor(s) 16. For example, the turbine 18 can drive the compressor 16 by a friction wheel drive that is frictionally connected to the turbine 18 and is connected by a belt, a chain, or directly to a drive shaft or gear of the compressor 16. The compressed air can be heated or cooled. The compressed air can be heated or cooled while main training Substantially constant Volume. The compressed air can be heated or cooled while maintaining Substantially constant pressure. The compressed air can be heated or cooled by a heat source selected from at least one of the following: Solar, ocean, river, pond, lake, other sources of water, power plant effluent, industrial process effluent, com bustion, nuclear, and geothermal energy. The expander 20 can operate independently of the turbine 18 and the compressor 16. The expander 20 and compressor 16 can be approximately the same or different sizes. A heat exchanger 34 can be provided and coupled to an expander exhaust opening.

At least a portion of the compressed air energy can be used as a coolant. In one specific embodiment, a rotatable turbine 18 is mounted to a mast. In one embodiment, as mentioned above, a toroidal intersecting vane compressor (TIVC) 16 is used. The TIVC is characterized by a fluid intake opening and a fluid exhaust opening, wherein the rotation of the turbine 18 drives the compressor 16. The system 10 permits good to excellent control over the hours of electrical power generation, thereby maximizing the commercial opportunity and meeting the public need during hours of high or peak usage. Additionally, the system 10 minimizes and can avoid the need to place an electrical generator 22 off-shore. The system 10 allows for an alternative method for transmission of power over long distance. Further, the system 10 can be operated with good to excellent efficiency rates. In one embodiment, a generator apparatus 22 includes, (a) a rotatable turbine 18 mounted to a mast, (b) at least one toroidal intersecting vane compressor 16 characterized by a fluid intake opening and a fluid exhaust opening, wherein the rotation of the turbine 18 drives the compressor 16; (c) a conduit having a proximal end and a distal end wherein the proximal end is attached to the fluid exhaust opening; (d) at least one toroidal intersecting Vane expander 20 characterized by a fluid intake opening attached to the distal end; (e) an electrical generator 22 operably attached to the expander 20 to convert rotational energy into electrical energy, and to connect the generator 22 to one or more customers or the electric grid to sell the electricity.

The turbine 18 can be powered to rotate by a number of means apparent to the person of skill in the art. One example is air flow, such as is created by wind. In this embodiment, the turbine 18 can be a wind turbine, such as those well known in the art. One example of a wind turbine is found in U.S. Pat. No. 6,270,308, which is incorporated herein by reference. Because wind velocities are particularly reliable offshore, the turbine 18 can be configured to stand or float off shore, as is known in the art. In yet another embodiment, the turbine 18 can be powered to rotate by water flow, such as is generated by a river or a dam. 0037 As mentioned above, the compressor 16 is prefer ably a toroidal intersecting vane compressor 16, Such as those described in Chomyszak U.S. Pat. No. 5,233,954, issued Aug. 10, 1993 and Tomcyzk, U.S. patent application Publication No. 2003/0111040, published Jun. 19, 2003. The contents of the patent and publication are incorporated herein by reference in their entirety. In a particularly preferred embodiment, the toroidal intersecting vane compressor 16 and elements of the system 10, are found in U.S. Publications Nos. 2005132999, 2005133000 and 20055232801, each incorporated herein fully by reference. 0038. In one embodiment, two or more toroidal intersecting vane compressors 16 are utilized. The compressors 16 can be configured in series or in parallel and/or can each be single stage or multistage compressors 16. The compressor 16 will generally compress air, however, other environments or applications may allow other compressible fluids to be used. The air exiting the compressor 16 through the compressor exhaust opening will directly or indirectly fill a conduit. Multiple turbines 18, and their associated compressors 16, can fill the same or different conduits. For example, a single conduit can receive the compressed air from an entire wind turbine farm, wind plant or wind power facility. Alternatively or additionally, the “wind turbine farm” or, the turbines 18 therein, can fill multiple conduits. The conduit(s) can be used to collect, store, and/or transmit the compressed fluid, or air. Depending upon the Volume of the conduit, large Volumes of compressed air can be stored and transmitted. The conduit can direct the air flow to a storage vessel or tank or directly to the expander 20. The conduit is preferably made of a material that can withstand high pressures, such as those generated by the compressors 16.

Further, the conduit should be manufactured out of a material appropriate to withstand the environmental stresses. For example, where the wind turbine 18 is located offshore, the conduit should be made of a material that will withstand seawater, Such as pipelines that are used in the natural gas industry. The compressed air can be heated or cooled in the conduit or in a slip, or side, stream off the conduit or in a storage vessel or tank. Cooling the fluid can have advantages in multi-stage compressing. Heating the fluid can have the advantage of increasing the energy stored within the fluid, prior to Subjecting it to an expander 20. The compressed air can be subjected to a constant Volume or constant pressure heating or cooling. The source of heating can be passive or active. For example, Sources of heat include Solar, ocean, river, pond, lake, other sources of water, power plant effluent, industrial process effluent, combustion, nuclear, and geothermal energy.

Result and Discussion

The conduit, or compressed air, can be passed through a heat exchanger to cool waste heat, such as can be found in power plant streams and effluents and industrial process streams and effluents (e.g., liquid and gas waste streams). In yet another embodiment, the compressed air can be heated via combustion. Like the TIVC, the expander 20 is preferably a toroidal intersecting vane expander 20 (TIVE), such as those described by Chomyszak, referenced above. Thus, the toroidal intersecting vane expander 20 can comprise a Support ing structure, a first and second intersecting rotors rotatably mounted in the Supporting structure, the first rotor having a plurality of primary vanes positioned in spaced relationship on a radially inner peripheral surface of the first rotor with the radially inner peripheral surface of the first rotor and a radially inner peripheral surface of each of the primary Vanes being transversely concave, with spaces between the primary vanes and the inside Surface defining a plurality of primary chambers, the second rotor having a plurality of secondary vanes positioned in spaced relationship on a radially outer peripheral surface of the second rotor with the radially outer peripheral surface of the second rotor and a radially outer peripheral surface of each of the secondary Vanes being transversely convex, with spaces between the secondary vanes and the inside Surface defining a plurality of secondary chambers, with a first axis of rotation of the first rotor and a second axis of rotation of the second rotor arranged so that the axes of rotation do not intersect, the first rotor, the second rotor, primary vanes and secondary Vanes being arranged so that the primary Vanes and the secondary Vanes intersect at only one location during their rotation. Similarly, the toroidal intersecting vane expander 20 is self-synchronizing. Like the TIVC, the expanders 20 can be multistage or single stage, used alone, in series or in parallel with additional TIVEs. A single TIVE can service a single conduit or multiple conduits. One of the advantages of the present invention is the ability to collect the compressed air or other fluid and convert the compressed air or fluid to electricity independently of each other. As such, the electricity generation can be accomplished at a different time and in a shorter, or longer, time period, as desired. Such as during periods of high power demand or when the price of the energy is at its highest. As such, the expander 20 is preferably configured to operate independently of the turbine 18 and compressor 16. Further, because the conduit that is directing the com pressed fluid, or air, to the expander 20 can be of a very large volume, the expander 20 need not be located proximally with the turbine 18 and compressor 16. As such, even where the wind turbine 18 is located offshore, the expander 20 can be located on land, Such as at a power plant, thereby avoiding the need to transmit electricity from the wind farm to the grid or customer. Further, the sizes and capacities of the TIVCs and TIVEs can be approximately the same or different. The capacity of the TIVE is preferably at least 0.5 times, the capacity of the TIVCs it services, preferably the capacity of the TIVE exceeds the capacity of the TIVCs it services. Generally, the capacity of the TIVE is between about 1 and 5 times the capacity of the TIVCs it serves. For example, if 100 turbines 18, with 100 TIVCs, each have a capacity of 2 megawatts, a TIVE that services all 100 turbines 18, preferably has the capacity to produce 100 megawatts, prefer ably at least about 200 to 1,000 megawatts. Of course, TIVEs and TIVCs of a wide range of capacities can be designed.

Multiplication of this *X* power and lifetime makes the total produced energy. The energy cost is delivered by dividing system cost by this energy. The wind pattern of 24 h repetition in above equation is changed to 6 h and 48 h to simulate different wind pattern. The units "kWh-t" mean energy storage by the thermal mode. The cost of tower and blade is estimated from published data. Expected future cost of NaS battery is employed. The practical NaS battery system cost including substation is 660$/kWh, i.e. 66 k\/kWh in the case of Long Island Bus PJ

Conclusion

A wind energy generating and storage system, com prising: a plurality of direct compression wind turbine stations, wherein direct compression is direct rotational motion of a shaft or a rotor coupled to one or more compressors; a storage device coupled to the at least a portion of the wind turbine stations; at least a first compressor coupled to the storage device to compress air, at least one expander configured to release compressed air from the storage device; and a generator configured to convert compressed air energy into electrical energy, wherein the direct compression wind turbine system has a top of tower power to weight ratio greater than 1 megawatt/10 tons excluding blades and rotor.

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