

**WIND TURBINE APPARATUS, METHOD FOR DELIVERING AIR TO
IMPELLER OF WIND TURBINE APPARATUS, AND SYSTEM FOR
GENERATING ELECTRIC ENERGY**

5 TECHNICAL FIELD

[0001] The present disclosure relates generally to operation of wind turbines. In particular, the present disclosure relates to improving efficiency of operation of wind turbines. Further, the present disclosure relates to a wind turbine apparatus that may be installed at site easily.

10 BACKGROUND

[0002] Background description includes information that may be useful in understanding the present invention. It is not an admission that any of the information provided herein is prior art or relevant to the presently claimed invention, or that any publication specifically or implicitly referenced is prior art.

15 [0003] In regions, such as, residential areas, cities, suburbs, etc. wind velocities are generally lower. Moreover, due to low availability of space, such areas may not be feasible for open blade wind power systems. Horizontal axis turbines with exposed blades may be installed at heights of greater than 80 meters for large capacity systems. For smaller capacities, the same systems may be scaled down to be used. However, such systems may not
20 be suitable at low wind velocities and may not be safe for operation owing to open rotating blades. Similarly, vertical axis turbines may not be scaled to increase power output, and may have maintenance issues since the wind load is not balanced across their rotor.

[0004] There is therefore a requirement in the art for a wind power generation means that may be used in regions with low inlet wind velocities, that are also safe to operate.

25 OBJECTS OF INVENTION

[0005] An object of the present invention is to provide a wind turbine apparatus that operates with improved efficiency.

[0006] Another object of the present invention is to provide a wind turbine apparatus operable at low wind speeds and varying speeds.

30 [0007] Another object of the present invention is to provide a wind turbine apparatus that may be operable by wind flowing in any direction.

[0008] Another object of the present invention is to provide a wind turbine apparatus that

may be installed at site easily.

[0009] Another object of the present invention is to provide a wind turbine apparatus that is compact.

5 [0010] Another object of the present invention is to provide a system for electric energy generation that includes one or more wind turbine apparatus stacked on top of each other.

[0011] Another object of the present invention is to provide a system for electric energy generation that is scalable.

SUMMARY

10 [0012] The present disclosure relates generally to operation of wind turbines. In particular, the present disclosure relates to improving efficiency of operation of wind turbines. Further, the present disclosure relates to a wind turbine apparatus that may be installed at site easily.

15 [0013] In a first aspect, the present disclosure provides a wind turbine apparatus. The wind turbine apparatus includes an inlet. The inlet includes a receiving section adapted to receive air along a first direction of the wind turbine apparatus. The inlet further includes a converging section disposed subsequent to, and downstream of the receiving section. The converging section is adapted to receive, and direct the air along a second direction of the wind turbine apparatus. The converging section is adapted to accelerate the received air as the air moves from a first end to a second end of the converging section. The wind turbine apparatus further includes an impeller disposed along the second direction, downstream of the inlet. The impeller is adapted to receive the air from the converging section. The received air impinges on the impeller to effect rotation of the impeller.

20 [0014] In some embodiments, the wind turbine apparatus further includes an outlet disposed downstream of the impeller, and adapted to allow exit of the air from the impeller from the wind turbine apparatus.

[0015] In some embodiments, the receiving section has a first cross-sectional area. The converging section has a tapered profile, varying from the first cross-sectional area at its first end to a second cross-sectional area lesser than the first cross-sectional area at its second end.

25 [0016] In some embodiments, the first cross-sectional area is defined as a function of a height of the receiving section along the second direction.

[0017] In some embodiments, the wind turbine apparatus further includes actuators operable to move a top wall of the inlet to vary the height of the receiving section.

[0018] In some embodiments, the wind turbine apparatus further includes a shaft coupled

to the impeller. The shaft is adapted to transmit rotary motion generated by the impeller.

[0019] In some embodiments, the shaft is adapted to be coupled to an electric generator. The electric generator is configured to generate electric energy based on rotary motion of the shaft.

5 [0020] In some embodiments, the wind turbine apparatus is adapted to be mounted on a mounting structure. The mounting structure is a pole.

[0021] In some embodiments, the mounting structure is adapted to accommodate one or more wind turbine apparatus.

10 [0022] In some embodiments, the impeller is any one of an axial flow impeller and a tangential flow impeller.

[0023] In a second aspect, the present disclosure provides a method for delivering air to an impeller of a wind turbine apparatus. The method includes providing an inlet. The inlet includes a receiving section adapted to receive air along a first direction of the wind turbine apparatus. The inlet further includes a converging section disposed subsequent to, and
15 downstream of the receiving section. The converging section is adapted to receive, and direct the air along a second direction of the wind turbine apparatus. The converging section is adapted to accelerate the received air as the air moves from a first end to a second end of the converging section. The method further includes directing, by the receiving section of the inlet, air received therethrough to the converging section. The converging section is adapted
20 to accelerate the received air as the air moves therethrough. The method further includes directing the air from the converging section towards the impeller to allow the received air to impinge on the impeller to effect rotation of the impeller.

[0024] In a third aspect, the present disclosure provides a system for generating electric energy. The system includes one or more wind turbine apparatus stacked on a mounting
25 structure along a second direction. Each of the one or more wind turbine apparatus includes an inlet. The inlet includes a receiving section adapted to receive air along a first direction of the wind turbine apparatus. The inlet further includes a converging section disposed subsequent to, and downstream of the receiving section. The converging section is adapted to receive, and direct the air along a second direction of the wind turbine apparatus. The
30 converging section is adapted to accelerate the received air as the air moves from a first end to a second end of the converging section. Each of the one or more wind turbine apparatus further includes an impeller disposed along the second direction, downstream of the inlet, and adapted to receive the air from the converging section. The received air impinges on the impeller to effect rotation of the impeller. The system further includes at least one electric

generator coupled to the one or more wind turbine apparatus and configured to generate electric energy based on rotary motion of the respective impellers of the one or more wind turbine apparatus.

5 [0025] In some embodiments, the system further includes a central shaft coupled to the one or more impellers of the respective one or more wind turbine apparatus. The at least one electric generator is coupled to the central shaft.

[0026] In some embodiments, the at least one electric generator includes one or more electric generators. Each of the one or more electric generators is coupled to a corresponding wind turbine apparatus.

10 [0027] Various objects, features, aspects, and advantages of the inventive subject matter will become more apparent from the following detailed description of preferred embodiments, along with the accompanying drawing figures in which like numerals represent like components.

BRIEF DESCRIPTION OF DRAWINGS

15 [0028] The accompanying drawings are included to provide a further understanding of the present disclosure and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the present disclosure and, together with the description, serve to explain the principles of the present disclosure.

[0029] FIG. 1A illustrates a schematic sectional diagram of a system for generation of
20 electric energy, according to an embodiment of the present disclosure;

[0030] FIG. 1B illustrates a schematic sectional diagram of a system for generation of electric energy, according to another embodiment of the present disclosure;

[0031] FIG. 2 illustrates a schematic sectional view of a single wind turbine apparatus of the system of FIG. 1, according to an embodiment of the present disclosure;

25 [0032] FIG. 3 illustrates a schematic flow diagram for a method for delivering air to an impeller of the wind turbine apparatus of FIGs. 1 and/or 2, according to an embodiment of the present disclosure;

[0033] FIG. 4A illustrates an exemplary schematic sectional view of the wind turbine apparatus having a first value for a first cross-sectional area of its inlet;

30 [0034] FIG. 4B illustrates an exemplary schematic sectional view of the wind turbine apparatus having a second value for a first cross-sectional area of its inlet; and

[0035] FIG. 4C illustrates an exemplary schematic sectional view of the wind turbine apparatus having a third value for a first cross-sectional area of its inlet; and.

DETAILED DESCRIPTION

[0036] The following is a detailed description of embodiments of the disclosure depicted in the accompanying drawings. The embodiments are in such details as to clearly communicate the disclosure. However, the amount of detail offered is not intended to limit
5 the anticipated variations of embodiments; on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present disclosure as defined by the appended claims.

[0037] In a first aspect, the present disclosure provides a wind turbine apparatus. The wind turbine apparatus includes an inlet. The inlet includes a receiving section adapted to
10 receive air along a first direction of the wind turbine apparatus. The inlet further includes a converging section disposed subsequent to, and downstream of the receiving section. The converging section is adapted to receive, and direct the air along a second direction of the wind turbine apparatus. The converging section is adapted to accelerate the received air as the air moves from a first end to a second end of the converging section. The wind turbine
15 apparatus further includes an impeller disposed along the second direction, downstream of the inlet. The impeller is adapted to receive the air from the converging section. The received air impinges on the impeller to effect rotation of the impeller.

[0038] In some embodiments, the wind turbine apparatus further includes an outlet disposed downstream of the impeller, and adapted to allow exit of the air from the impeller
20 from the wind turbine apparatus.

[0039] In some embodiments, the receiving section has a first cross-sectional area. The converging section has a tapered profile, varying from the first cross-sectional area at its first end to a second cross-sectional area lesser than the first cross-sectional area at its second end.

[0040] In some embodiments, the first cross-sectional area is defined as a function of a
25 height of the receiving section along the second direction.

[0041] In some embodiments, the wind turbine apparatus further includes actuators operable to move a top wall of the inlet to vary the height of the receiving section.

[0042] In some embodiments, the wind turbine apparatus further includes a shaft coupled to the impeller. The shaft is adapted to transmit rotary motion generated by the impeller.

30 [0043] In some embodiments, the shaft is adapted to be coupled to an electric generator. The electric generator is configured to generate electric energy based on rotary motion of the shaft.

[0044] In some embodiments, the wind turbine apparatus is adapted to be mounted on a mounting structure. The mounting structure is a pole.

[0045] In some embodiments, the mounting structure is adapted to accommodate one or more wind turbine apparatus.

[0046] In some embodiments, the impeller is any one of an axial flow impeller and a tangential flow impeller.

5 [0047] In a second aspect, the present disclosure provides a method for delivering air to an impeller of a wind turbine apparatus. The method includes providing an inlet. The inlet includes a receiving section adapted to receive air along a first direction of the wind turbine apparatus. The inlet further includes a converging section disposed subsequent to, and downstream of the receiving section. The converging section is adapted to receive, and direct
10 the air along a second direction of the wind turbine apparatus. The converging section is adapted to accelerate the received air as the air moves from a first end to a second end of the converging section. The method further includes directing, by the receiving section of the inlet, air received therethrough to the converging section. The converging section is adapted to accelerate the received air as the air moves therethrough. The method further includes
15 directing the air from the converging section towards the impeller to allow the received air to impinge on the impeller to effect rotation of the impeller.

[0048] In a third aspect, the present disclosure provides a system for generating electric energy. The system includes one or more wind turbine apparatus stacked on a mounting structure along a second direction. Each of the one or more wind turbine apparatus includes
20 an inlet. The inlet includes a receiving section adapted to receive air along a first direction of the wind turbine apparatus. The inlet further includes a converging section disposed subsequent to, and downstream of the receiving section. The converging section is adapted to receive, and direct the air along a second direction of the wind turbine apparatus. The converging section is adapted to accelerate the received air as the air moves from a first end
25 to a second end of the converging section. Each of the one or more wind turbine apparatus further includes an impeller disposed along the second direction, downstream of the inlet, and adapted to receive the air from the converging section. The received air impinges on the impeller to effect rotation of the impeller. The system further includes at least one electric generator coupled to the one or more wind turbine apparatus and configured to generate
30 electric energy based on rotary motion of the respective impellers of the one or more wind turbine apparatus.

[0049] In some embodiments, the system further includes a central shaft coupled to the one or more impellers of the respective one or more wind turbine apparatus. The at least one electric generator is coupled to the central shaft.

[0050] In some embodiments, the at least one electric generator includes one or more electric generators. Each of the one or more electric generators is coupled to a corresponding wind turbine apparatus.

[0051] FIG. 1A illustrates a schematic sectional diagram of a system 100 for generation of electric energy, according to an embodiment of the present disclosure. The system 100 may be defined along first and second directions 110, 112. The second direction 112 may be substantially orthogonal to the first direction 110. In the illustrated embodiment of FIG. 1, the first direction 110 may be along a horizontal direction, and the second direction 112 may be along a vertical direction. The system 100 may include one or more wind turbine apparatus 200-1, 200-2...200-N. The one or more wind turbine apparatus 200-1, 200-2...200-N may be individually and/or collectively referred to as "the apparatus 200". The apparatus 200 may be stacked one on top of another and mounted on a mounting structure 102. In other words, the apparatus 200 may be stacked on the mounting structure 102 along the second direction 112 defined for the system 100. In some embodiments, the mounting structure 102 may be a pole.

[0052] The system 100 may further include a central shaft (not shown in figure). In some embodiments, the central shaft may be a single shaft coupled to each of the apparatus 200. In some embodiments, the central shaft may kinematically coupled to respective shafts of each apparatus 200. The central shaft may receive rotary motion from the apparatus 200, and may itself rotate. The rotary motion of the central shaft may be a function of a sum of rotary motions received from each apparatus 200. In some other embodiments, the respective shafts of each apparatus 200 may be adapted to be independently arranged to each other. In other words, in such embodiments, there may not be a central shaft that kinematically links the respective shafts of each apparatus 200.

[0053] The system 100 may further include an electric generator 104 coupled to the central shaft. Rotation of the central shaft may effect an operation of the electric generator 104 causing the electric generator 104 to generate electric energy.

[0054] The system 100 may further include other components, such as, without limitations, electric circuitry configured to extract the electric energy generated by the electric generator 104, inverters, battery banks, electric circuitry to transmit the generated electric energy to other components such as a grid, a controller to control operations of the apparatus 200 and/or the electric generator 104, various sensors, etc. However, such components are not shown in FIG. 1A for the sake of clarity.

[0055] FIG. 1B illustrates a schematic sectional diagram of a system 150 for generation of electric energy, according to another embodiment of the present disclosure. Referring now

to FIGs. 1A and 1B, the system 150 is substantially similar to the system 100. Common components between the system 100 and the system 150 are referenced using the same reference numerals. The system 150 includes one or more electric generators 154-1, 154-2...154-N. The electric generators 154-1, 154-2...154-N may be individually referred to as
5 “the electric generator 154” and collectively referred to as “the electric generators 154”. Each electric generator 154 may be coupled with a shaft of a corresponding apparatus 200. Each of the apparatus 200 may cause a respective electric generator 154 to operate to generate electric energy.

[0056] FIG. 2 illustrates a schematic sectional view of a single apparatus 200 mounted
10 on the mounting structure 102, according to an embodiment of the present disclosure. In some embodiments, each of the apparatus 200 may have a substantially similar structure and design. Referring to FIGs. 1A to 2, the apparatus 200 may be arranged along the second direction 112 and a first direction 110 that is orthogonal to the second direction 112.

[0057] The apparatus 200 includes an inlet 202. The inlet 202 may include a receiving
15 section 204 and a converging section 206. The receiving section 204 may be adapted to receive air along the first direction 110 of the apparatus 200. In some embodiments, the receiving section may be adapted to receive air at least along the first direction 110. In other words, in such embodiments, the receiving section 204 may be oriented such that at least a portion of the air received by the receiving section 204 is along the first direction 110. In the
20 illustrated embodiment, the receiving section 204 may be oriented such that at least a portion of the air received by the receiving section 204 is along the horizontal direction. In some embodiments, the inlet 202 may be disposed such that air flowing in any direction may still enter the inlet 202.

[0058] In some embodiments, the receiving section 204 may have a first cross-sectional
25 area A1. In some embodiments, the first cross-sectional area A1 may be defined as a function of a height h1 of the receiving section, measured along the second direction 112. In some embodiments, the apparatus 200 may have a preconfigured height h1. The height h1 may be set during an initial assembly or manufacture of the apparatus 200. The height h1 may be set according to wind velocity data provided for a region in which the apparatus 100 is to be
30 installed.

[0059] In some embodiments, the apparatus 200 may further include actuators (not shown in figure). The actuators may be operable to vary the height h1 of the receiving section 204 to consequently vary the first cross-sectional area A1. By varying the cross-sectional area A1, a quantity of air entering the receiving section 204 may be correspondingly varied. In an

exemplary implementation, the actuators may be configured to move any one or both of a top wall 203-1 and a bottom wall 203-2 of the inlet 202 along the second direction 112 in order to either increase or decrease the height h_1 of the receiving section. In such a case, the apparatus 200 may be configured to dynamically determine varying wind velocity rates in the region in which it is installed. The wind velocity may be determined through sensors (not shown in figure) disposed in the apparatus 200 that are configured to measure wind velocity, or from a connected database configured to store information pertaining to wind velocity in the region in which the apparatus 200 is installed, or a combination thereof.

[0060] In some embodiments, the receiving section 204 may further include components, such as, without limitations, a valve (not shown in figure) that selectively allow air to enter the receiving section 204. For example, the valve may be configured to any one of open and close to correspondingly allow and block air from entering the receiving section 204 of the inlet 202. In some other embodiments, the valve may be configured to open to different limits, such that an effective first cross-sectional area A_1 of the receiving section 204 of the inlet varies. With a variation in the first cross-sectional area A_1 of the receiving section 204, a quantity of air entering the receiving section 204 may be correspondingly varied.

[0061] The converging section 206 is fluidically coupled to the receiving section 204. Further, the converging section is disposed subsequent to, and downstream of the receiving section 204. The converging section 206 may be coupled to the receiving section 204 at a first end 208 of the converging section 206. As a result, the first end 208 of the converging section may have a first cross-sectional area A_1 . The converging section 206 may have a tapered profile, such that the cross-sectional area of the converging section 206 decreases from the first end 208 to a second end 210 of the converging section 206. The second end 210 of the converging section 206 may have a second cross-sectional area A_2 that is less than the first cross-sectional area A_1 . Further, the converging section 206 may be designed such that the second end 210 of the converging section 206 is substantially along the second direction 112. Thus, the converging section 206 is adapted to receive, and direct the air from the receiving section 204, along the second direction 112. Furthermore, due to the tapered profile of the converging section 206, the air flowing through the converging section 206 is accelerated when moving from the first end 208 to the second end 210 of the converging section 206. As a result, the air exiting the converging section 206 of the inlet 202 may possess a higher velocity than the air entering the converging section 206. In other words, the air exiting the converging section 206 may possess a greater kinetic energy.

[0062] The apparatus 200 further includes an impeller 212 disposed along the second direction 112. The impeller 212 may be fluidically coupled to the converging section 206 of the inlet 202, and may be adapted to receive the air from the converging section 206. The received air may impinge on the impeller 212, effecting rotation of the impeller 212. In some
5 embodiments, the impeller 212 may include a plurality of impeller blades 214 arranged about a circumference of the impeller 212. As the air from the converging section impinges on the impeller, the air may pass through the impeller blades 214. The air may lose a portion of its kinetic energy to the impeller 212, causing the impeller 212 to rotate. A higher the amount of kinetic energy possessed by the air, a greater may be a rotary torque provided to the impeller
10 212 to rotate. Since the converging section 206 increases the kinetic energy of the air, the impeller 212 may rotate with greater torque (i.e., with higher velocity) than it would if the converging section 206 was not present.

[0063] Further, since the converging section 206 causes an acceleration of the air, the apparatus 200 may be implemented in regions where the ambient wind speed may be low. In
15 other words, the apparatus 200 may be implemented in regions where a velocity of air received by the receiving section 204 is low. The low velocity air may subsequently be accelerated to suitable or required velocities by the converging section 206.

[0064] In some embodiments, the impeller 212 may define a flow area A_f . The flow area A_f may refer to a cross-sectional area of the impeller 212 through which the air flows. The
20 flow area A_f of the impeller 212 may be a constant or uniform value. The flow area A_f may be predetermined during an initial manufacturing or assembly of the impeller 212. Further, the impeller 212 may define a design flow velocity V_f . The design flow velocity may refer to a flow velocity of air through the impeller 212 that facilitated optimal rotation of the impeller 212.

25 [0065] In some embodiments, the impeller 212 may be a tangential flow impeller or an axial flow impeller. Referring to FIG. 1A, the system 100 may include a mix of tangential flow impeller-based wind turbine apparatus and axial flow impeller-based wind turbine apparatus to be stacked on top of each other.

[0066] Referring again to FIGs. 1A to 2, the apparatus 200 further includes an outlet 216
30 disposed downstream of the impeller 212. The outlet 216 is adapted to allow air from the impeller 212 to exit the apparatus 200.

[0067] In some embodiments, the apparatus 200 includes a shaft (not shown in figure) coupled to the impeller 212. The shaft is adapted to carry the rotary motion of the impeller 212. The shaft may then be coupled to the electric generator 104 causing the electric

generator 104 to generate electric energy.

[0068] FIG. 3 illustrates a schematic flow diagram for a method 300 for delivering air to the impeller 212 of the apparatus 200, according to an embodiment of the present disclosure. Referring to FIGs. 1A to 3, at step 302, the method 300 includes providing the inlet 202 including the receiving section 204 and the converging section 206. At step 304, the method 300 further includes directing, by the receiving section 204, air received therethrough to the converging section 206. At step 306, the method 300 further includes directing the air from the converging section 206 towards the impeller 212 to allow the received air to impinge on the impeller 212 to effect rotation of the impeller 212.

[0069] FIG. 4A illustrates an exemplary schematic sectional view of an apparatus 400 having a first value for a first cross-sectional area A1 of its inlet 202. The apparatus 400 is substantially similar to the apparatus 200 of FIG. 2. Common elements between the apparatus 200 and the apparatus 400 are referenced using the same reference numerals. In the apparatus 400, the receiving section 204 of the inlet 202 has a first cross-sectional area A1-a. In the illustrated embodiment of FIG. 4A, the design flow rate Vf may be 5 meters per second (m/s); a ratio of first cross-sectional area A1-a to flow area Af may be A1-a/Af = 5; and a velocity of air entering the receiving section 204 of the apparatus 400 may be V1 = 1 m/s.

[0070] The apparatus 400 may operate based on continuity equation and Bernoulli's principle. In other words, a mass flow rate of air through the apparatus 400 may be constant. Therefore,

$$\text{Mass Flow through inlet} = \text{Mass flow through impeller}$$

$$A1 - a \times V1 = Af \times Vf$$

$$Vf = \frac{A1 - a \times V1}{Af}$$

$$Vf = 5 \times 1 = 5 \text{ m/s}$$

[0071] Thus, having a first cross-sectional area of A1-a when V1 is 1 m/s facilitates design flow rate value of 5m/s to be achieved.

[0072] FIG. 4B illustrates an exemplary schematic sectional view of the apparatus 450 having a second value for a first cross-sectional area A1 of its inlet 202. The apparatus 450 is substantially similar to the apparatus 400 of FIG. 4A. Common elements between the apparatus 400 and the apparatus 450 are referenced using the same reference numerals. In the apparatus 450, the receiving section 204 of the inlet 202 has a first cross-sectional area A1-b. In the illustrated embodiment of FIG. 4B, the design flow rate Vf may be 5 meters per second

(m/s); the area A1-b may be twice the area A1-a; a ratio of first cross-sectional area A1-b to flow area Af may be $A1-b/Af = 2 \times (A1-a)/Af = 2 \times 5 = 10$; and a velocity of air entering the receiving section 204 of the apparatus 400 may be $V1 = 0.5$ m/s.

Mass Flow through inlet = Mass flow through impeller

$$A1 - b \times V1 = Af \times Vf$$

$$Vf = \frac{A1 - b \times V1}{Af}$$

$$Vf = 10 \times 0.5 = 5 \text{ m/s}$$

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[0073] Thus, having a first cross-sectional area of A1-b when V1 is 0.5 m/s facilitates design flow rate value of 5m/s to be achieved.

[0074] FIG. 4C illustrates an exemplary schematic sectional view of the apparatus 470 having a third value for a first cross-sectional area A1 of its inlet 202. The apparatus 470 is substantially similar to the apparatus 400 of FIG. 4A. Common elements between the apparatus 400 and the apparatus 470 are referenced using the same reference numerals. In the apparatus 470, the receiving section 204 of the inlet 202 has a first cross-sectional area A1-c. In the illustrated embodiment of FIG. 4C, the design flow rate Vf may be 5 meters per second (m/s); the area A1-c may be a fourth of the area A1-a; a ratio of first cross-sectional area A1-c to flow area Af may be $A1-c/Af = 0.25 \times (A1-a)/Af = 0.25 \times 5 = 1.25$; and a velocity of air entering the receiving section 204 of the apparatus 400 may be $V1 = 4$ m/s.

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Mass Flow through inlet = Mass flow through impeller

$$A1 - c \times V1 = Af \times Vf$$

$$Vf = \frac{A1 - c \times V1}{Af}$$

$$Vf = 1.25 \times 4 = 5 \text{ m/s}$$

[0075] Thus, having a first cross-sectional area of A1-c when V1 is 4 m/s facilitates design flow rate value of 5m/s to be achieved.

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[0076] It should be apparent to those skilled in the art that many more modifications besides those already described are possible without departing from the inventive concepts herein. The inventive subject matter, therefore, is not to be restricted except in the spirit of the appended claims. Moreover, in interpreting both the specification and the claims, all terms

should be interpreted in the broadest possible manner consistent with the context. In particular, the terms “comprise” and “comprising” should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced. Where the specification claims refer to at least one of something selected from the group consisting of A, B, C ...and N, the text should be interpreted as requiring only one element from the group, not A plus N, or B plus N, etc. The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the appended claims.

[0077] While the foregoing describes various embodiments of the invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof. The scope of the invention is determined by the claims that follow. The invention is not limited to the described embodiments, versions, or examples, which are included to enable a person having ordinary skill in the art to make and use the invention when combined with information and knowledge available to the person having ordinary skill in the art.

ADVANTAGES OF INVENTION

[0078] The present invention provides a wind turbine apparatus that operates with improved efficiency.

[0079] The present invention provides a wind turbine apparatus operable at low wind speeds and varying speeds.

[0080] The present invention provides a wind turbine apparatus that may be operable by wind flowing in any direction.

[0081] The present invention provides a wind turbine apparatus that may be installed at site easily.

[0082] The present invention provides a wind turbine apparatus that is compact.

[0083] The present invention provides a system for electric energy generation that includes one or more wind turbine apparatus stacked on top of each other.

[0084] The present invention provides a system for electric energy generation that is scalable.

I Claim:

1. A wind turbine apparatus (200), comprising:
 - an inlet (202) comprising:
 - a receiving section (204) adapted to receive air along a first direction (110) of
5 the wind turbine apparatus (200); and
 - a converging section (206) disposed subsequent to, and downstream of the
receiving section (204), adapted to receive, and direct the air along a second
direction (112) of the wind turbine apparatus (200), wherein the converging
section (206) is adapted to accelerate the received air as the air moves from a first
10 end (208) to a second end (210) of the converging section (206); and
 - an impeller (212) disposed along the second direction (112), downstream of the
inlet (202), and adapted to receive the air from the converging section (206), wherein
the received air impinges on the impeller (212) to effect rotation of the impeller (212).
2. The wind turbine apparatus (200) as claimed in claim 1, wherein the wind turbine
15 apparatus (200) further comprises an outlet (216) disposed downstream of the
impeller (212), and adapted to allow exit of the air from the impeller (212) from the
wind turbine apparatus (200).
3. The wind turbine apparatus as claimed in claim 1, wherein the receiving section (204)
has a first cross-sectional area (A1), and wherein the converging section (206) has a
20 tapered profile varying from the first cross-sectional area (A1) at its first end (208) to
a second cross-sectional area (A2) lesser than the first cross-sectional area (A1) at its
second end (210).
4. The wind turbine apparatus as claimed in claim 3, wherein the first cross-sectional
area (A1) is defined as a function of a height (h1) of the receiving section (204) along
25 the second direction (112).
5. The wind turbine apparatus (200) as claimed in claim 4, wherein the wind turbine
apparatus (200) comprises actuators operable to move any one of a top wall (203-1)
and a bottom wall (203-2) of the inlet (202) to vary the height (h1) of the receiving
section (204).

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6. The wind turbine apparatus (200) as claimed in claim 1, wherein the wind turbine apparatus (200) comprises a shaft coupled to the impeller (212), the shaft adapted to transmit rotary motion generated by the impeller (212).
7. The wind turbine apparatus (200) as claimed in claim 4, wherein the shaft is adapted to be coupled to an electric generator (104), the electric generator (104) configured to generate electric energy based on rotary motion of the shaft.
8. The wind turbine apparatus (200) as claimed in claim 1, wherein the wind turbine apparatus (200) is adapted to be mounted on a mounting structure (102), and wherein the mounting structure (102) is a pole.
9. The wind turbine apparatus (200) as claimed in claim 8, wherein the mounting structure (102) is adapted to accommodate one or more wind turbine apparatus (200).
10. The wind turbine apparatus (200) as claimed in claim 1, wherein the impeller (212) is any one of an axial flow impeller and a tangential flow impeller.
11. A method (300) for delivering air to an impeller (212) of a wind turbine apparatus (200), the method (300) comprising:
- providing an inlet (202) comprising:
- a receiving section (204) adapted to receive air along a first direction (110) of the wind turbine apparatus (200); and
- a converging section (206) disposed subsequent to, and downstream of the receiving section (204), adapted to receive, and direct the air along a second direction (112) of the wind turbine apparatus (200), wherein the converging section (206) is adapted to accelerate the received air as the air moves from a first end (208) to a second end (210) of the converging section (206);
- directing, by the receiving section (204) of the inlet (202), air received therethrough to the converging section (206), wherein the converging section (206) is adapted to accelerate the received air as the air moves therethrough; and
- directing the air from the converging section (206) towards the impeller (212) to allow the received air to impinge on the impeller (212) to effect rotation of the impeller (212).

12. A system (100) for generating electric energy, the system (100) comprising:
one or more wind turbine apparatus (200) stacked on a mounting structure (102)
along a second direction (112), each of the one or more wind turbine apparatus (200)
comprising:
- 5 an inlet (202) comprising:
 a receiving section (204) adapted to receive air along a first direction
 (110) of the wind turbine apparatus (200); and
 a converging section (206) disposed subsequent to, and downstream of the
receiving section (204), adapted to receive, and direct the air along the
10 second direction (112) of the wind turbine apparatus (200), wherein the
converging section is adapted to accelerate the received air as the air moves
from a first end (208) to a second end (210) of the converging section (206);
and
 an impeller (212) disposed along the second direction (112), downstream of
15 the inlet (202), and adapted to receive the air from the converging section (206),
wherein the received air impinges on the impeller (212) to effect rotation of the
impeller (212); and
 at least one electric generator (154) coupled to the one or more wind turbine
apparatus (200) and configured to generate electric energy based on rotary motion of
20 the respective impellers (212) of the one or more wind turbine apparatus (200).
13. The system (100) as claimed in claim 12, wherein the system (100) further comprises
a central shaft coupled to the one or more impellers (212) of the respective one or
more wind turbine apparatus (200), and wherein the at least one electric generator
(154) is coupled to the central shaft.
- 25 14. The system (100) as claimed in claim 12, wherein the at least one electric generator
(154) comprises one or more electric generators (154), each of the one or more
electric generators (154) coupled to a corresponding wind turbine apparatus (200).