

WIND AND EXHAUST AIR ENERGY RECOVERY SYSTEM

FIELD OF INVENTION

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The present invention relates to a wind and exhaust air energy recovery system with a safety enclosure. More particularly, the invention relates to a system to reuse exhaust air from an exhaust outlet as well as natural wind energy to generate electricity.

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BACKGROUND OF THE INVENTION

Cooling towers are heat removal devices used to transfer waste heat out to the atmosphere by means of water, fan or the combination. They are usually used in oil refineries, chemical plants and large buildings such as hospitals, offices and schools for removal of heat as well as to cool down the temperature within. Cooling towers with ventilators are mechanically driven by fans and motors to draw out heated air from outlets of cooling towers. The drawn out air at the outlets usually has high wind speed and velocity.

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With the vast demand of electrical energy, wind power electrical generator systems where wind energy is converted to electrical energy through exhausted air are known in numerous patented technologies. One prior art which discloses a system in which wind power is converted to electrical power is US Patent Number US4447738. A system comprises a wind mill activating an air compressor to generate a supply of pressurized air and an air motor is activated by the supply of pressurized air to drive a generator is disclosed. However, this prior art utilizes additional energy to pressurized the exhausted air and consequently increases its power consumption.

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U.S. Patent Publication Number US2009/0224556A1 on the other hand discloses an energy recovery system that utilizes exhaust air flow from a ventilation system or exhaust to generate electrical energy. While the prior art discloses a windmill that rotates about a vertical axis of the exhaust air flow, it does not explore the rotation of the windmill about a horizontal axis. Moreover, the prior art provides a plurality of guide vanes that extends away from the body of the exhaust. Air flow is therefore not directed at an angle that optimize a wind-stream to interact with the windmill.

Therefore there is a need for a system to capture maximum exhaust air flow in order to generate a sufficiently large amount of electricity.

SUMMARY OF INVENTION

Accordingly, it is a primary object of the present invention to provide a system to reuse exhaust air from any exhaust outlet to generate electricity and/or mechanical power.

It is another object of the present invention to provide a system to generate electricity and/or mechanical power using wind energy when there is no exhaust air.

It is yet another object of the present invention to provide an efficient system that uses inexhaustible resource to generate electricity and/or mechanical power. The inexhaustible resource is natural wind energy and exhaust air flow.

It is another object of the present invention to provide an electrical generating system that does not produce hazardous emissions and waste that damage the environment.

It is a further object of the present invention to provide a wind and exhaust air energy

recovery system that is easily installed neighbouring to any existing exhaust or ventilation outlets.

It is yet another object of the present invention to provide a system to reduce the power consumption of power-driven fans located in the exhaust outlets.

To fulfill the aforementioned objectives, a wind and exhaust air energy recovery system comprising a supportive frame; a turbine rotor assembly mounted on the supportive frame and being able to rotate about a horizontal axis; wherein the turbine rotor assembly are positioned neighbouring an exhaust outlet that exhaust air flow from the outlet in which the exhaust air flow drives the turbine rotor assembly to rotate; and a electric generator connected to the turbine rotor assembly for converting kinetic energy caused by movement of the turbine rotor assembly to electrical or mechanical energy; characterized in that at least one guide vane is arranged in between the outlet and the turbine rotor assembly to direct the air flow towards the turbine rotor assembly at a predetermined angle. Exhaust air flow is directed towards the turbine rotor assembly so that the turbine rotor assembly that interacts with an optimum air flow speed is able to rotate at high speed, thus generating large amount of electricity.

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Another embodiment of the present invention discloses that the predetermined angle of the guide vanes ranges from -80 degrees to 80 degrees in relative to the vertical axis of the exhaust air flow.

25 Yet another embodiment of the present invention discloses that the system further comprises at least one air diffuser.

Still another embodiment of the present invention discloses that the air diffuser is a plate, air duct or a combination thereof.

Another embodiment of the present invention describes that the air diffuser is a plate being inclined outwardly in an angle ranging from 2 to 30 degrees in relative to the vertical axis of the exhaust air flow.

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Another embodiment of the present invention discloses that the exhaust outlet is an outlet from a ventilation system, air-conditioning system, cooling tower, heat exchanger or furnace.

- 10 A further embodiment of the present invention discloses that the supportive frame includes at least one holding structure and a safety enclosure.

The present preferred embodiments of the invention consists of novel features and a combination of parts hereinafter fully described and illustrated in the accompanying
15 drawings and particularly pointed out in the appended claims; it being understood that various changes in the details may be effected by those skilled in the arts but without departing from the scope of the invention or sacrificing any of the advantages of the present invention.

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BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects and advantages of the present invention will be more fully understood when considered with respect to the following detailed descriptions,
25 appended claims and accompanying drawings wherein:

Figure 1 shows a cross-sectional view of a wind and exhaust air energy recovery system in accordance with the preferred embodiment of the present invention.

Figure 2 shows a perspective view of a wind and exhaust air energy recovery system in accordance with the preferred embodiment of the present invention.

Figure 3 shows an enlarged fragmentary view of the turbine rotor assembly (103),
5 supportive frame (101) and a safety enclosure (102) in accordance with the embodiments of the present invention.

Figure 4 shows a perspective view of two wind and exhaust air energy system with air diffuser (205) in accordance with the embodiments of the present invention.

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Figure 5 shows a cross-sectional view of two wind and exhaust air energy recovery systems positioned neighbouring to an exhaust outlet (111) in accordance with an embodiment of the present invention.

15 Figure 6 shows a side view of two a wind and exhaust air energy recovery systems positioned neighbouring to an exhaust outlet (111) in accordance with an embodiment of the present invention.

20 DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, the present invention shall be described according to the preferred embodiments of the present invention and by referring to the accompanying description and drawings. However, it is to be understood that limiting the description
25 to the preferred embodiments of the invention and to the drawings is merely to facilitate discussion of the present invention and it is envisioned that those skilled in the art may devise various modifications without departing from the scope of the appended claim.

Referring to Figure 1 and Figure 2, the present invention is aimed at providing an efficient wind and exhaust air energy recovery system comprising a supportive frame (101); a safety enclosure (102); a turbine rotor assembly (103) mounted on the supportive frame (101) and being able to rotate about a horizontal axis; wherein the turbine rotor assembly (103) are positioned neighbouring an exhaust outlet (111) that exhaust air flow from the outlet (111) in which the exhaust air flow drives the turbine rotor assembly (103) to rotate; and at least one electric generator connected to the turbine rotor assembly (103) for converting kinetic energy caused by movement of the turbine rotor assembly (103) to electrical or mechanical energy; characterized in that at least one guide vane (107) is arranged in between the outlet (111) and the turbine rotor assembly (103) to direct the air flow towards the turbine rotor assembly (103) at a predetermined angle. Exhaust air flow is directed towards the turbine rotor assembly (103) by the guide vane (107) so that the turbine rotor assembly (103) that interacts with an optimum air flow speed is able to rotate at high speed, thus generating large amount of electricity.

Still referring to Figure 1 and Figure 2, the supportive frame (101) and the safety enclosure (102), having the turbine rotor assembly (103) mounted within, are positioned neighbouring to the exhaust outlet (111) and preferred to be spaced at a distance. The distance is essential to prevent drawback of the exhaust air flow performance of the power driven fan (115) from the exhaust outlet (111) as well as to capture the optimum velocity of air flow. The supportive frame (101) having the safety enclosure (102) can be supported with additional holding structures (109) so as to be firmly secured to the exterior of the exhaust outlet (111) without obstructing the exhaust air flow.

Now referring to Figure 4, the system further comprises at least one air diffuser (205) which are placed neighbouring the exhaust outlet (111). The air diffuser (205) is a plate, air duct or a combination thereof. The air duct can be a circular duct. The air

diffuser (205) improves the aerodynamic properties by enhancing the transition between the low velocity of exhaust air flow from the exhaust outlet (111) and the high velocity exhaust air flow towards the turbine rotor assembly (103). The air diffuser (205) accelerate the exhaust air flow from the exhaust outlet (111) towards
5 the turbine rotor assembly (103). Preferably, the air diffuser (205) is a pair of diffuser plates being inclined outwardly in an angle ranging from 2 to 30 degrees in relative to the vertical axis of the exhaust air flow. The diffuser plates can be placed at the outer surface of the supportive frame (101) each at opposite side or replacing the supportive frame (101) to hold on to the turbine rotor assembly (103). The inclined diffuser
10 plates create a widening effect for the exhaust air flow from the exhaust outlet, thus decreasing the pressure behind the turbine rotor assembly (103) so that mass flow rate of the exhaust air flow is increased.

In yet another embodiment of the present invention discloses that the predetermined
15 angle of each guide vane (107) ranges from -80 degrees to 80 degrees in relative to the vertical axis of the exhaust air flow. The guide vanes (107) are constructed to such a preferred angle so as to guide an optimum amount of exhaust air flow towards the turbine rotor assembly (103). The optimum angle of exhaust air flow is directed to act on the turbine rotor assembly (103), which therefore rotates at a relatively high speed.
20 The guide vanes (107) create a venturi effect where velocity of the exhaust air flow is increased to approximately 30% to 50%. Besides, a low pressure region is created by the system at the exhaust outlet (111) and this induces more exhaust air towards the turbine rotor assembly (103), consequently reduces the power consumption of the power-driven fan (113).

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A further embodiment of the present invention discloses that the exhaust outlet (111) is an outlet from a ventilation system or cooling tower. The exhaust outlet (111) can be outlet of an air-conditioning system, heating system or ventilation system of a building, factory, heat exchanger, furnace, fireplace, mine or tunnel. The exhaust air is

the air discharged from any system where the exhausted air is not being put into applicable usage. The velocity of exhaust air expelled from these outlets varies depending on the air flow volume delivered by power driven fans (115) within the outlets (111).

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Based on the embodiments of the present invention, the turbine rotor assembly (103) comprises a plurality of rotor blades (201) extended from the longitudinal axis of an axle (105). The plurality of rotor blades (201) are extended radially from the longitudinal axis of the axle (105). Preferably, each rotor blade (201) is connected to a rotor arm (203) extended from the axle (105), as shown in Figure 3. Each rotor blade (201) is preferred to be in a form of an air foil which has a hollow body in order to reduce the weight of the rotor blade (201), moment of inertia of the rotation as well as to allow the exhaust air flow to rotate the turbine rotor assembly (103) even at low velocity. The exhaust air flow exiting the exhaust outlet (111) acts upon the plurality of rotor blades (201) and consequently rotates the turbine rotor assembly (103).

In accordance to the preferred embodiment of the present invention, the supportive frame (101) supports the rotor assembly (103). Preferably, the supportive frame (101) supports the rotor assembly (103) at the axle (105) of the turbine rotor assembly (103). The axle (105) is preferred to be rotatable through direct drive or transmission system such as a bearing, belt-pulley system or gearbox upon the rotation of the turbine rotor assembly (103) so as to act on the electric generator to generate electrical power through a power transmission system. The bearing or gearbox functions to allow one rotational motion of the axle (105) and provide a constant direction and speed to the axle (105).

Another embodiment of the present invention discloses that the turbine rotor assembly (103) is positioned neighbouring the exhaust outlet (111). As the exhaust air flow is directed towards the turbine rotor assembly (103), the turbine rotor assembly (103) is

turned by the moving exhaust air. The turbine rotor assembly (103) tends to rotate about an axis that is perpendicular or approximately perpendicular to the streamlines of the exhaust air flow. Alternatively, the turbine rotor assembly (103) is rotatable by wind energy. It should be understood that the turbine rotor assembly (103) is able to rotate even it is not pointed to the direction of the wind energy. As such, when the exhaust outlet (111) is not operating to produce exhaust air, wind flowing from variable directions is able to act on the rotor blades (201) to rotate the turbine rotor assembly (103). At least one electric generator is preferred to be connected to the axle (105) to convert the rotating kinetic energy to electricity.

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Alternatively, the turbine rotor assembly (103) can be a Savonius-type rotor assembly, a Darrieus-type rotor assembly or any other turbine rotor assembly that can rotate about a horizontal axis.

15 In another aspect of the present invention, the supportive frame (101) is preferred to have a safety enclosure. Most preferably, the safety enclosure is a layer of mesh. The mesh is able to enclose the supportive frame (101) in order to enhance safety features of the system. The possibility of injury or damage caused by the turbine rotor assembly's failure is reduced by blocking any object from flying inwards and
20 outwards of the supportive frame (101) such as bird strike and turbine rotor assembly (103) fly off. The mesh is preferred not to obstruct the exhaust air flow or reduce the exhaust air flow from the exhaust outlet (111).

The exhaust outlet (111) may also employ two or more of the wind and exhaust air
25 energy recovery systems as disclosed in the embodiments of the present invention. Referring to Figure 5 and Figure 6, two similar sized exhaust air recovery systems are employed. Preferably, each system has turbine rotor assembly (103) rotating in opposite directions from the other system and the guide vanes (107) in opposite angles. Exhaust outlet (111) with huge diameter is preferred to employ more than two

systems so as to recover maximum amount of kinetic energy. The plurality of systems can also be positioned in stacks or layers. Diameter of the turbine rotor assembly (103) may vary from 0.2 times to 1.5 times the diameter of the exhaust outlet (111).

- 5 Electricity generated by the present invention can be used to reduce the electrical power requirements of operating the ventilation or exhaust system. Electrical energy usage of the ventilation or exhaust system can be reduced to 10% to 15% of the total electrical energy used. The electrical power output of the present invention is dependent upon the velocity of the exhaust air flow acting on the turbine rotor
10 assembly (103). It is to be understood that different performance characteristics may be utilized for the exhaust air flow expelled from the exhaust outlet (111).

- Although this disclosure has described and illustrated certain preferred embodiments of the invention, it is to be understood that the invention is not restricted to those
15 particular embodiments. Rather, the invention include all embodiments which are functional or mechanical equivalence of the specific embodiments and features that have been described and illustrated.

20 **EXAMPLE**

An example is provided below to illustrate different aspects and embodiments of the present invention. The example is not intended in any way to limit the disclosed invention, which is limited only by the claims.

25 **Example 1**

An example of the present invention is described to show the effectiveness of the wind and exhaust air energy recovery system. A cooling tower having exhaust outlet in a diameter of 2 meters is equipped with the exhaust air recovery system as described according to the embodiments of the present invention. The cooling tower,

without the addition of the present invention, consumes approximately 0.5 kWh of electricity in certain period. With the addition of the wind and exhaust air energy recovery system as described in the embodiments of the present invention, approximately at a distance of 0.7m, nearly 13% of power consumption is reduced by
 5 utilizing the electricity produced back to the cooling tower. As a result, the cooling tower as described in this example merely uses 0.43kWh of electricity, which is a reduction of approximately 65Wh.

10 Example 2

Laboratory testing model	Cooling tower without wind and exhaust air energy recovery system	Cooling tower with wind and exhaust air energy recovery system (without guide vanes)	Cooling tower with wind and exhaust air energy recovery system (with guide vanes and diffuser plates)
Current consumption of cooling tower's fan motor	0.39 Ampere	0.39 Ampere	0.39 Ampere
Intake air velocity	1.6 – 1.8 m/s	1.6 – 1.8 m/s	1.6 – 1.8 m/s
turbine rotor assembly rotational speed	-	115 rpm	150 rpm

Table 1

Table 1 shows a laboratory testing results on a scaled model according to the preferred
 15 embodiment of the present invention. The purpose of the laboratory testing is to recover part of the exhaust air energy from a cooling tower without causing negative impact on the performance of the cooling tower. Based on a set-up of the scaled model of the cooling tower, the air flow speed measured from the outlet (111) of the cooling tower is 8.0 m/s. The power consumption or current drawn by a fan motor

- (113) of the cooling tower is approximately 0.39 Ampere and the intake air velocity is in the range of 1.6 to 1.8 m/s. For comparison, the wind and exhaust air energy recovery system without the guide vanes is installed at the cooling tower's exhaust outlet (111). A constant rotational speed of 115 rpm is recorded for the turbine rotor assembly (103). Whereas for the wind and exhaust air energy recovery system with the guide vanes (107) and the diffuser plates as disclosed in the preferred embodiment of the present invention, the rotational speed of 150 rpm is recorded for the turbine rotor assembly (103).
- 10 The results as shown in Table 1 explains that the guide vanes (107) and diffuser plates effectively increase the speed of the turbine rotor assembly (103) by approximately 30.4%. There was no difference on the current consumption and intake air velocity of the cooling tower for all three test conditions. The result shows that the installation of the system will not affect the performance of the cooling tower or any exhaust outlets
- 15 and no additional load is added on the fan motor (113).

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CLAIMS

1. A wind and exhaust air energy recovery system comprising
5 a supportive frame (101);
a turbine rotor assembly (103) mounted on the supportive frame (101) and
being able to rotate about a horizontal axis; wherein the turbine rotor assembly
(103) are positioned neighbouring an exhaust outlet (111) that exhaust air flow
from the outlet (111) in which the exhaust air flow drives the turbine rotor
10 assembly (103) to rotate; and
at least one electric generator connected to the turbine rotor assembly (103) for
converting kinetic energy caused by movement of the turbine rotor assembly
(103) to electrical or mechanical energy;
characterized in that at least one guide vane (107) is arranged in between the
15 outlet (111) and the turbine rotor assembly (103) to direct the air flow towards
the turbine rotor assembly (103) at a predetermined angle.
2. A system according to claim 1, wherein the predetermined angle of the guide
vane (107) ranges from -80 degrees to 80 degrees in relative to the vertical
20 axis of the exhaust air flow.
3. A system according to claim 1 further comprises at least one air diffuser (205).
4. A system according to claim 3, wherein the air diffuser (205) is a plate, air
25 duct or a combination thereof.
5. A system according to claim 4, wherein the air diffuser (205) is a plate being
inclined outwardly in an angle ranging from 2 to 30 degrees in relative to the
vertical axis of the exhaust air flow.

6. A system according to claim 1, wherein the exhaust outlet (111) is an outlet from a ventilation system, air-conditioning system, cooling tower, heat exchanger or furnace.

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7. A system according to claim 1, wherein the supportive frame (101) includes at least one holding structure (109) and a safety enclosure (102).