Horizontal and Vertical Axis Wind Turbines

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I. SIGNIFICANCE[1]

Wind turbines are good media for generating electricity from a clean and renewable resource for our homes and businesses. It comes with a couple of advantages for both humans and the environment, namely the following:

- A wind turbine can harness a plentiful energy source, wind.
- The use of wind electricity can cut our carbon footprint (the total amount of greenhouse gases used to support human activity[2]) because it doesn't release any harmful gases or pollutants in the process of generating electricity.
- The use of wind energy can cut our electricity bills because wind is free, and thus, after the payment for the initial installation, electricity costs will be reduced.
- We can store energy even on a calm day. If our houses are not connected to the National Power Grid, we can store the excess electricity produced from the wind turbine in batteries and use it when there is no wind.
- We can sell electricity back to the grid, meaning if our wind system is producing more than what we need, someone else can use it, and thus, we can sell it.

II. DEFINITION OF WIND TURBINES

Wind turbines are machines that generate electricity from the kinetic energy of the wind. In history,they were more frequently used as a mechanical device that turned machinery. Today, turbines can be used to generate large amounts of electrical energy in wind farms both onshore and offshore. [3]

There are two kinds of wind turbine, namely the Horizontal Axis Wind Turbine (HAWT)

1 "Wind Turbines". Energy Saving Trust. Energy Saving Trust.org. 8 March 2011. <http://www.energysavingtrust.org.uk/Generate-your-own-energy/Wind-Turbines#Thebenefitsofwindelectricity>
2 "What is a carbon footprint- definition". Time for Change. Time for Change. 8 March 2011. <http://timeforchange.org/what-is-a-carbon-footprint-definition>
3 "Wind Turbines". Wind Turbines. Alternative Energy. 8 March 2011. <http://www.alternative-energy-news.info/technology/wind-power/wind-turbines/>

and the Vertical Axis Wind Turbine (VAWT). Though many VAWTs are used nowadays to produce electricity, the HAWT still remains more practical and popular than the VAWT and is assumed as the focus of most wind turbine discussions.[4]

III. HORIZONTAL AXIS WIND TURBINES

a. Definition

Illustration 1: Horizontal Axis Wind Turbine

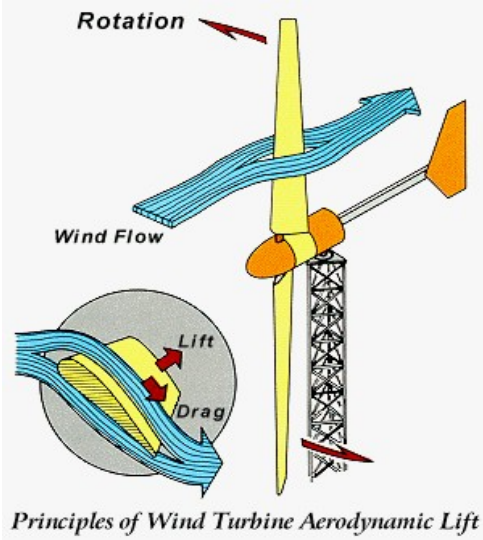

Illustration 2: Principle behind HAWTs

The horizontal wind turbine is a turbine in which the axis of the rotor's rotation is parallel to the wind stream and the ground. Most HAWTs today are two- or three-bladed, though some may have fewer or more blades. There are two kinds of Horizontal Axis Wind Turbines: the upwind wind turbine and the downwind wind turbine.

The HAWT works when the wind passes over both surfaces of the airfoil shaped blade but passes more rapidly at the upper side of the blade, thus, creating a lower-pressure area above the airfoil. The difference in the pressures of the top and bottom surfaces results in an aerodynamic lift. The blades

4 "Wind Turbine Types". The Solar Guide. The Solar Guide. 8 March 2011.<http://www.thesolarguide.com/wind-power/turbine-types.aspx>

of the wind turbine are constrained to move in a plane with a hub at its center, thus, the lift force causes rotation about the hub. In addition to the lifting force, the drag force,which is perpendicular to the lift force, impedes rotor rotation.[5]

b. Kind/ Types

1. Upwind Turbine[6]

Illustration 3: Upwind Wind Turbine

The upwind turbine is a type of turbine in which the rotor faces the wind. A vast majority of wind turbines have this design. Its basic advantage is that it avoids the wind shade behind the tower. On the other hand, its basic drawback is that the rotor needs to be rather inflexible, and placed at some distance from the tower. In addition, this kind of HAWT also needs a yaw mechanism to keep the rotor facing the wind.

2. Downwind Turbine[7]

5 "horizontal-axis wind turbine (HAWT)". The Encyclopedia of Alternative Energy and Sustainable Living. Worlds of David Darling. 8 March 2011. <http://www.daviddarling.info/encyclopedia/H/AE_horizontal-axis_wind_turbine.html>

6 "upwind turbine". The Encyclopedia of Alternative Energy and Sustainable Living. Worlds of David Darling. 8 March 2011. <http://www.daviddarling.info/encyclopedia/U/AE_upwind_wind_turbine.html>

7 "downwind wind turbine". The Encyclopedia of Alternative Energy and Sustainable Living. Worlds of David Darling. 8 March 2011.

Illustration 4: Downwind Wind Turbine

The downwind turbine is a turbine in which the rotor is on the downwind side (lee side) of the tower. It has the theoretical advantage that they maybe built without a yaw mechanism,considering that their rotors and nacelles have the suitable design that makes the nacelle follow the wind passively. Another advantage is that the rotor may be made more flexible. Its basic drawback, on the other hand, is the fluctuation in the wind power due to the rotor passing through the wind shade of the tower.

c. Advantages and Disadvantages[8]

The advantages of the HAWT over the VAWT, according to the Norwegian University of Science and Technology, is:

- blades are to the side of the turbine's center of gravity, helping stability
- the turbine collects the maximum amount of wind energy by allowing the angle of attack to be remotely adjusted
- the ability to pitch the rotor blades in a storm so that damage is minimized
- the tall tower allows the access to stronger wind in sites with wind shear and placement on uneven land or in offshore locations

<http://www.daviddarling.info/encyclopedia/D/AE_downwind_wind_turbine.html>

8 "Advantages and disadvantages with HAWT". NTNU. NTNU. 8 March 2011.<http://www.ivt.ntnu.no/offshore2/?page_id=391>

- most HAWTs are self-starting
- can be cheaper because of higher production volume

On the other hand, the disadvantages of the HAWT compared to the VAWT is that:

- it has difficulties operating near the ground
- the tall towers and long blades are hard to transport from one place to another and they need a special installation procedure
- they can cause a navigation problem when placed offshore

IV. VERTICAL AXIS WIND TURBINES

a. Definition[9]

The vertical axis wind turbine is an old technology,dating back to almost 4,000 years ago. Unlike the HAWT, the rotor of the VAWT rotates vertically around its axis instead of horizontally. Though it is not as efficient as a HAWT, it does offer benefits in low wind situations wherein HAWTs have a hard time operating. It tends to be easier and safer to build, and it can be mounted close to the ground and handle turbulence better than the HAWT. Because its maximum efficiency is only 30%,it is only usually just for private use.

b. Kinds/ Types[10]

1. Darrieus Turbine

9 "Vertical Axis Wind Turbine (VAWT)". NTNU. NTNU. 8 March 2011. <http://www.ivt.ntnu.no/offshore2/?page_id=394>
10 "Vertical Axis Wind Turbine (VAWT)". NTNU. NTNU. 8 March 2011. <http://www.ivt.ntnu.no/offshore2/?page_id=394>

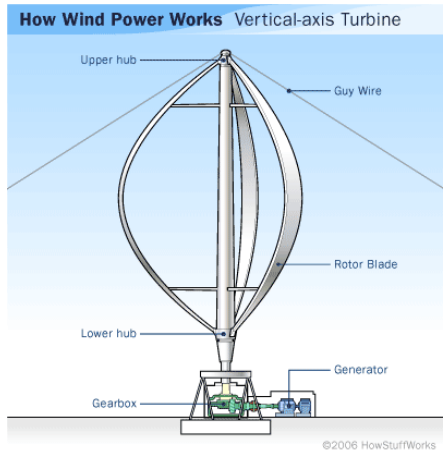

Illustration 5: Darrieus Wind Turbine

The Darrieus turbine is composed of a vertical rotor and several vertically-oriented blades. A small powered motor is required to start its rotation, since it is not self-starting. When it already has enough speed, the wind passing through the airfoils generate torque and thus, the rotor is driven around by the wind. The Darrieus turbine is then powered by the lift forces produced by the airfoils. The blades allow the turbine to reach speeds that are higher than the actual speed of the wind, thus, this makes them well-suited to electricity generation when there is a turbulent wind.

2. Giromill Turbine

Illustration 7: Helical Giromill Wind Turbine

Illustration 6: Giromill Wind Turbine

The Giromill Turbine is a special type of Darrieus Wind Turbine. It uses the same principle as the Darrieus Wind Turbine to capture energy , but it uses 2-3 straight blades individually attached to the vertical axis instead of curved blades. It is alsoapplicable to use helical blades attached around the vertical axis to minimize the pulsating torque.

3. Savonius Turbine

Illustration 8: Savonius Wind Turbine

The Savonius wind turbine is one of the simplest turbines. It is a drag-type device that consists of two to three scoops. Because the scoop is curved,the drag when it is moving with the wind is more than when it is moving against the

wind. This differential drag is now what causes the Savonius turbine to spin. Because they are drag-type devices, this kind of turbine extracts much less than the wind power extracted by the previous types of turbine.

c. Advantages and Disadvantages[11]

Just like the HAWT, the VAWT also comes with a handful of advantages over the HAWT, namely:

- since VAWT components are placed nearer to the ground, it has an easier access to maintenance
- smaller cost of production, installation, and transport
- turbine does not need to be pointed towards the wind in order to be effective
- VAWTs are suitable in places like hilltops, ridgelines and passes
- blades spin at a lower velocity, thus, lessening the chances of bird injury
- suitable for areas with extreme weather conditions like mountains

The disadvantages of the VAWT, on the other hand are:

- most of them are only half as efficient as HAWTs due to the dragging force
- air flow near the ground and other objects can create a turbulent flow, introducing issues of vibration
- VAWTs may need guy wires to hold it up (guy wires are impractical and heavy in farm areas)

SIDELINE NOTES

11 "Advantages and disadvantages with VAWT". NTNU. NTNU. 8 March 2011. <http://www.ivt.ntnu.no/offshore2/?page_id=396>

Picture references:

Illustration 1. [Horizontal Axis Wind Turbine] "HorizontalAxis Wind Turbines". Wind Turbines Now. Wind Turbines Now. 8 March 2011.<http://www.windturbinesnow.com/horizontalaxis-windturbines.htm>

Illustration 2. [Principle behind HAWTs] "horizontal-axis wind turbine (HAWT)". The Encyclopedia of Alternative Energy and Sustainable Living. Worlds of David Darling. 8 March 2011.<http://www.daviddarling.info/encyclopedia/H/AE_horizontal-axis_wind_turbine.html>

Illustration 3. [Upwind Wind Turbine] "Upwind Turbine vs. Downwind". Power-talk. Power-talk.net. 8March 2011. <http://www.power-talk.net/upwind-turbine.html>

Illustration 4. [Downwind Wind Turbine] "Upwind Turbine vs. Downwind". Power-talk. Power-talk.net. 8March 2011. <http://www.power-talk.net/upwind-turbine.html>

Illustration 5. [Darrieus Wind Turbine] Layton, Julia. How Wind Power Works. howstuffworks. Howstuffworks. 8 March 2011. <http://science.howstuffworks.com/environmental/green-science/wind-power2.htm>

Illustration 6. [Helical Giromill Wind Turbine] "Wind Turbine Types". WindDose. WindDose.com. 8 March 2011.<http://winddose.com/wind-turbine-techologies.html>

Illustration 7. [Giromill Wind Turbine] "Giromill Darrieus Wind Turbines". REUK. 30 January 2007. REUK.co.uk. 8 March 2011.<http://www.reuk.co.uk/Giromill-Darrieus-Wind-Turbines.htm>

Illustration 8. [Savonius Wind Turbine] "Savonius Wind Turbines". REUK. 23 July2008. REUK.co.uk. 8 March2011.<http://www.reuk.co.uk/Savonius-Wind-Turbines.htm>