ENE 505 – Applied Computational Fluid Dynamics in Renewable Energy Technologies

WEEK 7: Vertical Axis Wind Turbines

VERTICAL AXIS WIND TURBINES (VAWT):

- **VAWT Technology:**

  - All types of vertical axis wind turbines (VAWTs) have the main rotor shaft arranged vertically
  - It can take advantage of any wind direction where wind shifts direction or where turbulent flow exists
  - Vertical rotor does not require a yawing mechanism for accepting the wind from any direction so they need less moving parts and in addition it can provide direct rotary drive to a fixed load [1]
  - Blades of VAWT may be of uniform section and untwisted, making them relatively easy to fabricate or extrude, unlike the blades of HAWT, which should be twisted and tapered for optimum performance.
  - It is also expected that the maintenance costs will be minimal with VAWTs in comparison to Horizontal Axis Wind Turbines (HAWT) or diesel gensets typically used as a backup or off-grid power source. Under these backdrops, straight-bladed VAWT is expected to be ideal for urban and remote applications in Canada, which has a huge wind energy potential [2].

- **VAWT Classifications:**

  - Vertical axis wind turbines (VAWT) were initially started as drag devices (Savonious) and only recently researchers have given emphasis into the lift driven vertical axis wind turbines. The lift driven wind turbines were proposed by a French engineer, Darrieus, in 1925 [3]. Vertical axis wind turbines are generally described in three fundamental types:

    - Savonious wind turbines

- Darrieus wind turbines
- Giromill or H-Rotor wind turbines

  - All types of vertical axis wind turbines (VAWTs) have the main rotor shaft arranged vertically.
  - It can take advantage of any wind direction where wind shifts direction or where turbulent flow exists.
  - Thus, this design works equally well with winds from any direction, enabling it to easily accommodate horizontal and vertical wind shear.

- **VAWT Disadvantages:**

  - The main drawback for the VAWTs is on the other hand the non-self-starting capability. Many researches though-out the years have been conducted for an elucidation of the problem, with recent use of cambered airfoils on a straight bladed Darrieus type vertical axis wind turbine [1].
  - These are characterized by its low rotation speed and high torque in comparison with the HAWT consequently higher costs for drive train
  - Blades are subject to high dynamic loading due to the full crown rotation.
  - The key drawbacks of a VAWT include difficulties facing for modelling the wind flow conditions accurately (due to the complexity of its interfering blades region and turbulence separation) and analysis of prototype prior to manufacturing.

- **HAWT vs VAWT:**

  - At present, HAWT technology is more mature than VAWT technology because of strong US and European research efforts, ready adaptability of certain aerodynamic and structural analysis techniques for propellers and helicopter rotors and an existing foundation of HAWT design philosophy from early nineteenth century
  - Though the HAWT is highly developed and used all over the world, the recent R&D has shown that the VAWT is more economical and efficient in respect of using land [4].

- Nevertheless, growing environmental concerns and the demand for enhanced energy security also emphasize the need to enhance VAWTs adaptive capacity and their possible cost effective solutions to the market provided that more funding has been given for further research and development activities.

References:

[1] H. Beri and Y. Yao, "Effect of Camber Airfoil on Self Starting of Vertical Axis Wind Turbine", Enviromental Science and Technology, pp. 302-312, 2011.

[2] M. Islam, V. Esfhanian, D. S-K. Ting, A. Fartaj, “Applications of Vertical Axis Wind Turbines for Remote Areas”, 5th Iran National Energy Conference, World Energy Council, Tehran, Iran 2005.

[3] E. Hau, Wind Turbines- Fundamentals, Technologies, Applications, Economics 2nd edition, Berlin Hetdelberg: Springer, 2006.

[4] M.R. Islam, S. Mekhilef, R. Saidur, “Progress and Recent Trends of Wind Energy Technology”, Renewable and Sustainable Energy Reviews, Vol. 21, pp. 456-468, 2013.