Tsinghua University Certificate Program
"Innovation & Entrepreneurship for Digital Economy"

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Title :Integrating Artificial Intelligence for Controlling Energy Efficiency of Modern Wind Turbines

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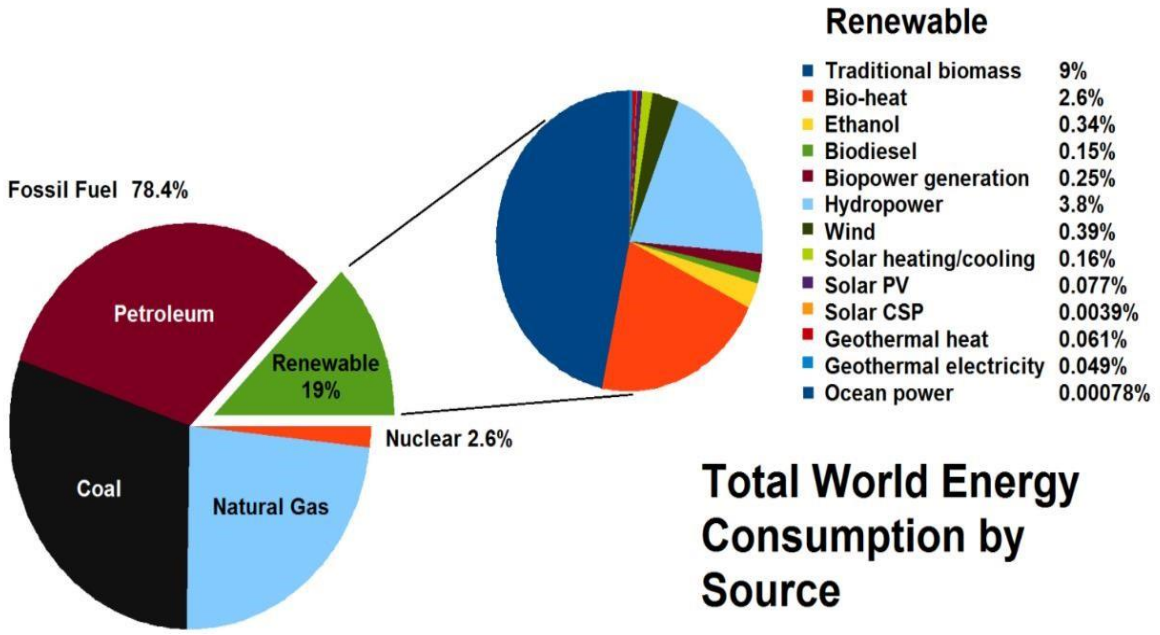


Background & Significance of Topic

- Renewable Energy (RE), in particular Wind Energy is attracting the majority of investment worldwide. It facilitates competition in the electricity market.
- Supply chain issues have dictated delivery capabilities, product strategies and pricing for every turbine supplier.
- Variable Speed Turbines (VST's) commonly employ active pitch systems to change the aerodynamic properties of rotor blades, reduce mechanical loads, and mitigate output power and torque fluctuations above rated Wind Speed (WS) incidents.
- Condition monitoring of wind turbine is an integral part, monitoring control of the wind farm site, preventive or predictive, the signals provided by warnings for the whole turbine.
- The functional behaviour of the power coefficient C_p is the result of certain control strategies as well as of Betz limit (59.3%).

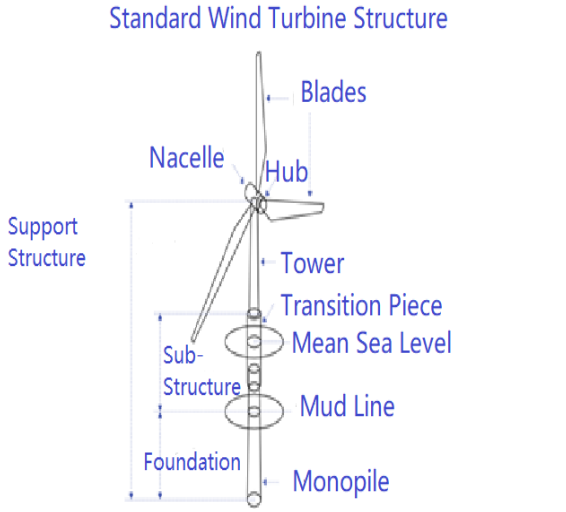
Artificial Intelligence and Wind Turbine Efficiency

- The purpose of this study is to develop the basic understanding and foundation for pitch control mechanisms and there importance for extraction of maximum energy from the available wind.
- The power extracted from the available wind depends upon the Tip Speed Ratio (λ) of rotor blade and its pitch angle (ß). By implementing an effective control methodology, ß – angle can be controlled, hence enhancing the efficiency and life time of the wind energy conversion system.
- According to Betz Limit, the power coefficient C_p can maximum attain the value of 59.3%.

$$C_p(\lambda, ß) = 0.5176 \cdot \left[116 \cdot \frac{1}{\lambda_i} - 0.4 \cdot ß - 5\right] e^{\frac{21}{\lambda_i}} + 0.0068\lambda$$

$$\frac{1}{\lambda_i} = \frac{1}{\lambda + 0.008\beta} - \frac{0.035}{ß^3 + 1}$$

$$\lambda = \frac{\Omega_r . R}{z}$$

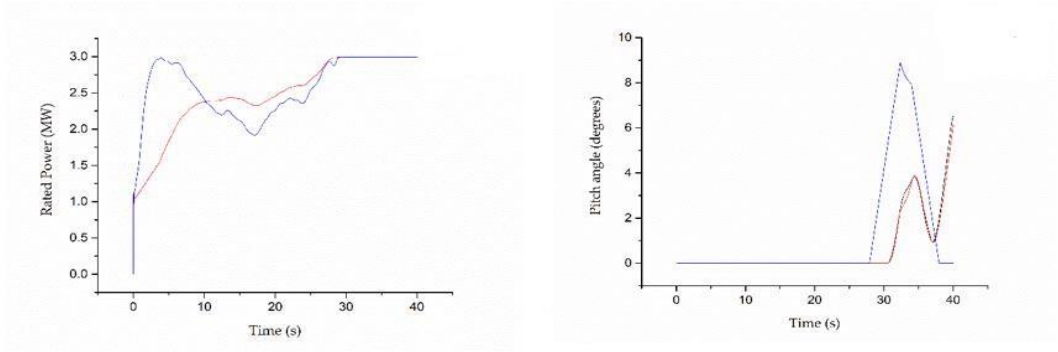


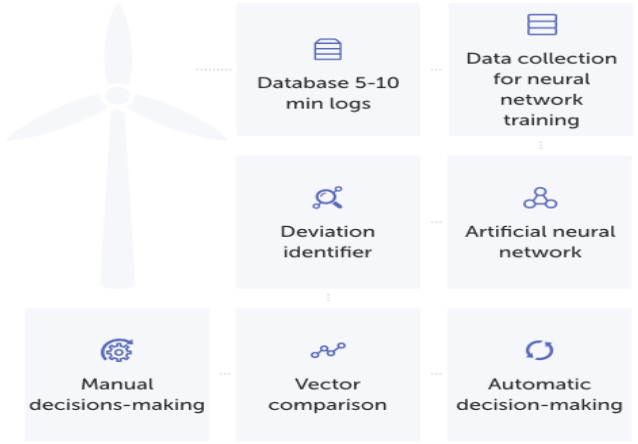
Rotor-Nacelle assemply (RNA) Blades + hub + nacelle

- Predictive maintenance is a great way to mitigate this issue. A study by the Electric Power Research Institute found that predictive maintenance techniques can cut annual wind turbine maintenance costs by up to 47%. And as turbines collect data about themselves, they're perfect candidates for predictive maintenance based on artificial intelligence (AI).

Results and Discussion

- In response to the wind profile with a base wind speed of 14 m/s, 3MW Wind Turbine has been controlled for 40 seconds dynamic simulation using MATLAB / SIMULINK model.
- Model Reference control shows superiority by generating the rated power with stable and efficient pitch control mechanism.
- Predictive maintenance of wind turbines combined with AI can cut wind turbine maintenance costs upto 47%. (Thought from GitHub)





Conclusion and Future Work

- Pitch angles (measured from the theoretical 0° position) can have a significant impact on the power production of the VSVPT unit.
- Artificial Intelligence in Supply Chain of Wind Turbines carries great importance where components of wind turbines needs to be explained and addressed according to market needs. Technically, two different perspectives are adapted to build the wind turbine models. MATLAB and GitHub are utilized to apply the adaptive control methodology to control pitch angle of modern wind turbines in order to check the power efficiency of the wind turbines. AI technology when utilized with modern wind turbine control systems can improve the annual power production of wind turbine parks.
- Future work includes research of wind turbine efficiency monitoring through Artificial Intelligence.

Finished Presentation

Thanking the honorable members of the committee, organizers and everyone who attended