ABSTRACT

The conventional resources used for the generation of power, such as coal, oil and nuclear are finite and will not last long. Many environmental, political and economic issues are concerned with conventional generation. In spite of all the odds, the requirement of energy grows steadily and new reliable energies sources are emerging, that is not harmful to the environment and is sustainable. The renewable energies such as solar and wind are clean, green and inexhaustible, which can support to the growing demand significantly. Solar insolation on the earth's surface is estimated at 165 x 1018 W, but available in most dispersed form. The wind, which is also one form of solar energy, is available in the most concentrated form and a primitive energy, harnessed by man effectively from early days.

The total installed wind energy capacity till 2015 was 392.927 GW according to World Wind Energy Association (WWEA). The generation of power from renewable energy sources was initiated in India, during the seventh plan (1992) and the installed capacity at the end of seventh plan was 32MW. The nation’s generation capacity by wind power grew up to 26,769 MW in 2015, which was about 8.6% of the total installed capacity of the country. The estimated wind power in India of producing potential power is about 49,130 MW at 50 m height and 102,788 MW at 80 m height from the ground level. The present installed wind power as on 2015, is only about 17.6% of the potential wind power available. India ranks fourth after China, United States and German, in the cumulative installed capacity of wind power generation. The density of wind turbines may be increased across the country to tap the entire potential wind power, but the annual average wind speed prevailing across the country varies from 21m/s to less than 1 m/s. Wind power generation form high windy areas are highly successful

conversely, the energy generation from the low windy regimes are not successful. The reasons being not successful are 1) wind resources data are not available for these areas, 2) wind turbines do not match the site specific requirements.

The objective of this research work is to develop a wind turbine blade for small wind turbines, which can perform effectively in a low wind regime and harness the power in the site with low wind speed.

A sample site is selected and an evaluation is made to assess the availability of wind power. The wind speed at ten-minute average is recorded, a sample period of 365 days is considered for assessment. The wind speed during various seasons such as high, moderate and low are analysed. The annual average wind speed prevailing over the site is 2.8 m/s and the maximum speed of wind experienced is up to 12 m/s. The wind power density at 20 m above ground level is 14 Watts.

A small wind turbine is subjected to investigation for the operating performances and suitability of the turbine to the wind prevailing in the sample site assessed. The investigation revealed that, the wind turbineis designed for high wind speed and it has produced 270kWh of electrical power in a year.

In order to make the small wind turbines perform effectively in the low wind regime like the site assessed, the blades are designed and modified with bionic features. The bionic feature of the humpback whale flipper bumps is incorporated on the leading edge of the blade. The airfoils NACA 0012, S 809 and S1223 are selected for the blades of small wind turbine and for which the modification is carried. The aerodynamic performances of the normal and modified blades are analysed, numerically

using the Ansys-Fluent CFD solver. The numerical analysis, predicted an increased lift coefficient of10 to 30 percent for the modified blade over the normal blade.

The results of the numerically evaluated normal and modified blades are validated using a wind tunnel experiments. Models of wind turbine rotor with normal and modified blades are made by Rapid Prototyping process. The RP developed models are tested in wind tunnel. From the wind tunnel experiments, the operating performances of the normal and modified blades such as the cut-in speed, rated speed and the maximum speed with respect to the corresponding wind velocities are predicted.

The operating parameters predicted from the wind tunnel experiment gave the estimate of energy produced by the small wind turbine rotors with normal and modified blades. The operating time of the modified rotors will increase and thereby increasing the electrical energy production. The annual energy produced by the modified blades will increase by 160 percent for NACA 0012, 11.3 percent of S 809 and 75 percent for S1223.