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Wind Energy - A Brief Survey with Wind Turbine Simulations

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***Abstract* - Today wind energy is very fast growing renewable energy source with enormous amount of advantages. The main part of the windmill is obviously wind turbine. This paper focus on the different wind turbine models using PSIM software and MATLAB SIMULINK Toolbox environment. These wind turbines directly connected with the generator and connected with grid utility after step-up transformer.**

***Index Terms*—** Power, Torque, Wind turbines.

1. INTRODUCTION

The continued growth and expansion of the wind power industry in the face of a global recession *and* a financial crisis is a testament to the inherent attractiveness of the technology. Wind power is clean, reliable, and quick to install; it's the leading electricity generation technology in the fight against climate change, enhancing energy security, stabilizing electricity prices, cleaning up our air and creating thousands of quality jobs in the manufacturing sector when they're particularly hard to come by.[1] India rank 4th in all over global market of wind energy and there are many number of installations are there for India in 2010.

2. WIND ENERGY SURVEY

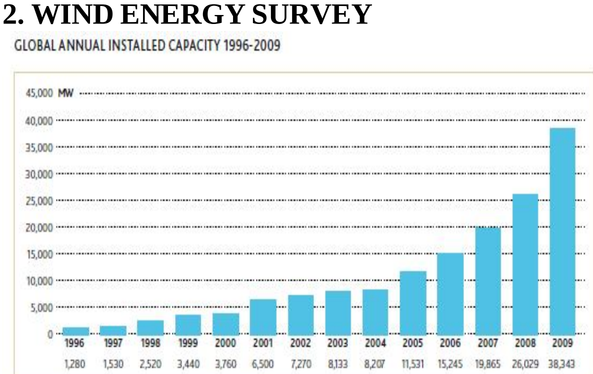

Figure 1.Present Wind Energy Scenario [1]

Estimated Wind Power Potential in India		
Sl. No.	State	Gross Potential (MW)
1	Andhra Pradesh	8275
2	Gujarat	9675
3	Karnataka	6620
4	Kerala	875
5	Madhy Pradesh	5500
6	Maharashtra	3650
7	Orissa	1700
8	Rajasthan	5400
9	Tamil Nadu	3050
10	West Bengal	450
Total		45195

Figure 2. Estimated Wind Power Potential in India [2]

World Wind Energy Association (WWEA) also has done some prediction. In next 3 years, the installed capacity is going to be doubled. It will reach 160000 MW.

A. Terms related Wind energy:[2]

Cut-in wind speed: the speed at which the wind turbine starts to operate.

Cut-out wind speed: is the wind speed where the wind turbine stops production and turns out of the main wind direction.

TSR is the speed of the blade at its tip divided by the speed of the wind.

If the rotor of the wind turbine spins too slowly, most of the wind will pass straight through the gap between the blades, therefore giving it no power! But if the rotor spins too fast, the blades will blur (make or become less distinct) and act like a solid wall to the wind.

During entire paper the data sheet of Enercon E-53 is taking as a reference.

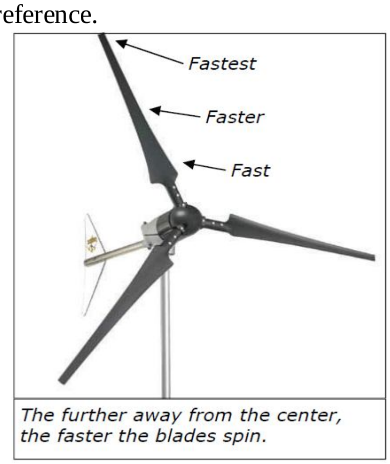

Figure 3. Tip Speed Ratio

The optimum Tip Speed Ratio for maximum power output, this formula has been empirically proven***Output of Scope1:***
λ (max power) = 4Π / n
wheren(n = number of blades)[3]
Table shows optimum TSRs,

Tip Speed Ratio	Number of blades
~6-7	2
~5-6	3
~2-3	5

3. BASIC WIND TURBINE MODELS

With MATLAB environment:[5]
Wind turbine Basic Model (at speed 10m/s):

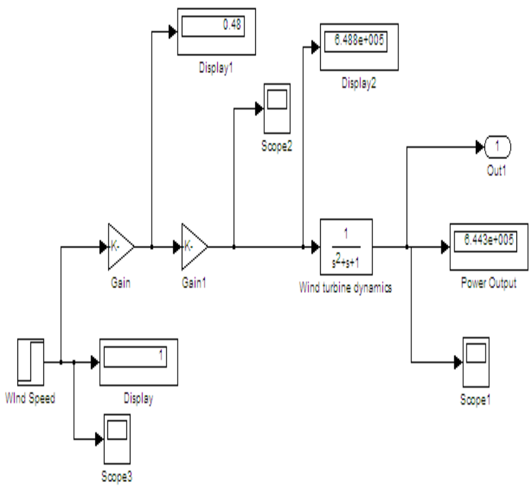

Figure 4. Wind turbine Model

Output of Scope1:

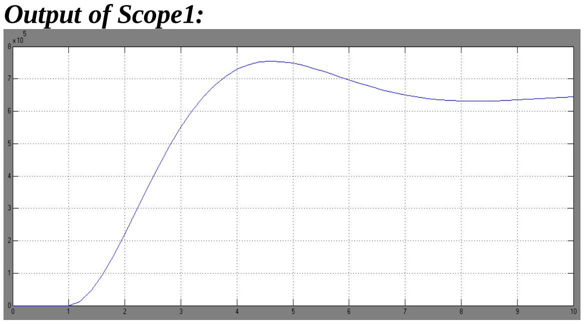

Figure 5. Output response

Wind turbine Basic Model(at speed 15m/s):

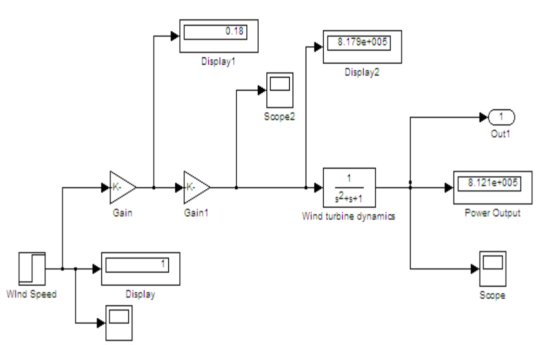

Figure.6. Wind turbine Model

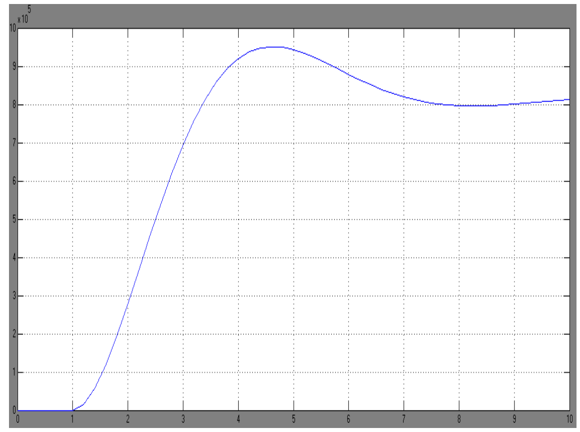

Figure 7. Output response

Curves at various wind speed for 10m/s, 15m/s and 20m/s of Scope 1:

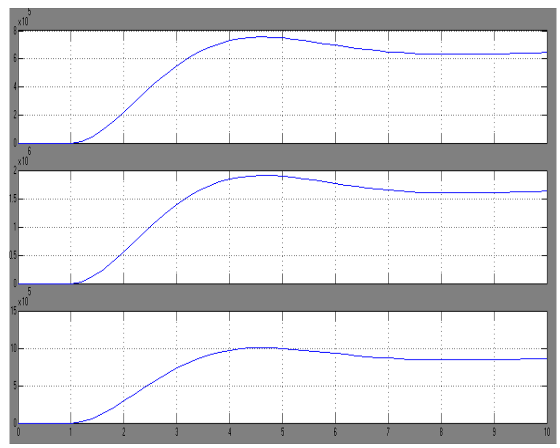

Figure 8. Output response at various wind speed

Now another model is from generalized equation means after the successful completion of turbine design the output is given to the generation system means shaft of any generator so the power and torque equations are important here two another models of power and torque equations are present in the MATLAB 7.8 environment.
The equations of output power and shaft are as under.

= – * * * ……….(1)

Where,
P=Wind power developed
Cp=The power co-efficient
P=Air density=1.23 kg/m^3
A=Area of wind turbine blades in m^2
And the torque equation,

= – / ………(2)

Where,
T=Output torque

λ = Tip Speed Ratio

Now according to these equation another MATLAB simulation has been done and graph has plotted between output power and speed.[4]

With MATLAB environment,

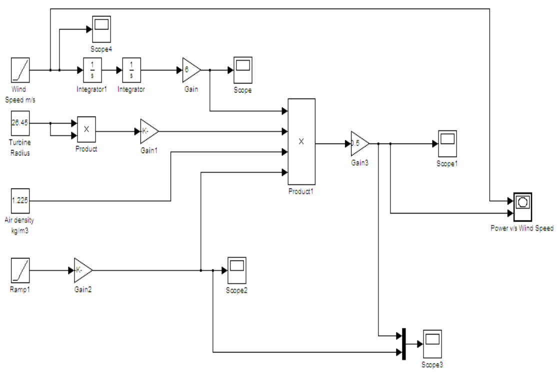

Figure 9. Wind turbine model for Power output v/s wind speed

Power output v/s Wind Speed(X-Y graph):

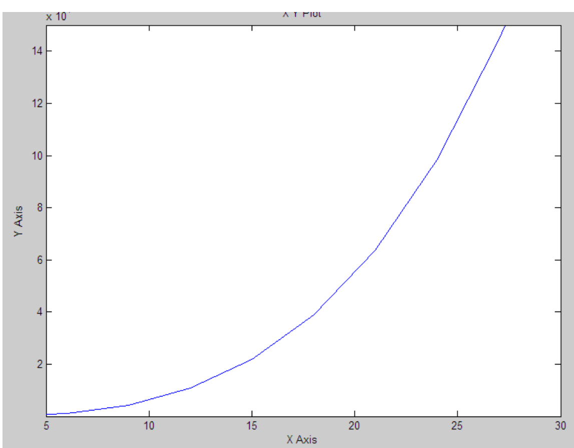

Figure 10. Graph of output v/s wind speed

X-axis shows wind speed and Y-axis shows power output
With PSIM environment:
Now with using PSIM environment from equation (2),
For example in case Enercon wind turbine E-53 data,[6]
Rated Power 800kW
Rotor Diameter 52.9m
Swept Area 2198m^2
Air density 1.225 kg/m^3
Tip Speed Ratio 5

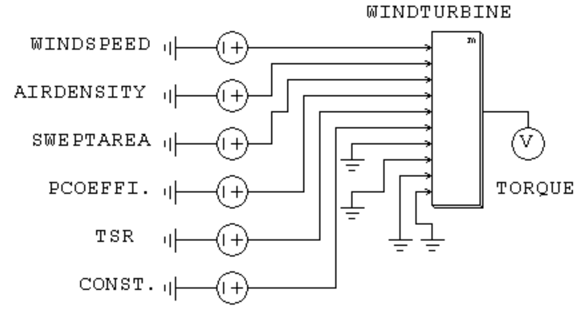

Figure 11. Wind turbine block using PSIM Torque as an Output

So from equation (2), for wind speed = 10m/s,
Tturbine = 1297 N.m

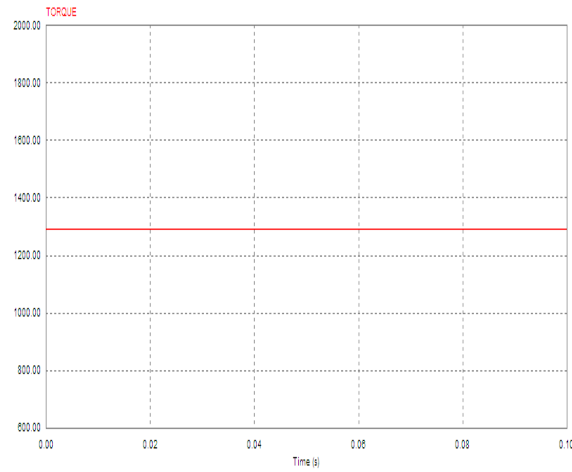

Figure 12. Torque value

Now from power equation (1),

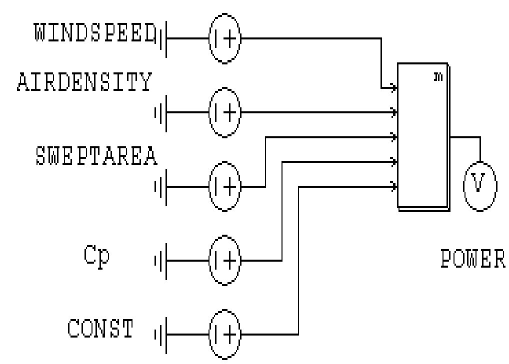

Figure 13. Wind turbine block using PSIM Power as a Output

P= 646kW

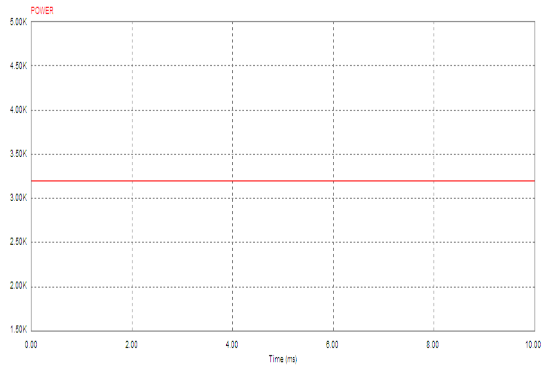

Figure 14. Power output value

TABLE – I VAROIUS GENERATOR CONPARISION USED IN WIND ENERGY CONVERSION SYSTEM

Particular	**DFIG with single stage gear box**	**DFIG with tree stage gear box**	**Direct drive electri--cally excited Syn. Generator**	**Direct drive permanent generator / Alternator**
Weight	Light	Lightest	Heaviest	**Active Weight nearly halved**
Cost	Reduction of converter cost & converter loss recues cost	Low cost solution (Less expensive)	Most expensive	**Expensive compared to Generator with gear box**
Energy yield	Energy yield by cost is Good	Low energy yield due to high losses in gear box	Energy yield is good	**Energy is yield is few percent higher**
Other Features				**Further improve--ment is possible Due to permanent Magnet & power converters used**

5. CONCLUSION AND FUTURE WORK

From this paper one can easily understand the various type of simulation topologies of wind turbine at various speed of wind speed and made calculations of torque and speed. This wind turbine connected with various types of generators and connected with grid for pollution free power and act as a very advantageous green energy source.

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