Wind Turbine

(1) First calculate the torque on the shaft due to the wind: We find the tip-speed ratio

$$\lambda = \frac{\omega R}{v_{wind}}$$

(2) Then use this to calculate the power coefficient (this is coded as a look-up table)

Cp = lookupPowerCoefficient(tsr,beta);

(3) and calculate the torque on the turbine

$$\tau_{wind} = \frac{1}{2}\rho\pi R^5 \frac{C_p}{\lambda^3}\omega^2$$

(4) Now we calculate the torque exerted on the shaft by the generator to hold the blade speed at its optimal value

$$\tau_{gen} = \frac{1}{2}\rho\pi R^5 \frac{C_{pMax}}{\lambda_{opt}^3}\omega^2$$

(5) Next find the difference in torque and use this as our error signal

$$e = \tau_{wind} - \tau_{gen}$$

(6) Apply the error signal to change the angular speed of the rotor to its optimum.

$$\Delta\omega = \frac{e}{J}\Delta t$$

$$\omega = \omega + \Delta\omega$$

$$\theta = \theta + \omega\Delta t$$

(7) Calculate the power generated

$$P = \tau_{gen}\,\omega$$

Math	Code	Meaning	ICs
v_{wind}	windV	wind velocity m/w	
ω	omega	angular speed of turbine shaft	0
θ	theta	angle of turbine shaft	
C_p	coeffPow	power coefficient	
λ	tsr	tip-speed ratio	
P	power	power output	
τ_{wind}	torqueW	torque on shaft due to wind	
τ_{gen}	torqueG	torque on shaft due to generator	
e	error	difference between two torques	
β	not used	pitch of the rotor blades	

Math	Code	default	Meaning
R	R	20	radius of blades
ρ	rho	1.2	air density
J	J	644877	moment of intertia of turbine
C_{pMax}	cpMax	0.4528	maximum of power coefficient
λ_{opt}	tsrOpt	5.29	optimal value of tip-speed ratio