

Tutorial 6

- 1- Explain briefly two incentive programs proposed by governments and regulators to encourage wider adoption of renewable energy generation.

- 2- A workshop owner installed solar panels to generate a portion of the 9000kWh annual energy consumption of the workshop. The solar system generated 4700kWh of energy in the first year of operation. Using **Table Q2**:
 - (i) Assuming no bidirectional meter is installed to record energy exported to the utility, calculate the net financial benefit the workshop owner achieved in the first year through the Feed-in Tariff (FiT) incentive.
 - (ii) If a bidirectional meter is installed and records that 1700kWh have been exported to the utility in the first year, what would be the net financial benefit the owner achieves through FiT in this case?

Table Q2

Tariff Category	Rate in (p/kWh)
Import from utility	11
Export to utility	4.64
Generation	21.65

- 3- Sketch a simple schematic diagram showing the main mechanical and electrical components of a variable speed wind turbine up to the point of connection to the power collecting network. Explain briefly the function of each component.

- 4- Derive an expression of the performance coefficient (aerodynamic efficiency) of a wind turbine as a function of incoming wind speed (v_1) and outgoing wind speed (v_2). Find the maximum theoretical value of aerodynamic efficiency (Betz limit) and corresponding ratio of v_2 and v_1 .

- 5- A wind turbine has a rotor diameter of 82m.
- (i) What is the outgoing wind speed for maximum aerodynamic efficiency if the incoming wind speed is 12m/s?
 - (ii) Using the equations developed in question 4, what would be the mechanical power output of wind turbine at maximum value of c_p if the wind speed is 12m/s and air density is 1.225 kg/m³?
 - (iii) If the wind turbine aerodynamic design achieves $c_p = 0.47$ at the optimal tip-speed ratio, what is the electrical power output from this turbine at the same wind speed if gearbox efficiency is 80% and combined generator and power converters efficiency is 92%? What is the overall wind turbine efficiency?
 - (iv) Comment on the results obtained in (ii) and (iii).
- 6- A variable speed wind turbine whose c_p - λ curve is given in **Table Q6** operates at the maximum power point tracking curve.
- (i) Find the wind speed corresponding to a rotor speed of 15 rpm if the rotor swept area is 7850 m².
 - (ii) Find the incoming wind power and the captured wind power by the blades (i.e. wind turbine mechanical power) if air density is 1.225 kg/m³
 - (iii) Find the overall wind turbine efficiency and electric output power if the combined mechanical efficiency is 82% and the combined electrical efficiency is 93%.

Table Q6

c_p (performance coeff.)	λ (tip-speed ratio)
0.29	6
0.33	6.5
0.36	7
0.39	7.5
0.42	8
0.43	8.5
0.42	9
0.3	10.5
0.21	12
0.15	13