2025Q5 **ENERGY AND POWER**

LEVEL 1 QUESTION (GRADES 5 – 8)

Solution: Calculating Efficiency

Step 1: Calculate efficiency in decimal using useful power output and gross wind power output

$$P_{useful} = \eta P_{wind}$$

$$475\,W = \eta \times 500\,W$$

$$\eta = \frac{475\,W}{500\,W}$$

$$\eta = \frac{19}{20}$$

$$\eta = 0.95$$

Step 2: Convert the decimal to a percentage by multiplying by 100%

$$\eta = 0.95 \times 100\%$$

$$\eta = 95\%$$

Final answer: The turbine efficiency = **95%**

LEVEL 2 QUESTION (GRADES 8 –11)

Solution: Findling Final Useful Power Output in kW

Step 1: Calculate P_{wind} using $P_{wind} = \frac{1}{2}\dot{m}({v_{in}}^2 - {v_{out}}^2)$

What is known:

$$\dot{m} = 53kg/s \qquad v_{in} = 14m/s \qquad v_{out} = 9m/s$$

Therefore,

$$P_{wind} = \frac{1}{2} \times \frac{53kg}{s} \times ((14m/s)^2 - (9m/s)^2)$$

$$P_{wind} = \frac{1}{2} \times \frac{5kg}{s} \times \left(196\frac{m^2}{s^2} - 81\frac{m^2}{s^2}\right)$$

$$P_{wind} = \frac{1}{2} \times \frac{53kg}{s} \times 115\frac{m^2}{s^2}$$

$$P_{wind} = 3047.5\frac{kg - m^2}{s^3}$$

Recall that 1 kg-m^2/s^3 = 1 J/s = 1 W

$$P_{wind} = 3047.5\ W$$

Step 2: Calculate useful power output

$$P_{useful} = \eta P_{wind}$$

Remember, the turbine loses 18% of its total output due to inefficiencies. This means it operates at 82% efficiency because 100% - 18% = 82%.

$$P_{useful} = \frac{82\%}{100\%} \times 3047.5\ W$$

$$P_{useful} = 2498.95\ W$$

$$P_{useful} = 2498.95\ W \times \frac{1\ kW}{1000\ W}$$

$$P_{useful} = 2.49895\ kW$$

Final Answer: The final useful power output (in kW) = **2.5 kW**