2021A19 (YAW, ENERGY EFFICIENCY OVER TIME)

Level 1: This problem can be solved via ratios.

$$\frac{Energy\ Spent\ for\ Full\ Rotation}{Full\ Rotation} = \frac{Energy\ Spent\ for\ Partial\ Rotation}{Partial\ Rotation}$$

$$\frac{780\ kwh}{360°} = \frac{Energy\ Spent\ for\ Partial\ Rotation}{13.38°}$$

$$Energy\ Spent\ for\ Partial\ Rotation = \frac{780\ kwh * 13.38°}{360°}$$

$$Energy\ Spent\ for\ Partial\ Rotation = 29kwh$$

Level 2: First, we recognize that the power output when the turbine directly faces the wind is the 1.5 MW value given in the first part of the problem.

Then, we need to find the power output if the turbine did not yaw.

$$Actual\ Power\ Output = Max\ Power\ Output * Percent\ Power\ Output\ Achieved$$

$$= 1.5\ MW * 0.97$$

$$= 1.455\ MW$$

Next, we should find the energy produced by these two scenarios.

$$Energy\ Output\ with\ Yaw = Power * Time$$

$$= 1.5\ MW * 12\ hr$$

$$= 18\ MWh$$

$$Energy\ Output\ without\ Yaw = Power * Time$$

$$= 1.455\ MW * 12\ hr$$

$$= 17.46\ MWh$$

However, we must consider the amount of energy spent by the yaw motors to rotate the turbine.

$$Net\ Energy\ Output\ with\ Yaw = Energy\ Produced - Energy\ Consumed$$

$$= 18\ MWh - 29\ kwh$$

$$= 18{,}000\ kwh - 29\ kwh$$

$$= 17{,}971\ kwh = 17.97\ MWh$$

To get the net energy difference between the two scenarios, we simply subtract one from the other.

$$Net\ Energy\ With\ Yaw = Energy\ Produced\ with\ Yaw - Energy\ Produced\ without\ Yaw$$

$$= 17.97\ MWh - 17.46\ MWh$$

$$= 0.51\ MWh$$

For context, the One Energy office campus uses about 16.5 MWh in a month. The energy benefit of the yaw produced enough energy in 12 hours to power the office for about 2 full days!

This One Energy turbine is currently yawed to face the facility on the left of the image. However, our turbines can rotate 360°, so they can always face the wind!