

2023Q10

POWER CURVES

Salutations all you studious students, today we'll be talking about power curves! A power curve is a function that relates wind speed to power production. One Energy utilizes power curves in project development, construction, and operation. They are an important resource for determining the power output of a turbine over a given time. Below is a graph representing a generic power curve:

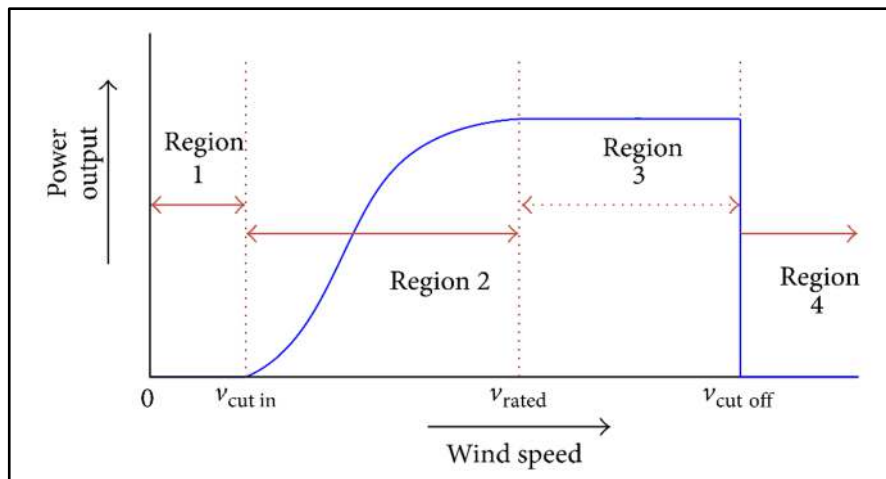


Figure 1: Example power curve

In a power curve, there are three distinct wind speeds (represented by v_{cut-in} , v_{rated} , and $v_{cut-off}$ in Figure 1) that determine the shape of the power curve: cut-in, rated, and cut-off speed. Cut-in wind speed defines the speed at which the turbine will start generating power, the minimum wind speed for operation. Rated wind speed is the speed at which the turbine generates its maximum power output. Finally, cut-off wind speed is the speed at which the turbine will stop generation. Thus, the power curve can be expressed as:

$$P(v) = \begin{cases} 0, & v < v_{cut-in}, v > v_{cut-off} \\ f(v), & v_{cut-in} < v < v_{rated} \\ P_r, & v_{rated} \leq v \leq v_{cut-off} \end{cases}$$

where $f(v)$ is the function which defines the relationship between wind speed and power production between the cut-in and rated wind speeds. P_r is the rated power output for the wind turbine between the rated and cut-off wind speeds.

Now that we know a little more about power curves, let's dive into this week's questions! We'll be using Figure 2 below as a reference for both questions.

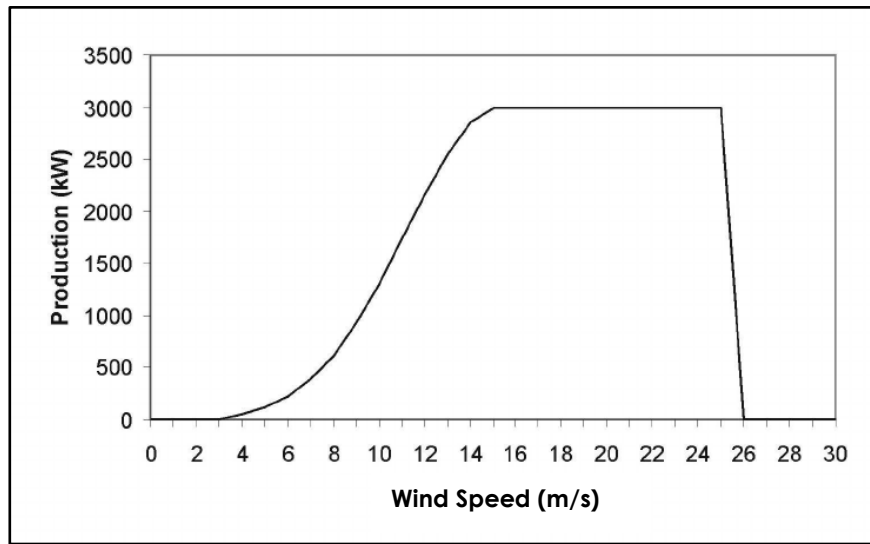


Figure 2: Example power curve

Level 1: Based upon the example power curve (Figure 2), use your knowledge of the various regions on the graph to determine the following.

What is the: (a) cut-in wind speed? (b) rated wind speed? (c) and cut-off wind speed?

Level 2: The following table contains wind speeds over an 8-hour period:

TIME	WIND SPEED (m/s)
12:00	7
01:00	7
02:00	8
03:00	10
04:00	10
05:00	11
06:00	11
07:00	9

Using Figure 2 for your calculations: What is the average power output for the 8-hour time period? What is the standard deviation of the 8-hour power output dataset? (Power output can be approximated to the nearest 50 kW).

Reference:

Vaishali Sohoni, S. C. Gupta, R. K. Nema, "A Critical Review on Wind Turbine Power Curve Modelling Techniques and Their Applications in Wind Based Energy Systems", *Journal of Energy*, vol. 2016, Article ID 8519785, 18 pages, 2016. <https://doi.org/10.1155/2016/8519785>