



## Wind turbine faults detection

### 1. subject description

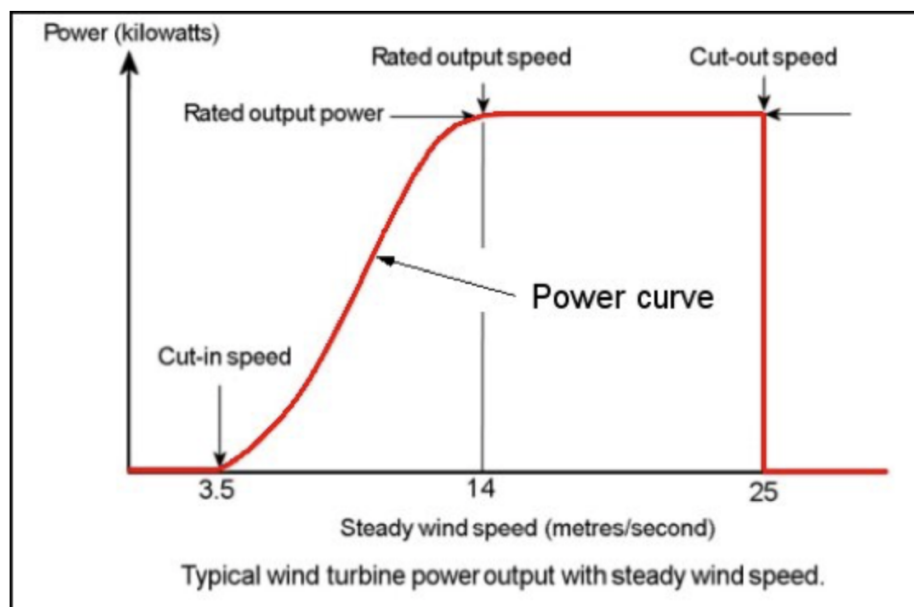
Fault detection in wind turbines is an important task in renewable energy, which enables them to prevent turbine breakdown, gear loss,...

Power curve analysis is an optimal approach for fault detection by analyzing the generated power and comparing the reference power according to the wind speed in a timestamp. In the following we introduce the project goals, data description evaluation measure and some important references.

### 2. goals

- Train normal behavior model for power prediction.
- Fault detection based on reference power and the predicted power.

### 3. previews



A typical wind power curve is shown above. Each wind turbine manufacturer provides an ideal energy production curve for their turbines. Here is a brief overview about what it means:

- The power curve of a wind turbine presents the electrical power output ratings of the machine for different wind speeds.
- A typical wind turbine power curve has three main characteristic speeds: 1) cut-in ( $V_c$ ); 2) rated ( $V_r$ ); and 3) cut-out ( $V_s$ ) speeds.

The turbine starts generating power when the wind speed reaches the cut-in value. The rated speed is the wind speed at which the generator is producing the machine's rated power. When the wind speed reaches the cut-out speed, the power generation is shut down to prevent defects and damages. Theoretical power curves are supplied by manufacturers assuming ideal meteorological and topographical conditions.

### 4. data description



In Wind Turbines, Scada Systems measure and save data's like wind speed, wind direction, generated power etc. for 10 minutes intervals. This file was taken from a wind turbine's scada system that is working and generating power in Turkey.

The data's in the file are:

- Date/Time (for 10 minutes intervals)
- LV ActivePower (kW): The power generated by the turbine for that moment
- Wind Speed (m/s): The wind speed at the hub height of the turbine (the wind speed that turbine use for electricity generation)
- TheoreticalPowerCurve (KWh): The theoretical power values that the turbine generates with that wind speed which is given by the turbine manufacturer, and
- Wind Direction (°): The wind direction at the hub height of the turbine (wind turbines turn to this direction automaticly)

	LV ActivePower (kW)	Wind Speed (m/s)	Theoretical_Power_Curve (KWh)	Wind Direction (°)
count	50530.000000	50530.000000	50530.000000	50530.000000
mean	1307.684332	7.557952	1492.175463	123.687559
std	1312.459242	4.227166	1368.018238	93.443736
min	-2.471405	0.000000	0.000000	0.000000
25%	50.677890	4.201395	161.328167	49.315437
50%	825.838074	7.104594	1063.776283	73.712978
75%	2482.507568	10.300020	2964.972462	201.696720
max	3618.732910	25.206011	3600.000000	359.997589

## 5. evaluation measures

- mean squared error.
- fault detection rate.

## 6. references

- <https://www.sciencedirect.com/science/article/pii/S2405896322005481>
- <https://www.sciencedirect.com/science/article/abs/pii/S1364032113007296>
- <https://www.sciencedirect.com/science/article/abs/pii/S0960148121017134>
- <https://ieeexplore.ieee.org/document/8359063>