Wind Farm Optimization

FACULTY OF ENGINEERING AND NATURAL SCIENCES

Student(s)
Ezgi Aydın, 19228
Berk Erdoğan, 17799
İdil Özdemirci, 19448

Faculty Member(s)
Serhat Yeşilyurt

Company Advisor(s)
Nihat Arı
Hakan Nalbant
Ezgi Deniz

ABSTRACT

The main advantages of wind turbines, beside the contribution to the environment, include an unlimited, free, renewable resource, economic value, maintenance cost, and placement of wind harvesting facilities. The project aims to investigate the performance criteria of wind turbines and the effect of wind speed on power generated turbines. Wind turbine efficiency and the cost of manufacturing a turbine are subject to the wind regime planning. The driving force behind the project is to understand if the wind turbine is operating at optimal conditions based on the telemetry data. Our undertaking is to empower EnerjiSA to enhance their wind control ventures, so that the company could construct more proficient wind turbines.

OBJECTIVES

- ❖ Examining the fault records of the system and the loss of energy because of non-optimised planning.
- ❖ Translating the distinctions on power curves of the turbines, analyzing the power changes in absence of productivity under various circumstances.
- ❖ Enable EnerjiSA to improve the working efficiency of the wind turbines, procrastinate the maintenance times of the turbines and minimize the costs related to the maintenance processes.

METHODOLOGY

To examine these problems and come up with a conclusion, the following steps must be considered:

- ❖ The selection of the turbine that intended to be examined; from the BARES Fault List, according to the fault duration, date and maintenance duration.
- ❖ The examination of the power curves and noises of the turbine before and after the fault and maintenance.
- ❖ Selection of different periods for the turbine to compare and contrast the properties, characteristics, changes and similarities.
- ❖ Comparing cumulative distributions of power data with cross validation. (By determining a specific control turbine, compare 2016 and 2017 to see how much they correlate)
- ❖ The generation of the MATLAB code to check and plot the graphs of the clean turbine data.
- ❖ The turbines with the smallest difference from the average power output of all the turbines are chosen as "*Control Turbines*" as representatives of the wind farm and the others are chosen as "*Target Turbines*".

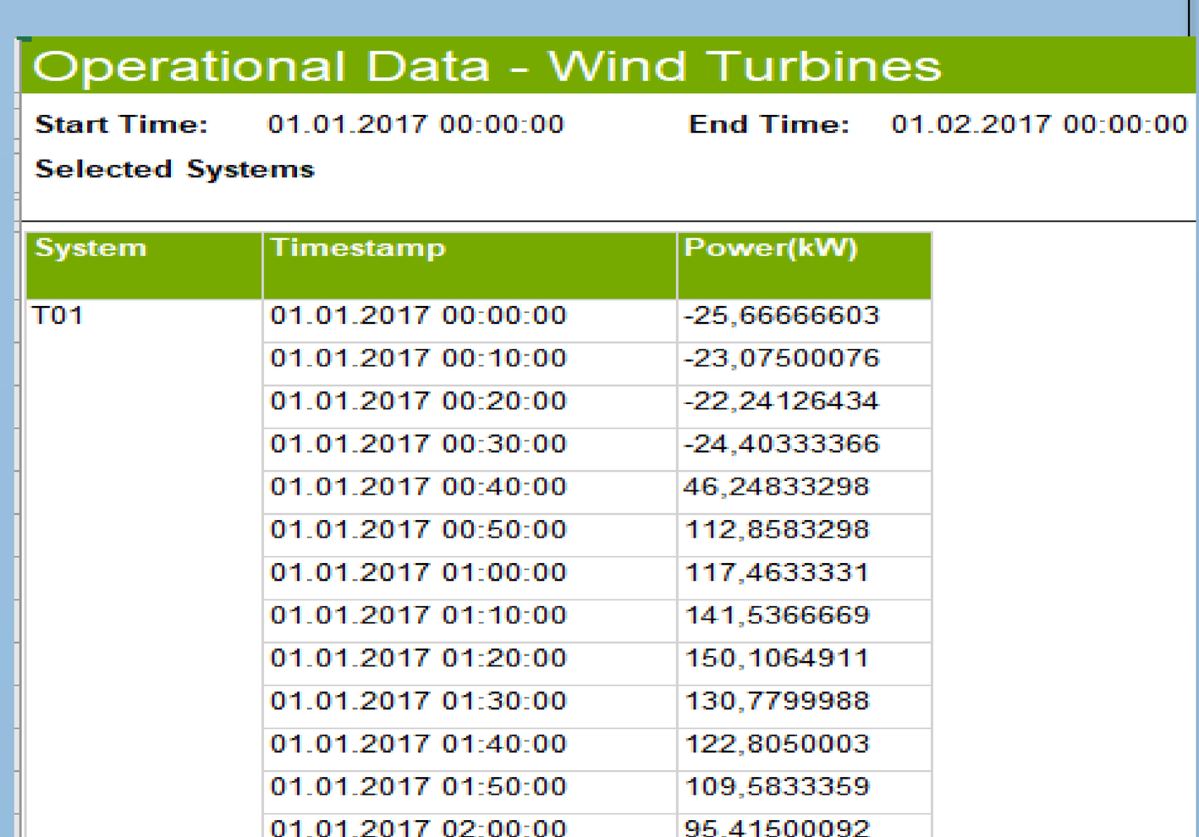
PROJECT DETAILS

The daily power generation data of 52 turbines for 10-min intervals during years 2016 & 2017 and the fault list of the turbines were provided by the company. In order to reach the clean data of the turbines, the dates that contain faults are excluded from the excel sheet by defining binary numbers to compare the past and current power outputs by cross check validation.

BALIKESİR WPP ARIZA TAKİP LİSTESİ (GE-F-3235_3)

S.	TARİH		DURUŞ BAŞLA	DURUŞ	DURUŞ NEDENİ		ERROR MESSAGE	STATUS CATEGORY	BİRİM	AÇIKLAMA	Duruş Süresi		ENERJİ KAYBI
5637	8.10.2017	T36	03:36	03:39	Fault	71	Dirty gearing oil filter (switching off)	fault	Gearbox	Remote reset	00:03	0,050	448,92 kWh
5672	9.10.2017	T36	13:57	16:29	Harici mücbir	147	Load shutdown	information	No Fault	Türbin RMU flair sistem kurulumu yapılıyor.Toroidal akım trafosu montajı yapıldı.Kablosu çekildi.	02:32	2,533	1074,35 kWh
5677	9.10.2017	T36	16:29	18:24	Fault	179	Emergency braking system test required	safety crit. fault	Pitch	Axis 1-3 nolu batarya ve charger 10 A sig. değişti.	01:55	1,917	938,99 kWh
5773	13.10.2017	T36	03:18	03:19	Fault	144	Blade angle asymmetry	fault	Pitch	Remote reset	00:01	0,017	25,44 kWh
5775	13.10.2017	T36	02:25	02:26	Fault	71	Dirty gearing oil filter (switching off)	fault	Gearbox	Remote reset	00:01	0,017	0,00 kWh
5867	16.10.2017	T36	11:17	11:34	Fault	71	Dirty gearing oil filter (switching off)	fault	Gearbox	Remote reset	00:17	0,283	234,35 kWh
5959	19.10.2017	T36	19:25	19:27	Fault	71	Dirty gearing oil filter (switching off)	fault	Gearbox	Remote reset	00:02	0,033	107,67 kWh
6005	23.10.2017	T36	03:18	03:21	Fault	71	Dirty gearing oil filter (switching off)	fault	Gearbox	Remote reset	00:03	0,050	0,00 kWh
6083	26.10.2017	T36	09:56	11:10	Unplanned Work	155	Maintenance	information	User	Cable connection fault detection system installation.Flair sistem montajı	01:14	1,233	88,51 kWh
6086	26.10.2017	T36	11:39	11:42	Fault	71	Dirty gearing oil filter (switching off)	fault	Gearbox	Remote reset	00:03	0,050	4,27 kWh
6090	26.10.2017	T36	12:25	14:08	Unplanned Work	156	Repair	information	User	End of warranty inspection (Garanti sonu denetimi) yapıldı.	01:43	1,717	833,21 kWh
6155	29.10.2017	T36	22:14	22:15	Fault	71	Dirty gearing oil filter (switching off)	fault	Gearbox	Remote reset	00:01	0,017	350,93 kWh
6222	1.11.2017	T36	20:42	20:55	Fault	177	Tower vibration	fault	Sensor Fault	Remote reset	00:13	0,217	167,70 kWh
6223	1.11.2017	T36	21:47	21:51	Fault	177	Tower vibration	fault	Sensor Fault	Remote reset	00:04	0,067	66,84 kWh
6225	1.11.2017	T36	23:31	23:50	Fault	177	Tower vibration	fault	Sensor Fault	Remote reset	00:19	0,317	139,85 kWh

BARES Fault List



Operational Data - Wind Turbines

Start Time: 01.01.2017 00:00:00 End Time: 01.02.2017 00:00:00

Selected Systems

System	Timestamp	Power(kW)
T01	01.01.2017 00:00:00	-25,66666603
	01.01.2017 00:10:00	-23,07500076
	01.01.2017 00:20:00	-22,24126434
	01.01.2017 00:30:00	-24,40333366
	01.01.2017 00:40:00	46,24833298
	01.01.2017 00:50:00	112,8583298
	01.01.2017 01:00:00	117,4633331
	01.01.2017 01:10:00	141,5366669
	01.01.2017 01:20:00	150,1064911
	01.01.2017 01:30:00	130,7799988
	01.01.2017 01:40:00	122,8050003
	01.01.2017 01:50:00	109,5833359
	01.01.2017 02:00:00	95,41500092

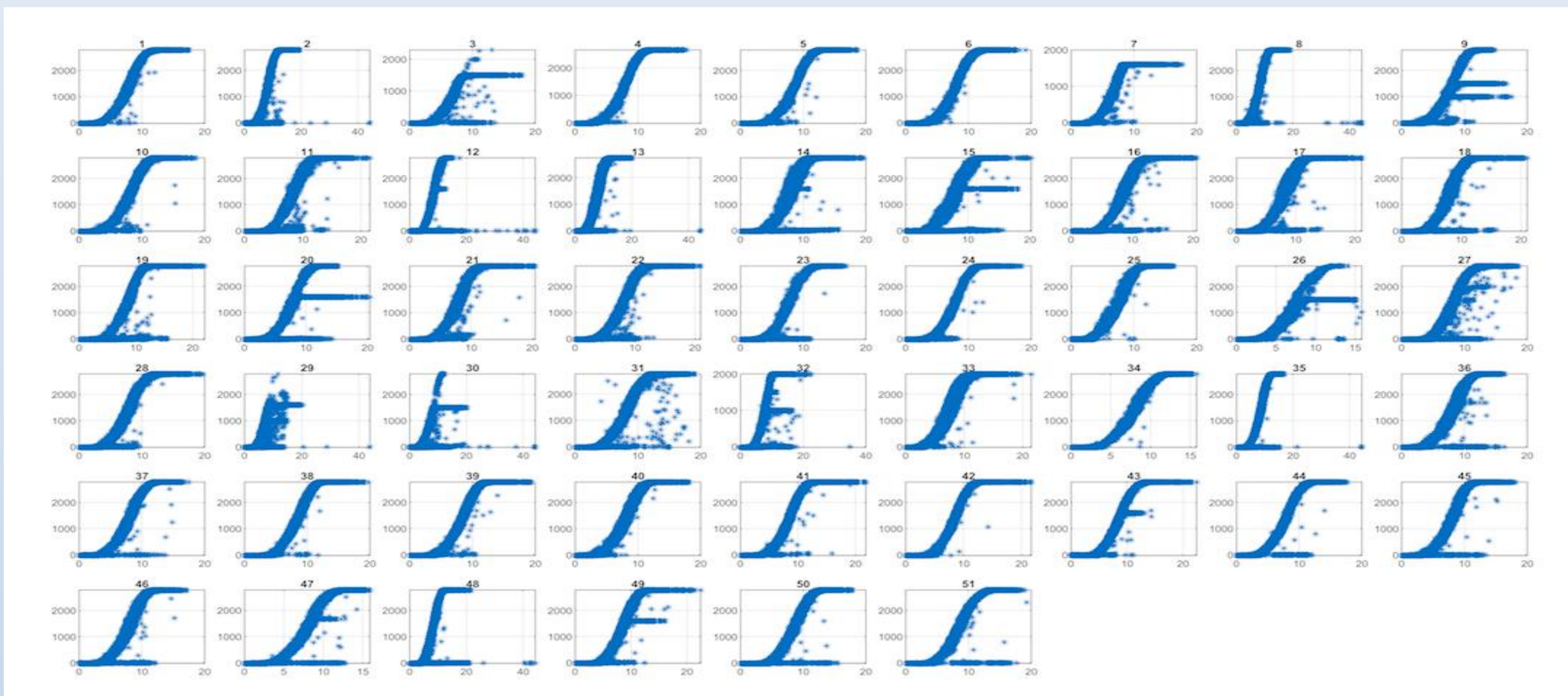
Turbine01 Jan 2017 data

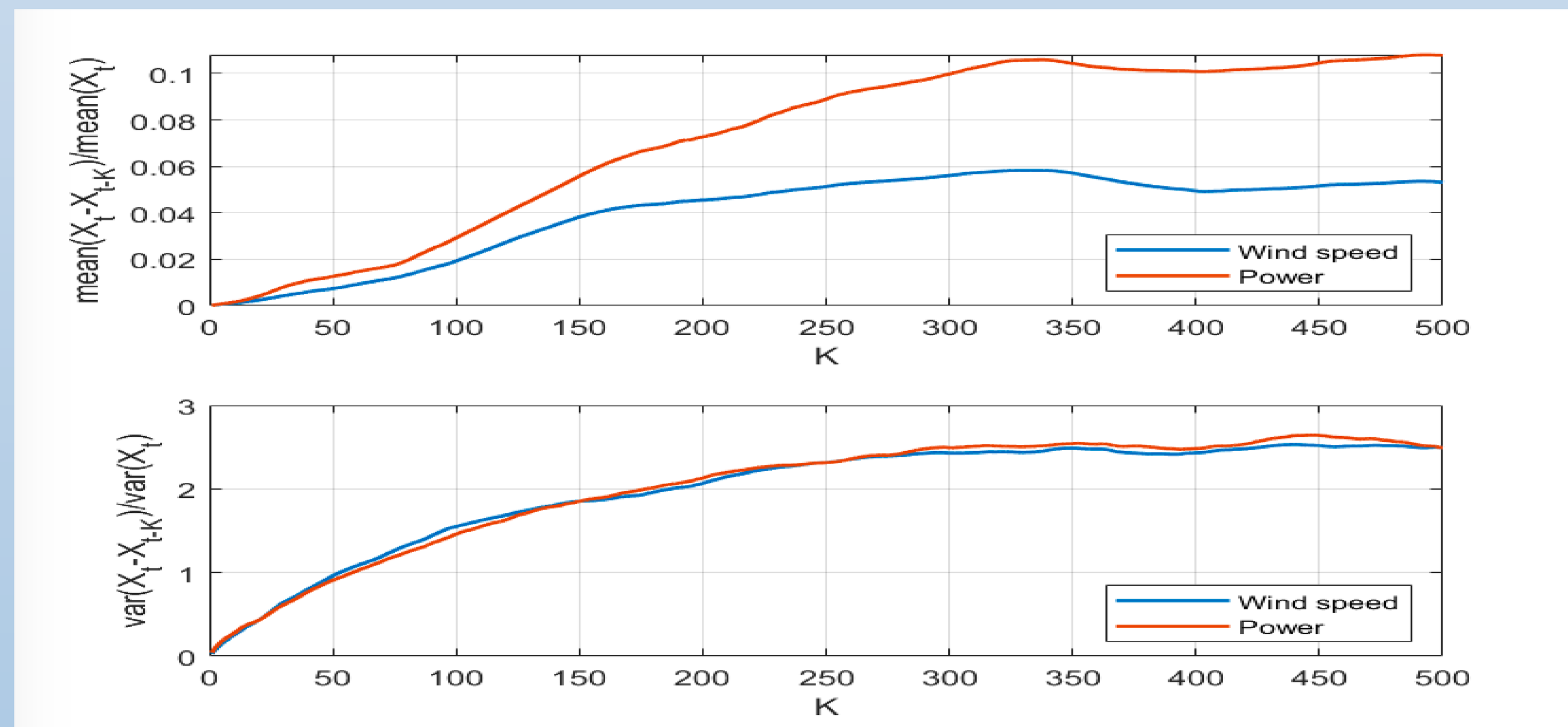
With the code generated, all turbines' monthly and yearly power outputs and graphs are plotted seperately through MATLAB. Data must be filtered to remove the curtailment (various losses from the regular operation of the turbines. In order to select the control and target turbines, the average power output of all turbines is generated and the most stable, infrequently errored turbines are selected as the control turbines.

```
clear all
yillar = [2016,2017];
for j = 1:1  %1:1 2016 only, 1:2 2016 and 2017, ...
 for m=1:12
 strmonth = strcat('m',num2str(m+(j-1)*12));
  for k = [27:29 43:45]
    clear tmp1 txt1 raw1
    fname = string(strcat('power2016-27-28-29-43-44-45/',num2str(m),'.xls'));
    [tmp1,txt1,raw1] = xlsread(fname,strcat('Sheet',num2str(k)));
    strtur = string(strcat('t',num2str(k)));
    powers.(strtur).(strmonth) = tmp1(:,1);
    dates.(strtur).(strmonth)  = txt1(:,2);
    faults.(strtur).(strmonth) = tmp1(:,2);
    nofaults = find(tmp1(:,2)~=1);
    cleanpowers.(strtur).(strmonth) = tmp1(nofaults,1);
    cleandates.(strtur).(strmonth)  = txt1(nofaults,2);
  end
    for k = [46:48]
    clear tmp1 txt1 raw1
    fname = string(strcat('power2016-46-47-48/',num2str(m),'.xlsx'));
    [tmp1,txt1,raw1] = xlsread(fname,strcat('Sheet',num2str(k)));
    strtur = string(strcat('t',num2str(k)));
    powers.(strtur).(strmonth) = tmp1(:,1);
    dates.(strtur).(strmonth)  = txt1(:,2);
    faults.(strtur).(strmonth) = tmp1(:,2);
    nofaults = find(tmp1(:,2)~=1);
    cleanpowers.(strtur).(strmonth) = tmp1(nofaults,1);
    cleandates.(strtur).(strmonth)  = txt1(nofaults,2);
  end
 end
end
```

```
clear all
load('io_cleanfiles.mat')
load('test_cleanfiles.mat')
%% use the following loops to combine different cleanpowers and cleandates
% for j = 1:1  %1:1 2016 only, 1:2 2016 and 2017, ...
%  for m=1:1
%  strmonth = strcat('m',num2str(m+(j-1)*12));
%   for k = [29]
%       strtur = string(strcat('t',num2str(k)));
%       cleandates.(strtur).(strmonth) = cleandates2.(strtur).(strmonth);
%       cleanturbines.(strtur).(strmonth) = cleandturbines2.(strtur).(strmonth);
%   end
%  end
% end
%
%
%%
clear bins
powers = [100:100:2800]
for m = 1:1
 strmonth = strcat('m',num2str(m));
 for k = [30:32];
    strtur = string(strcat('t',num2str(k)));
    for j = 1:length(powers)
       bins.(strtur).(strmonth)(j) = ...
           sum(abs(cleanpowers.(strtur).(strmonth)-powers(j)) < 50);
    end
 end
end
```

Codes genereated for the data analysis





DISCUSSION

- How the power output changed after the operations?
- What kind of similarities/differences does a turbine show before/after the operation?
- How the turbine reacts under some parameters like same/different wind speed and/or temperature?
- Will developing different alternatives (i.e for pitch control) helps with with the optimization of turbines?

REFERENCES

- Etherington D. *"Google says it will hit renewable energy by 2017"* Techcrunch, December 6, 2016
- *F. Pelletier, Ch Masson, A. Tahan, Wind turbine power curve modelling using artificial neural network, Renew. Energy 89 (2016) 207-214,*
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- *Marciukaitis, M., Zutautaite, I., Martisauskas, L., Joksas, B., Gecevicius, V., Sfetsos, A., (13 January 2017) Non-linear regression model for wind turbine power curve.*