Wind Farm Optimization

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Enerjisa operates two main business lines of electricity distribution and sales, reaching 9.2 million customers in 14 provinces, and provide distribution services to more than 20 million users. Enerjisa contributes significantly to sustainability through their investments in electricity distribution and human and technology solutions. Moreover, the company also aims to create value for their customers, partners, employees, suppliers, mainly the community by assessing new opportunities in the sector.

Enerjisa Enerji achieved the largest private sector public offering of Turkey by taking 20 percent of its shares public on February 8th, 2018 and started trading on Borsa Istanbul.

Abstract

This project consists of analyzing and evaluating the data of the 52 wind turbines which are currently operated by Enerjisa. The project's aim is to determine whether the wind turbines maintain their production according to the given power curve, determine the main factors affecting the efficiency of turbines and improve performance monitoring systems. The project aims to achieve these goals by investigating the wind turbine's production data, error codes and power curves with the help of statistical models which will enable us to see consistency of the power curves and percentage of outliers.

Objectives

The project's objective is to determine whether Enerjisa's wind turbines are working efficiently according to the power curves given by them and determine the main factors affecting the performance of the turbines. In order to fulfill these objectives a suitable and accurate statistical modelling system is created to evaluate the statistics of the wind turbines. As a result, this project aims to improve performance monitoring systems of Enerjisa.

Typical wind turbine power output with steady wind speed.
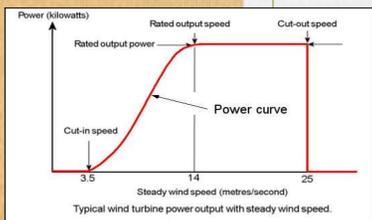
Motivation and Project Information

In this project, we are aiming to determine whether Enerjisa's wind turbines are working efficiently according to the wind turbine power data given by them and determine the main factors affecting the performance of the turbines. In order to fulfill these objectives an accurate statistical modeling system has to be created to evaluate the statistics of the wind turbines.

In the project, our main goal is to provide wind farm optimization. To improve the performance of the wind farms, together with decreasing the power generation costs is a crucial aspect for the wind energy industry.

There can be two approaches two this, one of them is regarding physics. The other one is regarding statistics and we are focusing in this aspect of the wind farm optimization. The optimization of the performance of a wind farm is to minimize the cost of the wind turbine operations and to maximize the power taken from it.

Enerjisa is working together with General Electric in order to increase the efficiency of their wind turbines. However, they cannot interpret their current data to evaluate General Electric's improvements. Our first step is to clean these data and find error-clear areas to compare the efficiencies before and after the improvement done by General Electric. However, finding clean of error areas is not enough by itself in order to compare the change, we should check statistically, if they have for similar wind profiles in order to be sure.

We have got data of 52 different wind turbines for 2 years period. These 2 years periods were separated by ten minutes intervals. We were able to see how much power gained in these intervals. In order to reach our intended results, we had to organize this data. After we have organized the data, we will analyze the data using Matlab.

After all these steps are accomplished, we will finally be able to detect if the change made by General Electric has increased the efficiency of the wind turbine or otherwise.

Method

As a group we shared wind turbines among ourselves and to marked the defective time periods according to the information given to us by Enerjisa. While we are doing this, we first marked the faulty ones from excel as red, maintenance periods as yellow and everything else green. The reason why we did was in order to make a trustworthy and good statistical analysis, we first need to get rid of the faulty data. Otherwise our results can be wrong and misleading.

In order to color mark the data we wrote a macro on excel I which marks the faulty data as 1 and the clean data as 0 .We needed to do that be cause after we clean the turbine data I we have to transfer the data into matlab as the statistical method will be done in matlab.

You can find the picture of our excel sheet which has the color marks and the code of the macro which enables us to put zeros and ones instead of greens and reds.

Because we had 52 turbines data of 10 minutes interval, transferring this data needed a particular job. At first we couldn't able to transfer the data easily so we searched for various methods. Through the use of import all script function in matlab we managed to put the data of all turbines into one array.then we can filter out the data labeled one I which is defaulted data end added to our and analysis is without deleting it in case we need it sometime. I in fact we will need it when we are comparing the data before and after the changes of General Electric. The code given below is the code which enables us to import the data into matlab in such a way that we can work on every data, every month, each turbine seperately

```
%% Import data from spreadsheet
% Script for importing data from the following spreadsheet:
%
%    Workbook: G:\My Drive\COURSES\ENS491-2\2018-19\BARES_Data\Power\2016\3.xls
%    Worksheet: Sheet1
%
% Auto-generated by MATLAB on 26-Apr-2019 10:30:35

%% Setup the Import Options
opts = spreadsheetImportOptions("NumVariables", 5);

% Specify sheet and range
opts.Sheet = "Sheet1";
opts.DataRange = "C12:022";

% Specify column names and types
opts.VariableNames = ["VarName3", "VarName4", "VarName5", "VarName6", "VarName7"];
opts.VariableTypes = ["string", "datetime", "datetime", "string", "double"];
opts = setvaropts(opts, [1, 4], "WhitespaceRule", "preserve");
opts = setvaropts(opts, [1, 4], "EmptyFieldRule", "auto");

% Import the data
Untitled = readtable("G:\My Drive\COURSES\ENS491-2\2018-19\BARES_Data\Power\2016\3.xls", opts, "UseExcel", false);

%% Clear temporary variables
```

Following Steps

After the clean data is filtered, we need to find the control turbines. In order to find out the control turbines we should check the average wind powers and the RMSE method which stands for Root Mean Square Error of the turbines. Then we will be separating the power values into bins of 100 kW and after the control and target turbines have been chosen, we will conduct the correlation analysis. The RMSE method will give us the turbines with the most consistent data, which will be used for finding the correlation between the turbine data until the General Electric's intervention and after the General Electric's intervention. In this data the similar wind profiles at different times will be found and checked if the power output for similar wind profiles before and after the intervention of General Electric has changed. With the code given below we have conducted an exemplary correlation analysis. Now we need to conduct the same analysis into our turbine data to check if the interventions of General Electric has been successful.