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Excel Wind Analysis-Instructions for Use

Key
Red Text: Words to be defined, see Glossary of Terms
Blue Text: Buttons from on-screen toolbar, shown in sequence
Green Text: Keystrokes

Introduction

Gathering and recording of wind data is necessary for further development of wind power, but it must be taken a step further. The purpose of this spreadsheet is the analysis of wind data to prove a wind resource exists at a specific location (steps for using the analysis spreadsheet are described below). Included with the spreadsheet is a program to create a Wind Rose graph, as well as a folder containing power curves for various wind turbines. Some important items calculated by the spreadsheet are the average wind speed, capacity factor, and estimated annual energy production. A report sheet is also included, formatted for printing, which summarizes results and displays graphs.

Getting Started

1. Open *New_Excel_Analysis.xls* file

2. Click File-Save As from the toolbar at the top of the screen. Enter a desired name for the file (for purposes of this text, I will call it *My_Excel),* and save in a file where it can be located easily.

3. Click on *Analysis* worksheet, if not already there.

Obtaining Sample Data File

1. Data collected by the INEEL can be viewed by visiting the INEEL-Wind Powering America Support website at http://energy.inel.gov/powersystems/wind/. Scroll down to the map of Idaho and click on a desired site, displayed as dots on the map.

2. You will be directed to a brief site summary. Scroll down until you see a link that says "comma delimited files," and click on this link.

3. To download one of the data files:

- Click on one of the filenames, and a window should appear asking to open the file or save it to your computer. If it does not, Right-click on the filename and select **Save Target As**.

- Click the drop-down arrow next to the **Save In:** label and select **Desktop**. Click **Save** to save the file to the desktop.

- Return to Microsoft Excel, and click on File-Open or on the **Open** button on the toolbar.

- Browse to the desktop, and if the filename is not listed, select the drop-down arrow next to the **Files of type:** label and select **All Files (*.*)**.

- Select the filename and click **Open**.

- Select **Delimited** and click **Next**, then check the box next to **Comma** and click **Finish**. The file should now be opened correctly in Excel.

4. Return to *My_Excel* and click on the *Analysis* worksheet if not already selected.

Data Entry

1. Push Ctrl e to run macro 1, clearing site information and logger data. If running program for the first time, data will not be present for clearing.

2. Open data file (.n## or .xls format), select the first row of data under *Speed*, *Standard Deviation*, and *Direction* headings.

3. To select data:

- Scroll page to the bottom of the data, hold down shift key, and select the last entry in *Direction* column, or…

- Hold Ctrl, Shift, and down arrow

4. To copy data:

- Right-click mouse, select "copy," or…

- Select Edit-Copy under toolbar at top of screen, or...

- Hold Ctrl c

5. Return to *My_Excel* file, *Analysis* worksheet, and select cell B13.

6. To paste data:

- Right-click mouse, select "paste," or…

- Select Edit-Paste under toolbar at top of screen, or…

- Hold Ctrl v. Data should be displayed in columns B-D.

Entering Wind Data

1. Enter site information in green cells B1-B8. This information is stated in the downloaded data file.

- For cells B7-B8, enter timestamps exactly as shown with first and last data points in downloaded data file, rounded to 10-minute increments.

- For cell B5, enter data in meters. Tower height is also found under the site description in the downloaded data file, but may be listed in feet (i.e. 66 ft = 20 m, 98 ft = 30 m).

2. Enter calculation information in cells E1-E5.

- For an explanation about cell E1, see Patching Data section.

- If data was collected using a Symphony data logger, enter a 1 in cell E2. Otherwise, simply leave blank. This is necessary because a Symphony logger has a different offset, that is, all data at 0 mph will be recorded as .8 mph. This must be considered in the calculations.

- Enter desired month (number 1-12) for *Monthly_Wind_Variation* graph in cell E3.

- Enter a wind shear value in cell E4. The default value is 1/7 = .1429. This is for normal shear. Use this number if you don't have a calculation of the wind shear for your location.

- Enter the time stamp increment value in cell E5. Most data is recorded in 10-minute intervals, but some data loggers allow for data to be recorded using other intervals.

3. Enter the desired scale height in cell J24 and…

4. Push Ctrl d to run macro 2, filling in timestamps for each data point.

Note: Comments have been placed in certain cells within the spreadsheet to provide tips and helpful information. To view, simply place the mouse arrow over one of the cells with the red flag in the corner.

Selecting and Using a Power Curve

1. Open desired power curve file, located in the folder labeled Power Curves.

2. Select…

   - Worksheet containing desired turbine power curve (see Appendix A).

   - Small square above row 1 label and left of column A label.

3. Copy data using method described above.

4. Return to *My_Excel* file; choose *PwrCrv_Data* worksheet, and select cell A1.

5. Paste data using method described above.

   - If power curve file or desired turbine data is unavailable, data can be entered manually in *PwrCrv_Data* worksheet under Manufacturer's Power Curve Table beginning with cell C21.

6. Push Shift F9 to calculate worksheet.

7. Select *Analysis* worksheet; push Shift F9 to calculate worksheet.

8. Select *Summary_Report* worksheet; push Shift F9 to calculate worksheet.

9. Select File-Save from toolbar or push save button.

Running and Inserting Wind Rose graph

1. Open *WindR.exe*.

2. Select File-Load Excel File from toolbar (unless prompted to do this). Browse for and select *My_Excel* file.

3. Close *WindR* by clicking on x in top right corner of window or by selecting File-Exit from toolbar.

4. Reopen *WindR* as before and graph will be drawn.

5. Select File-Copy from toolbar.

6. Return to *Summary_Report* worksheet in *My_Excel* file.

7. Paste wind rose using method described above. Graph will be pasted as a picture, and can be modified using the Picture Toolbar. If toolbar does not automatically appear, select View-Toolbars-Picture.

8. Use crop button and select and drag edges of the picture to resize. Drag picture to the designated area and resize as needed for best viewing and printing.

Patching Data

In some cases, wind data files may contain bad data, that is, data with 0 mph average wind speeds. This usually occurs when an anemometer becomes iced during the winter. It may be desired to perform analysis without taking this data into account. To do this, type a zero in cell E1 on *Analysis* worksheet, or leave this cell blank. The spreadsheet will then make calculations while excluding the bad data. To calculate the data as is, enter a 1 into cell E1 before pushing Shift F9.

The final option is to patch the data. This is generally done if data has been gathered from another site in close proximity and with similar wind during the same time periods. To do this, simply locate the bad data and enter alternate data in the *Average Speed* column. Enter a 1 in cell E1 and push Shift F9.

Appendix A
Glossary of Terms

Wind Rose graph—Polar graph displaying prevalent wind direction as well as percentage of total wind energy produced in each direction.

Capacity Factor—The ratio of the average load on the turbine to its capacity rating during the specified time period (i.e. a turbine producing and full capacity all of the time have a capacity factor of 1).

Wind Shear—The change in wind speed or direction with distance, usually vertical.

Analysis worksheet—Worksheet that displays data as well as performs calculations for analysis. Only enter information into green cells.

PwrCrv_Data worksheet—Worksheet that displays data for creating the power curve graph of a specified turbine.

Summary_Report worksheet—Worksheet that gives a summary of results, site information, and relevant graphs. Sheet is formatted for printing.

Macro 1—VBA code written to clear all entered wind data and site information. Can be viewed by selecting Tools-Macro-Macros-Edit from toolbar. Ctrl e is the hotkey for this macro. Be careful that is not used accidentally because action cannot be undone.

Macro 2—VBA code written to enter timestamps into the data. This macro reads from the start and stop times entered into cells B7-B8, and will not work correctly if values are not entered or are entered erroneously. Can be viewed with Macro 1 as described above. Ctrl d is the hotkey for this macro.

Data file—File containing recorded wind data. These can be converted to a comma-delimited format that can be opened using Microsoft Excel.

Cell B13—First cell under the Average Speed heading. It is necessary that changes not be made to the spreadsheet, as most of the formulas run using cell B13 as the first cell.

Cells B1-B8—Cells used for site description entry. Highlighted in green.

Cell J24—Enter desired tower height here to scale data and perform calculations. Highlighted in green.

Cell E3—Enter a number, 1-12, representing the month to graph wind variation (see description below). Highlighted in green.

Cell E1—Enter a 1 to analyze data as is or if using patched data. Enter a 0 or leave blank to perform calculations without using bad data (0 mph wind speed). Highlighted in green.

Monthly_Wind_Variation graph—Graph displaying each recorded wind speed average data point in the desired month. Used to find where the wind was 0 mph and data may need patching.

Power Curve—Graph showing the output of a wind turbine at a given wind velocity.

Power Curve file—Microsoft Excel file created for use with this analysis spreadsheet. Files are organized by turbine manufacturer, and each file contains different power curves organized by turbine size. See Appendix A for a list of these curves.

Manufacturer's Power Curve Table—Table of data for the given power curve, provided by the manufacturer. Data can be entered in as desired.

Shift F9—Use this for calculating spreadsheet one worksheet at a time. This is the suggested method of calculation due to the length of time it takes to calculate the whole worksheet. Can be changed by choosing Tools-Options-Calculations, and then by checking the desired box.

WindR.exe—Executable written to create wind rose graph. Pulls data from columns Y, Z, and AA in analysis spreadsheet, and will only work correctly if columns are not modified. Graph can be printed directly or copied as a picture.

Appendix B
List of Power Curves

1. **Bergey**
   a. BWC XL, 1 kW
   b. BWC Excel-R, 7.5 kW
   c. BWC Excel-S, 10 kW
2. **Bonus**
   a. 300 kW Mk II
   b. 450 kW Mk III
   c. 500 kW
   d. 600 kW Mk II
   e. 600 kW Mk IV
   f. 1000 kW
   g. 1300 kW
   h. 2000 kW
   i. 2300 kW
3. **Carter**
   a. Carter 300 kW, 67ft. rotor
   b. Carter 300 kW, 78ft. rotor
4. **DeWind**
   a. DW 600 kW, 46m rotor
   b. DW 600 kW, 48m rotor
   c. DW 1250 kW, 62m rotor
   d. DW 1250 kW, 64m rotor
   e. DW 2000 kW
5. **Fuhrlaender**
   a. FL 30 kW
   b. FL 100 kW
   c. FL 25 kW
   d. FL 1000 kW
6. **Gamesa Eolica**
   a. G52-800 kW
   b. G58-850 kW
   c. G80-1500 kW
   d. G80-2000 kW
7. **GE Wind**
   a. GE 900 kW Series
   b. GE 1.5 S
   c. GE 1.5 SL

8. **Jacobs**
   a. Jacobs 20 kW
9. **Lagerwey**
   a. LW52, 750 kW
   b. LW58, 750 kW
   c. LW72, 2000 kW
10. **NEG Micon**
    a. NM44, 750 kW
    b. NM48, 750 kW, IEC II, Arctic
    c. NM52, 900 kW, IEC II, Arctic
    d. NM 54, 950 kW, IEC II b, Power Trim
    e. NM60, 1000 kW
    f. NM72C, 1500 kW, 60 Hz
    g. NM72, 1650 kW, IEC I
    h. NM82, 1500 kW
    i. NM82, 1650 kW, IEC III
11. **Nordex**
    a. N50, 800 kW
    b. N60, 1300 kW
    c. N62, 1300 kW
    d. S70, 1500 kW
    e. S77, 1500 kW
    f. N80, 2500 kW
    g. N90, 2300 kW
12. **Norwin**
    a. N 150 kW
    b. N 29-Stall-225 kW
    c. 47-ASR-750 kW
13. **REpower**
    a. REpower48, 600 kW
    b. REpower48, 750 kW
    c. REpower MD 70, 1500 kW
    d. REpower MD 77, 1500 kW
    e. REpower MM 70, 2000 kW
    f. REpower MM 82, 2000 kW
14. **Suzlon**
    a. S33, 350 kW
    b. S64, 950 kW
    c. S60, 1000 kW
    d. S62, 1000 kW

      e. S64, 1000 kW

      f. S60, 1250 kW

      g. S64, 1250 kW

      h. S66, 1250 kW

15. Turbowinds

      a. T52, 600 kW

16. Vestas

      a. V27, 225 kW

      b. V29, 225 kW

      c. V39, 500 kW

      d. V39, 600 kW

      e. V42, 600 kW

      f. V44, 600 kW

      g. V47, 660 kW

      h. V52, 850 kW

      i. V66, 1650 kW

      j. V66, 1750 kW

      k. V80, 1800 IEC class I

      l. V80, 1800 IEC class II