CHAPTER 11 : The POWER Tool software

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11.1 The POWER Tool

The data on wind and wave parameters for European waters produced by the POWER project has been compiled as a set of Microsoft Excel work books (hereafter referred to as 'the database', though note that the data are not strictly in database format). The POWER tool is a simple graphical user interface (GUI) allowing a user to display data, both in numerical and graphical form, from the database of wind and wave parameters.

The POWER tool presents four tabbed dialogue boxes (TDBs) to the user, entitled "Wind Details", "Wind Map", "Wave Map" and "Wave Details" respectively. Each TDB presents different aspects of the wind and wave database, and the user may switch freely between TDBs at any time. Each of the four tabbed dialogue boxes is now described in turn.

11.1.1 The Wind Details Box

The Wind Details TDB allows the user to view wind parameters associated with a selected offshore location. Data is available for offshore locations on a latitude-longitude grid ranging from 30° to 70° N and 15° W to 30° E, at a grid spacing of 0.5° in both latitude and longitude.

The available grid points are presented to the user in the "Latitude" and "Longitude" drop-down boxes at the top of the window. A negative value of longitude corresponds to a location west of the meridian.

Note that the longitude drop-down box remains empty until the user selects a latitude, and is cleared on selection of a new latitude value. The longitude values corresponding to offshore locations at the specified latitude are then selectable. The user next specifies a height above mean sea level from the range 10-150 m (selectable in 20 m increments) and clicks "OK". The following data for the selected location and height are now displayed :

In the five text boxes :

The mean annual wind speed, the Weibull A and k parameters of the annual wind speed probability distribution (see Section 11.3 for a description of the Weibull function), and the mean power density associated with the kinetic energy of the wind.

By choice of a suitable wind turbine power curve, the mean annual power output of a specific installation may be estimated from the Weibull parameters. The default power curve supplied is for a Vestas 1.65 MW machine. See Section 11.4 for details of the mean power calculation, and Section 11.5 for instructions on how to supply a power curve of your choice.

In the five polar or Cartesian plots :

The wind rose, showing the distribution (as a percentage) of wind direction at the selected height, over twelve 30° sectors. Due north is plotted in the upward direction.

The height profile, showing the variation of mean wind speed over the height range 10-150 m.

The wind speed probability distribution function p(v) as a Weibull function determined by the A and k parameters displayed above, for the selected height.

The mean monthly wind speed over the period 1985-1997 (see Section 11.6 for definition of terms)
the mean yearly wind speed.

11.1.2 The Wind Map Box

The Wind Map TDB can be used to inspect contour maps of :

- The mean annual wind speed at heights of 10-150 m in 20 m increments. Choice of the appropriate height in the upper drop-down box switches between contour maps of the different heights; or
- The mean monthly wind speeds at a pre-set height of 50 m. Selection of different months is possible through the lower drop-down box.

If a coordinate position and height has already been selected in the Wind Details TDB, the map for the relevant height is automatically displayed, with the coordinates of the selected location shown in the upper text box and a red circle marking the location on the map.

11.1.3 The Wave Map Box

The Wave Map TDB is analogous to the Wind Map TDB. The contour maps are available for three sea conditions :

- significant waves
- swell
- wind-sea waves

and for each of the above, for three wave parameters :

- mean wave height
- mean wave period
- a fifty-year extreme wave height

The means are taken over the 10-year period 1987-1996.

In addition, a map of the fifty-year extreme wind speed at 19.5 m is available.

11.1.4 The Wave Details Box

The Wave Details TDB can be used to extract data on sea conditions for fourteen “footprint” locations, each chosen to be representative of a sea area (for example, the North Atlantic or Aegean Sea). *Note that the data on sea state displayed in the Wave Details TDB does not necessarily bear any relation to a grid point selected in the Wind Details TDB.* Selection of different sea areas is made through the drop-down box at the top right of the TDB.

The following sea condition data are displayed :

In one polar and one Cartesian plots at the top of the GUI window :

- the wave rose, showing the distribution (as a percentage) of wave over twelve 30° sectors. Due north is plotted in the upward direction.

- the probability distribution p(H) of the significant wave height H.

In four Cartesian plots at the bottom of the GUI window :

- The mean yearly and mean monthly wave heights, for significant waves, swell and wind-sea waves.
- The mean yearly and mean monthly wave periods, for significant waves, swell and wind-sea waves.

In five text boxes at the right-hand side :

- The average and the maximum significant wave height over the period 1987-96
- The fifty-year extreme wave height
- The Weibull A and k parameters derived from a fit to the significant wave height probability distribution shown in the plot described above.

11.2 Installation of POWER Tool

It is recommended that installation of the POWER tool is performed by a user with Administrator rights on the relevant machine.

The following instructions have been used under MS Windows 98 (and on Windows 2000) to install the POWER tool :

1) Create a directory on your hard disk from which you want to run POWER. As an example, I created c:\Power.
2) Copy the first four files and all the directories from the CD to this directory. Do NOT copy the two files St6unst.log and St6unst.004.
3) In the example directory c:\Power, I now have 3 files and 6 sub-folders.
4) If I right-click on c:\Power in Windows Explorer, and select Properties, I find a total of 3828 files and 7 folders (the Package sub-folder has one sub-folder of its own).
5) Right-click on the file MainPath.txt, and select Properties. The Read-only box will be ticked. Click on it to clear the tick, and then click OK to close the Properties menu.
6) Edit the file MainPath.txt and replace the first line with the directory you copied the POWER files to. [In my example, it was c:\Power]. Now Save MainPath.txt.
7) Go to the sub-directory Package [in my case this is c:\Power\Package] and double click the setup.exe program.
8) The first message you have is about closing down other programs. It is important that, as a general rule, you don't have other programs running when installing new software. Attend to this and click OK.
9) If you don't want to use the suggested install directory [c:\Program Files\POWER\] click Change Directory and enter your choice. [I used c:\Power].
10) Make sure the correct directory is displayed and click the button with the picture of a computer on it.
11) Deal with the Program Group request. I used the default. Press Enter and install commences.
    {You may at this point receive various warning/error messages, particularly if you do not have administrator rights. In general either click 'OK' or 'ignore'. For more details see the next page of these notes}
12) If it is present, Click the Power Offshore Wind Resource Data icon to run the program; otherwise Run the application Power.exe in the C:\Power folder.

N.B. If you have had a failed install, use Settings-Control Panel-Add/Remove Programs to uninstall POWER. Then make sure that all traces of POWER files on your hard disk have gone (apart from those in the Windows directory and sub-directories of Windows). Then follow the above instructions.

Technical Notes :
The POWER CD supplied has following folder structure :
\Power
\Power\Curves
\Power\Data
\Power\Package
\Power\Package\Support
\Power\WaveData
\Power\WaveGIFs
\Power\WindGIFs

If you are installing POWER on a machine for which you do **not** have Administrator rights, you may receive the error message “Setup Error 168 : Setup has encountered a problem updating your system registry”. If so, click “OK”. You might also receive various messages about difficulties in installing various DLL files – ‘ignore’ these messages – the performance of POWER does not seem to be affected

If you are installing POWER on a machine for which you **do** have Administrator rights, you may receive the error message “Unable to configure ODBC driver Microsoft dBase driver (*.dbf) : Could not load the setup or translator library. If so, click “OK”. The performance of the POWER will not in either case be affected.

NOTE : It is strongly recommended that you do not store any files in the \Power\ sub-folders, other than those installed there by the Setup program.

11.3 Technical Appendix – The Weibull distribution

The "Wind Details" and "Wave Details" TDBs display the A and k parameters of the Weibull function used to fit wind speed and wave height distributions. The function is :

where the independent variable x is in this case either wave height (m) or wind speed (m/s).

$$p(x) = \left(\frac{k}{A}\right)\left(\frac{x}{A}\right)^{k-1} \exp\left[-\left(\frac{x}{A}\right)^{k}\right]$$

11.4 Technical Appendix – Calculation of wind turbine power

The "Wind Details" TDB gives the option of calculating the mean power output of a given model of wind turbine at the offshore location selected, using the turbine's power curve. Prediction of turbine power output from speed-to-power conversion must be done with care, and the facility offered by the POWER tool should be regarded as giving a first estimate only.

The calculation is performed by taking a power curve, consisting of a set of N wind speeds v_i and the corresponding observed power outputs $P(v_i)$, and calculating the Weibull probability $p(v_i)$of each v_i , using the relevant Weibull A and k parameters. The predicted mean power output P is then calculated as :

For an accurate power output estimate, the expression above implicitly assumes that the first data point

$$P = \sum_{i=2}^{N} \left[p(v_i)P(v_i) + p(v_{i-1})P(v_{i-1}) \right] \left[v_i - v_{i-1} \right] / 2$$

in the power curve defines the turbine's cut-in speed, and that the final data point defines the power output immediately prior to turbine stall To minimise the errors in this power output estimate, therefore, it is important that power curve supplied has data close to both the cut-in speed and stall speed of the turbine.

11.5 Technical Appendix – Defining a power curve

The POWER tool provides a power curve of a Vestas 1.65 MW turbine as a default. Users may supply an alternative power curve as follows : open an ASCII text file and enter the wind speed v_i and power output $P(v_i)$ values of each power curve data point as comma-delimited text, placing each pair of v_i, $P(v_i)$ values on a new line in the text file. The file \Power\Curves\Template.txt can be used as a template. Ensure that there are no trailing return characters at the end of the file. Save the new power curve as a text file in the \Power\Curves folder. The new file will appear in the power curves drop-down box the next time the POWER tool is run.

11.6 Technical Appendix - Definition of terms

The POWER tool makes reference to average wind and wave parameters as "mean annual", "mean monthly" or "mean yearly" values. The precise meaning of these terms is as follows :

"mean annual" refers to the average value over all months and all years in the period for which data was used (1985-1997 for wind data, 1987-1996 for wave data)

"mean monthly" refers to the average value for each individual month, over all years

"mean yearly" refers to the average value for each individual year, over all 12 months.