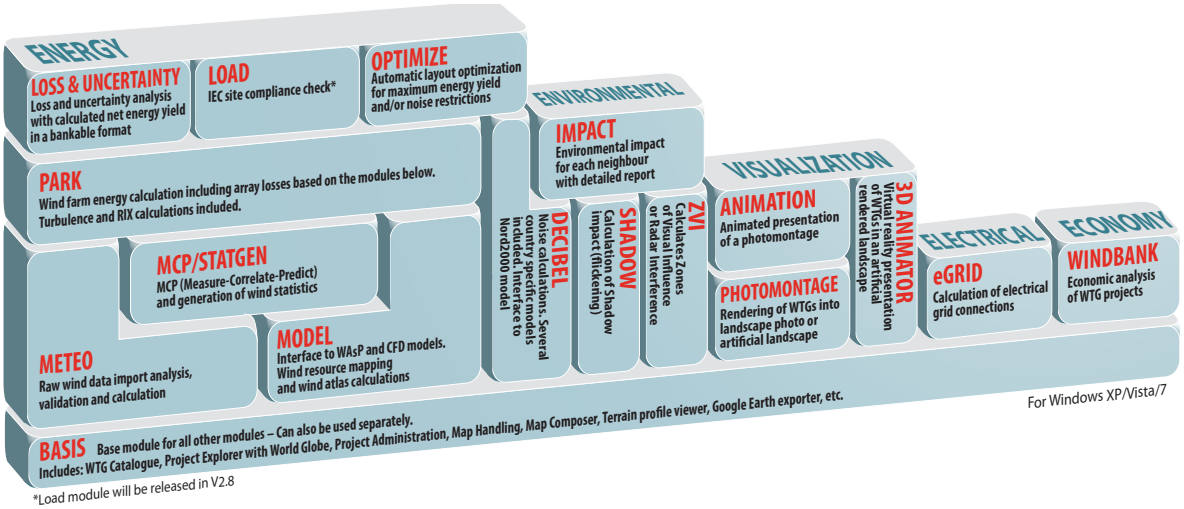


*Load module will be released in V2.8

WindPRO Software

Module Description

EMD
www.emd.dk

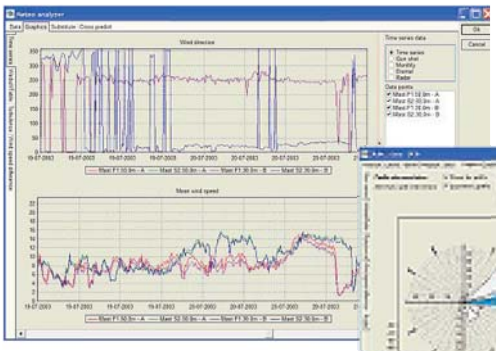
BASIC

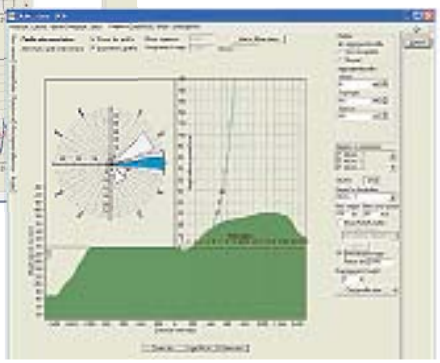
BASIS

The BASIS module in WindPRO is necessary for the use of any of the other calculation modules. It contains the following key elements:

- Project Management - A tool for the effective administration of your projects with full overview of your projects on the Project Explorer globe.
- WTG Catalogue. This catalogue is the most comprehensive wind turbine catalogue in the world. The WTG Catalogue contains data on more than 800 different types of WTGs, which have been gathered by EMD over the years. The data is constantly being updated and can be supplemented with your own turbine definitions.
- The Map Management System is the tool for linking scanned maps or maps from the Internet or other digital sources to WindPRO, making them available for project work and the input of data, which is done directly on top of such digital background maps.
- Project design / Input Data. With BASIS the user can prepare a WindPRO project ready to calculate.Special tools for many purposes such as advanced digitisation of height contour line data based on software recognition of the color differences on the background map; tools for trimming and adjusting digital data; terrain profile presentation including WTGs and measurement masts; quick profile tool for checking site elevation data; map composer for creating maps for reports with specified resolution and with customable legends etc; layer structure to organize the input data efficiently.
- On-line data services with free access to: Elevation data covering nearly the whole world (SRTM + other data sources), roughness data from different sources, satellite images (worldwide) and other maps for use as background maps.
- Export tools to present your wind farm project as photo-realistic turbines, in Google Earth with just a single mouse click. Photomontages can be exported as "fly in" photos in Google Earth and other information like wind resource maps can be shown as transparent draping. Import of Google Earth KMZ files into WindPRO is also possible.
- Data handling tools and features for easy import / export of e.g. shape files and GPS data.

ENERGY





METEO

The METEO module has two functions:

- Import, analysis and presentation of measured wind data (screening of wind data).
- Calculation of the energy yield of a WTG based on measured on-site wind data (without applying a flow model, like WAsP).

The data screening facilities of METEO are widely recognized. It is possible to read almost any kind of wind data, arrange them in time series or summary frequency tables and obtain the Weibull parameters. It is possible to visually inspect the time series, produce gunshot graphs, directional distributions, diurnal graphs etc. Time series for multiple heights can be compared with each other in all diagrams and selected data can be disabled both through selection filters and visually in the time series plots, which makes it easy to identify and eliminate errors in the measurements. Data files from all leading wind logger manufacturers can easily be imported to the METEO object. The screened wind data can be used in the calculation of wind statistics (a set of wind data cleaned for local terrain influence) with the MODEL module and the WAsP software.
The module includes special wind profile analysis features with tools allowing the user to specify day/night and seasonal variations and directly compare measurements with WAsP calculations as well as comprehensive shear analysis tools with easy cut and paste to Microsoft Excel or other spreadsheet programs.
The METEO module also includes the METEO ANALYZER tool for graphical comparison of data from different masts, substitution of data between different measurement heights and masts, graphical comparison of wind data from different masts and cross-prediction of wind data based on data from several masts and/or heights.
In the METEO ANALYZER it is possible to prepare for subsequent time varying calculations for each WTG in the PARK module either based on measured wind data transformed through WAsP or using a WTI (wind time variation file).

MODEL

The MODEL module provides the interface between a WAsP wind model calculation and the production result in typically the PARK calculation. It is also possible to interface with other external models like CFD models by providing raw data for the calculation and loading the resulting wind resource map. Finally, EMD's own ATLAS model can be used with this module. Depending on the model used, different objects and information are required.

Creation of wind statistic (WAsP):
This will require a terrain description of roughness and elevation prepared in area, line and obstacle objects. These are assembled in a site data object and sent to WAsP together with wind measurement data from a Meteo object or an MCP calculation.

Calculation of AEP (Annual Energy Production) (WAsP):
For this the same terrain input is used as above with the addition of a wind statistic. The calculation can be made for a single point using a range of wind turbine types.

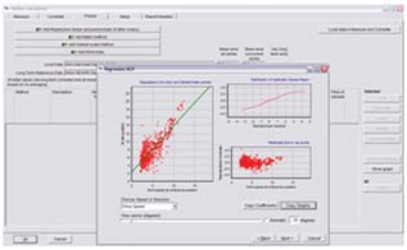
Calculation of wind resource map (WAsP):
The same terrain description and (multiple) wind statistics can be used to calculate a wind resource map. An irregular shaped area for the map can

be defined with a WTG area object. The resulting resource map can be presented on the working map and used as wind model for a PARK calculation or for energy optimization of the wind farm layout with OPTIMIZE

Calculation with CFD PRE/POST:
While WindPRO does not directly operate CFD models, it does prepare data for them. To pre-process data for CFD calculation, the same data and objects are needed as for a WAsP wind statistic calculation. The post processing requires the resource map created by the CFD model and any other resource map calculated for the site for comparison.

Calculation with ATLAS:
ATLAS is a flow model suitable for simple terrain. To run an ATLAS calculation, simple sector-wise roughness and an elevation input are needed. The ATLAS model is typically used for small-scale projects, where the AEP calculation process must be simple, fast and cost efficient. The ATLAS also requires a pre-made wind statistics. The ATLAS model is integrated in WindPRO, so no additional software is needed. ATLAS can either be calculated for a single turbine or used as input for a wind farm in a PARK calculation.

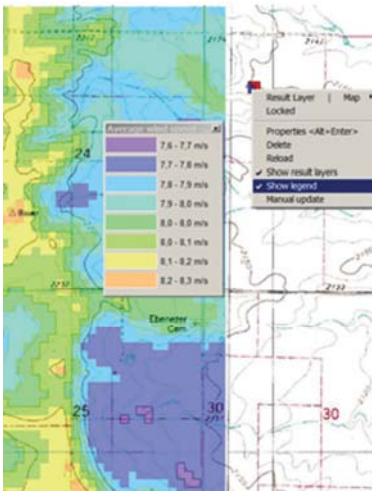
MCP Module



The MCP (Measure-Correlate-Predict) module is for long-term correction of measured wind data on site and based on the correlation with long-term reference data. The module includes the four most common MCP methods: Linear Regression, Matrix, Weibull Scale and Wind Index. Within the module, users can download both worldwide NCEP/NCAR wind data sets from 1948 until last month with a grid resolution of 2.5° longitude/latitude, NARR data (North America, 32 km resolution), QSCAT data (offshore, variable resolution, but only until end 2009 when the satellite mission stopped)), METAR data (5,000 airports worldwide) and SYNOP data (7,000 synoptical stations worldwide). These data can be imported directly into a METEO object and used as long term reference data if the user is in need of additional reference data. The "end result" from the MCP analysis is a wind statistic generated with WAsP based on a terrain description and the long term corrected site data. This can be used directly in a PARK calculation or for a wind resource map calculation. For non-WAsP use or further analyses, the long term corrected site data can be exported as time series. A very strong feature of the MCP module is the graphic comparison between local measurements and concurrent predictions based on long term reference and calculated transfer function from any of the four methods.

PARK

The PARK module is a very flexible tool for calculating the AEP of one or more wind farms. WTGs can be entered as both existing and new WTGs and treated separately in the printout, while all are included in the calculation. Even the loss of energy at existing WTGs caused by the new WTGs is calculated automatically in one process, if required. There are no limits in using different WTG types or hub heights in same calculation. With the WindPRO layer structure, several different layouts can quickly and easily be tested against each other. The PARK module contains several different wake loss models and facilities for advanced turbulence and RIX calculations.
The PARK module includes reports with 24-12 tables and duration curves based on time series with wind variations. Detailed data files with time varying production for production analyses in e.g. Excel can be extracted. The calculated production including transformation of the wind measurements to each WTG position and wake loss calculation for each time step gives new dimensions for analyzing actual versus calculated production figures. Finally, the PARK model can calculate data for park power curve verification, etc.



LOSS & UNCERTAINTY

The LOSS & UNCERTAINTY module is used on top of a PARK calculation for several issues to be considered before the calculation has reached a bankable level. The LOSS & UNCERTAINTY module offers an efficient and structured way of addressing these remaining issues. In a wind farm project several important losses have to be considered and their resulting reduction calculated; the module helps the user through this process with a full list of the relevant losses. The losses are grouped and organized according to the recommendations made by an international group of experts. A few examples of losses that can be calculated in the module are losses due to: high wind hysteresis, wind sector management and fully customizable curtailment settings. In complex terrain, industry standard flow models like the WAsP model may come short. In the bias correction part of the module it is possible to automatically correct for such model shortcomings in particular via the so-called RIX correction, provided that a RIX calculation is included in the utilized PARK calculation.
The assessment of project AEP uncertainties is an equally important step to enable evaluation of the risk of the investment. This also Includes AEP at exceedance levels between P50 and P95.
In the module all the important uncertainty components are grouped according to their origin. The main uncertainty components resulting from horizontal and vertical extrapolation may be calculated using a setup based on EMD's vast international project experience. Uncertainty due to the power curve may also be calculated according to the IEC61400-12 standard.

OPTIMIZE

The OPTIMIZE module operates with three different methods which can be used for the optimization, either independently or in combination:

A: Park design with strict requirements to a geometrical layout (straight parallel lines with equal distances between the WTGs e.g. off-shore, but also arc layouts can be handled, for example). The software can create an array based on a large number of parameters automatically (e.g. angles, distances, row offset etc). Boundaries can be digitized to keep the layout within a limited area. Once the best layout is established, calculations of energy yield, noise impact, visual impact, etc., can be carried out quickly and efficiently. Each calculation can be exported to a spreadsheet and processed to find the most cost efficient layout.
B: Automatic optimization of a WTG layout with regard to the total energy production within specified wind farm areas. Restricted areas can be defined manually or loaded as a shape file. The optimization process can automatically adjust the layout to ensure required distances to neighbors.
C: Noise optimization – Given a fixed layout, The OPTIMIZE module will optimize the operation modes in the wind farm to comply with noise requirements.

ENVIRONMENT

DECIBEL

The DECIBEL module makes noise calculations an easy task. Existing and new wind turbines can both be included, and it is possible to define noise receptors (Noise Sensitive Areas) as spot locations as well as areas described by polygons. It is also possible to enter the initial background noise level without turbines if known, and then calculate the additional noise generated by the wind turbines. Most of country-specific calculation models and noise limits are implemented. Interactive noise lines can help to adjust the position of the turbines so that the noise limits are fulfilled.

SHADOW

The SHADOW module makes it possible to calculate the annual hours of shadow flicker impact generated by one or more WTGs at either specified recipients or for a given area. As part of the calculation, the module checks for non-visual contact between recipients and WTGs through a pre-calculation of zones of visual influence within the area. A worst-case calculation based on maximum possible impact or a real-case value (weather-statistic based) calculations can be performed. Calculation output such as a shadow flicker calendar for each recipient is included. Shadow flicker calendars for each turbine can also be calculated and the results can be exported directly to and implemented in the control system of the WTGs.

ZVI (Zones of Visual Influence)

The ZVI module enables users to analyze the long distance visual effect of WTGs and to evaluate how several groups of WTGs affect the visual impact in a region. In a ZVI calculation, the user can optionally include forests, villages and other blocking elements in the calculations. The module includes features for calculating the cumulative impact of several wind farms within a specified region and it includes optional distance reduced impact. In addition, the ZVI module also includes features for radar calculations allowing the user to create a planning map of non-visibility of WTGs for radars or calculate the clearance height between the line of sight and the turbine.

IMPACT

The IMPACT module combines DECIBEL, SHADOW, ZVI and PHOTOMONTAGE to a one-page calculation result for each individual neighbor. This module can be used for informing neighbors close to a proposed wind farm of the individual environmental impacts that they may experience from the project. This precise information can often avoid unnecessary opposition and protests among neighbors to a new project.

VISUALIZATION

PHOTOMONTAGE

The PHOTOMONTAGE module is used to create a realistic visualization of a WTG project in a landscape photo (normal or panoramic view) or wireframe before it is installed. The properties of the photo used (focal length, date/time, coordinates) are loaded automatically if available. Special features such as the horizon line or various control points make it easy to calibrate the photomontage and get a precise result. This module can be used to evaluate different project alternatives, in discussions with planning authorities, neighbors, etc. as well as to adjust a project to fit into the landscape in the best possible way.

ANIMATION

After creating a photomontage, the animated visualization is just 3 mouse clicks away with this module. On the computer screen, the rotor blades rotate at the proper speed and aviation lighting can be added. The file can be exported to GIF or other formats for publication on the internet. With ANIMATION it is easy to get a realistic impression of the dynamic appearance of the wind turbines in a wind farm project.

3D-ANIMATOR

The 3D-ANIMATOR module is used for virtual reality (VR) modeling of any given wind turbine project and any 3D objects (e.g. power masts, houses, forest). The artificial landscape is rendered based on the height contour lines. This surface is then draped with a texture surface, (i.e. a map, an aerial photo or any texture), that will provide a realistic presentation of the landscape. After rendering, you can freely move through the model with rotating turbines. Movement can be controlled from the keypad, mouse or joystick. The VR-project, together with an external viewer, can also be e-mailed or burned on a CD Rom for onward distribution, so that anybody can take a virtual tour through the wind farm area.

GRID

eGRID

The eGRID module is used for the design and calculation of WTG grid integration. It calculates the following: 1) Annual losses in cables and transformers based on the local wind climate; 2) Design check of the cables and transformers (load as a percentage of capacity); 3) Steady state voltage variations based on two freely-definable load situations or auto-defined; 4) Short circuit power and current; 5) Voltage fluctuations (long-term flicker); 6) Voltage variations caused by switching effects; 7) Verification of the calculated values with demands given by the utility, for example, and finally; 8) List of cables and components used for cost calculations, including both cable length and excavation length, taking topography and gradients into account.

ECONOMY

WINDBANK

The WINDBANK module makes it easy to calculate the financial or economic feasibility of the wind turbine/-farm investment in question. The flexible nature of the module enables the user to tailor the calculations according to the specific conditions in various countries. The strength of this module is that the data handling and key figure reports are specifically designed for wind energy projects.

EMD International A/S
Niels Jernes Vej 10
DK-9220 Aalborg Ø
Tel: +45 96 35 44 44
Fax: +45 96 35 44 46
E-mail: emd@emd.dk
V.A.T. no: DK 27491529

EMD Deutschland GbR
Breitscheidstraße 6
DE-34119 Kassel
Tel: +49 (0)561 310 59-60
Fax: +49 (0)561 310 59-69
E-mail: emd-de@emd.dk

EMD France
118-122, avenue de France
FR-75013 Paris
Tel: + 33 (0)1 44 64 13 81
Email: france@emd.dk

EMD Spain
Normawind S.L.
Travessera de Gràcia 58.
Entlo.3ª
ES-08006 Barcelona
Tel: +34 93 241 12 75
Fax: +34 93 241 13 21
E-mail: info@normawind.com

EMD United Kingdom
The Wind Consultancy Service
17 Ford Lane, Morton, Bourne,
UK-Lincolnshire, PE10 0RQ
Tel: +44 (0) 1778-571786
Mob: +44 (0) 7989-018513
E-mail: windpro@windconsult.co.uk

EMD Middle East
T-EMD ltd. Sti.
Yakut Sokak, Huzur Apt.
No:39/6 Bakirkoy
34140 Istanbul - Turkey
Tel.: +90 212 543 88 48
Fax: +90 212 543 37 46
E-mail: ft@emd.dk

EMD North America
EAPC Wind Energy
3100 DeMers Avenue
US-Grand Forks, ND 58201
Tel: +1-701 775 3000
Fax: +1 701 772 3605
E-mail: wind@eapc.net

EMD China
CEPRI
No.15 Xiaoying East Road
CN-Qinghe, Beijing 100192
Tel: +86-10-82813166-305
Fax: +86-10-62956185
E-mail:xrwang@epri.sgcc.com.cn