QUICK GUIDE – PARK WITH SCALER AND MEASURED WIND DATA

Purpose:

To calculate expected AEP (Annual Energy Production) as time step calculations based on local wind measurements.

PARK calculates in time steps (e.g. 10 min) based on measured data, where the SCALER transforms the measurements to each turbine position. The SCALER can handle, as well, more measurement heights as well as more measurement mast positions, and even individual displacement heights by direction sector for individual masts and turbines (only from windPRO ver.3.1). The SCALER, thereby, can handle an enormous amount of "book keeping work". The SCALER transfer functions are based on WAsP or WASP-CFD or FLOWRES (generalized format open for all model providers) calculations and takes speed up as well as turns into account. Also, measured turbulence can be transformed to turbine positions.

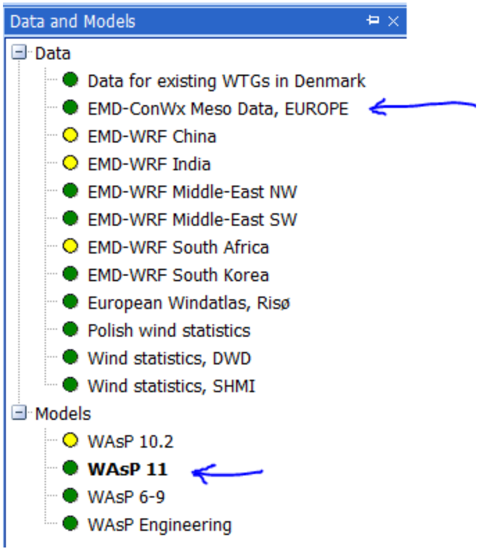
This guide assumes the user are familiar with the basic use of windPRO, establishment of objects and tasks like importing of measured data into METEO objects.

Outline of Guide:

1. **License and version requirements**
2. **Setup input data for PARK**
3. **Calculation**
4. **Results in PARK/MESO**
5. **Additional SCALER calculation options**

1. LICENSE AND VERSION REQUIREMENTS

WindPRO 3.1 with license to the module PARK and a subscription to EMD-WRF (or EMD-ConWx) Meso scale data OR purchase of WRF on demand cluster credits. Also, a WAsP 11 license must be installed.



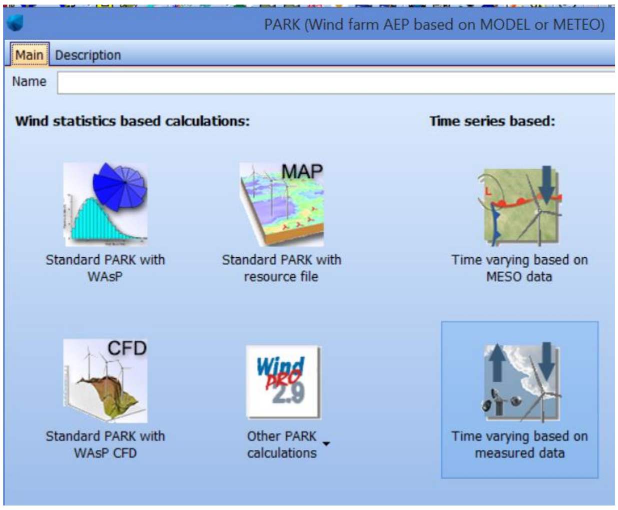
2. SETUP INPUT DATA FOR PARK

Establish the local measured wind data in METEO objects.

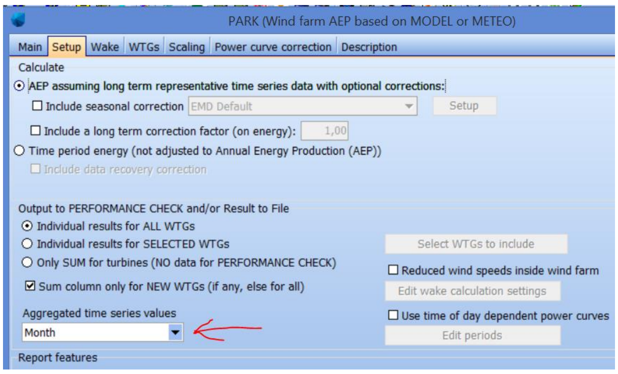
If not already established in project:

- Create the turbines to be calculated (objects).
- Create micro terrain data (roughness and elevation) and make a site data object with a link to these. The purpose for the site data object can be, e.g., STATGEN, thus, no wind statistics is needed in the site data object. Or, WAsP CFD result files or FLOWRES files can be used.

3. CALCULATION

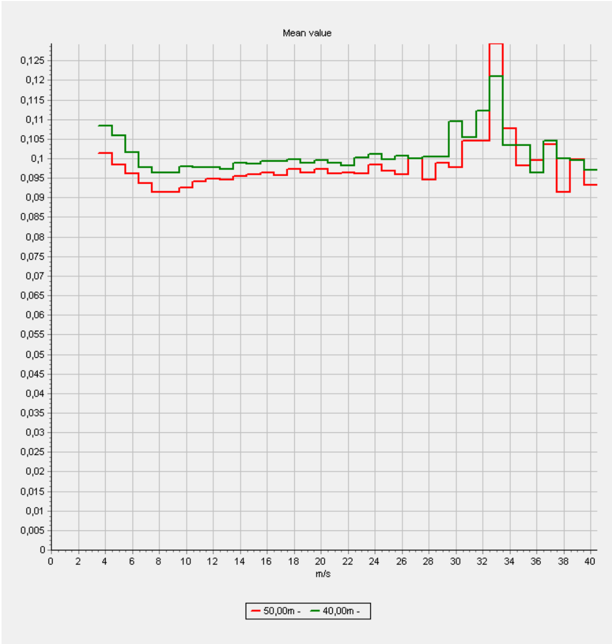


Click the lower right button to choose a time series calculation based on measured data.



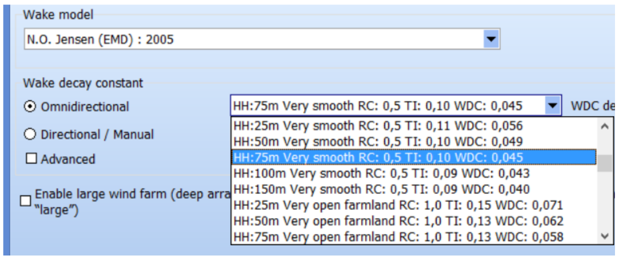
In **Setup**, note especially the "Aggregate" level. This is,, by default Month, partly to save memory. But if there is a need for the, e.g., 10 min values (for use in PERFORMANCE CHECK or for some detailed calculations in LOSS & UNCERTAINTY), this must be changed to "none".

In **Wake,** the only wake model available is the N.O.Jensen model. It is not as much the wake model that decides the accuracy of the wake loss calculation as the as it is the parameters that are used. For this model, the Wake Decay Constant (WDC) decides the results. The WDC should, basically, be chosen based on the turbulence, if this is available. If not, there are described different terrain types that, in combination with hub height, give reasonable choices.



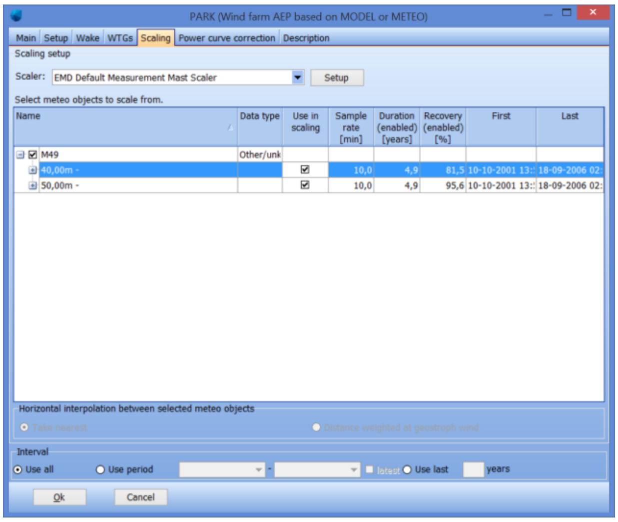
Here, turbulence measurements are available, and are used as support for the decision to choose WDC . This data shows around a 0.1 turbulence average measured close to hub height (47m for the project established here).

In the list below, this points at a wake decay constant of around 0.045 for the site. (The importance, by the choice, is that TI= 0.1, the remaining details are unimportant for this).

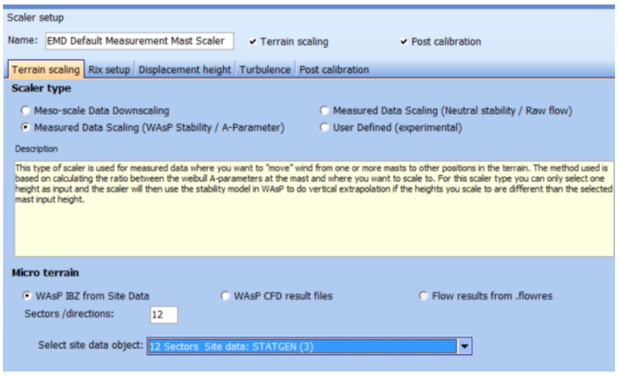


There are more refined options. If turbulence is available for the entire calculation period (which it, unfortunately, is not in the EMDConwx Europe data set (only from 2013 – but in all other EMD WRF datasets it is), the WDC can be controlled by turbulence for each time step – this is the easy and "safe" choice. For very large wind farms (+5 rows), deep array model corrections are available and is highly recommended to use.

After choosing the turbines for calculation, choose the SCALER.



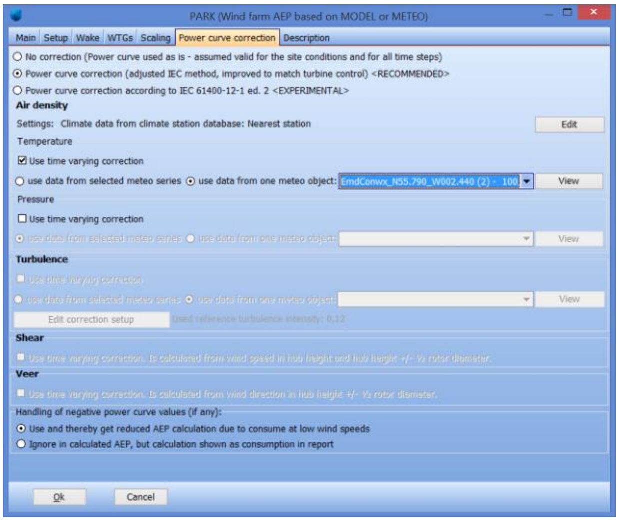
Here, simply choose the "EMD Default Measurement scaler".



Open the SCALER setup and make sure the right Site data object is chosen – or if WAsP-CFD or FLOWRES should be used as the model. The number of sectors can be chosen as well. This is used for deciding how many sector wise transfer functions shall be calculated and, later, used when scaling each time record from the time series. Normally, 12 is recommended. The use of 36 can, in some special cases, improve accuracy, but it requires very good data, e.g., a very high accuracy of the measured direction. Close the setup.

The different options will be described later. Choose the measured data. Here are 40m as 50m measurements. Hub height is 47m, but the SCALER will be able to interpolate. If there is not data "around" the hub height, the model used (default WAsP) will do the extrapolation.

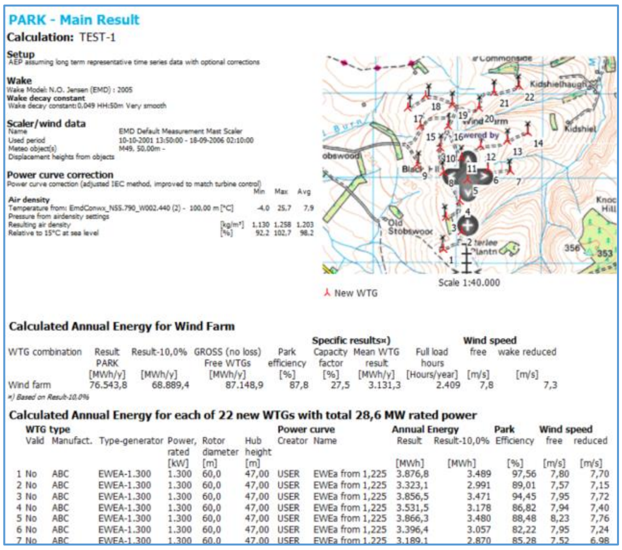
Finally, the power curve correction is entered. The recommendation here is only to check the Temperature correction since this gives a more precise month by month calculation.



If there is no temperature data in the measurements, it is possible to get temperature from, e.g., MESO data such as Merra data, where an interpolation will be made in the hourly data to establish 10-min data. The other corrections are more for "experimental use". In general, these do not affect the AEP result significantly, although at "special sites" with, e.g., extreme shear, there might be some effect.

Now run the calculation.

4. RESULTS OF PARK/MESO CALCULATION



The standard report document provides the calculation assumptions and gives the expected AEP as the average for the period calculated. There will automatically be compensation for data recovery, and, optionally, season unbiasing can be chosen. Note that free wake reduced wind speeds are shown as well. The park efficiency is calculated as 87.8%, meaning a wake loss of 12.2%.

The strongest feature when calculating in time step is the very detailed calculation validations offered. With the "result to file" output, the result in time can be taken into, e.g., Excel for further processing or analyses. In this calculation, it is an existing wind farm "Black Hill" that is calculated. From the British REF, the actual production data can be found:

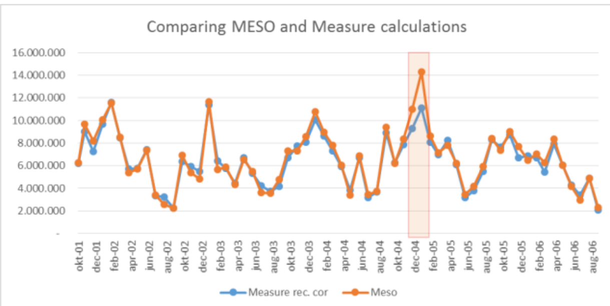
http://www.ref.org.uk/generators/index.php

The data is annual production (AEP) for the full wind farm with 22 Bonus (now Siemens) 1300 kW turbines with 60m rotor diameter and 47m hub height. The AEP periods are 1. April to 31.March with 8 full years (2007-15) available.

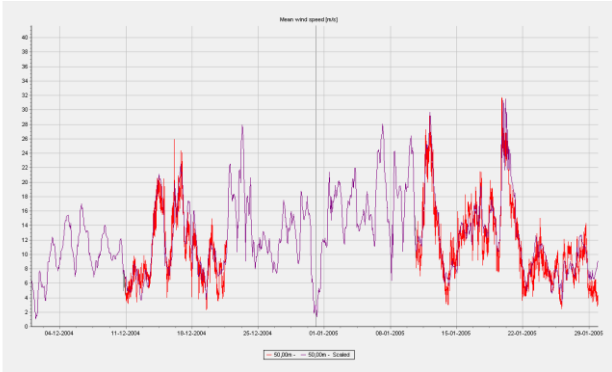
Measure scaler, 10-10-2001 to 18-9-2006 (~5y)

Calculation setup	Calc. AEP	Relative	Real/calc.	Recovery	Park eff.
40 & 50m, WDC 0.049	76.544	0,995	99%	81,5	87,8
50m, WDC 0.049	76.834	0,999	98%	95,6	87,6
50m, WDC 0.045	76.496	0,994	99%	95,6	87,2
50m WDC by turbulence	76.928	1,000	98%	95,6	87,7
" with Season correction	77.171	1,003	98%	95,6	87,7
" with Turb. PC correction	77.170	1,003	98%	95,6	87,7
MESO, same period	80.380	1,045	94%	100	87,6
MESO 20y	83.046	1,080	91%	100	88,2
Real production	75.541				

In the table above, a number of different settings in the measurement based calculation are tested and a compared to MESO wind data calculation (see Quick guide: PARK_MESO_SCALER_MEasurementCalibration). As observed, there is almost no difference using measured data (blue area) with different settings. But, the MESO data based calculations are 4.5% higher and 8% higher when using a full 20y period. Comparing to real production (8 year based), the first impression would be that the measurement based result seems better. But, it looks better for the wrong reason:



The deviation is mainly related to two months that explain the malority of the difference, Dec.04 and Jan.05, where the measurements were not recording for more than 50% of the time. If only the months with 100% recovery rate in the measurements are used, the difference between meso and measurement based calculations is just 1%. There is, thereby, an underprediction of 3.5% compared to if the data period had 100% recovery rate. This is due to the missing samples having, in general, higher wind speeds since they are winter months.



Comparing measurements and Meso scale data shows that the periods with missing measurements in Dec.04 and Jan.05 were very high wind periods compared to the average of the period where measurements were working. Thereby, the calculations based on measurements give figures that are too low despite that a data recovery compensation is made. This can only be made based on assuming the missing data, on average is the same as the existing data.

The difference between calculated and measured, when Meso data based, is on long term expectations of 9% and can (at least partly) be explained by losses. It is known that there are following loss "components" not deducted in the calculations:

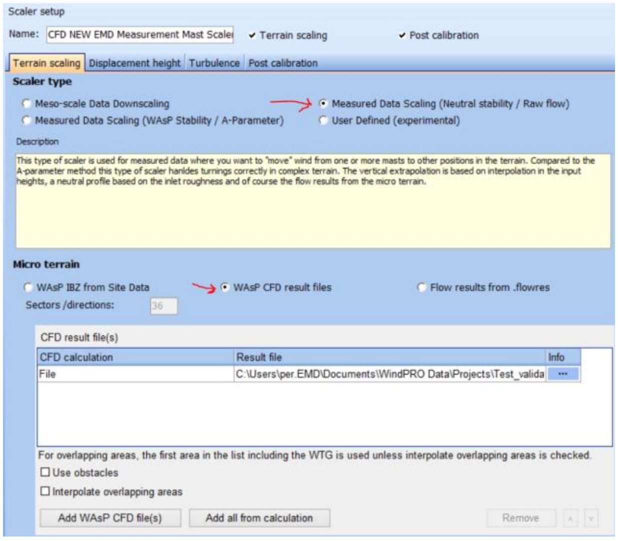
- Grid
- High wind hysteresis
- Icing
- Availability

These could explain the 9% difference, although this might not be the full explanation. The "real loss" is not known. An obvious reason for possible over prediction is that the mast is located at a higher elevation than the turbines. This is a well-known model problem. Another possible over prediction reason can be the power curve.

To conclude: The measurement based calculation is 4.5% lower than the Meso based calculation (only using the concurrent period), which is explained by the lack of data, especially in two extreme high wind months, where the measurement equipment was out of order. Further, results are around 3.5% lower than the long term Meso based calculations (using the entire Meso series) due to less wind in the measurement period compared to the long term period.

It is, thereby, not the methodology that creates different results, but the data quality. It should be noted that using the measured turbulence for controlling the WDC gives the same result as setting the WDC based on the average measured turbulence to 0.049.

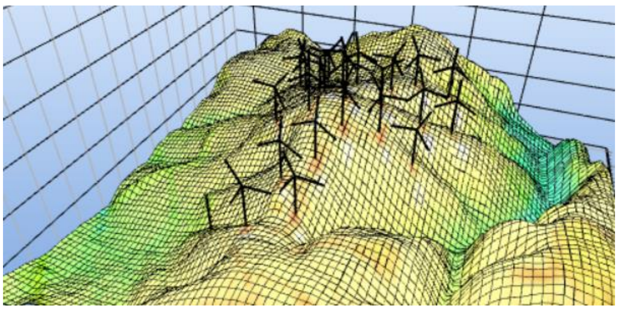
5. ADDITIONAL SCALER CALC. OPTIONS

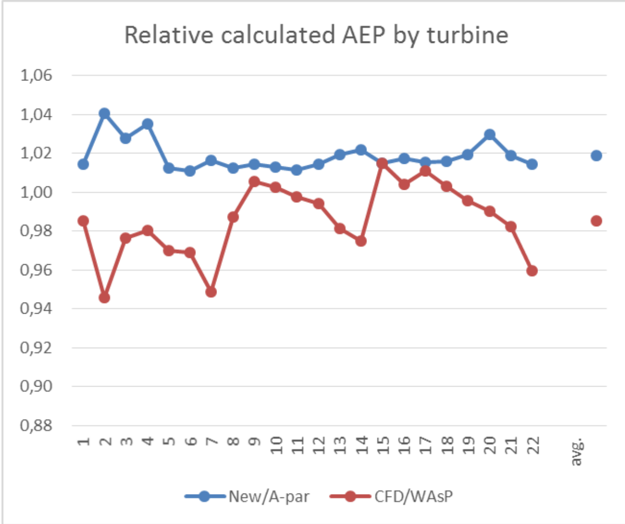


Using the SCALER on local measurements offers additional choices.

- One is to use the "Neutral stability / Raw flow"(NEW) as alternative to the "WAsP Stability / -Parameter".
- The other (also available with MESO Downscaling) is to use WAsP CFD result files or FLOWRES files (from e.g. other CFD providers.

In the test case used here, the changes in calculation results are tested. Below ia a 3D view of the turbines.





As observed, the "NEW" scaler here calculates a 2% higher AEP than the A-parameter scaling, but very small differences by turbine. The "NEW" is assumed to be more correct, while the A-parameter scaling has the built in problem that the possible change in Weibull k parameter is not handled. The "NEW" simply uses the raw WAsP speed ups. A disadvantage with the NEW is that no stability correction is applied since this does not exist as a separate output from the WAsP model. This also means that, by default, it only works if the calculation height differs by less than 20% from the measurement height.

For the WAsP CFD as an alternative to WAsP, the calculation result is around 2% less. However, in this case, larger variations by turbine are seen - up to 6%. It is mainly the turbines 2,7, 14, and 22 close to the "valley" east of the site that are calculated lower by the CFD model.