QUICK GUIDE - SITE COMPLIANCE

Purpose:

To check if a particular IEC turbine class (e.g., IA) complies with the site and layout conditions.

SITE COMPLIANCE calculates the seven main checks required in IEC 61400-1 ed. 3 (2010) site assessments:

- Terrain Complexity
- Extreme Wind
- Effective Turbulence
- Wind Distribution
- Wind Shear
- Flow Inclination
- Air density

Three additional IEC checks are also included:

- Temperature range
- Seismic hazard
- Lightning rate

Note: From windPRO version 3.3 SITE COMPLIANCE supports the IEC61400-1 ed. 4 (2019) which includes additional three checks under Ultimate/Extreme conditions.

WEng 4.0 is required for including effect of obstacles.

Outline of Guide:

1. **Data and models needed in SITE COMPLIANCE**
2. **Setup input data in SITE COMPLIANCE**
3. **IEC Main calculations in SITE COMPLIANCE**
4. **Re-calculate for a different WTG class**
5. **Calculation of Other IEC checks**

1. DATA AND MODELS NEEDED IN SITE COMPLIANCE

SITE COMPLIANCE can be used at various levels of input data and external software licenses.

Full functionality is obtained in projects with site mast(s) with multiple heights, a long-term reference series and valid external licenses for both WAsP and WAsP Engineering (WEng 4.0).

Minimum data level is a site mast with multiple measuring heights but no external model licenses.

Projects with no on-site mast require valid external licenses for both WAsP and WEng and a wind statistics (lib file) to complete all seven IEC main checks.

Make sure that your project at least contains following data/licenses before you start SITE COMPLIANCE:

1. A layout of WTGs
2. A digital elevation model, line or grid (TIN)

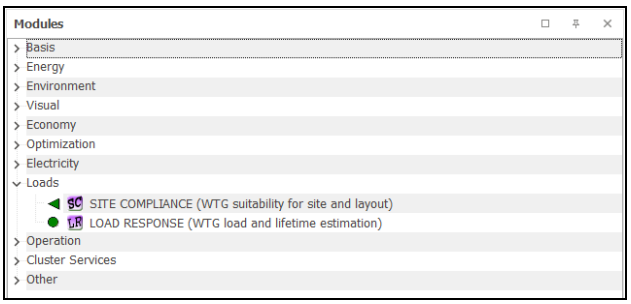
3A. A site mast with multiple heights

3B. A site data object (with a wind statistic)
A valid WAsP license
A valid WEng 3.0 or 4.0 license

In the following guide we assume a project allowing full functionality in SITE COMPLIANCE, i.e., a project with a site mast with multiple measuring heights and valid WAsP and WEng 3.0 or 4.0 licenses. We also assume that long-term corrected wind statistics have already been created from MCP, although this is not a general prerequisite.

2. SETUP INPUT DATA IN SITE COMPLIANCE

Start **Site compliance** from the main menu.



Main - tab

In this example we have both **mast and flow models** available, so we check this option.

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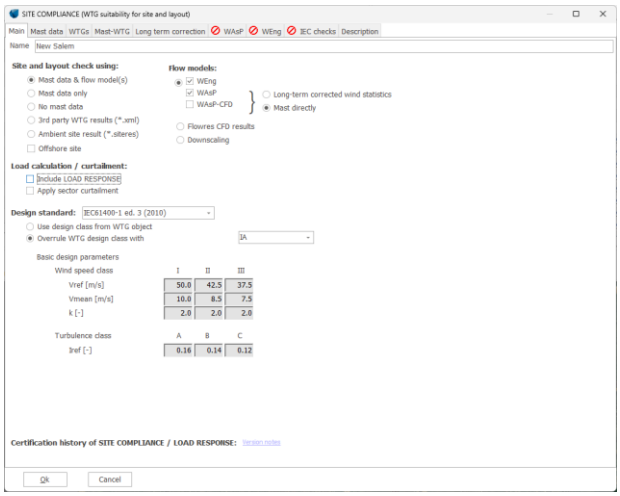
Mark the flow models available: **WEng** (check), **WAsP** (check) and **WAsP-CFD** (check). In this example we have a site data object with a **long-term corrected wind statistics** available (check).

For the WTG positions in this example, we wish to test an IEC class of IA. You may select this class specifically via **overrule WTG design class with** IA (dropdown box).

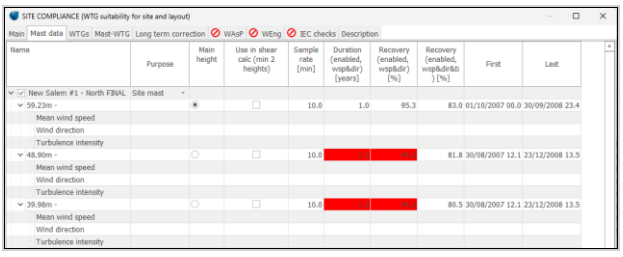


Alternatively, the WTG class may be defined individually in each WTG object prior to starting SITE COMPLIANCE.

Mast data - tab

Here you see a list of all the Meteo objects in the project. Check the site mast(s) you want to use and it will expand and show the heights to be selected.

Purpose should be **Site mast** (default) and you must define the **Main height** (check) and the heights to be **used in shear calculations** (multiple checks).

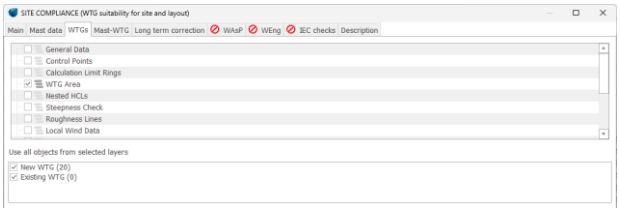


Note:
Any red data fields might indicate potential problems with the data, like too short data period, too low recovery rate or non-standard sample rate and should be investigated further in the Meteo object!

Check your long-term reference series (if any) and set "Purpose" to "Long term reference" (dropdown) and define the "Main height" (check).

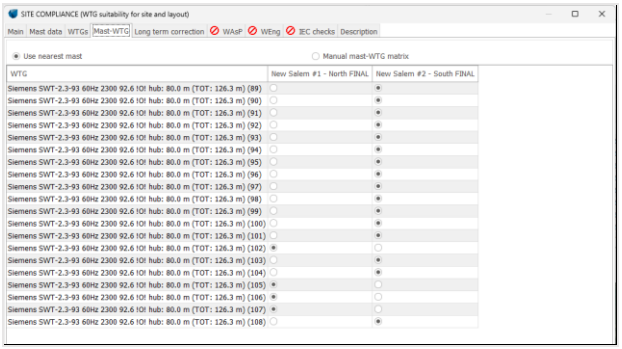
WTGs - tab

Select the layer(s) with your WTGs tab (check).



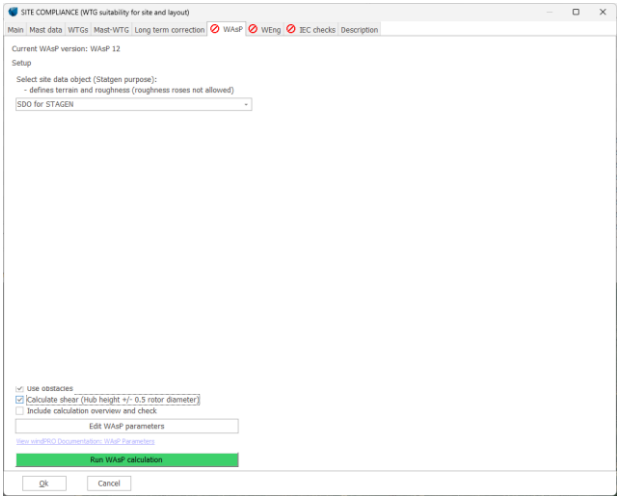
Mast-WTG - tab

Select which site mast is representative for each WTG, default is nearest site mast.



WAsP - tab

Match each mast in the list with the relevant site data object that contains the long-term corrected wind statistics based on that mast (dropdown).



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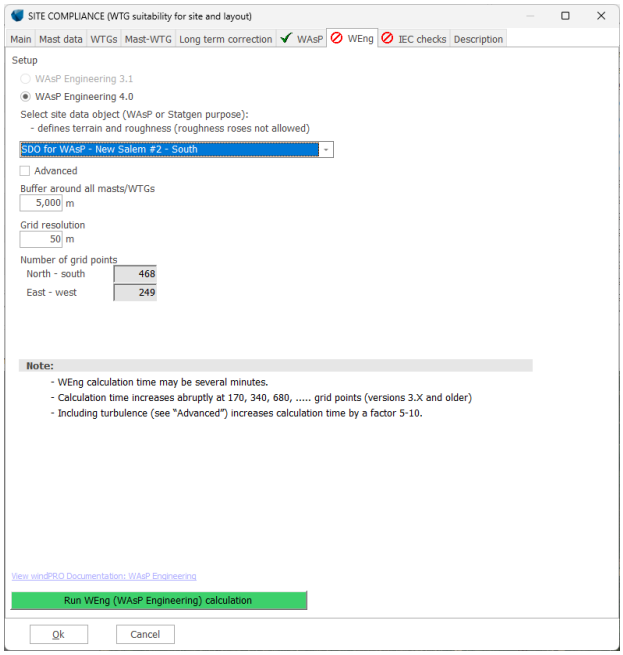
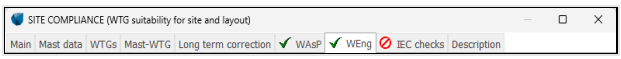
Press the yellow **Run WAsP calculation** button. The red stop icon on the WAsP tab becomes a green tick mark when WAsP is done.

WEng - tab

Select a site data object (dropdown) to define the terrain and roughness files to be used by WEng.



Press the yellow **Run WEng (WAsP Engineering) calculation** button. The red stop icon on the WEng tab becomes a green tick mark when WEng is done. Note that WEng may take several minutes for large projects.



3. IEC MAIN CALCULATIONS IN SITE COMPLIANCE

The **Calculations** tab is where the calculation of the IEC checks takes place.

Mark all the **Main checks** (check) to prepare a full site assessment. This enables an "Edit" button for each check which is ready for calculation. Notice that **Terrain complexity** check is required by the effective turbulence check.

Notice the "Result legend":

Red = Critical

Issues likely to hamper the project - must be approved by the manufacturer.

Yellow = Caution

Issues not likely to threaten the project but should be discussed with the manufacturer.

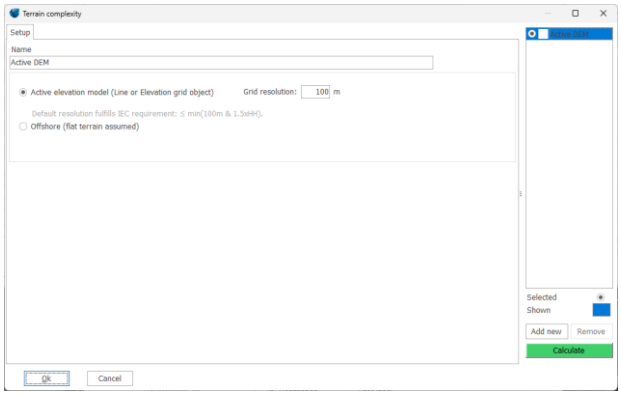
Green = OK

Unlikely to cause problems to the project.

Terrain complexity - check

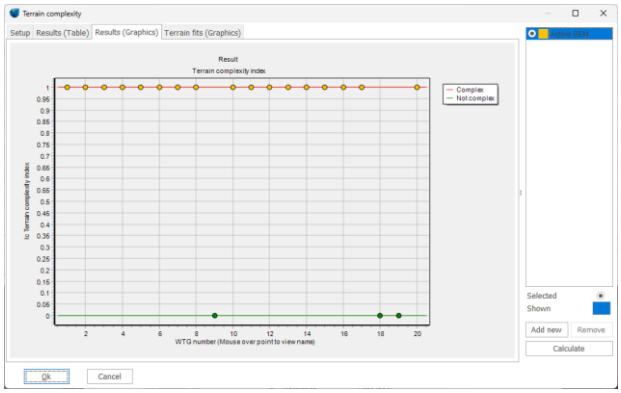
Start the **Terrain complexity** check by pressing **Edit**.

You only have one active elevation model, the Active DEM (Digital elevation model).



Press **Calculate** (lower right).

This enables more tabs showing the results of this IEC check. Notice the yellow square in the upper right corner indicating that in this case the overall result of the check is "Caution", as the terrain complexity as the site is complex.



Effective turbulence - check

The Effective turbulence check is maybe the most complex of the IEC calculations. This check does not

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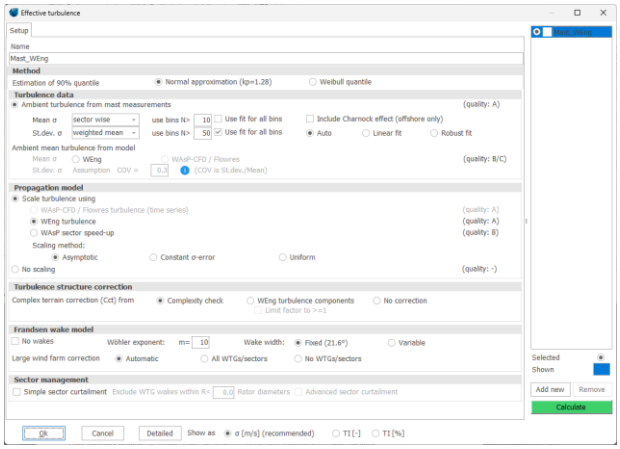
result in a single result per WTG, but the effective turbulence must be calculated and checked for a range of wind speeds.

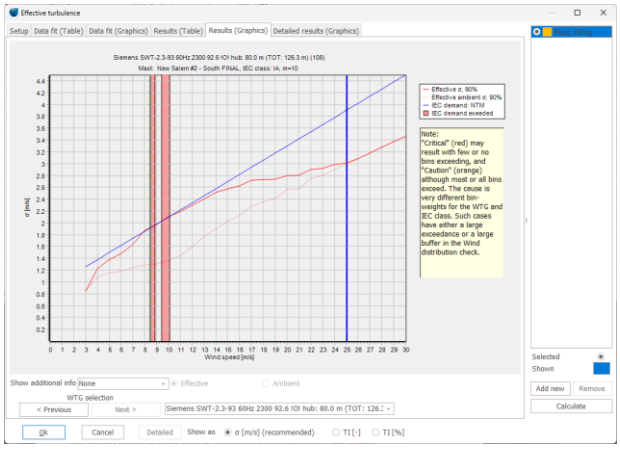
Press **Edit** to initiate the calculation.

Fortunately, the default settings will usually be a good choice. The setup has three main decisions/sections. **Turbulence data**, defines ambient turbulence and it should be handled. **Propagation model**, defines how/if the turbulence data shall be transferred from the mast to each WTG position and hub height. **Frandsen model**, defines the parameters in the Effective turbulence calculation, mainly the **Wöhler exponent**, where m=10 represents fiberglass composites.



Press **calculate**.

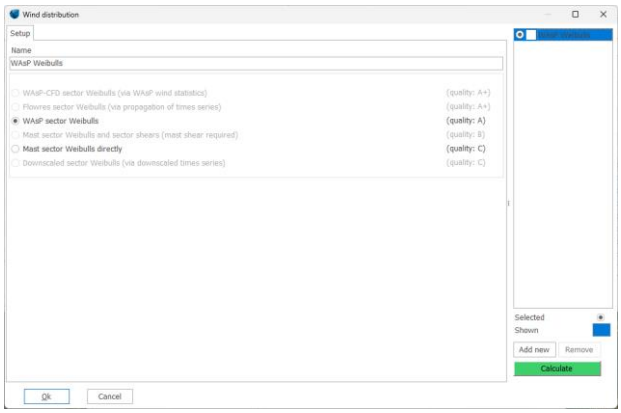
Results (Graphics) present the results graphically and the relevant check interval, here from 9 to 25 m/s. Light red highlights where the calculated WTG effective turbulence exceeds the IEC limit (here at low wind speeds) within the check interval.



Click OK and the turbulence calculation gets an overall yellow result. Thus, the WTG effective turbulence exceeds the IEC limit for some wind speeds, but not in a critical way.

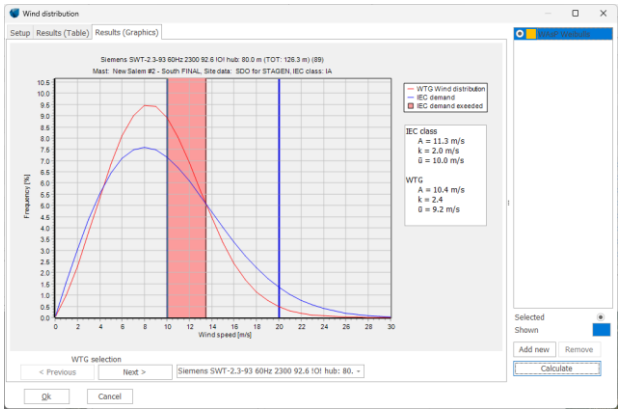
Wind distribution – check

Press **Edit** to initiate the Wind distribution check.



In most cases, a WAsP calculation has been run prior and these results predicted at each WTG will then be the default option. Hence with this setup is default option is **WAsP sector Weibulls**. Press **Calculate**.

In this case the check is not fully passed. In **Results (Graphics),** light red highlights wind speeds within the check interval where the IEC limit is exceeded.



Flow inclination check

Press **Edit** to initiate the Flow inclination check.

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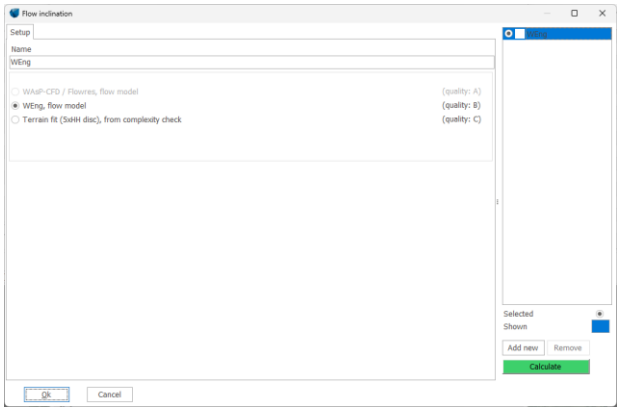
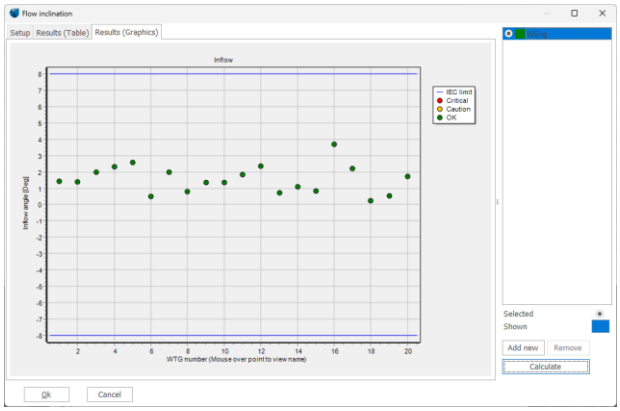
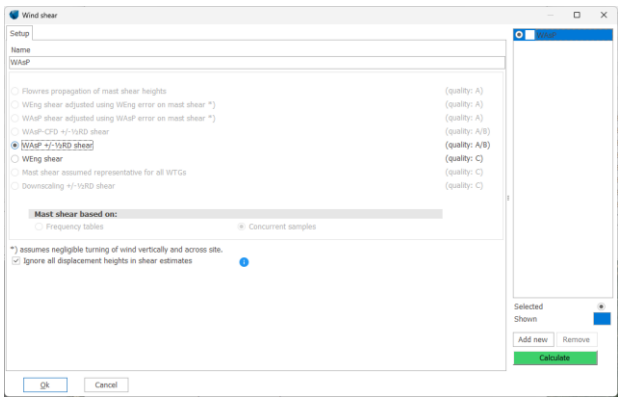


The inflow angles may be estimated using either the flow result from **WEng** or from the **Terrain complexity** calculation. We use **WEng** as it is the default option and expected to produce the best results. On the **Result (Graphics)** we can see that all angles are within the IEC limits of +/-8 degrees; all the dots are green (OK) and the overall result marker in the upper right corner is also green.

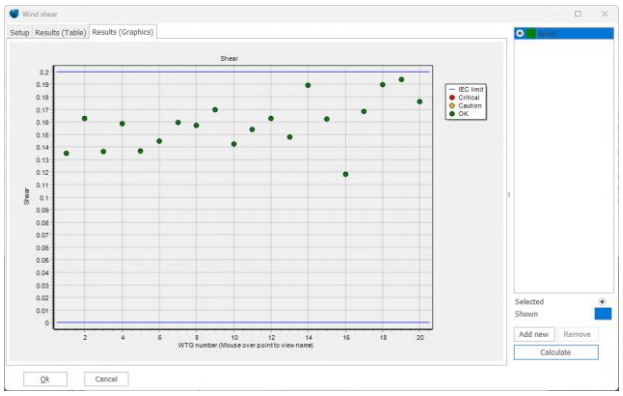


Wind shear - check

Press **Edit** to initiate the Wind shear check.



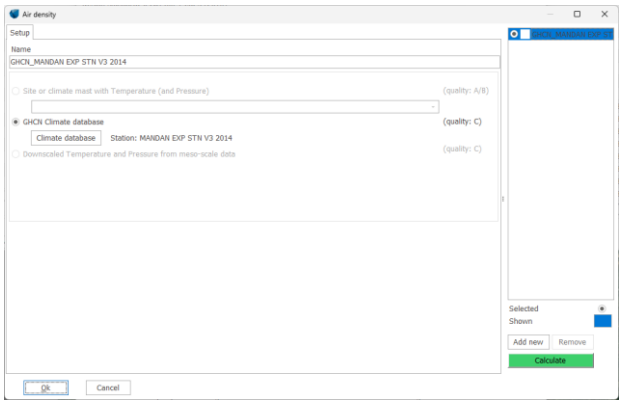
Default selection for this project is wind shear calculation using **WAsP +/-½RD shear**. Again, after pressing **Calculate** a Results (Graphics) tab appears and shows that for all WTGs wind shear is within the IEC limits.



Air density - check

Press **Edit** to initiate the Air density check.

Calculation of this check may be based on temperature (and pressure if available) measurements on the **site mast** or using statistical data from the GHCN Climate database. As no temperature or pressure measurements are available from the site mast of this particular project the database is used.



Pressing **Calculate** reveals that all WTGs are within the IEC limit of 1.225kg/m^3.

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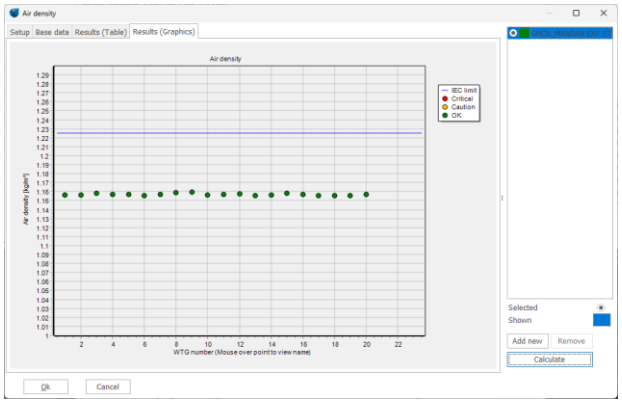
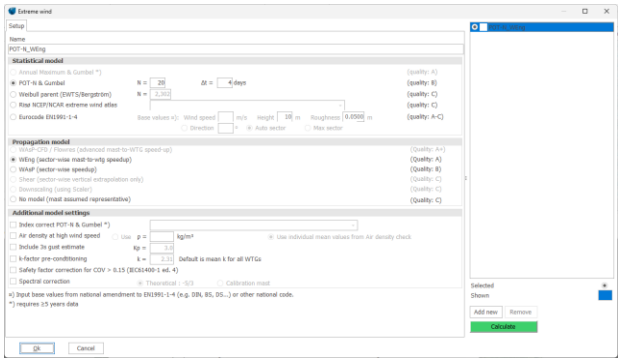


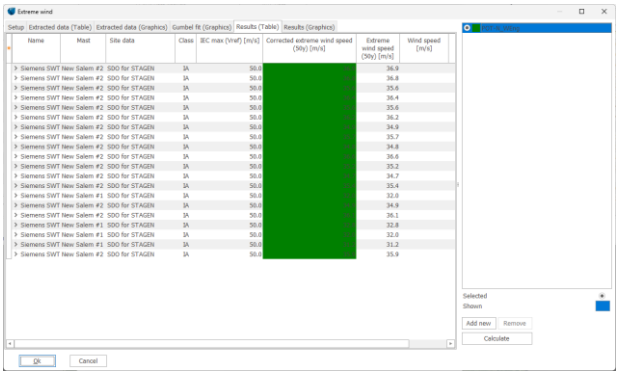
Extreme wind - check

Start the **Extreme wind** speed calculation by pressing **Edit**.



The default **Statistical model** with this setup is the **POT-N & Gumbel** method**. N** is the number of extracted storm events and can be adjusted, but 10-20 events is usually a good choice. **Δt** is the minimum time separation required for storm events to be independent. Four days is a typical value for synoptic events (extratropical storms).

After pressing **Calculate**. The Results (Table) summarizes the 50-year extreme wind speed result for each WTG and the IEC limit for the WTG class. In the case shown all WTGs are OK (green), and hence the overall result for the park (see square in upper right corner) is also green (OK).



You may click **Add new** (lower right corner) to add another calculation setup for extreme wind to compare the results. Try selecting e.g., "Weibull parent (EWTS/Bergström)" and press **Calculate.** Now you have two result options you can compare. Try also "Risø NCEP/NCAR extreme wind atlas" which covers most of Europe and US. Each calculation adds a line in the right pane. Click on a calculation in the pane to highlight it and view its setup and results tabs. The calculation which is checked defines the result to be used in the site assessment.

Now all the main checks have been calculated and it is time to have a look at the overall result.

In this case four of the main checks are OK, three checks is caution (Terrain complexity, Effective turbulence and Wind distribution). Thus, the suitability of an IEC class IA wind turbine should be discussed with the manufacturer.

4. CALCULATION OF OTHER IEC CHECKS

Check the three **Other checks**, **Seismic hazard**, **Temperature range** and **Lightning rate.**

These checks are more general and output a single value representative for the site and all WTGs. The IEC standard does not define specific limits for these checks, but their result values serve as input parameters to the turbine manufacturer's evaluations.

Seismic hazard check

Click **Edit** to open the check and click **Calculate** to perform it. This check leaves no calculation settings to the user.

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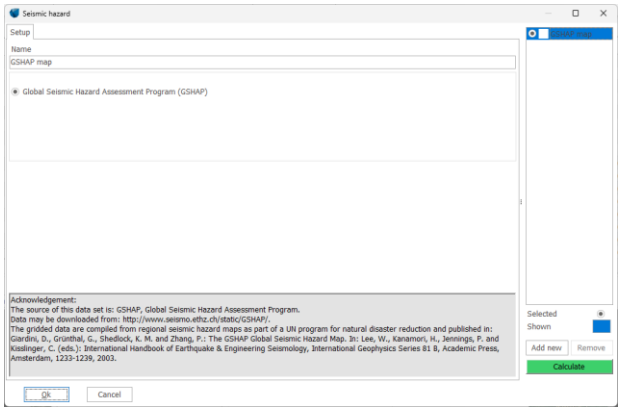
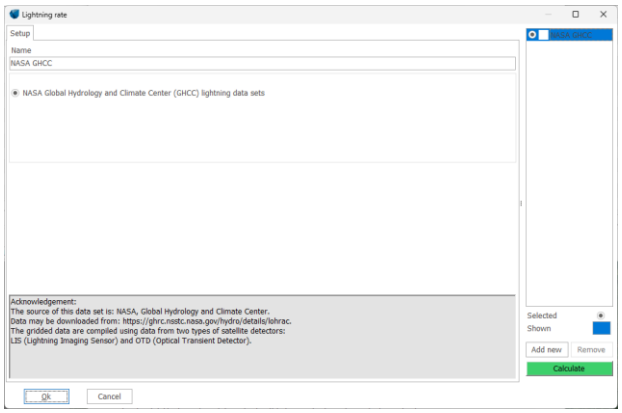


Result (Graphics) shows the variation of Seismic hazard around the site for an area of ca. 1000km by 1000km.

The **Result (Table)** illustrates that for this site the Peak Ground Acceleration (PGA) is very small and hence the Seismic hazard is very low.

Lightning rate check

Click **Edit** to open the check and click **Calculate** to perform it. This check leaves no calculation settings to the user.



Result (Graphics) shows the variation of Lightning rate around the site for an area of ca. 1000km by 1000km.

The **Result (Table)** illustrates that for this site the Lightning rate is low.

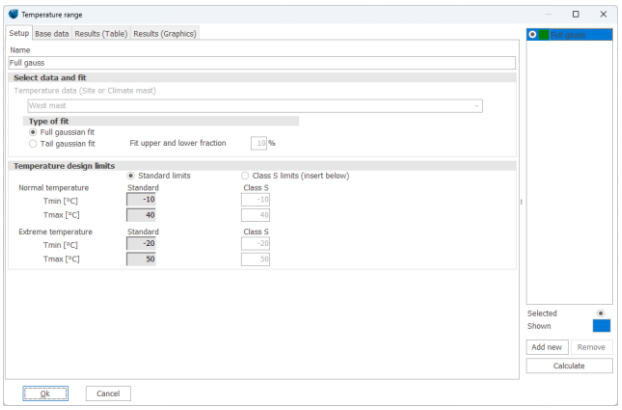
Temperature range check

Click **Edit** to open the check. A site mast with temperature is needed for this calculation.

There are two fit options for the on-site temperature distribution **Gaussian fit** and **Tail Gaussian fit**.

The default WTG temperature ranges, Normal (operation) and Extreme (survival), represent the standard WTG classes WTGs. Custom (Class S) temperature limits may be defined too as user input.

After setup press **Calculate**.



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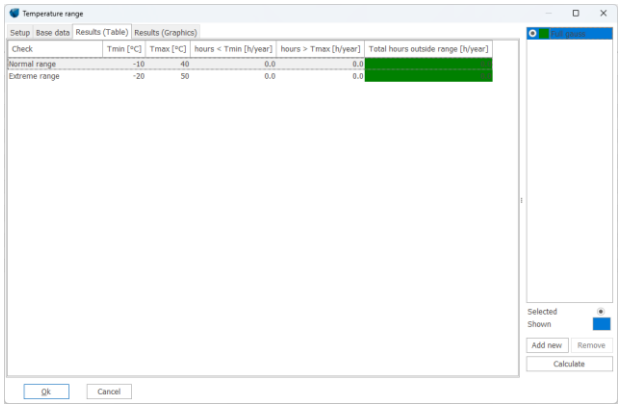

In this example the result is ok, as no hours per year are expected outside the Normal or extreme range temperature range.

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