

# SHADOW

## Calculation of Flickering from WTGs



### Function

Calculation and documentation of flickering effects in terms of hours per year during which a neighbor or an area would be exposed to flickering from nearby WTG rotors. Also maximum minutes per day are calculated. SHADOW can calculate the Worst Case results (sun always shining in daytime, WTG always rotating and wind direction "worst case") or the "real expected values", based on assumptions on solar statistics and operating hours divided by wind direction.

### Calculation model

Calculations can be made either for a set of shadow recipients (e.g. windows) or for a user defined area. The calculation engine then performs a complete simulation of the sun path throughout a whole year in user definable time steps. The size and orientation of shadow recipients as well as the raster size for an area calculation can be freely chosen. Results are presented in form of calendars, cumulated hours with flicker or - for the area calculation - as maps of flicker hour isolines. If a digital height contour map is available, the terrain levels can be taken into consideration. This includes a ZVI calculation that checks whether or not the receptor can see the individual turbines.

### Necessary Input Data (objects)

Please note that the objects are entered in the WindPRO module BASIS. Please read the description of the WindPRO module BASIS for further details.

#### Wind Turbines (WTGs):

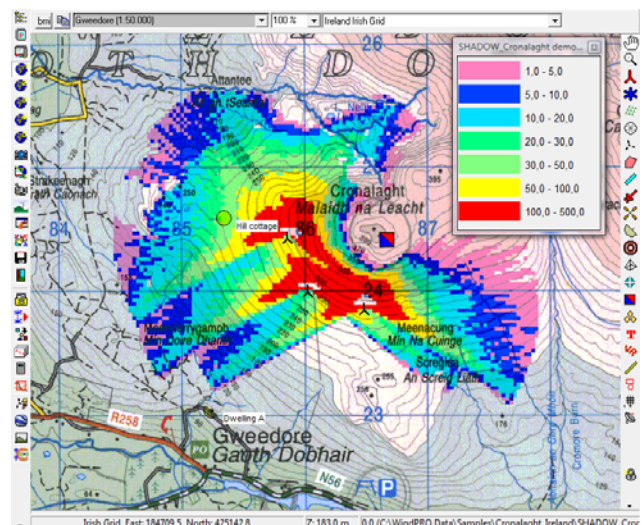
One or more WTGs are entered (position and type). The WTG can normally be found in the WTG catalogue, which contains more than 500 different WTG types. The hub height, rotor diameter and blade width are used in the calculation.

#### Shadow recipients:

The shadow recipients are positioned where a calculation of the potential shadow impact is required. As many shadow recipients as needed can be included in the same calculation.

### Description

The WindPRO module SHADOW for shadow impact calculation makes it possible to calculate the annual hours of shadow impact for a given area which one or more wind turbine rotors generates. A worst-case calculation based on worst weather conditions or real values (statistic values) can be calculated based on entered solar statistics and operating hours per wind direction sector. The solar statistics can be obtained from a built-in database while the latter can be auto-calculated when an energy calculation is present. The calculation can also be made for the turbines calculating how many hours of flickering each turbine may cause and when it will happen. If the wind turbines are exceeding the allowed shadow flickering this calendar can be used to plan the operation of the turbine to avoid flickering. The accumulated hours the turbine will be stopped due to flickering can be used as input in a Loss and Uncertainty calculation.



### Calculation report

The calculation report includes the following four printout options:

**Main printout:** Prints the main assumptions including a map segment showing the positions of WTGs and the shadow recipients. For each shadow recipient, the potential amount of hours with shadow impact is printed.

**Calendar (tabular and graphic)** for receptors: Shows the exact days, the time of the day, the duration and origin of possible shadow impact. At the bottom line for each month, the deduction due to solar statistics and operating hours will appear. The graphic version shows the impact of the shadow clearly arranged for intuitive understanding.

**Calendar (tabular and graphic)** for the turbines: These are calendars giving the date, time and duration for the flickering caused by each turbine. This is useful for planning if and when to stop the turbines to protect against flickering

**Map:** A map with isolines for potential shadow impact is plotted for areas with WTGs. This way it is possible to reveal the extent of the possible shadow nuisance, e.g. for areas where future development is planned. The user can adjust the values of the isolines to be printed, the line colors and the line widths. Also map with raster graphic showing the values by color scheme is available. Height contour levels can be taken into account when calculating the map.