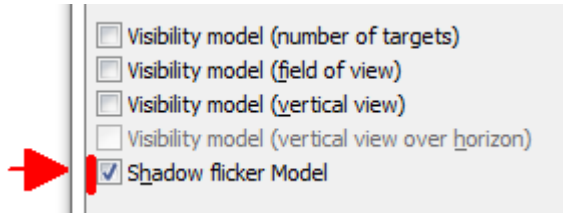
KTF software

ZTV Shadow Flicker analysis



What is it (*)?

*"The term **shadow flicker** refers to the flickering effect caused when rotating wind turbine blades periodically cast shadows over neighbouring properties as they turn, through constrained openings such as windows. The magnitude of the shadow flicker varies both spatially and temporally and depends on a number of environmental conditions coinciding at any particular point in time, including, the position and height of the sun, wind speed, direction, cloudiness, and position of the turbine to a sensitive receptor."*

Sun shining through the rotating wind turbine blades – OK, that's the shadow flicker.

Where does that happen in relation to the turbine position?

"The current recommendation in Companion Guide to PPS22 (2004) to assess shadow flicker impacts within 130 degrees either side of north is considered acceptable, as is the 10 rotor diameter distance from the nearest property."

What units are used to measure it? How much is acceptable?

Hours per one calendar year and minutes per one day. Shadow Flicker should be less than 30 hours per year and 30 minutes per day.

In UK see:

- Planning for Renewable Energy – A Companion Guide to PPS22 Office of the Deputy Prime Minister (2004)
- Onshore Wind Energy Planning Conditions Guidance Note, Renewables Advisory Board and BERR (2007)
- Best Practice Guidance to Planning Policy Statement 18 ‘Renewable Energy’, Northern Ireland Department of the Environment (2009)
- Practice Guidance – Planning Implications of Renewable and Low Carbon Energy, Planning Division – Welsh Assembly Government (2010)
- Planning Advice Note (PAN) 45: Renewable Energy Technologies Scottish Executive (2002)

How does KTF's ZTV Shadow Flicker work?

Set up the ZTV parameters generally the normal way.

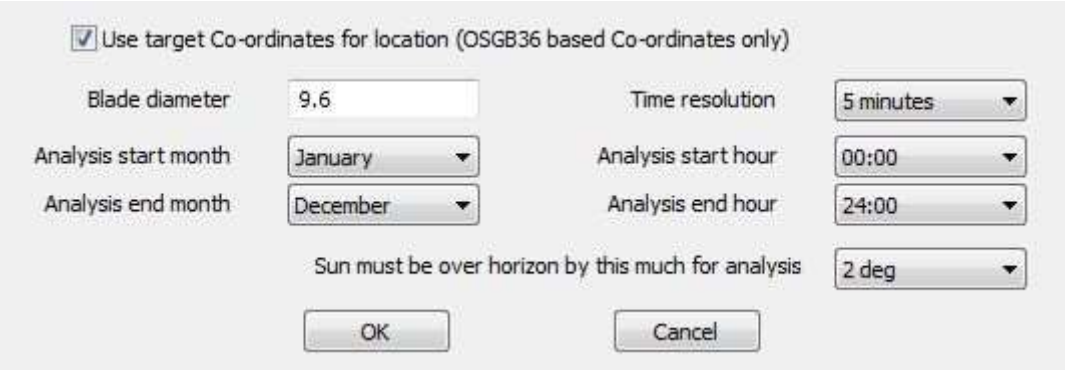
1. Note that the Analysis Start Distance (Distance 1) and the Extent distance (Distance 2) should be appropriate to Shadow Flicker analysis. Relatively small values like 10 for Start Distance and 2000 for Extent Distance should cover most analysis comprehensively.
2. Ray Resolution is good to keep small. Values between 5 and 20 for example might give nice and smooth looking color maps.
3. The Target Point is the **top of the blade**
4. The Observer Height, a ZTV parameter, can be interpreted to be the general height of the windows of the Locations (See below).
5. Set up Shadow Flicker parameters as described below and press the Start button in main dialog and give the analysis model file name normally . The program will produce all other analysis as usual plus then additional Shadow Flicker result files. See more details about the results under heading "What do KTF ZTV Shadow Flicker Results look like?" in following pages.

General Shadow Flicker Settings

In ZTV "`Settings`" toggle on "`Shadow Flicker Model`" and give your site details by pressing "`Shadow Flicker Settings`" button.

`Blade diameter`	Blade diameter in metres
`Start and end months`	Normally should be January to December
`Start and end hours`	Normally should be 00:00 to 24:00
`Time resolution`	Recommended value is 5 minutes
`Sun over horizon angle`	Recommended value is 2 degrees

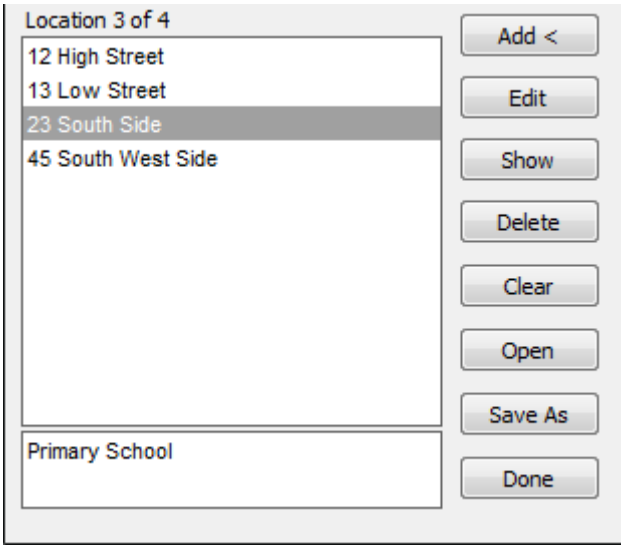
Normally leave the "`Use target Co-ordinates for location`" toggled on.



Shadow Flicker Locations

Normally there are specific buildings that need more attention and detailed reports about how the Shadow Flicker impacts them. Use "`Shadow Flicker Locations`" to specify any number of nearby places for automated reports. The ZTV parameter Observer Height should be set to the height from the ground of the windows in those buildings. It is advisable to set this to the height of the highest windows in order to assess the worst case scenario.

`Add`	Add new Location
`Edit`	Edit currently highlighted Location
`Show`	Show currently highlighted Location in plan view
`Delete`	Delete currently highlighted Location
`Clear`	Erase all Locations
`Open`	Read Locations from a file
`Save As`	Save Locations to a file
`Done`	Accept any changed made and go back to Settings dialog



What do KTF ZTV Shadow Flicker Results look like?

KTF produces up to three kinds of result files:

1. Shadow Flicker Impact model. This can be colored and superimposed onto map to see how the shadow flicker generally affects the whole area around the wind turbine(s).
2. Location Impact Summary. A text file reporting Shadow Flicker impact on each location.
3. Location Impact Details. A CSV file listing all days in the analysis period on which there is shadow flicker over each location and for how long that lasts. There is a separate file for each location.

Shadow Flicker Impact model

KTF will analyse every visible area for shadow flicker and add up all minutes in year (or defined months and times of day) where this happens. The resulting model's Z value tells how many minutes in one year the location is affected by shadow flicker.

This can be presented as color mapped overlay or as contours for example. See below.

Illustration 1: Color mapped result of a shadow flicker analysis

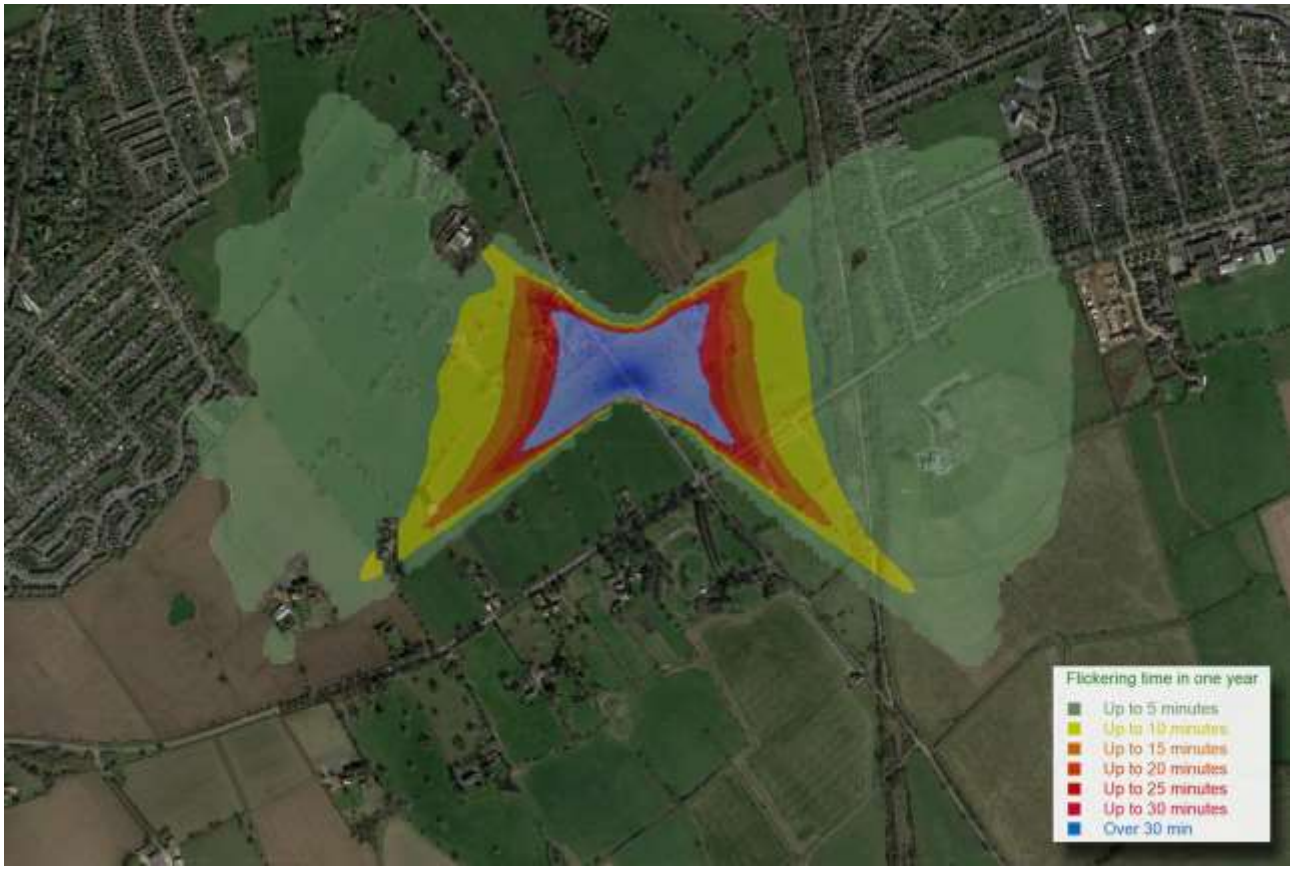


Illustration 2: Shadow flicker analysis superimposed on a map

Location Impact Summary

If Locations were defined in Shadow Flicker settings then KTF will create this summary file. See a sample below.

```
Shadow Flicker report for 4 locations against one Wind Turbine
Blade diameter: 30.0
Analysis period: January to December (12 months)
Shadow analysis frequency: 2 minutes
Analysed Locations' height from ground: 3.000
Analysing only between times 09:00 and 17:00
Sun has to be over 2 degrees over horizon to be counted for


Summary by Location:

12 High Street, Post Office (489922.553,510796.412)

   Shadow Flicker from Wind Turbine "Village's Wind Turbine":
      Distance from turbine 278
      Azimuth from turbine to Location: 331°53'57"
      Total minutes of Shadow Flicker in 12 month period: 220 (3h 40min)
      Number of days Shadow Flicker happens: 21
      Max minutes per day: 14
      Average minutes of Shadow Flicker on active day: 10.5
      For daily breakdown see: "Location_12 High Street.csv"


13 Moon Cresent, Doctor's Surgery (490175.579,510704.037)

   Shadow Flicker from Wind Turbine "Village's Wind Turbine":
      Distance from turbine 196
      Azimuth from turbine to Location: 38°33'41"
      Total minutes of Shadow Flicker in 12 month period: 174 (2h 54min)
      Number of days Shadow Flicker happens: 19
      Max minutes per day: 12
      Average minutes of Shadow Flicker on active day: 9.3
      For daily breakdown see: "Location_13 Moon Cresent.csv"
```

Location Impact Details

KTF gathers Shadow Flicker details for each Location into separete CSV file which can then be further analysed e.g. with a spreadsheet program. See a sample snippet below.

```
Shadow Flicker Impact details on location 12 High Street, Post Office

Date (yyyymmdd), Flicker in minutes, Start time (hh:mm), End time (hh:mm)
20131211, 5, 09:50, 09:55
20131212, 5, 09:50, 09:55
20131213, 10, 09:50, 10:00
20131214, 10, 09:50, 10:00
20131215, 10, 09:50, 10:00
20131216, 10, 09:50, 10:00
20131217, 10, 09:50, 10:00
20131218, 10, 09:50, 10:00
20131219, 15, 09:50, 10:05
[snip]
```

How does KTF actually calculate the shadow areas?

Each ZTV sub area in the analysis is verified against all 3D shadows projected onto the surface for every minute of day of one year. The cumulative time the ZTV sub area is in shadow is recorded and used as the Z value for the resulting model.

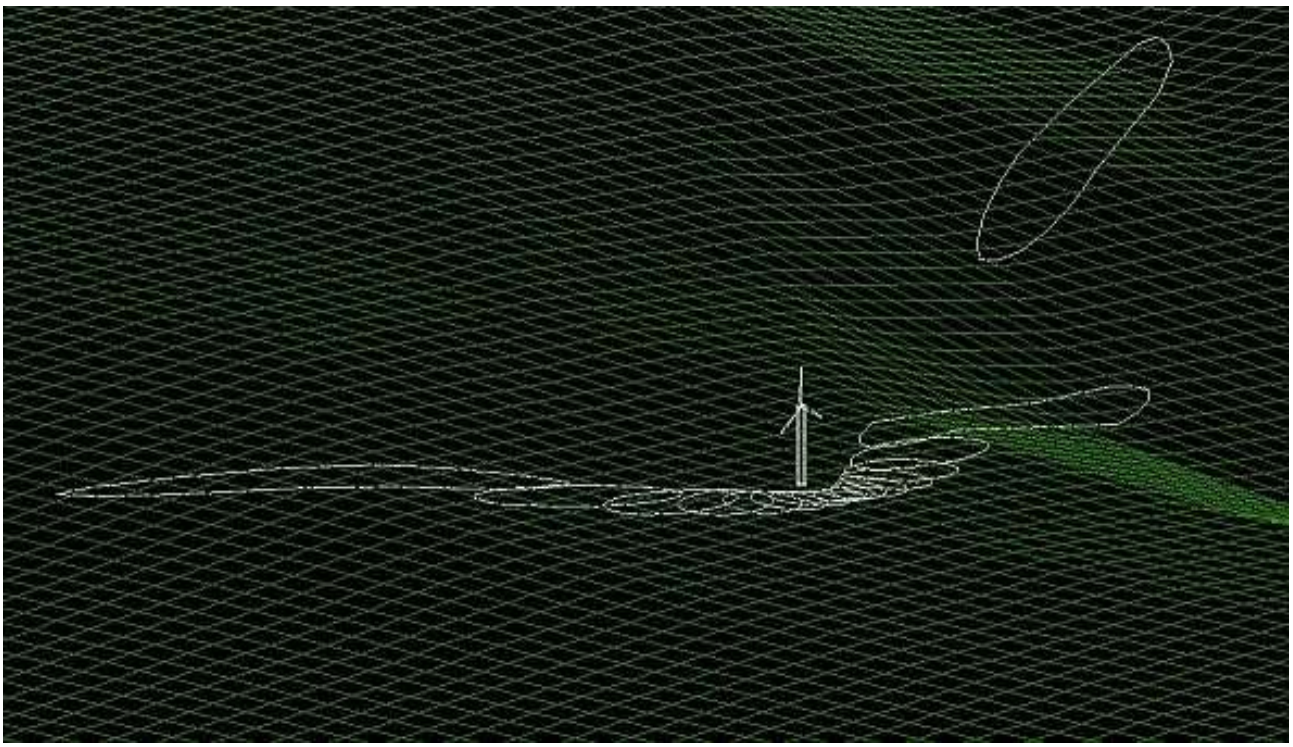


Illustration 3: Shadows cast by a wind turbine on June 29 at 09:00, 10:00 etc. 3D view from North East (For illustration purposes only, the program really drapes hundreds of shadows for each day of the year but the shadows are't drawn as 3D Polylines as in this picture. This hourly shadow drawing only helps to understand the concept.)

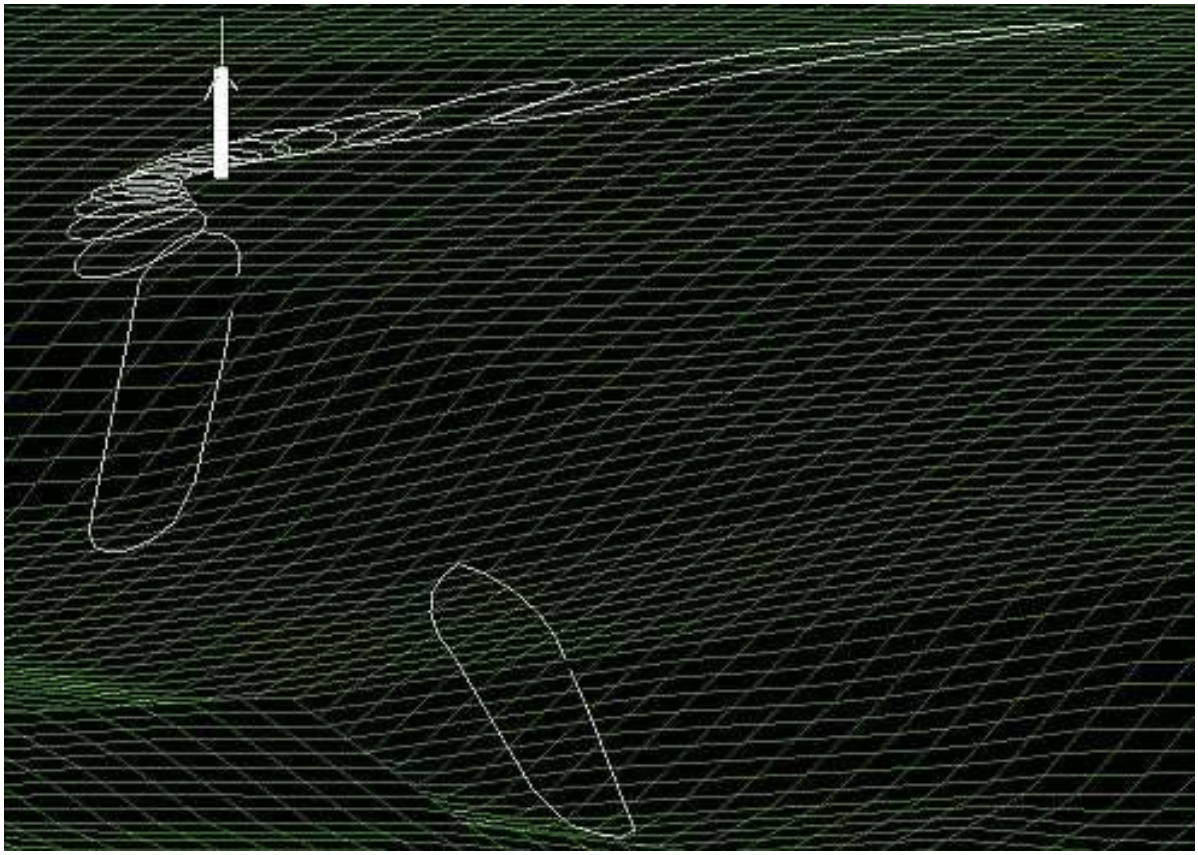


Illustration 4: Same as above but from different angle (From South West)

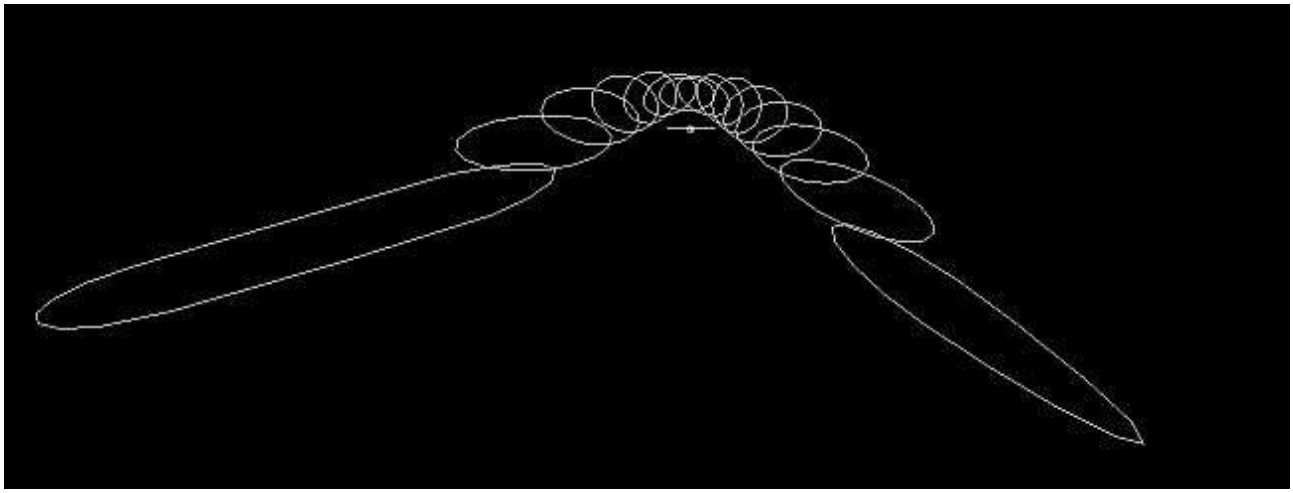


Illustration 5: Plan view of the hourly shadows on June 29.

(*) Quotes in *italics* are from document "Update of UK Shadow Flicker Evidence Base, Final Report, Department of Energy and Climate Change"