

## Coopers Gap CCC Meeting

Shadow Flicker



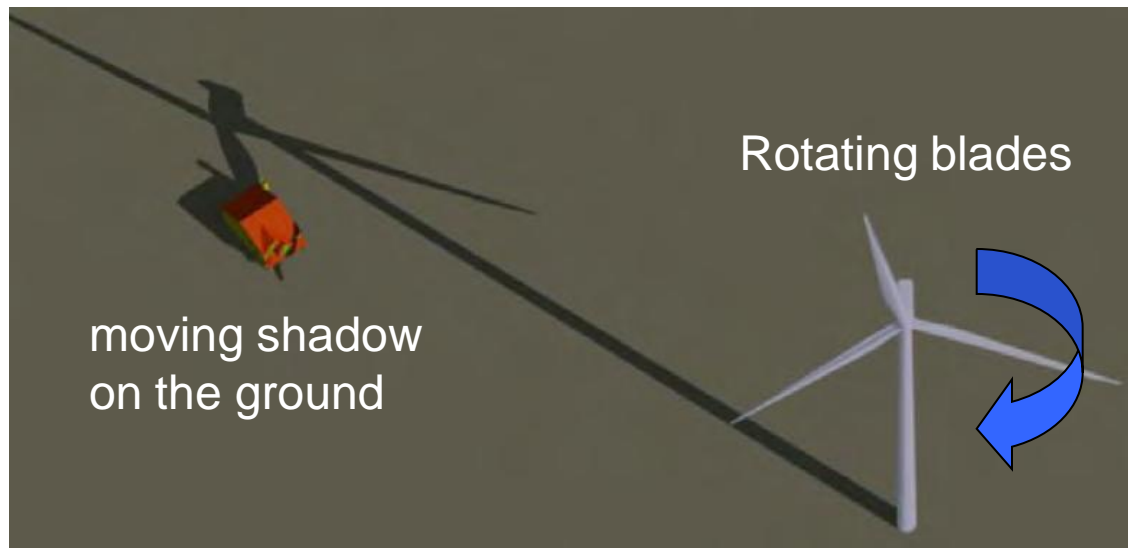
# Overview

- What is shadow flicker?
- What factors influence shadow flicker?
- What are the characteristics of shadow flicker?
- What are the impacts of shadow flicker?
- How is shadow flicker calculated?
- What are the limits on shadow flicker durations?
- Shadow flicker at Coopers Gap
- Mitigation of shadow flicker

GL Garrad Hassan are international technical consultants who have been engaged by AECOM to give an overview of the issues relating to the shadow flicker and EMI impacts of the proposed Coopers Gap wind farm. The information contained in the following presentation is based on current project information provided by AGL, AECOM and other entities.

# What is shadow flicker from wind farms?

Rotating wind turbine blades cast moving shadows. For an observer on the ground the moving shadows can cause a periodic variation in light levels, which is perceived as a flickering effect.



*From Paul Gipe <http://www.wind-works.org/>*

# What factors influence shadow flicker

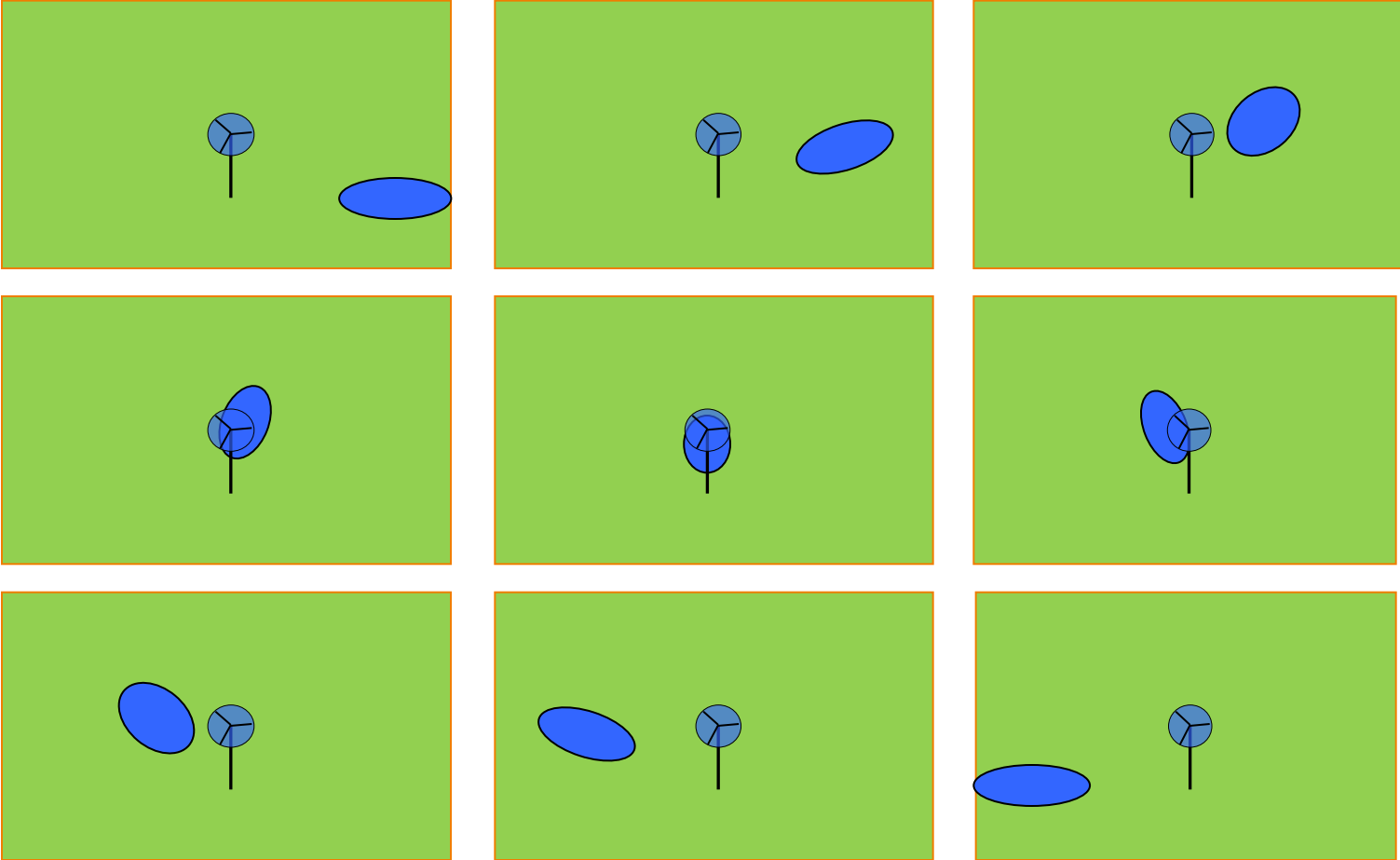
- Relative positions of sun, turbine and observer
  - Time of day & day of year
  - Elevation angle of sun
  - Distance between turbine and observer
- Turbine dimensions
- Wind speed
- Elevation
- Turbine orientation
- Cloud cover
- Position on Earth (Latitude/Longitude)
- Aerosols
- Vegetation or other screening

# What are the characteristics of shadow flicker?

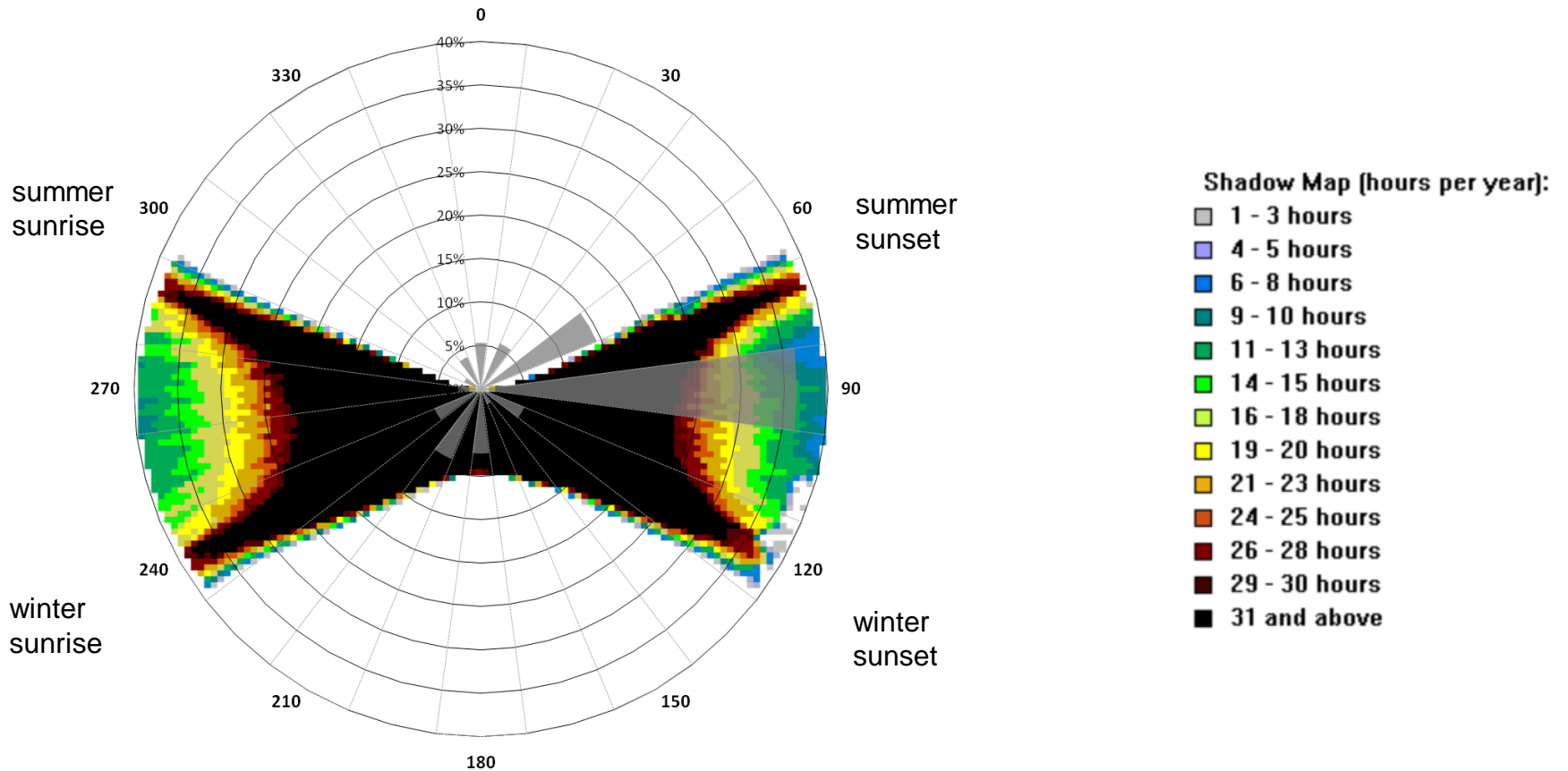
- Shadow flicker is most noticeable indoors, where the variation in light levels can be more significant.
- Shadow flicker can extend a significant distance from a turbine, but may only affect an area for a short period of time.
- Shadow intensity and the impact of shadow flicker reduces with distance from a turbine.
- Flicker frequency is approximately 1 Hz (or 1 pulse per second) for a modern wind turbine.

# Shadow flicker – variation with time of day

(standing to north of turbine, looking south)



# Indicative shadow flicker durations



# What are the impacts of shadow flicker on people?

- *“The key risk associated with shadow flicker is annoyance of residents”*
- The frequency of shadow flicker from a modern wind turbine is generally insufficient to affect people who suffer from photosensitive epilepsy.
- *“There is negligible risk associated with distraction of vehicle drivers who experience shadow flicker... In spite of extensive searches, no references to motor vehicle accidents caused by this phenomenon have been found”*

Draft National Wind Farm Development Guidelines, Environment Protection and Heritage Council, July 2010,  
<http://www.ephc.gov.au/node/449>



# What are the impacts of shadow flicker on animals?

- Surveys of impact on horses indicates that they may initially show a reaction to shadow flicker (e.g., standing still).
- However after repeated exposures (3 to 4), affected horses typically become conditioned to shadow movements.
- Many wind turbines have been installed near horses in many countries over many years with no evidence of a significant impact on behaviour.
- Livestock regularly graze in very close proximity to wind turbines.

Seddig, A, "Opinion: Wind Turbines And Horses", Faculty Of Biology, University Of Bielefeld, Germany. 17th November 2004.

lhde, S. "Preliminary expert opinion regarding the impact of wind turbines on horses"



# How is shadow flicker calculated?

- Model containing:
  - Elevation data
  - Earth & sun positions and orientations
  - Turbine locations and dimensions
  - House locations
- Turbine rotor represented as sphere or disc
- Model executed for every minute of day and day of year
  - Determine if shadow flicker occurs for every point of time
  - Add shadow flicker throughout year to determine total shadow flicker durations
- Shadow flicker assessed within 50 m of dwelling

*Methodology described in  
EPHC Draft National  
Wind Farm Development  
Guidelines (July 2010)*

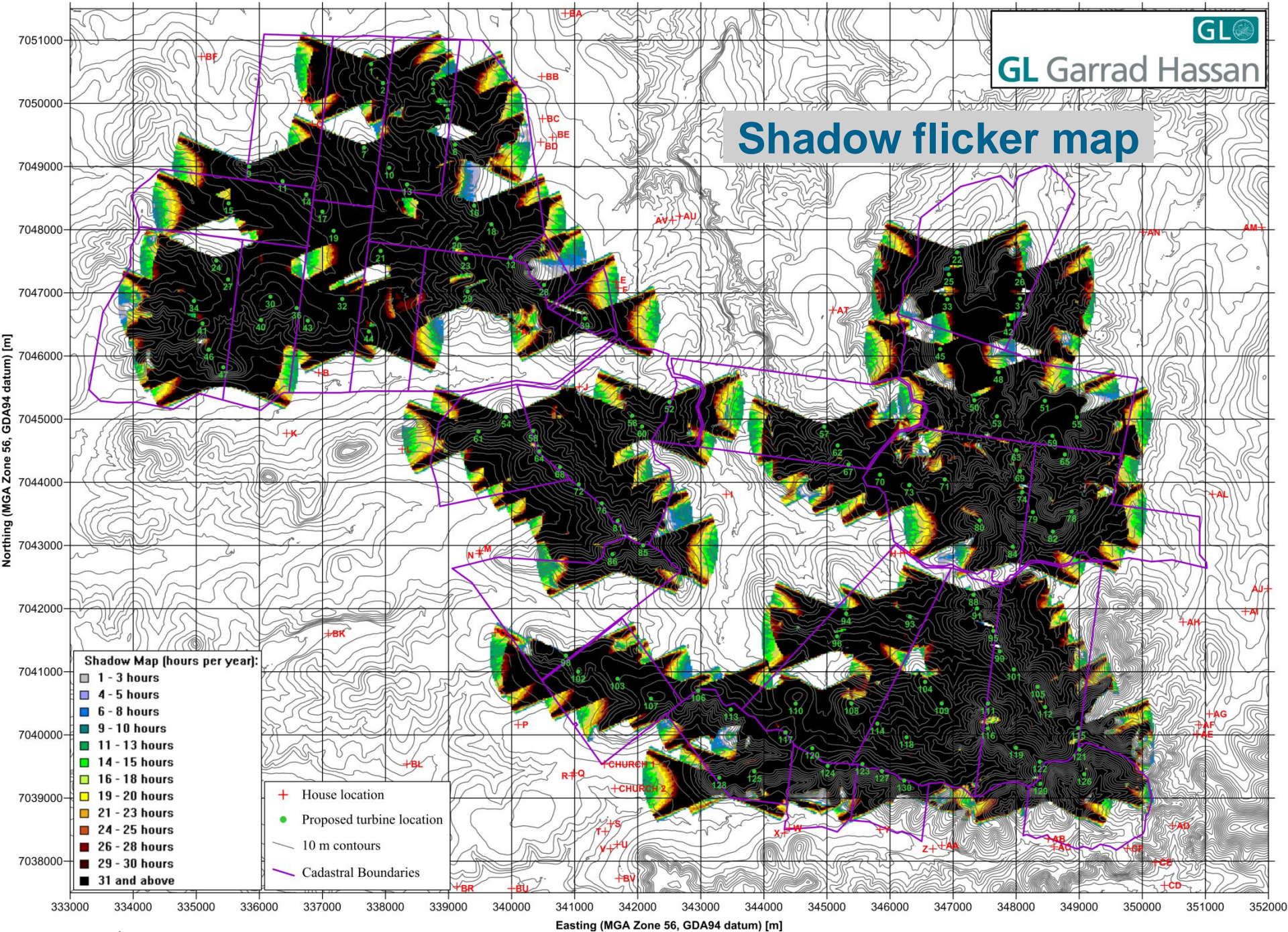
# How is shadow flicker calculated?

- **Theoretical calculation:** model only
- **Predicted actual:** assess likely reductions in shadow flicker durations due to:
  - Turbine orientation
  - Cloud Cover
- Factors not considered that may reduce shadow flicker durations
  - Periods when turbine is not rotating
  - Screening trees or structures

# What are the limits on shadow flicker durations?

- Shadow flicker limits (based on *EPHC Draft National Guidelines*)
  - Theoretical calculation: 30 hours per year
  - Predicted actual: 10 hours per year

# Shadow flicker map



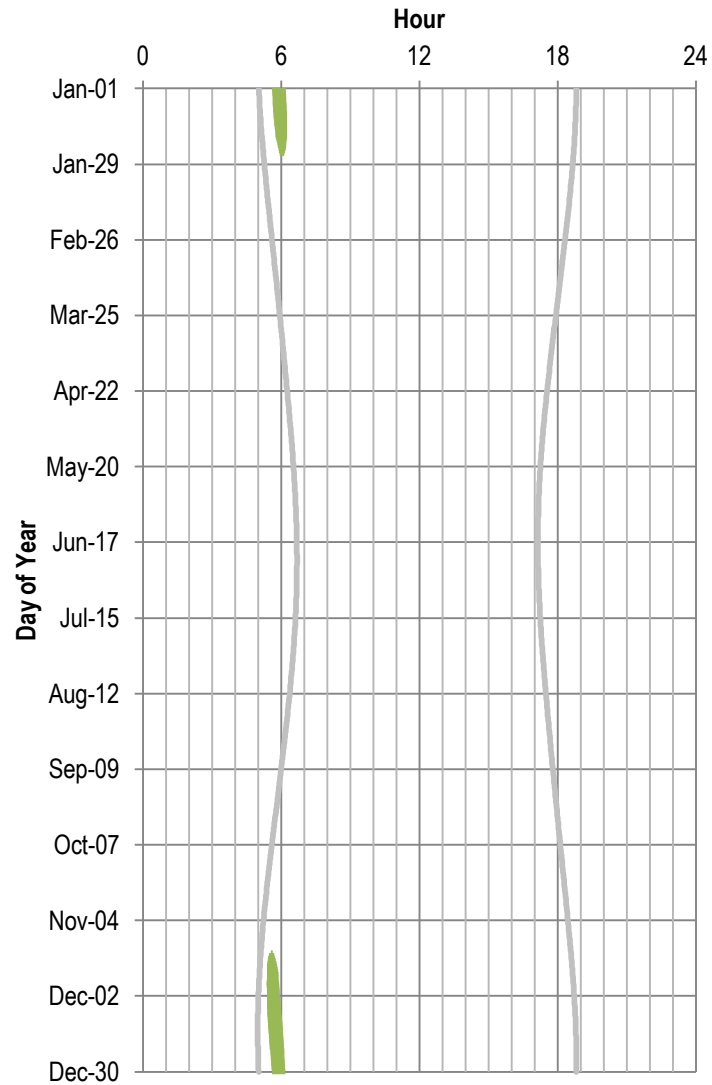
# Shadow flicker durations

House ID	Easting <sup>1</sup> [m]	Northing <sup>1</sup> [m]	Theoretical					Predicted Actual <sup>3</sup>	
			At Dwelling <sup>2</sup> [hr/yr]			Max Within 50m of Dwelling <sup>2</sup> [hr/yr]		Max Within 50m of Dwelling <sup>2</sup> [hr/yr]	
			At 2 m	At 6 m	Contributing Turbines	At 2 m	At 6 m	At 2 m	At 6 m
A	340083.6	7046383.9	12.5	12.5	39	13.4	13.4	6.1	6.0
C	336840.4	7049667.5	19.5	20.2	7	36.9	37.5	14.4	14.6
D <sup>4</sup>	336677.1	7050047.0	0.0	0.0	1	29.9	29.9	14.3	14.3
E	341658.5	7047167.5	11.4	11.4	28	12.2	12.3	5.5	5.5
F	341691.4	7047075.3	10.7	10.7	28	11.0	10.6	5.0	4.8
L	338266.8	7044523.4	0.0	0.0	61	10.9	10.7	4.9	4.9
O	339739.2	7041619.5	17.5	17.5	98	26.8	27.0	8.8	9.2
<b>Limits</b>			<b>30</b>	<b>30</b>	<b>n/a</b>	<b>30</b>	<b>30</b>	<b>10</b>	<b>10</b>

- Maximum shadow flicker predicted at non-participating landowner residence is 27 hrs/annum

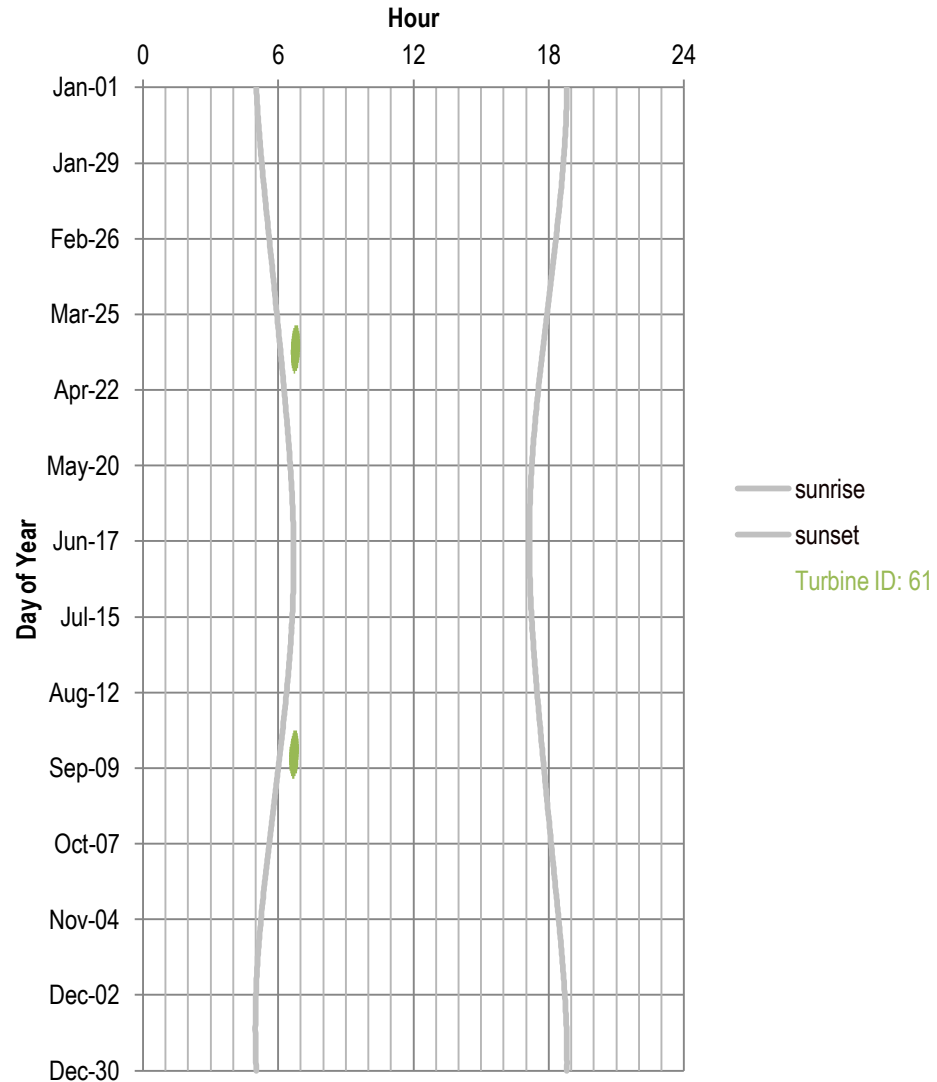
# When does shadow flicker occur? (theoretical calculation)

## House C (37 hours per year)



— sunrise  
— sunset  
Turbine ID: 7

## House L (10 hours per year)



— sunrise  
— sunset  
Turbine ID: 61

# Mitigation of shadow flicker

- If problems with shadow flicker occur, there are a range of options available to mitigate its effects, including:
  - Planting trees
  - Installation of screening structures
  - Shutting down turbines when shadow flicker occurs





## Questions?



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