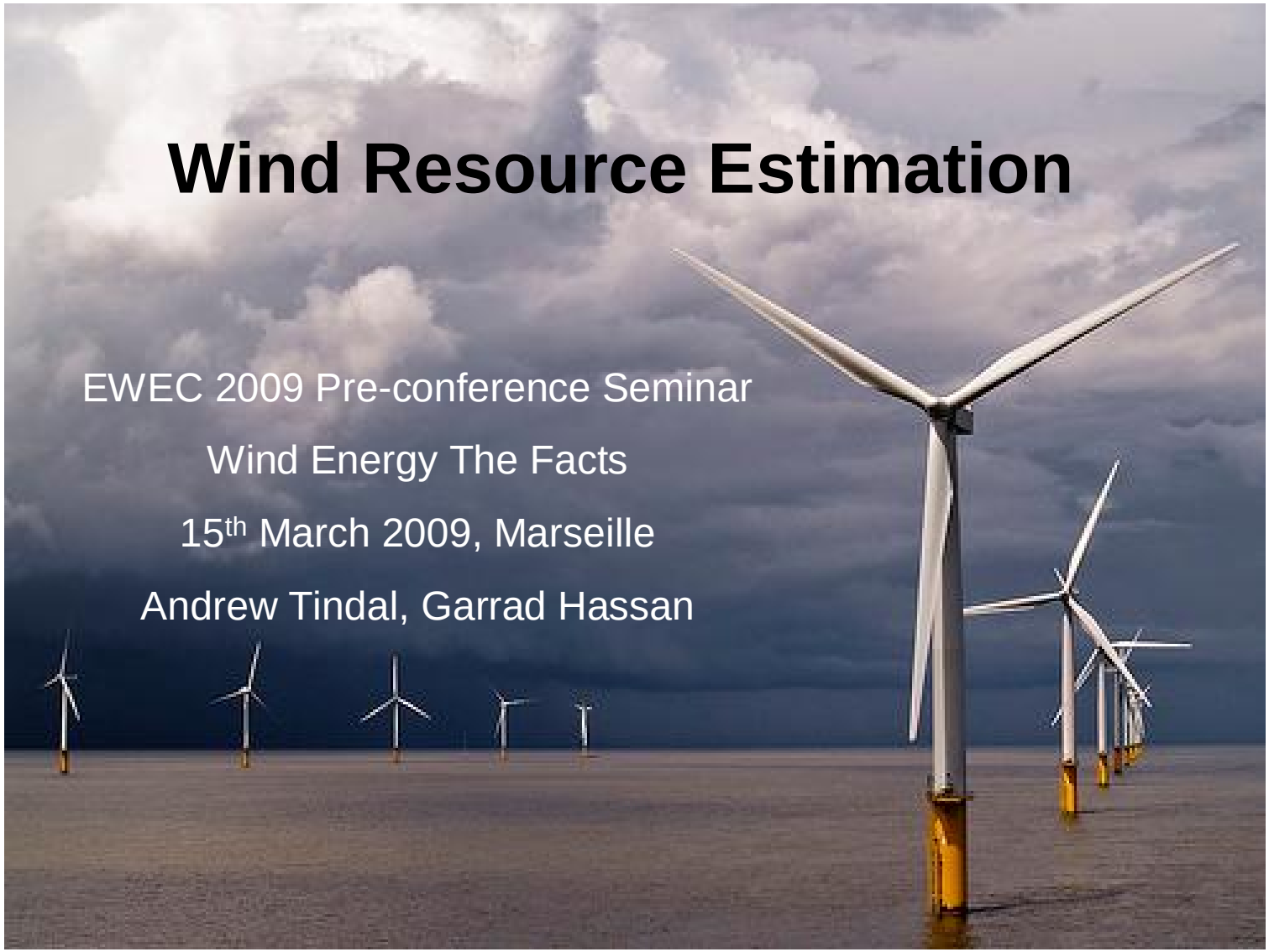
Wind Resource Estimation



EWEC 2009 Pre-conference Seminar

Wind Energy The Facts

15th March 2009, Marseille

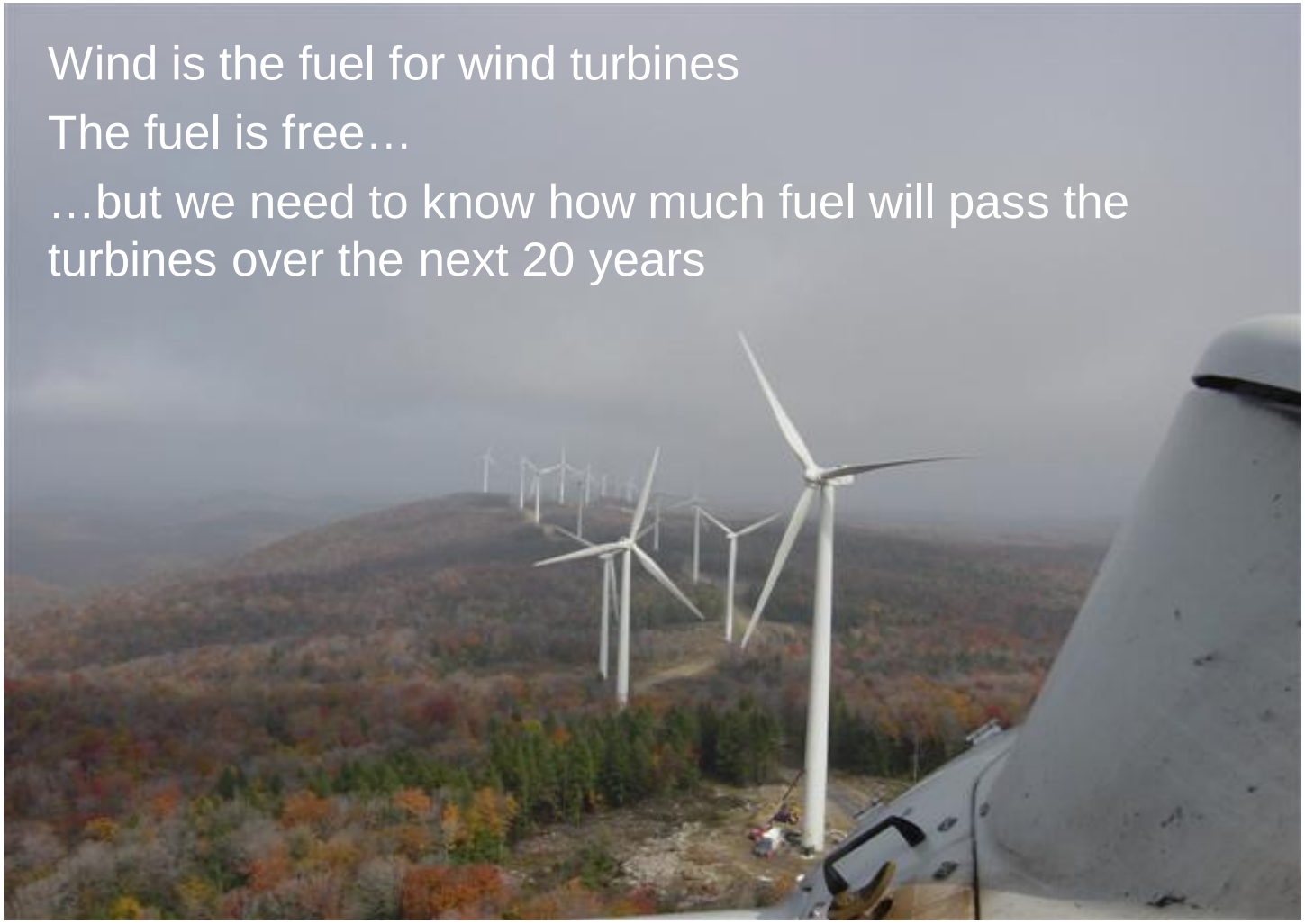
Andrew Tindal, Garrad Hassan

The challenge

Wind is the fuel for wind turbines

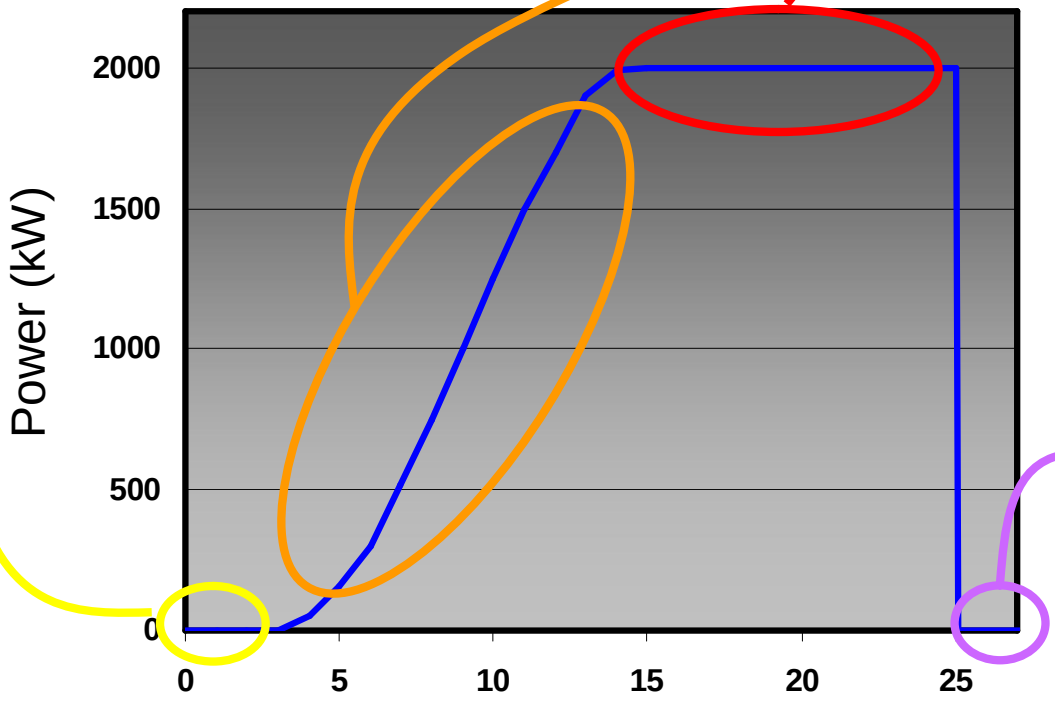
The fuel is free…

…but we need to know how much fuel will pass the turbines over the next 20 years



How does power vary with wind speed?

Beaufort scale useful
0 to 12



Beaufort Force 12 “Hurricane”

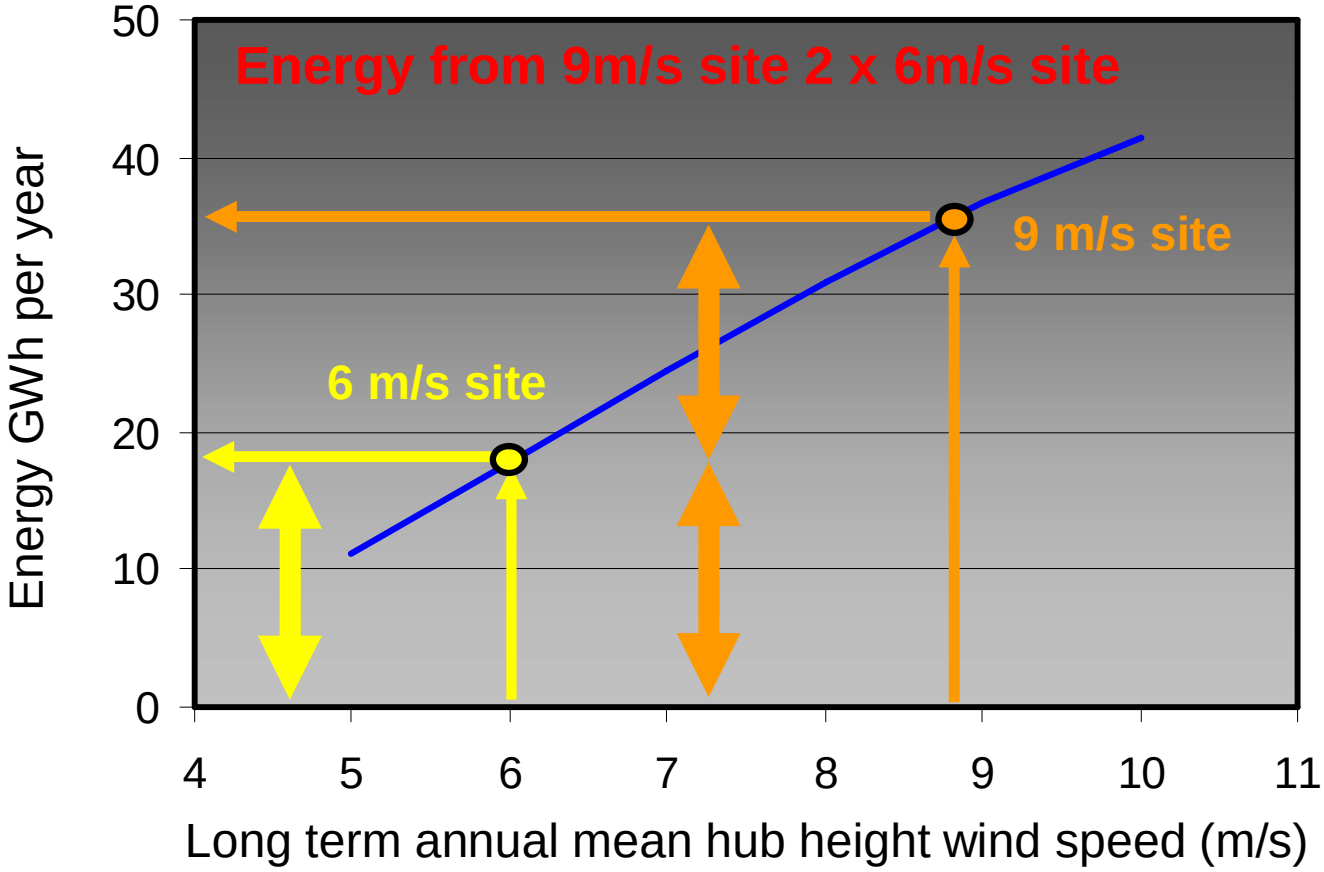
Turbines are designed to withstand hurricane force winds…

…but not to produce power when they happen

Wind Farm Energy vs Wind Speed

Example wind farm 5 x 2 MW wind turbines

Variation of energy with **long term annual mean** wind speed



In fact use different turbines on 6m/s and 9m/s sites so difference reduced a little

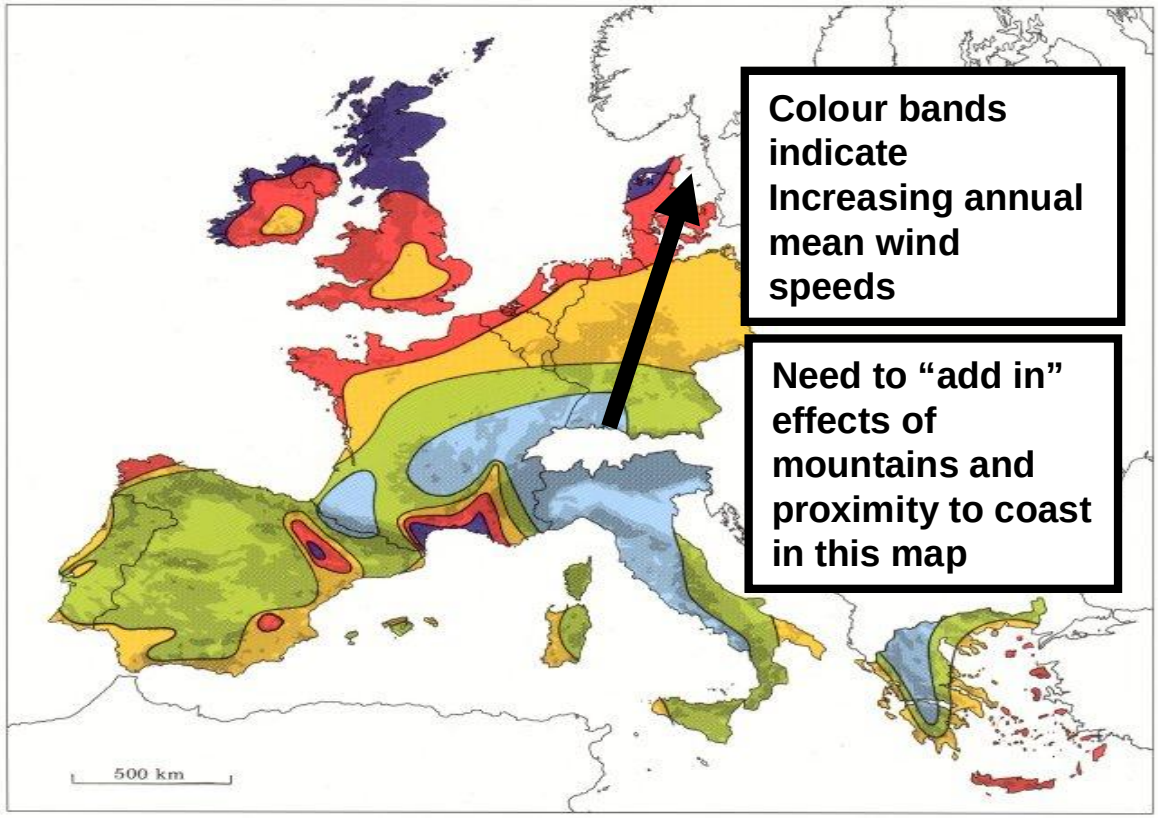
Importance of wind speed

Annual mean wind speed maps

Wind maps are a good starting point

To finance a € multi-million project wind maps insufficient

Need wind measurements

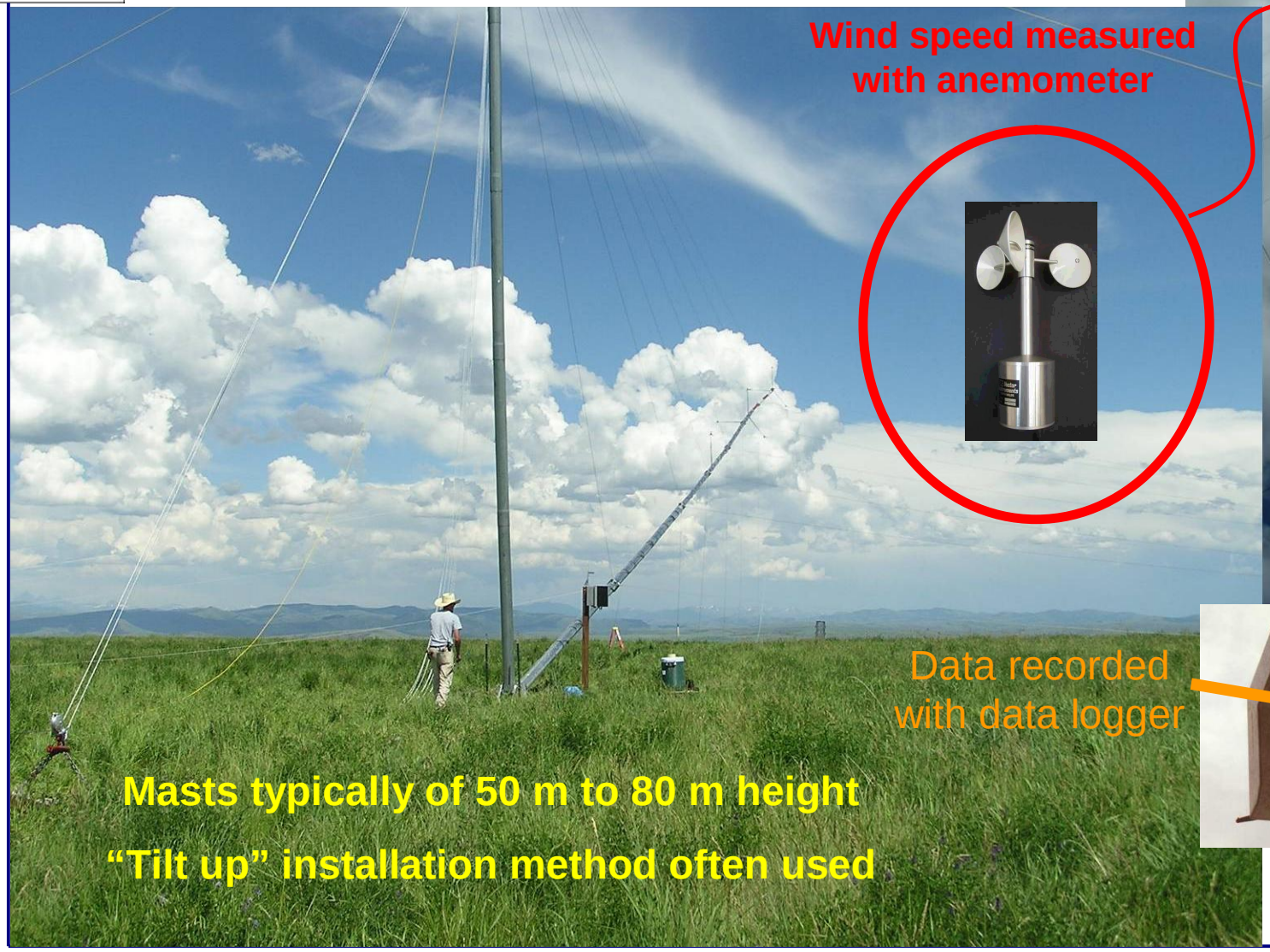


Wind resources[1] at 50 metres above ground level for five different topographic conditions

	Sheltered terrain[2]		Open plain[3]		At a sea coast[4]		Open sea[5]		Hills and ridges[6]	
	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}
	> 6.0	> 250	> 7.5	> 500	> 8.5	> 700	> 9.0	> 800	> 11.5	> 1800
	5.0-6.0	150-250	6.5-7.5	300-500	7.0-8.5	400-700	8.0-9.0	600-800	10.0-11.5	1200-1800
	4.5-5.0	100-150	5.5-6.5	200-300	6.0-7.0	250-400	7.0-8.0	400-600	8.5-10.0	700-1200
	3.5-4.5	50-100	4.5-5.5	100-200	5.0-6.0	150-250	5.5-7.0	200-400	7.0- 8.5	400- 700
	< 3.5	< 50	< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 7.0	< 400

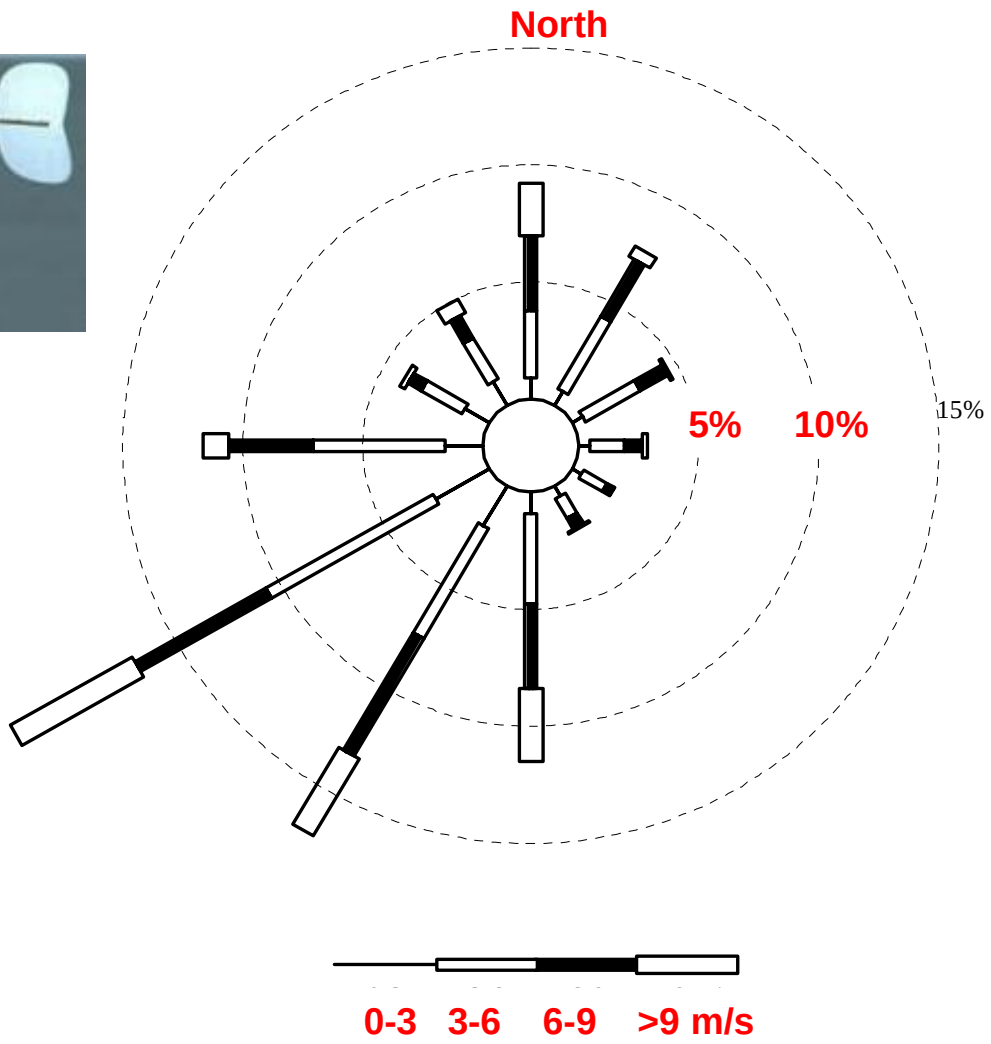
Onshore wind energy resource, as computed on a broad scale for the European Wind Atlas.

Wind speed measurements



Wind direction measurements important too

Example wind vane



Wind Rose:

Can be thought of as a wheel with spokes attached.

For each sector the wind is considered separately.

The length of a spoke shows the duration for which wind comes from this sector.

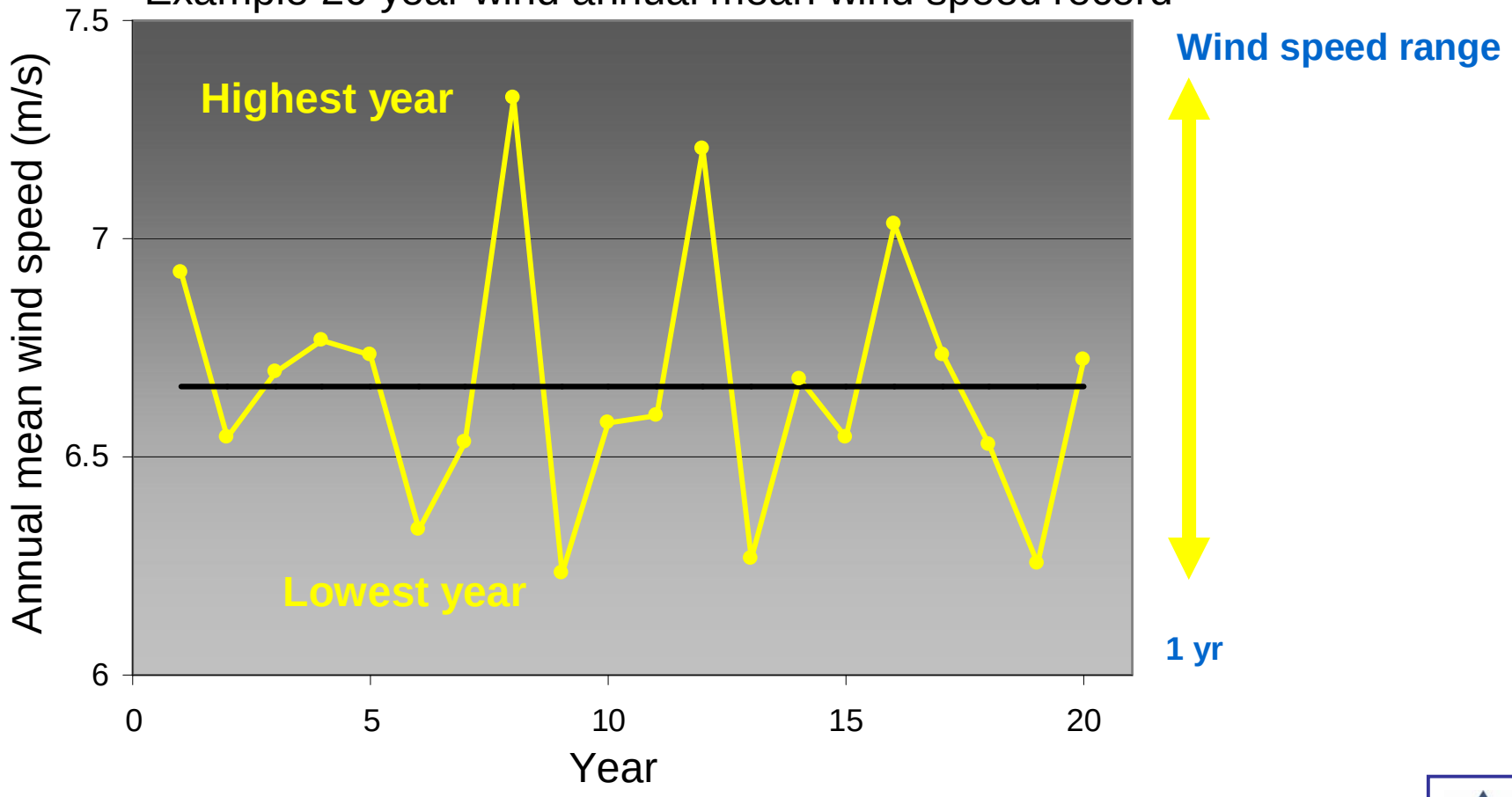
The thickness of a spoke shows the wind speed.

Used for design of wind farm

How long do measurements need to be?

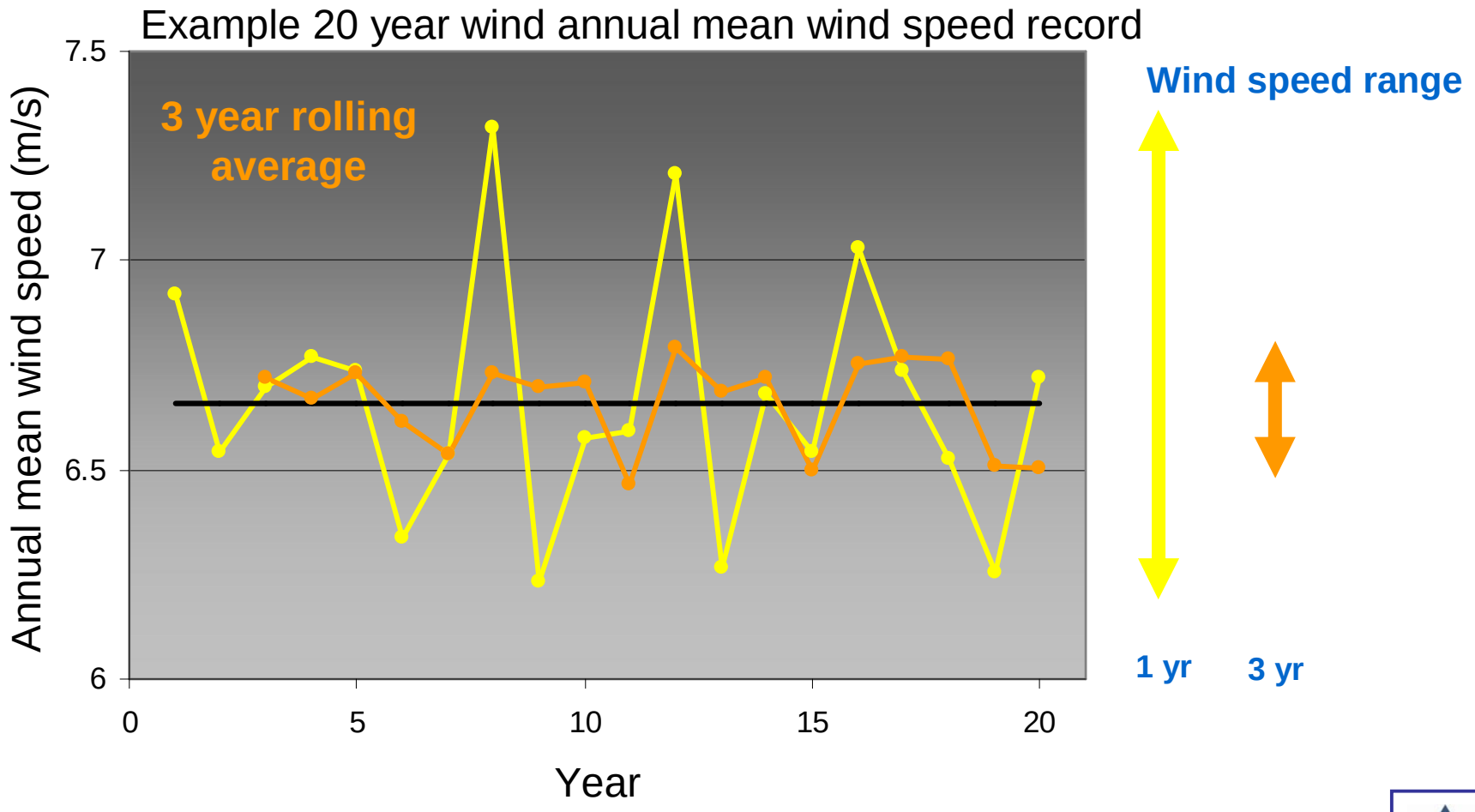
A year will capture seasonal variations,
but we could have a high or low wind speed year

Example 20 year wind annual mean wind speed record



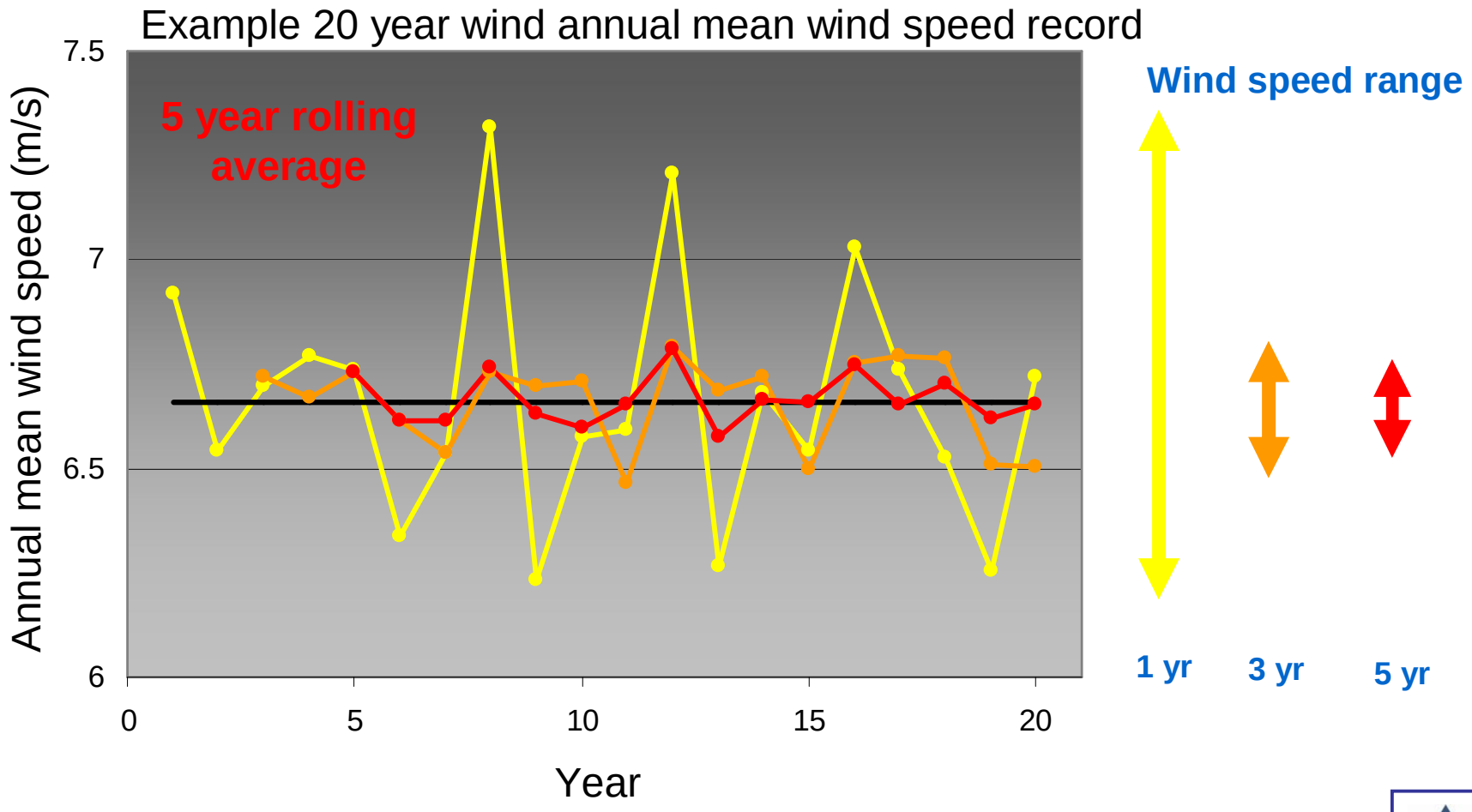
How long do measurements need to be?

Wind speed range substantially reduced with 3 year periods



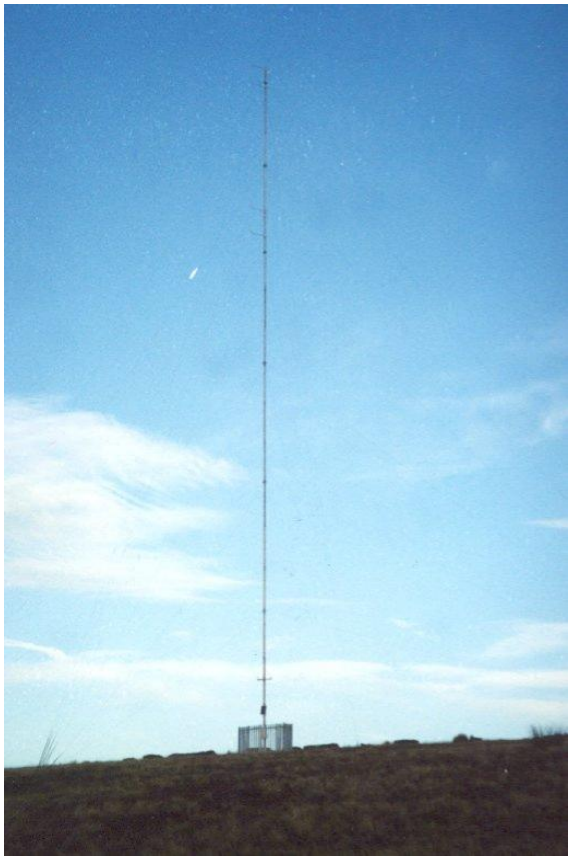
How long do measurements need to be?

Wind speed range further reduced with 5 year periods
Conclude the longer the site data the better!



What if site data are of short duration?

Wind Farm site
2 years of data



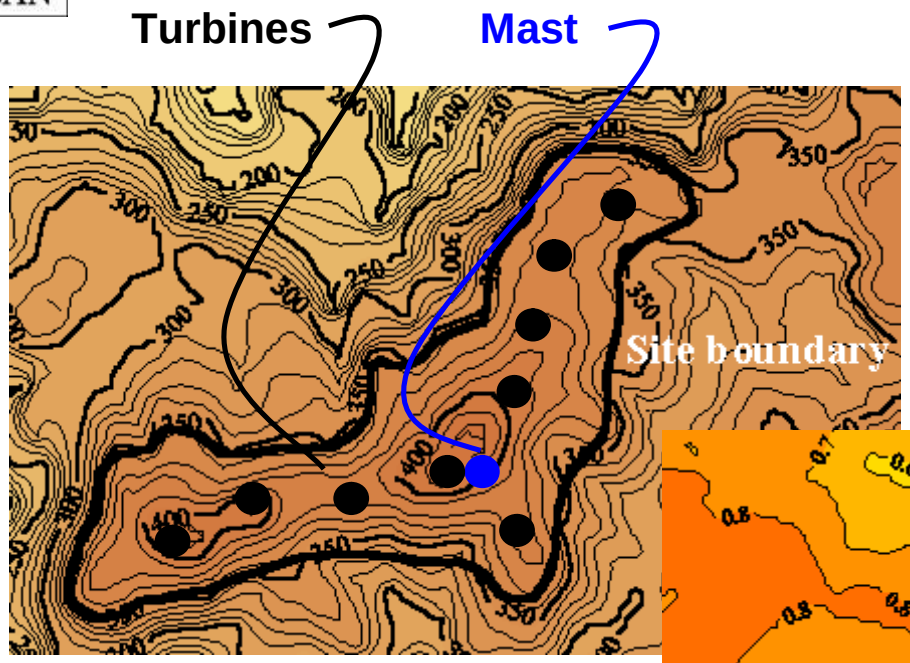
National met station
10 years of data

Can use “correlation” approach to make site data set longer but..

Reference station data **must** be consistent

Two data sets **must** correlate well

Predicting wind speed variation a site

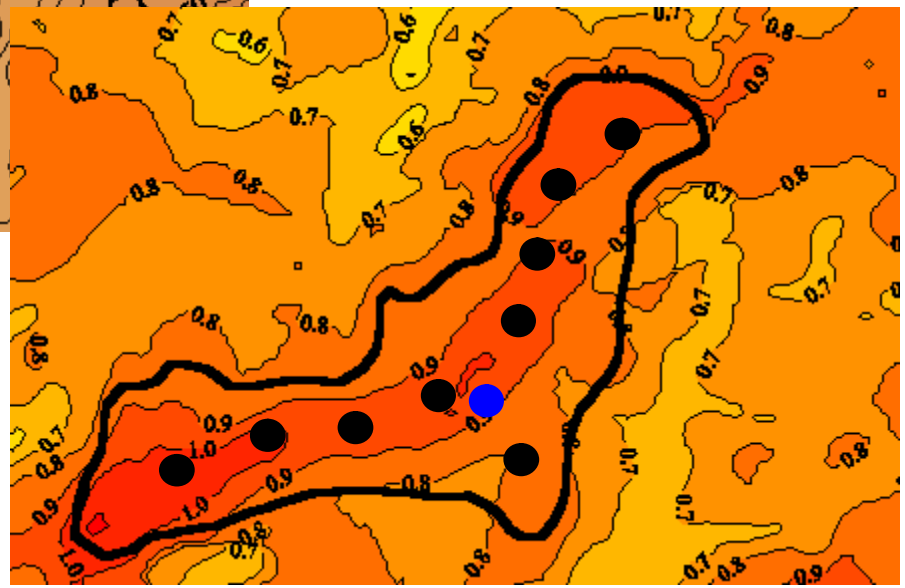


Input - topography

Computational flow modelling initiated from wind conditions at mast

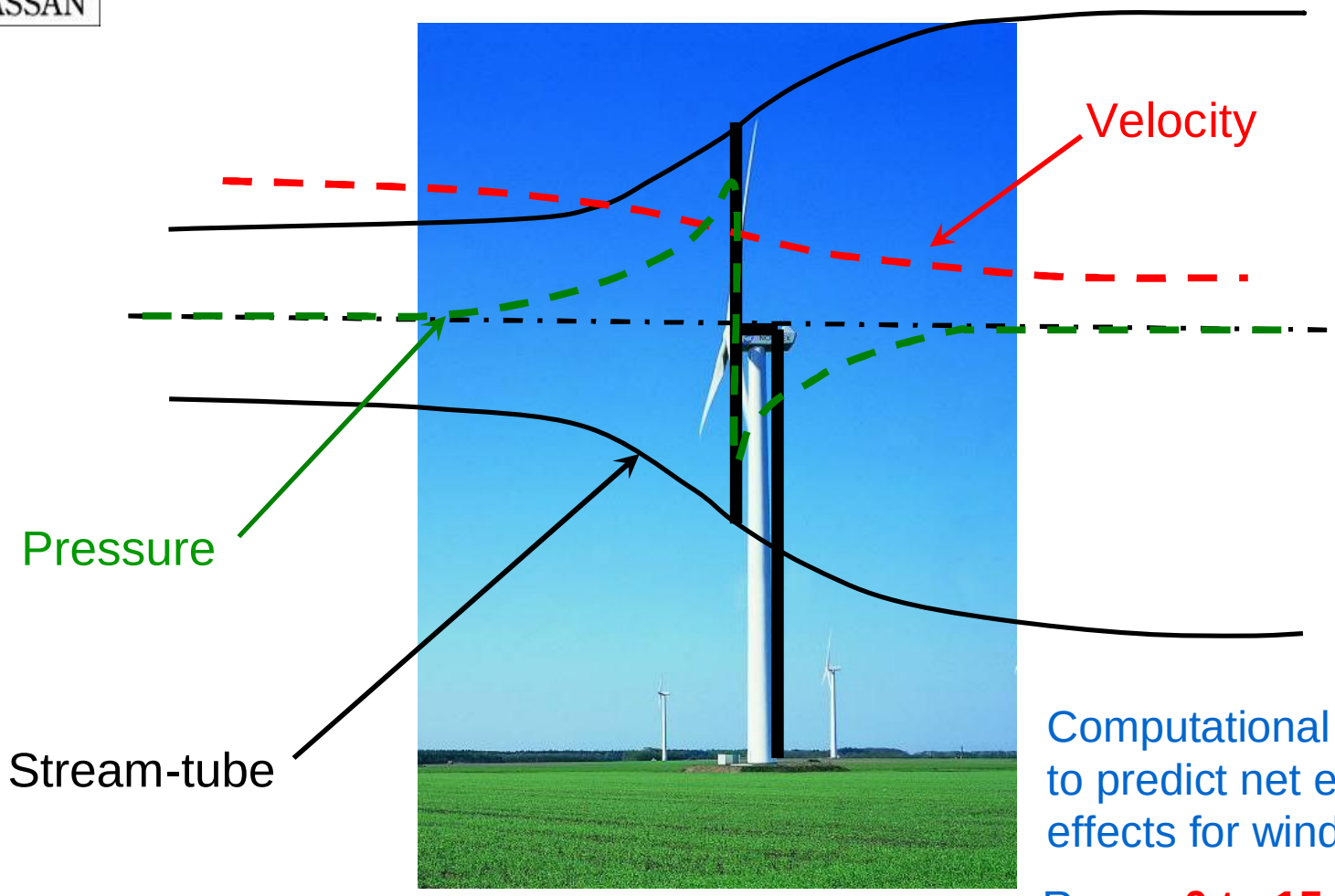
Have predicted wind conditions at each turbine location

In this example annual mean wind speed varies by 30 % over site area



Output normalised wind speed

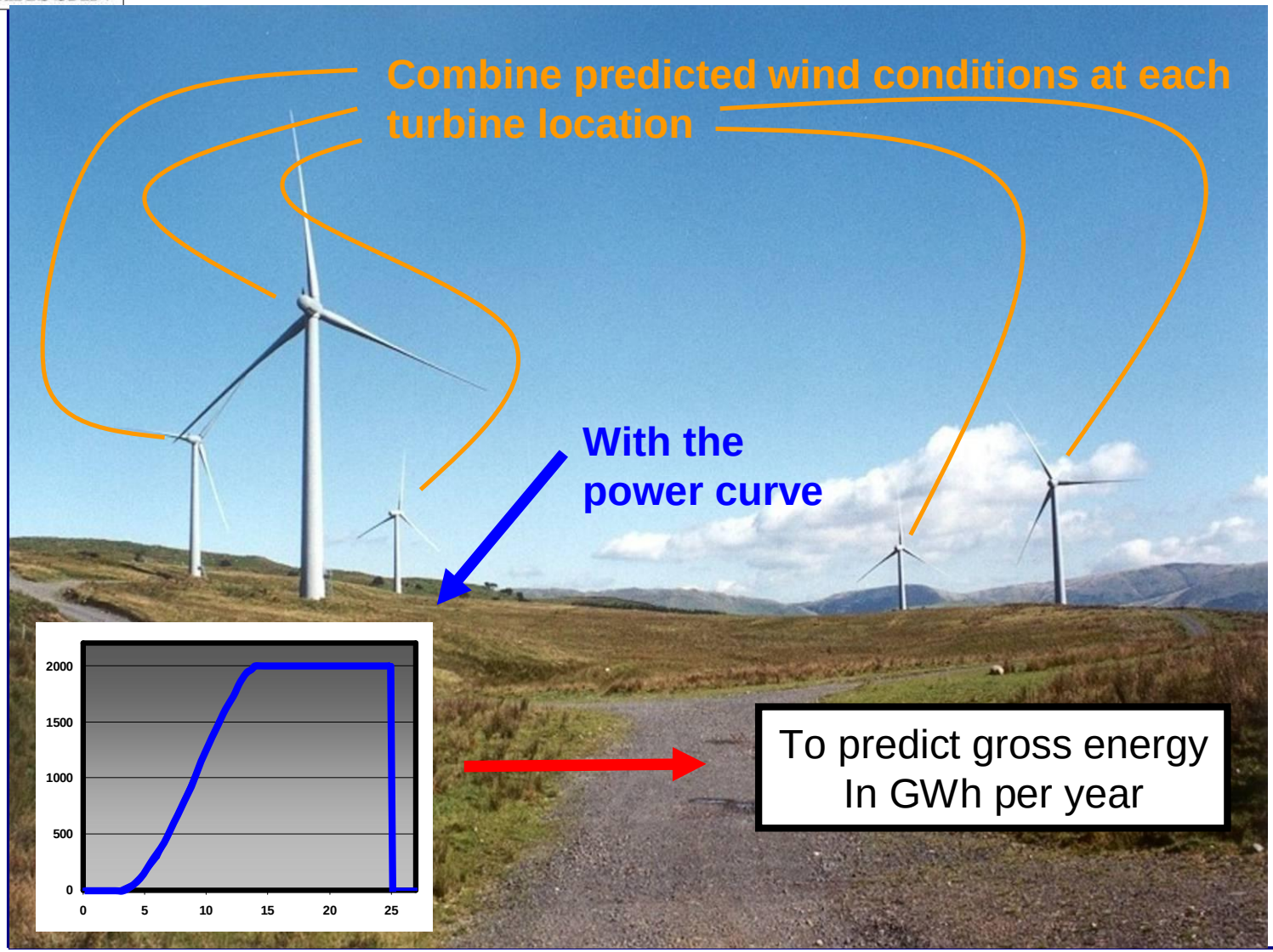
Predicting wake interactions between turbines



Computational models used to predict net effect of wake effects for wind farm

Range **0 to 15 %** on energy

Wind farm energy production



Wind farm energy production

Apply “loss factors” to gross energy to get net annual wind farm production

Gross Energy → Availability, Electrical losses, Other losses (such as icing!) → **Net energy**

Process complete

Short term forecasting

What is it?

Predicting what wind farms will produce in a few hours time to a few days time

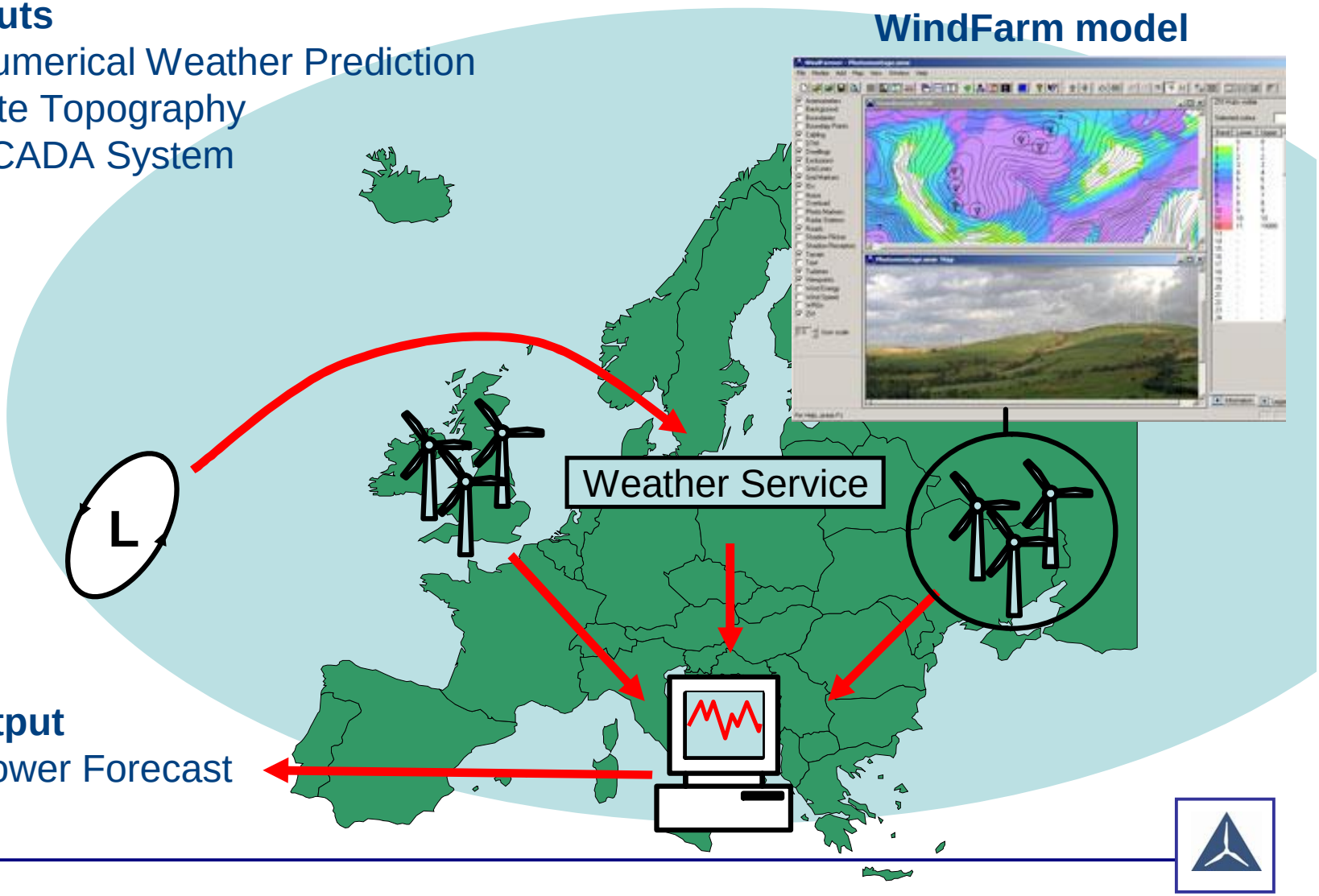
Why do we need it?

To help integrate wind energy into the electrical grid

Inputs and outputs

Inputs
- Numerical Weather Prediction
- Site Topography
- SCADA System

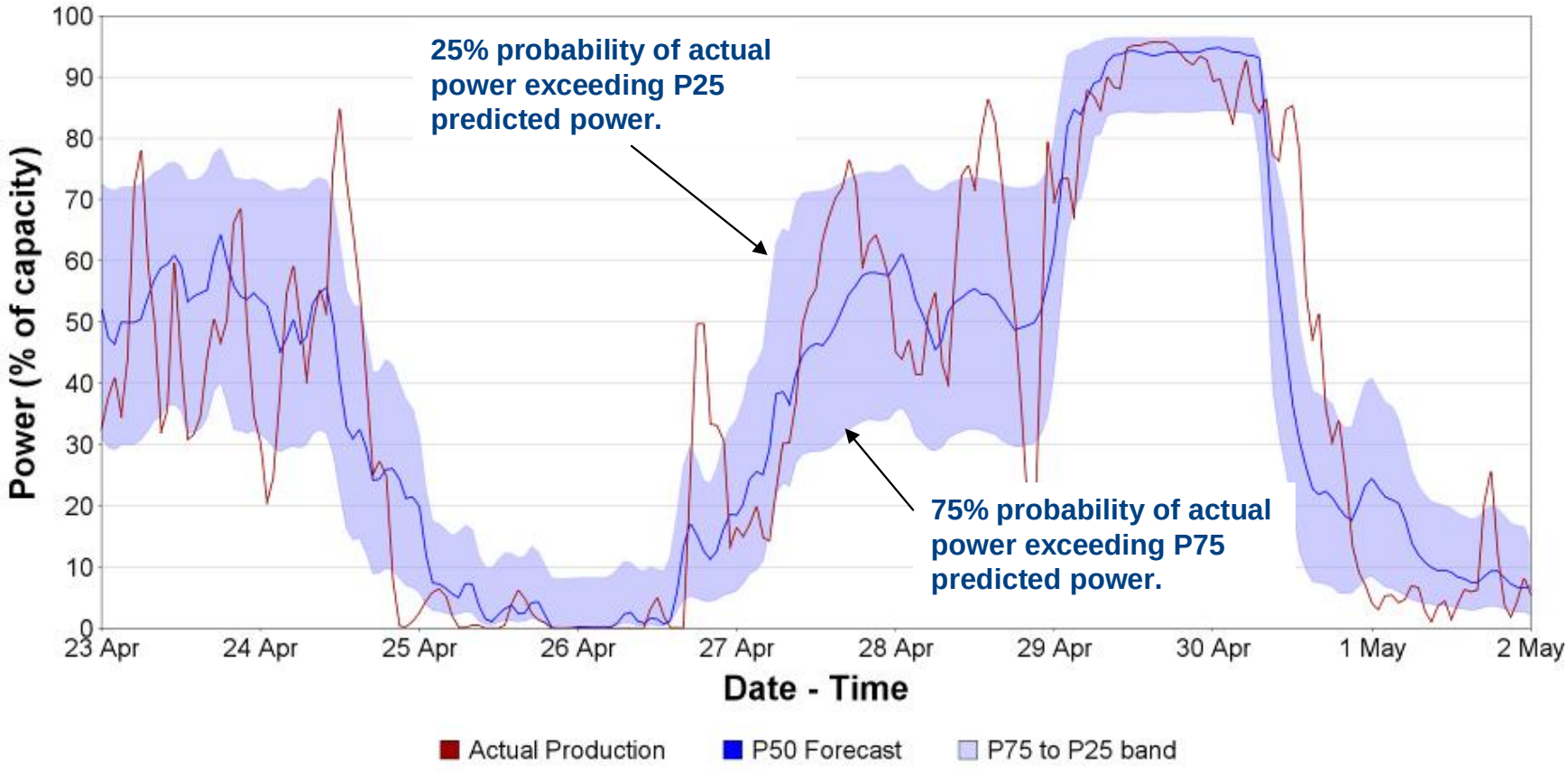
WindFarm model



Output
- Power Forecast

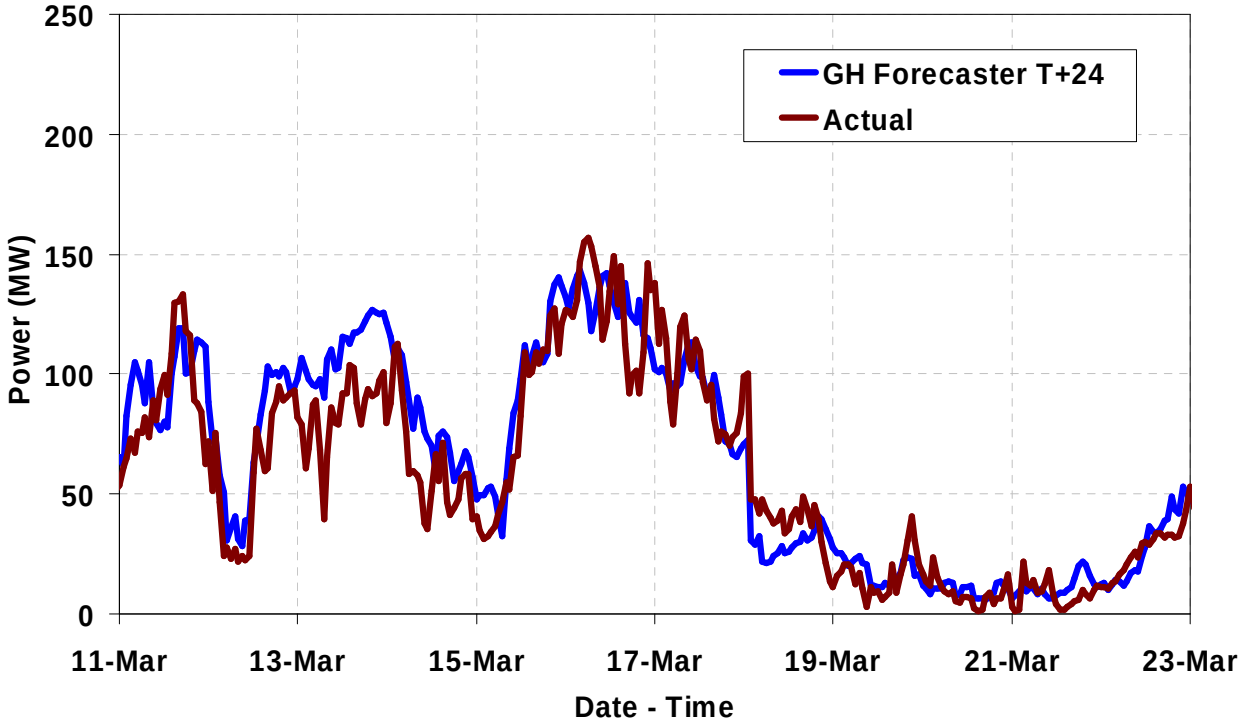
Example Forecast Power Prediction Results

Hourly data 12 hours in advance



Forecasting for a portfolio of wind farms

Time series of power forecast for a portfolio of 7 wind farms at T+24h.



Short term forecasts are currently being used in countries with high wind energy penetrations to facilitate the integration of wind energy into the grid

Thank you for listening

Full details in Wind Energy The Facts