

# Evaluating Wind Resource

How can I find the best site for a wind turbine



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# Wind - The Big Picture

Continental scale : 3 major factors:

- Large temp difference between polar air and subtropical air to south
- Distribution of land and sea – Atlantic to the west and large land-mass of Asia to east, Mediterranean sea and Africa to the south
- Orographical barriers: alps, Pyrenees, and Scandinavian mountain chain.

Dominant weather system:

- Cyclones and anticyclones moving east or north east across the Atlantic to Europe.
- As cyclones move to land from sea they become weakened, i.e. generally the further from the Atlantic the lesser the general effect of the cyclone systems.

Variation Across Europe:

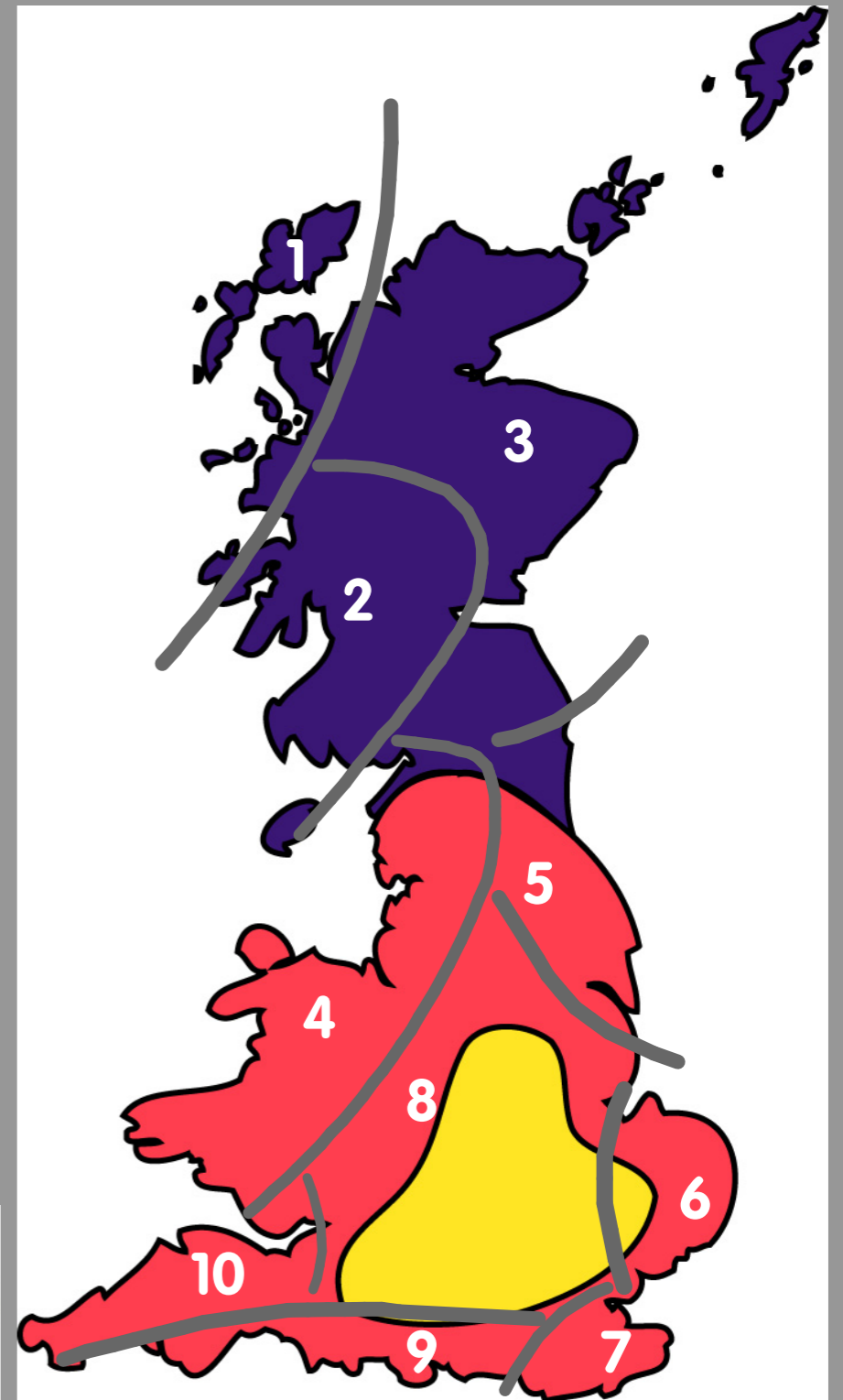
- The available energy from the highest wind resource country – the UK is 10x that of the country with the smallest wind resource.
- Substantial variations occur not only on the continental scale, but far more locally. Generally the more complex the terrain the more localised the variation will be.

World survey of climatology [landsberg and wallen 1970, 1977]



# Regional Wind Climate

1. Western Isles [Scotland]
2. West Scotland
3. East Scotland
4. Wales & NW England
5. NE England
6. East Anglia
7. SE England
8. Midlands [no coast]
9. S coast England
10. Devon & Cornwall



8

6

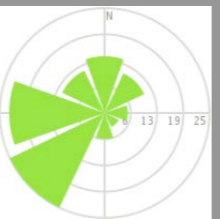
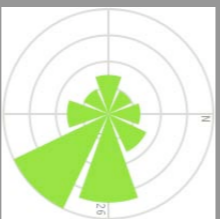
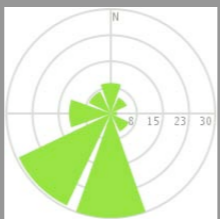
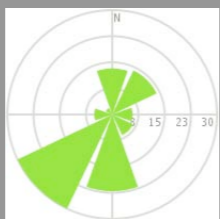
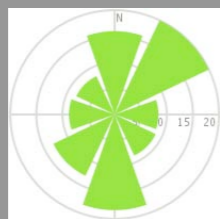
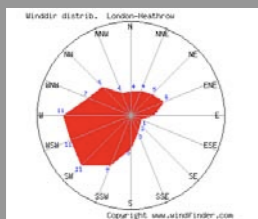
8

4

4

8

4



Heathrow - Typical ???



# AMWS : NOABL MAP of UK

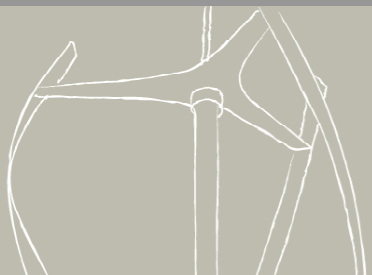
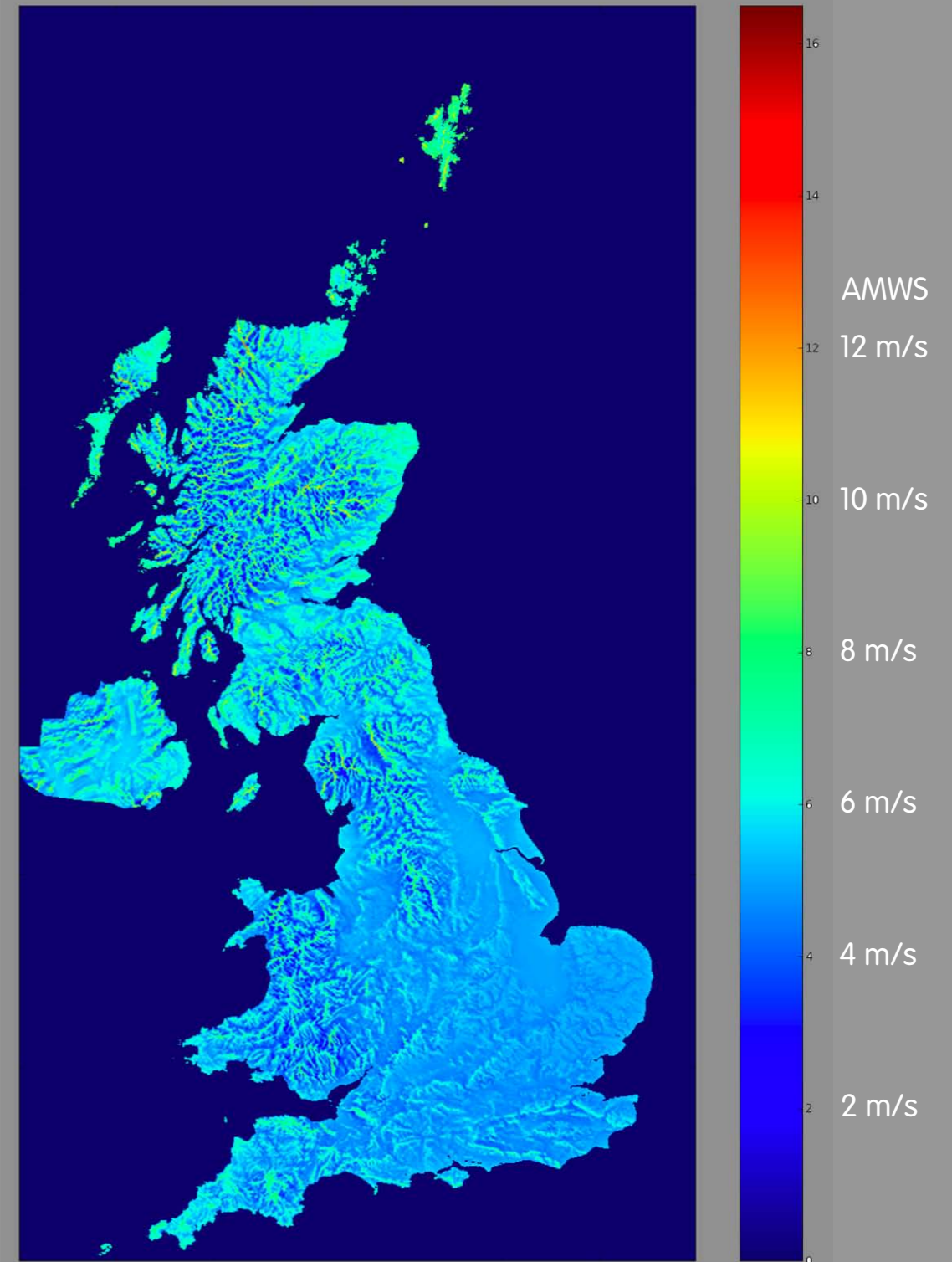
Air flow model that estimates the effect of elevation on wind speed

1km square resolution and takes no account of topography on a small scale

No allowance for the effect of local thermally driven winds such as sea breezes or mountain/valley breezes

No allowance for the effect of local surface roughness

No allowance for shadowing and acceleration effects due to topography



# Probability Distribution

The most important statistic derived from data sets.  
It is the distribution that provides the average annual energy production NOT the AMWS.

To obtain the power output for a site, one combines the wind probability distribution with the turbines power curve.

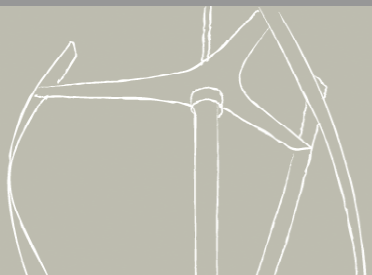
It is not possible to predict the probability distribution from the AMWS

Without detailed knowledge of a sites wind probability distribution it is usual to apply a Rayleigh distribution.

## Climate period

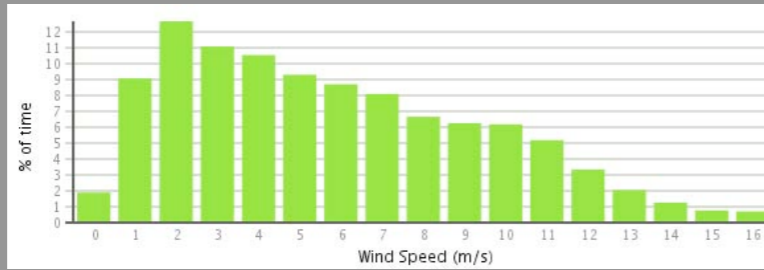
Seasonal variation  $\pm 12\%$

Year on year changes  $\pm 17\%$

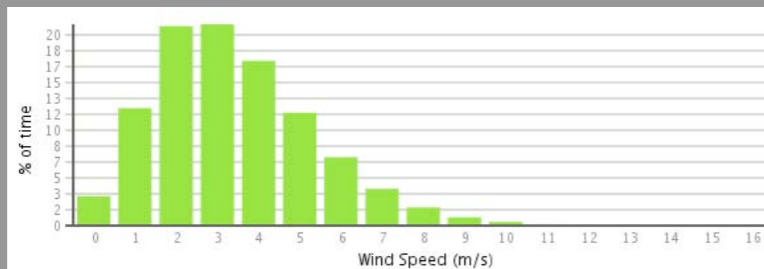


# Probability Distribution

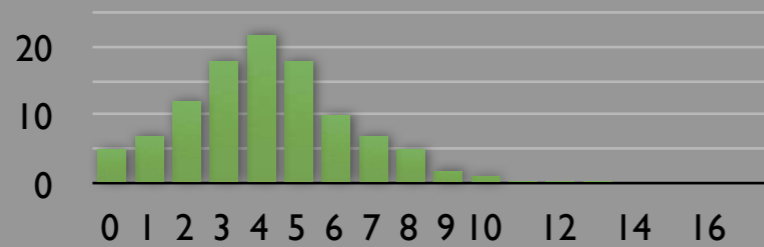
Coastal



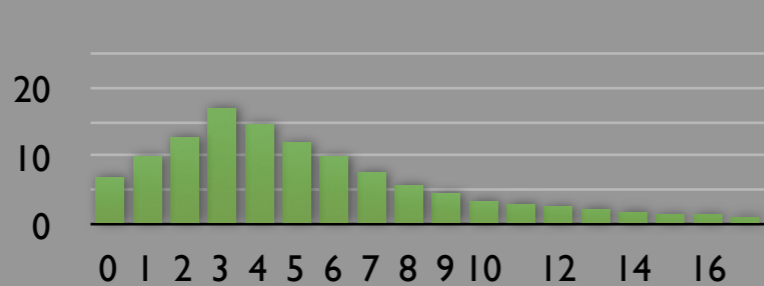
City Centre



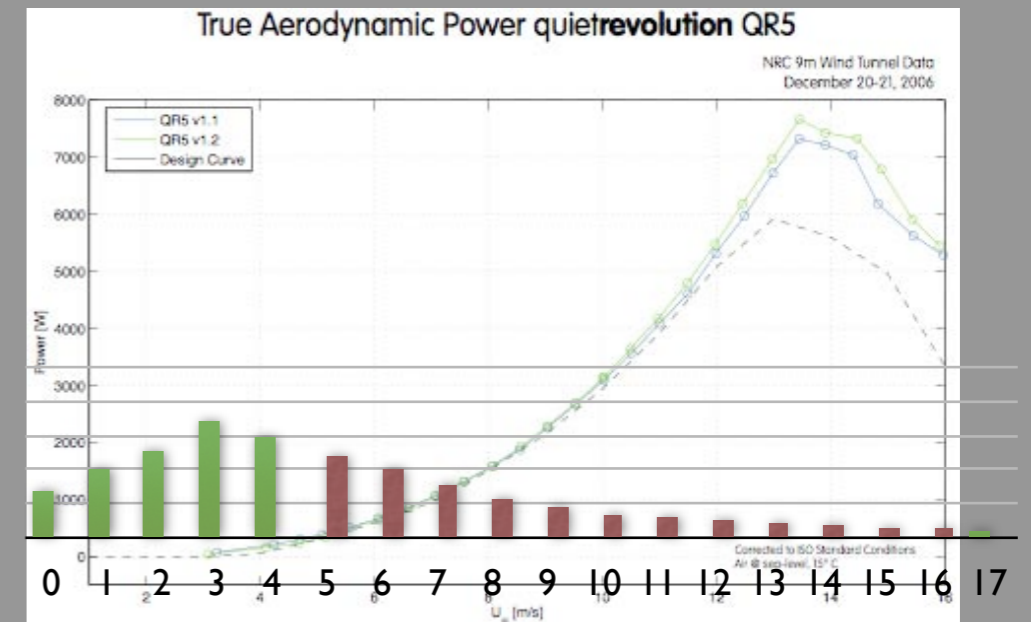
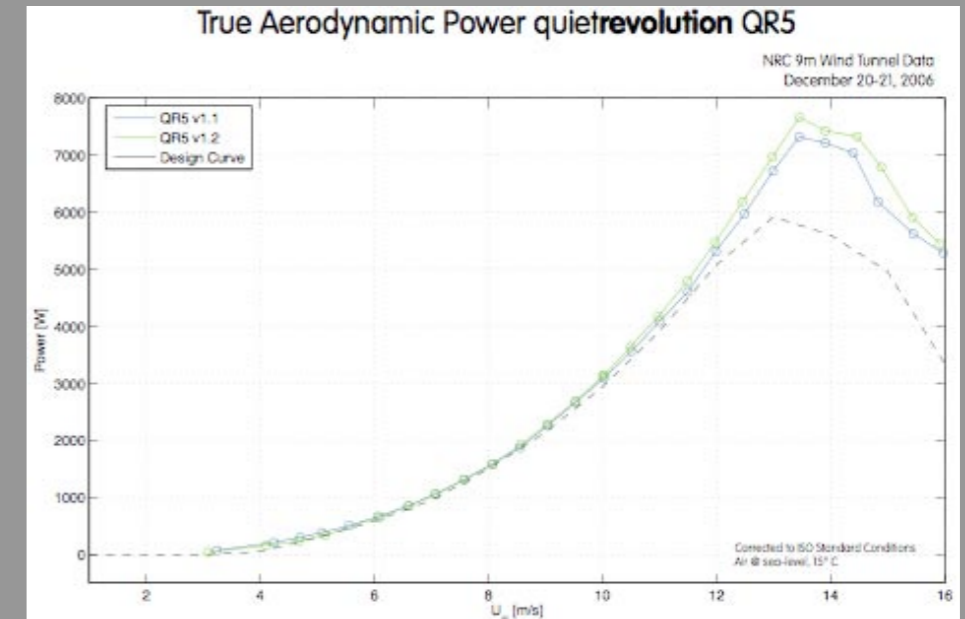
2 hypothetical sites



same 4 m/s  
AMWS  
different  
power  
outputs



because qr5 power curve



Red shows power generation



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# Orography

100-200km scale

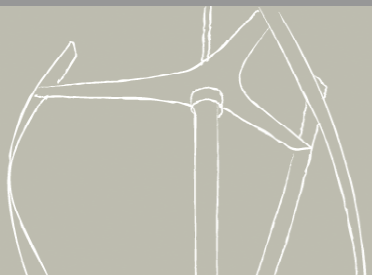
The study of the formation and relief of mountains, hills, and any part of a region's elevated terrain.

# Topography

10-20km scale

The study of Earth's surface features

Concerned with local detail, primarily relief, but also including vegetative and human-made features.



# Topography - single hill

10-20km scale

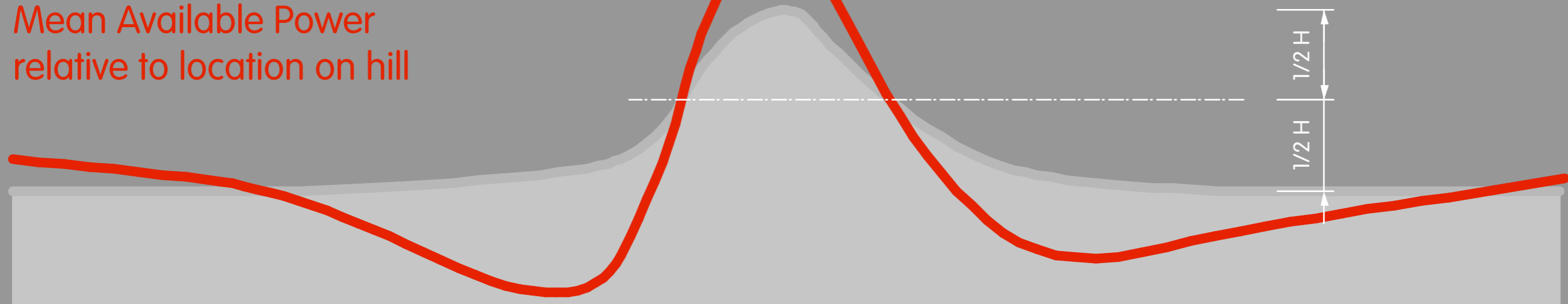
Steep slope

- Less power close to hill
- Quicker recovery away from hill

Shallower slope

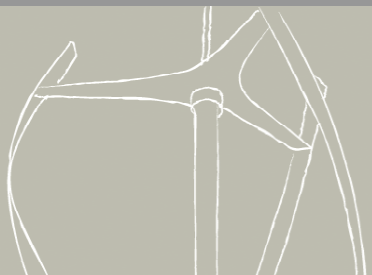
- Slower recovery

Mean Available Power  
relative to location on hill



**Acceleration**

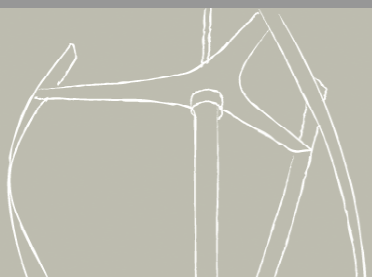
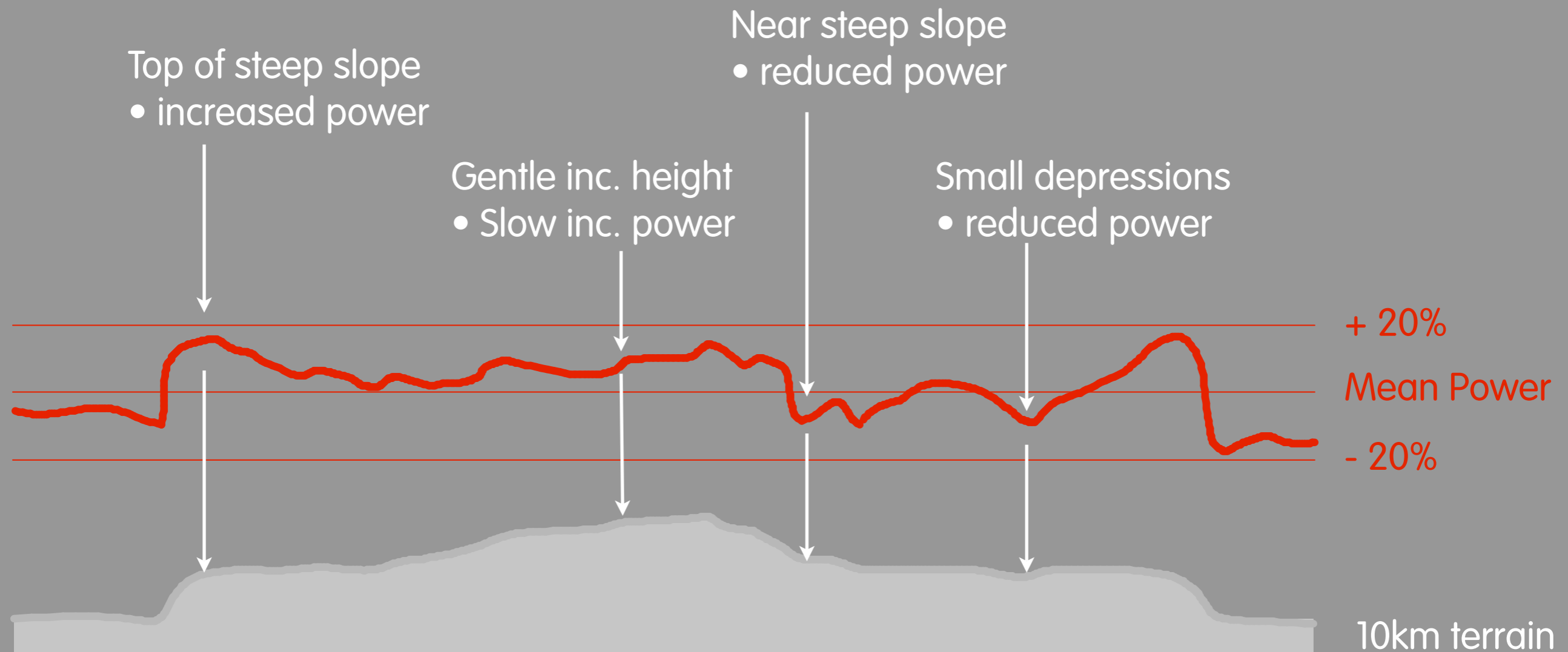
5% increase in power [not amws] for  
each 5% inc. height over 1/2 height



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# Topography - complex landscape

10-20km scale



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# Shadowing

Buildings  
Woodland  
Hills

## **The challenge:**

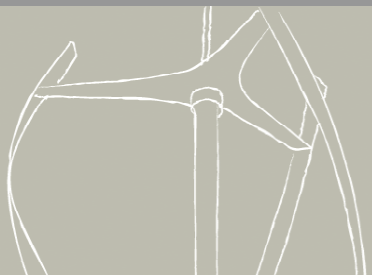
How to quantify the effects of obstructions and obstacles

# Acceleration

Buildings  
Hills

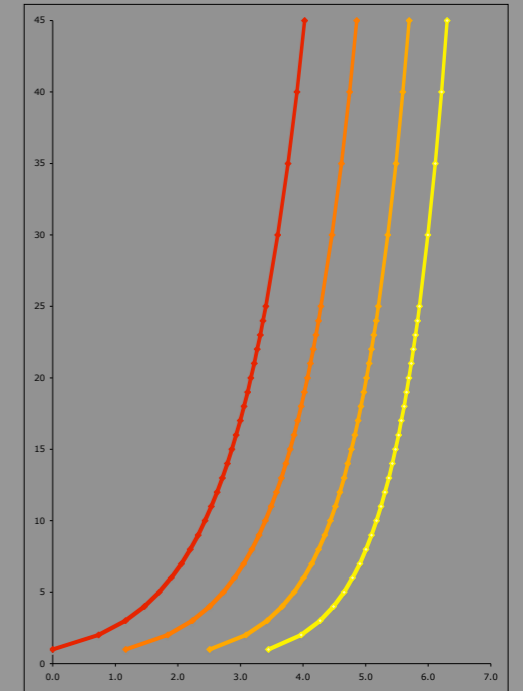
A very steeply sloping hill or a tower building can be considered as an extension to the turbine mast

A gently rising hill can be considered as a blockage causing accelerated flow



# Adjust for surface roughness

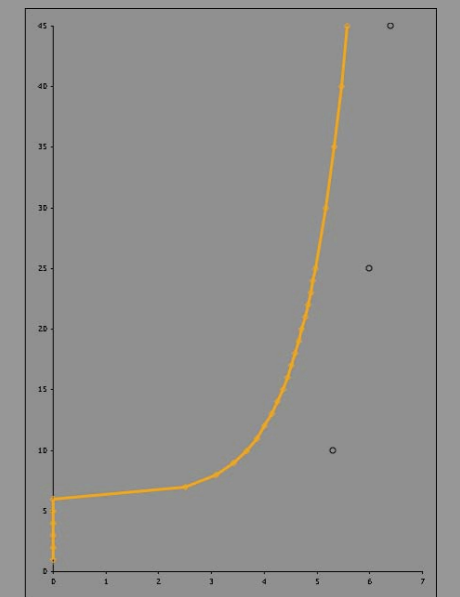
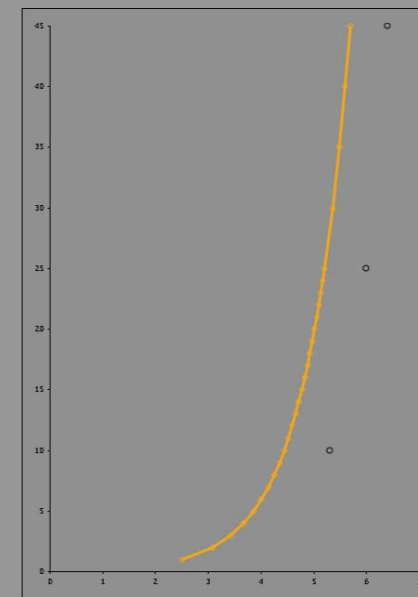
Coastal  
Rural  
Suburban  
Urban



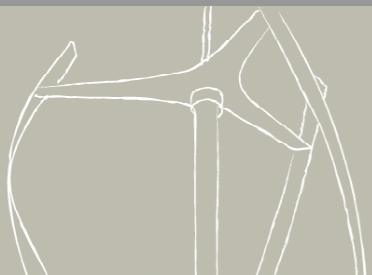
## Adjust Boundary layer height [Ground Plane Adjustment]

e.g. Suburb : roof tops 9m,  
assume the surface boundary layer starts at 4.5m

e.g. dense wood : canopy at 16m,  
assume the surface boundary layer starts at 16m

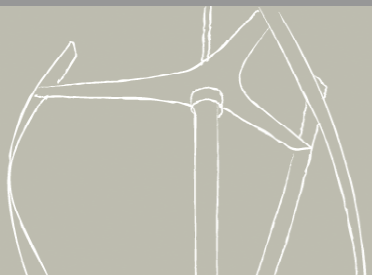
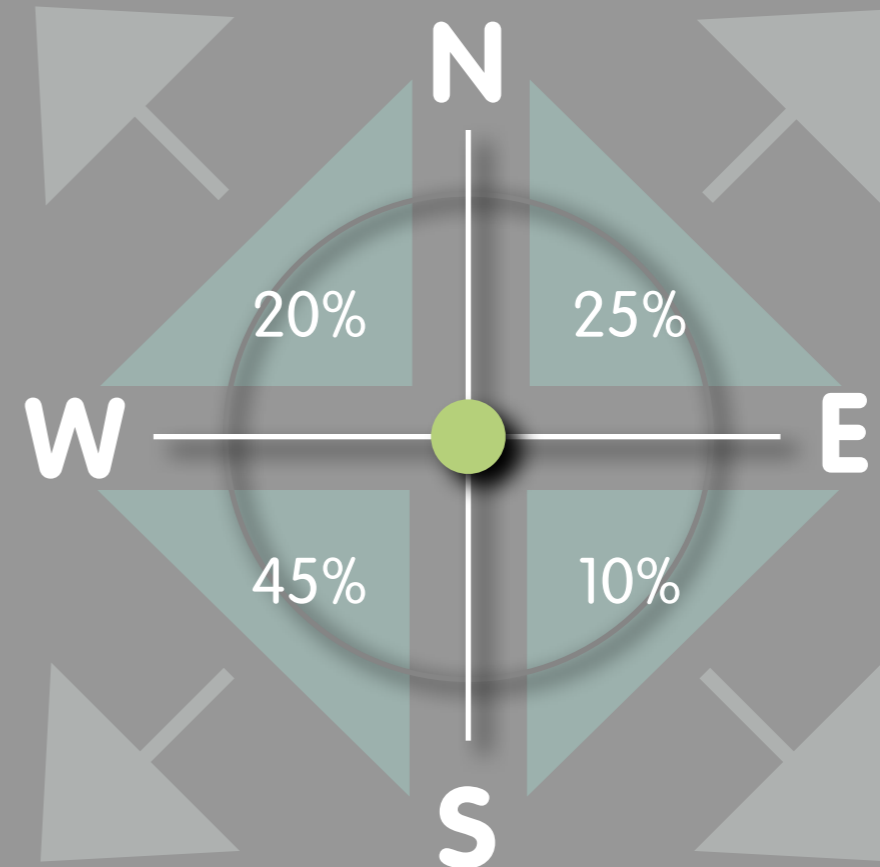


Measuring AMWS / Height



# quietrevolution methodology

1. Split compass into quarters
2. allocate percentage of wind from each quarter
3. adjust NOABL for terrain in each quarter [topography & roughness]
4. adjust for height above / below mean over 5 km<sup>2</sup>



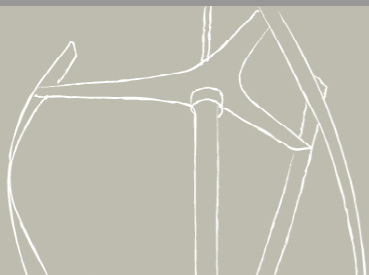
# Site : East Kilbride

## Description

- Turbines in grounds of store
- Location on relative high ground
- Town to South and open country to North

## Site Elevations

- Falling in all directions except West
- To West land rises approx. 10m and then falls.
- To S/E, S and S/W land rises slowly from approx. 3km to 10km



# Site Information

for the 1km grid square 264 656 (NS6456)

Wind speed at 45m agl (in m/s)

8.4	8	7.6
8.2	7.9	7.6
7.7	7.6	7.7

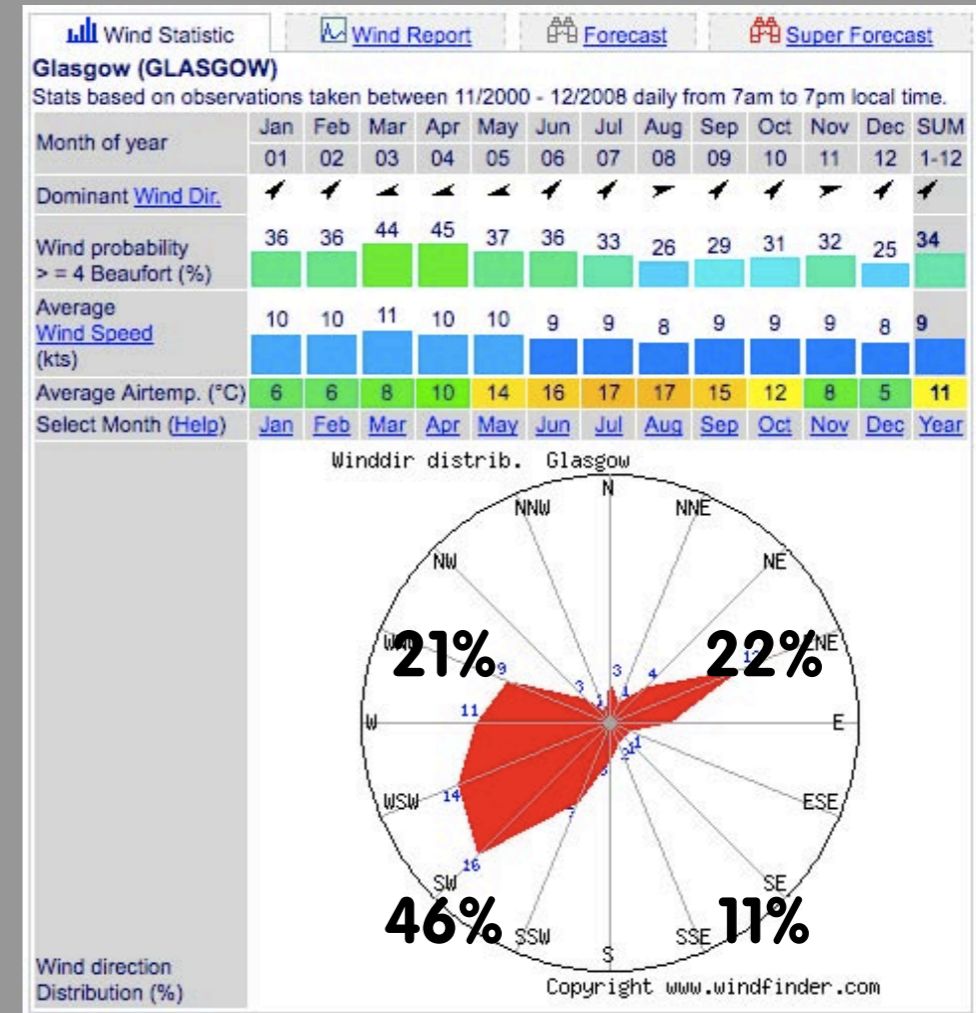
Wind speed at 25m agl (in m/s)

7.9	7.4	7
7.6	7.3	6.9
7	6.9	7

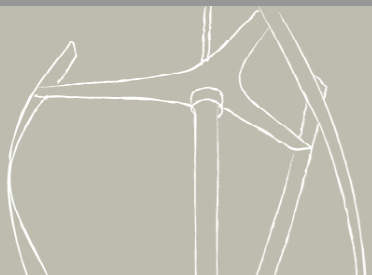
Wind speed at 10m agl (in m/s)

7.3	6.7	6.2
6.9	6.5	6.1
6.1	6.1	6.2

Grid Ref: NS640566  
NOABL Database information  
for 1km square at site



Wind rose  
Percentages of resource by quarters



# Site Information

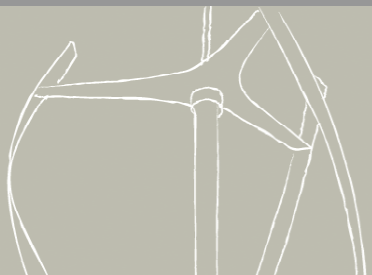
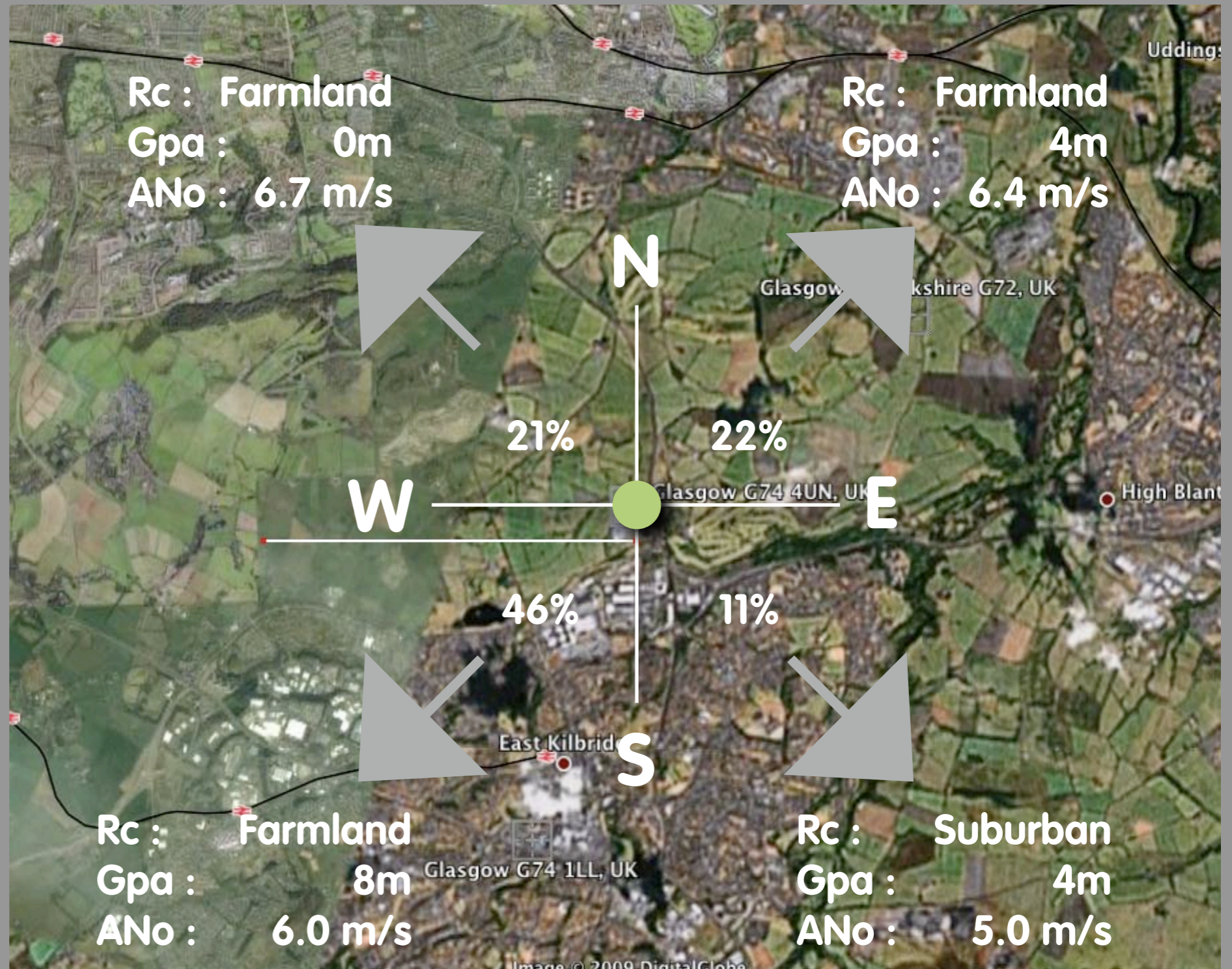
Calculations based on SAP

Centre of Rotor Height : 17.5m AGL

NOABL at CoR 6.9 m/s

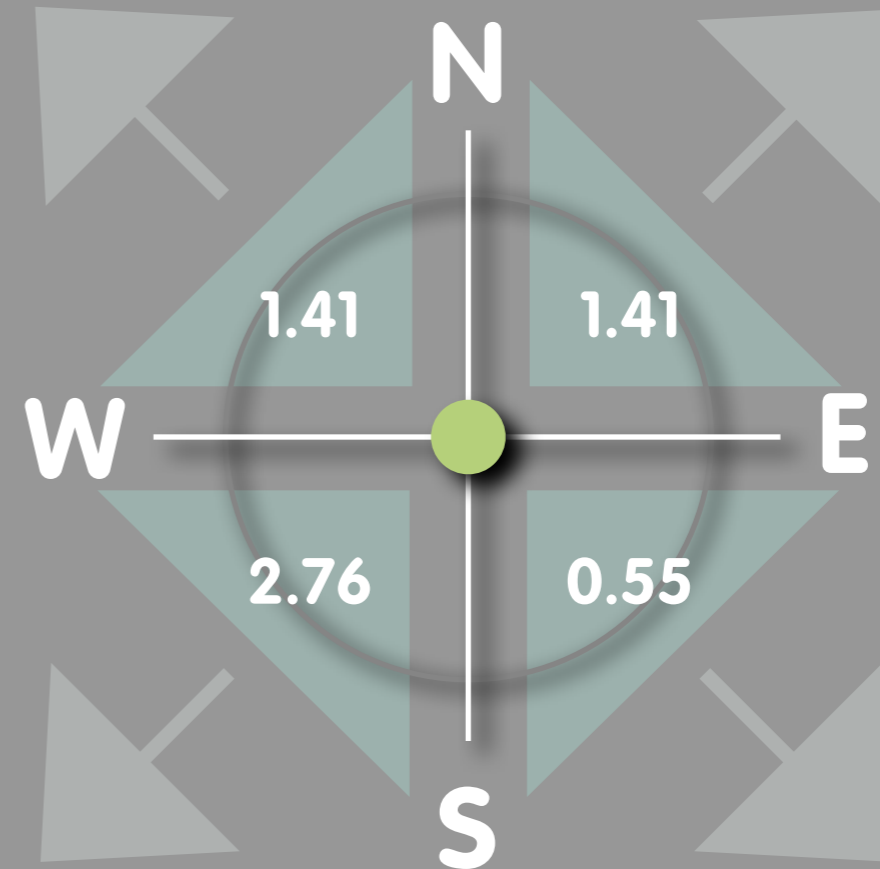
## Key

- Rc Roughness Category
- Gpa Ground Plane Adjustment
- ANo Adjusted NOABL



# quietrevolution conclusions

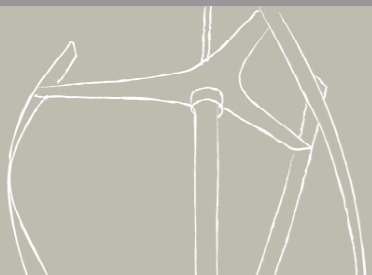
- allocate percentage of wind from each quarter
- adjust NOABL for terrain in each quarter [topography & roughness]
- adjust for height above / below mean over 3km<sup>2</sup>



**Predicted Annual Mean Wind Speed**

**6.1 m/s**

NOABL at CoR : 6.9 m/s



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# quietrevolution conclusions

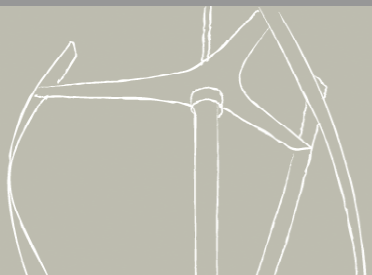
NE 3km		N 3km		Nw 3km
106		86		78
	NE 1km	N 1km	Nw 1km	
	192	173	149	
E 3km	E 1km	SITE	W 1km	W 3km
159	188	179	137	102
	SW 1km	S 1km	SE 1km	
	164	166	166	
SW 3km		S 3km		SE 3km
169		200		200

153.8	MEAN ELEVATION OF LOCALITY
200.0	MAX ELEVATION IN LOCALITY
78.0	MIN ELEVATION IN LOCALITY
179	SITE ELEVATION
25.2	SITE ELEVATION ABOVE/ BELOW MEAN
12.6	SITE HEIGHT ABOVE OR BELOW LINE OF ACCELERATED WIND
8%	EACH 5% INC. HEIGHT ABOVE MEAN WIND LINE = 5% INC. EACH 5% DROP HEIGHT BELOW MEAN WIND LINE = 5% DROP
2%	PERCENTAGE INCREASE / DECREASE IN AMWS

Height adjusted  
**Predicted Annual Mean Wind Speed**

**6.2 m/s**

NOABL at CoR : 6.9 m/s



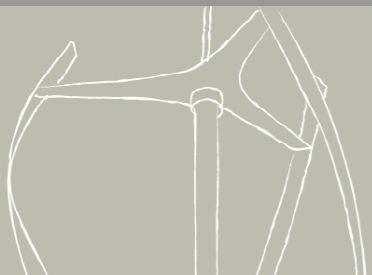
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# Evaluating Wind Resource

How can I find the best site for a wind turbine

## conclusions

- Local site conditions will have large impact
- Free database of wind speeds should be corrected
- It is not possible to predict the probability distribution from the AMWS
- On sites close to the ground a small increase in height will have a dramatic effect on wind resource and power output.
- Most sites do not fit neatly into once surface roughness category
- Quantify any anticipated shadowing and acceleration

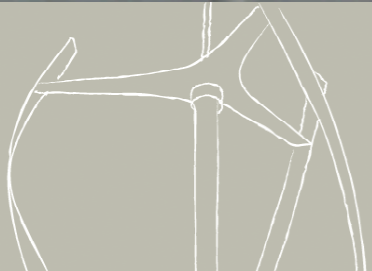


# Evaluating Wind Resource

How can I find the best site for a wind turbine



questions



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