Wind Power

Organization for Security and Co-operation in Europe
Office in Baku

Daniel Bernoulli
1700 – 1782

Born in Holland to a Swiss mathematical family

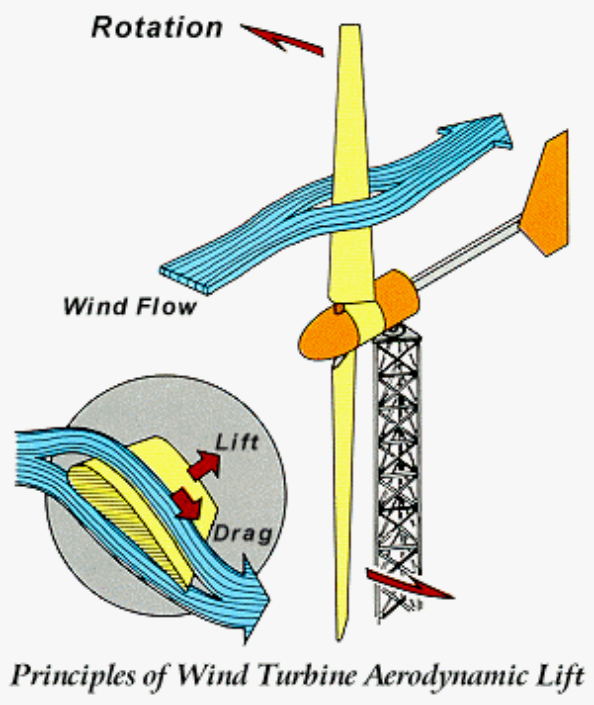
The scientist who discovered the principle of lift

Aeroplanes, wind turbine blades, even bird's wings

Power from wind

- Wind becomes electrical power through the formula: Power (Watts) = 0.5 x density of air x area swept by blades x wind speed cubed
- Turbines are normally “rated” at a wind speed of 12m/s, but some produce maximum output at higher wind speeds. Power rating (kW) is the maximum power that the turbine is designed to produce
- Mechanism to protect turbine at higher wind speeds – furling for small systems, brakes or pitch of blades for large systems

Principle



Source: www.awea.org/faq/basicop.html

- Wind blowing over the blades creates “lift” on one side
- The blades sweep around in a circle
- A generator uses the circular motion to generate electricity

- A traditional “Dutch” type windmill
- Used to mill grain
- 100,000’s in Europe by 1900

- Wind pump
- Used to pump water from wells
- Multi-bladed
- Typical in the USA “wild west”

Wind Turbines

- Generate electricity
- Modern and aerodynamic
- Large turbines are connected to the grid
- Small turbines can charge batteries

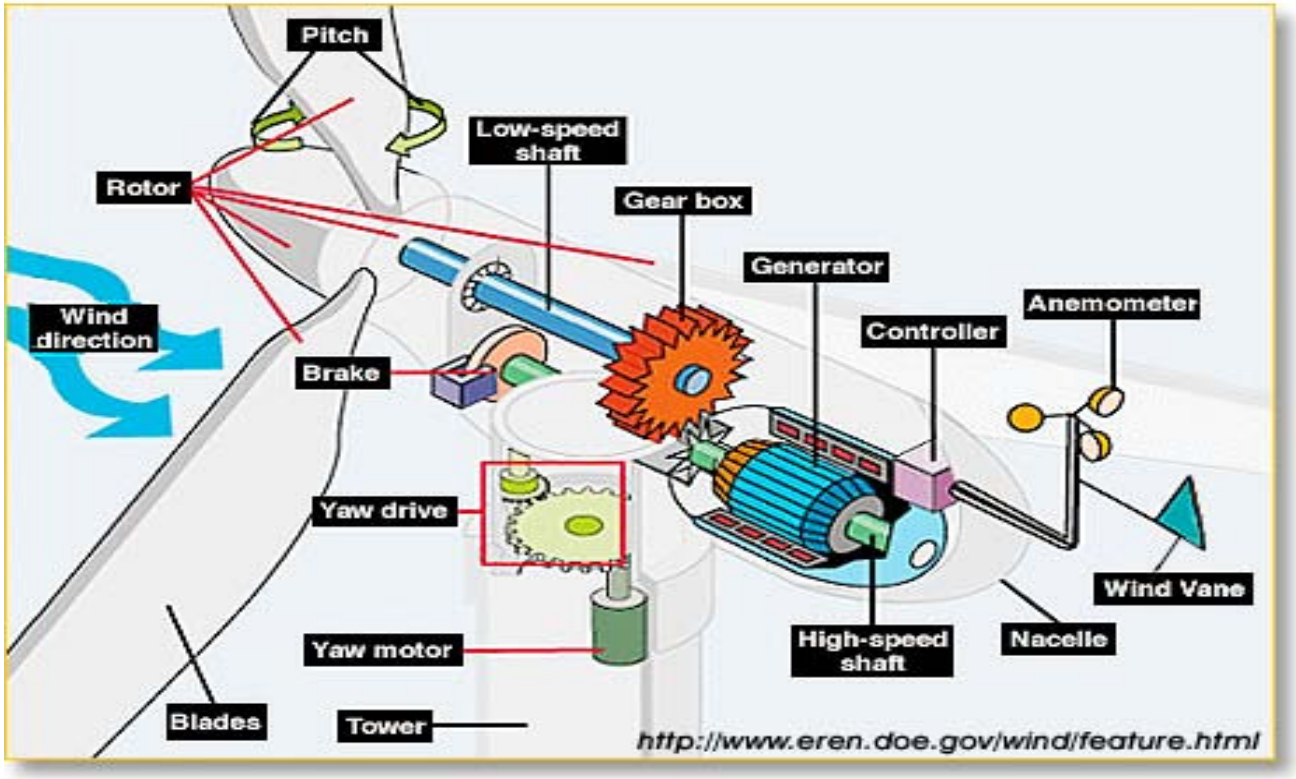
- One-bladed wind turbine
- Spins faster
- Needs counterweight
- Blade can be “parked” behind the tower in storms

- Two bladed wind turbine
- Spins faster – creates more noise

- Vertical axis wind turbines
- Called “Darreius”
- Much less efficient, but good in turbulent conditions

- Most large modern wind turbines are 3-bladed
- Most efficient design
- Stable

Parts of a modern wind turbine



Generation of Electricity

- Some modern large wind turbines are gearless
  - Rotor connects directly to the electricity generator
  - Generator turns at same speed as rotor – 18 to 38 rpm
  - More efficient than gearbox turbines
  - Larger and heavier
  - 20% more expensive
  - Less prone to breakdown
  - Quieter
- For example, Enercon 800 kW

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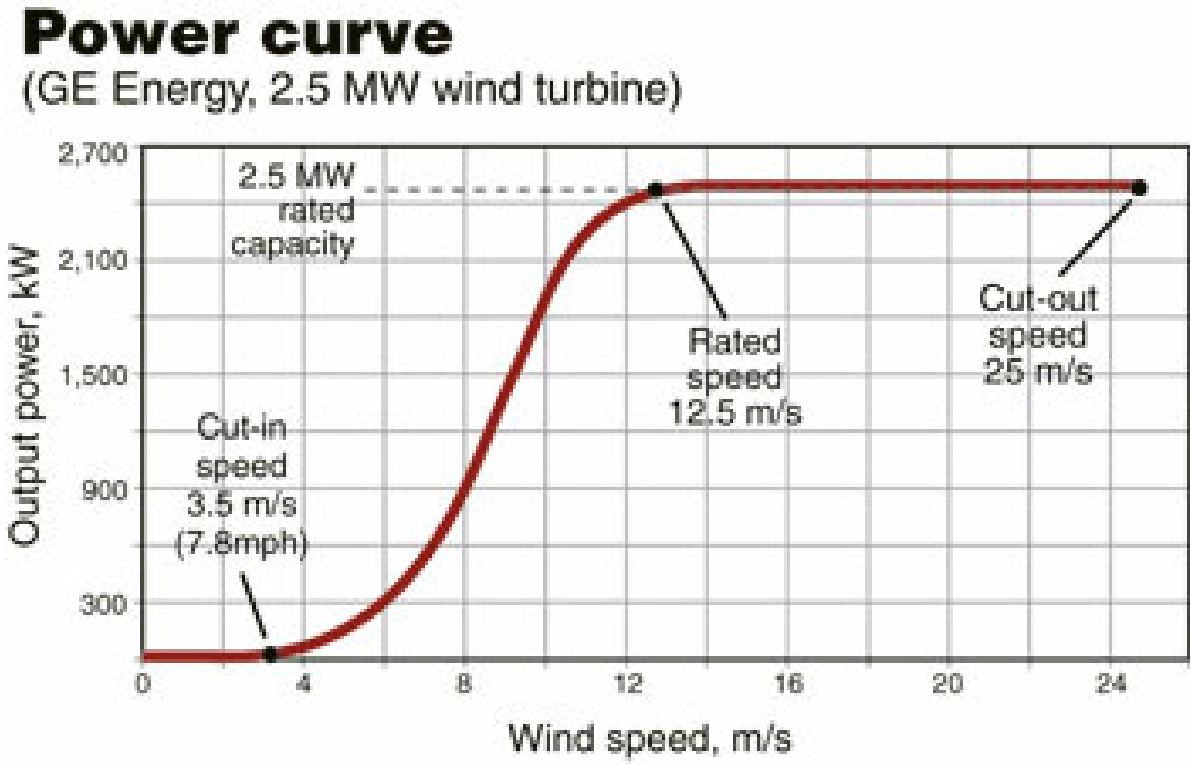
Calculations of energy potential

- The maximum efficiency of extracting the kinetic energy in wind and converting it to electrical energy is 59.3%. This is the Betz limit.
- Modern wind turbines can reach 80% of this limit
- However, the wind is variable
- Turbine capacities are rated at maximum output in winds of around 12m/s
- Combining the wind variability, the Betz limit and turbine efficiency gives the “Load Factor”
- Good onshore load factors are 30% to 35%
- Good offshore load factors are 35% to 40%

- Wind turbine power curves use load factors to predict output in various average wind speeds



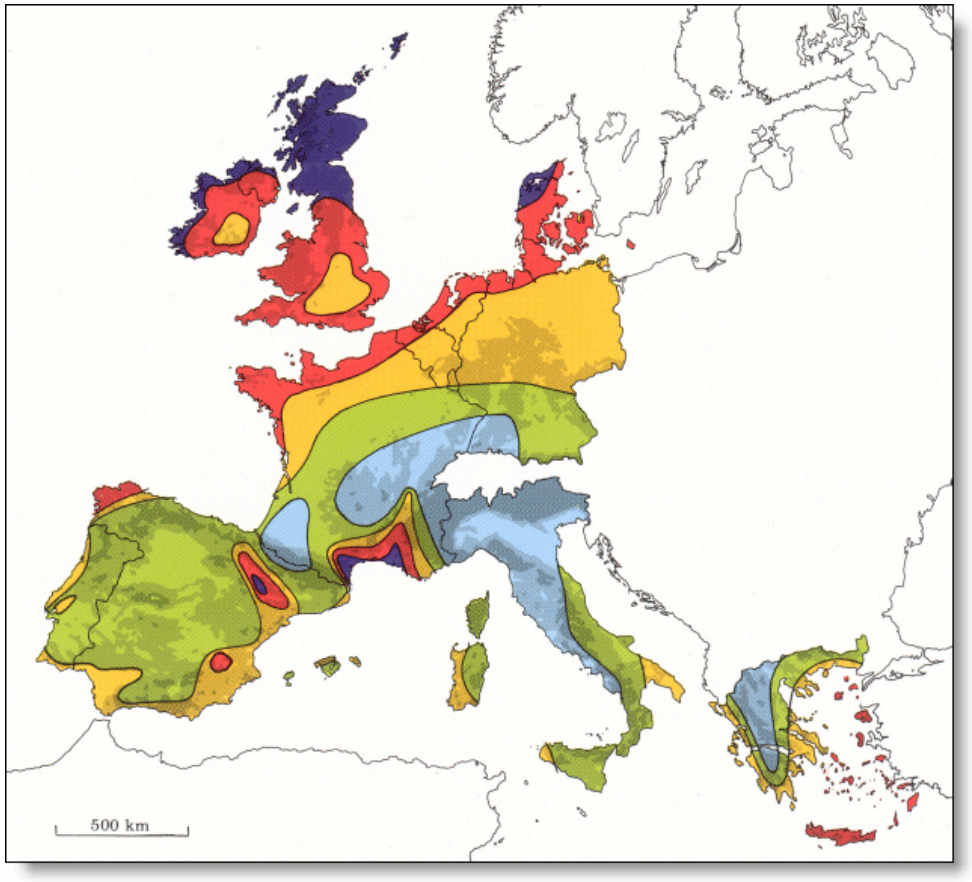
Source: GE Energy and Control Engineering

Some of the largest wind turbines

Manufacturer	Model	Power(kW)	Blade Diameter(m)	Hub height(m)
Enercon	E126	6000	126	ND
Enercon	E112	6000	114	124
Bard	Bard VM	5000	122	90
Darwind	Darwind	5000	115	100
Multibrid	M5000	5000	116	ND
Repower	5M	5000	129	80 - 120
GE Energy	3.6sl	3600	111	ND
Siemens	SWT-3.6-107	3600	107	80 - 96
Scanwind	SW-90-3500 DL	3500	91	ND
Scanwind	SW-100-3500 DL	3500	100	ND
Ecotecnia	100	3000	100	70 - 100
GE Energy	GE 3000	3000	104	ND
GE Energy	3.0s	3000	90	70
GE Energy	3.0sl	3000	94	85
Vestas	V90-3.0	3000	90	80 - 105
Winwind	WWD-3-90	3000	90	80 - 100
Winwind	WWD-3-100	3000	100	90 - 100

Wind Resource

Source - Riso

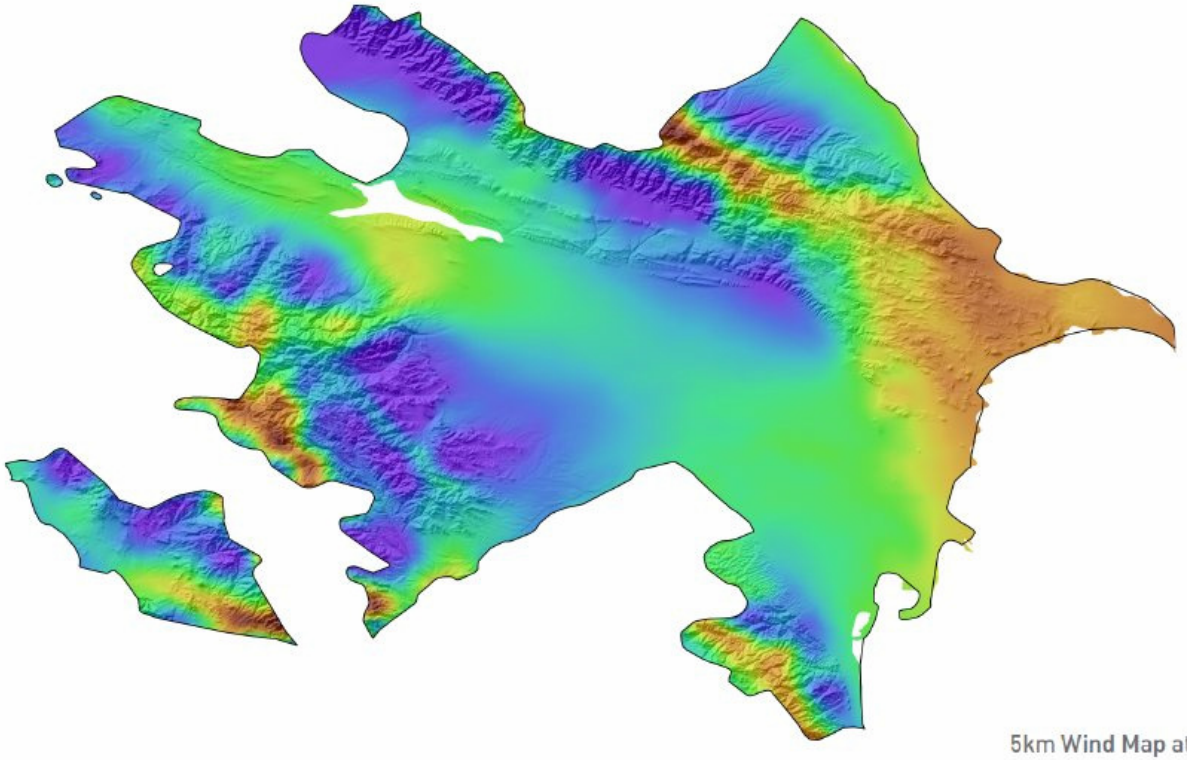


Azerbaijan

- Study of the local resource is necessary
- Some past studies, such as a Soviet study, do exist, but need to be expanded and in more detail
- Satellite and Met Station data are good for an overview, but not sufficient for detailed site selection and turbine output planning
- Parts of USA and Europe have so many turbines, with reliable output data, that detailed wind speed databases have been built
- These allow accurate prediction of wind movements across nations

Azerbaijan Wind Map at 80m

3TIER
www.3tier.com



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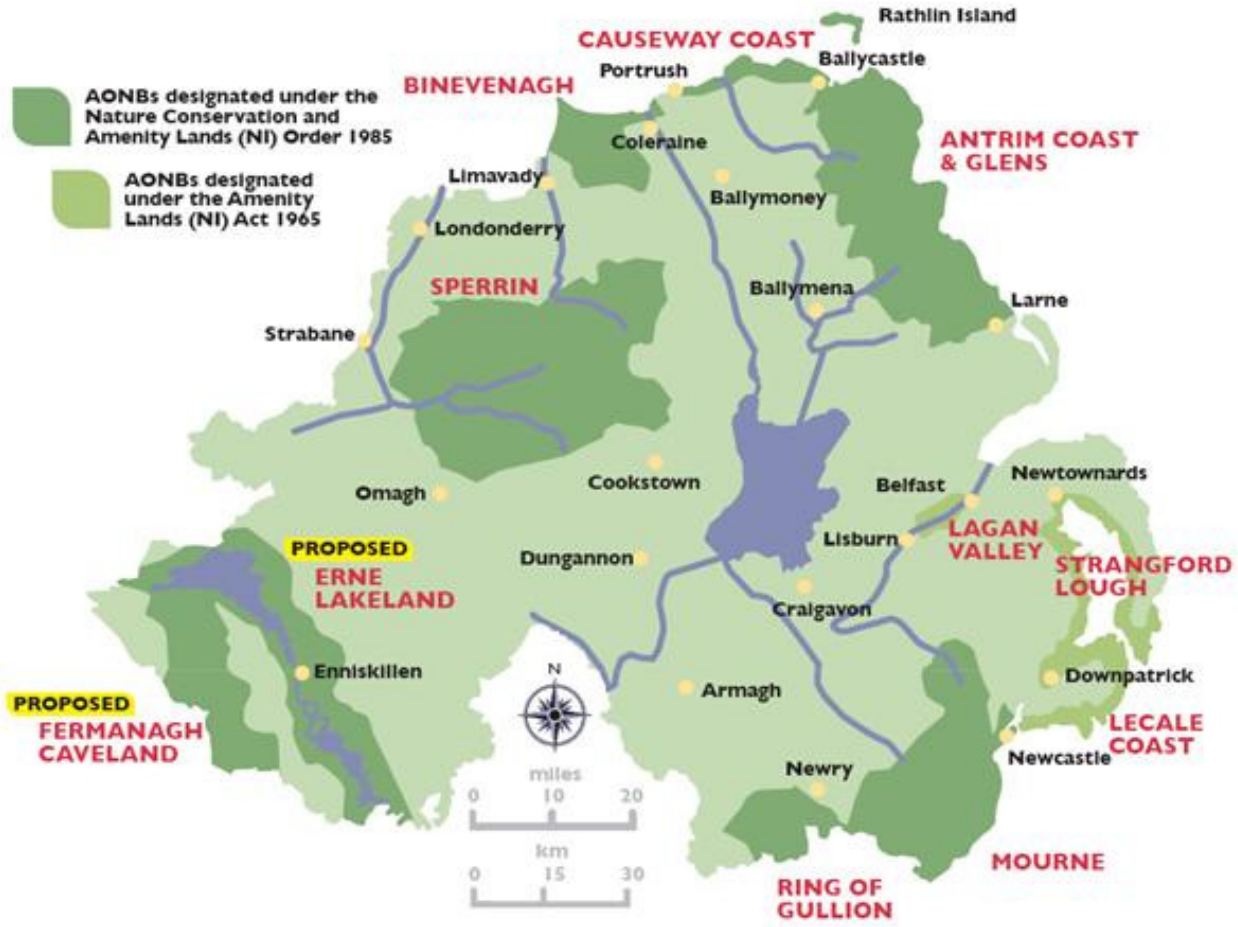
Site selection

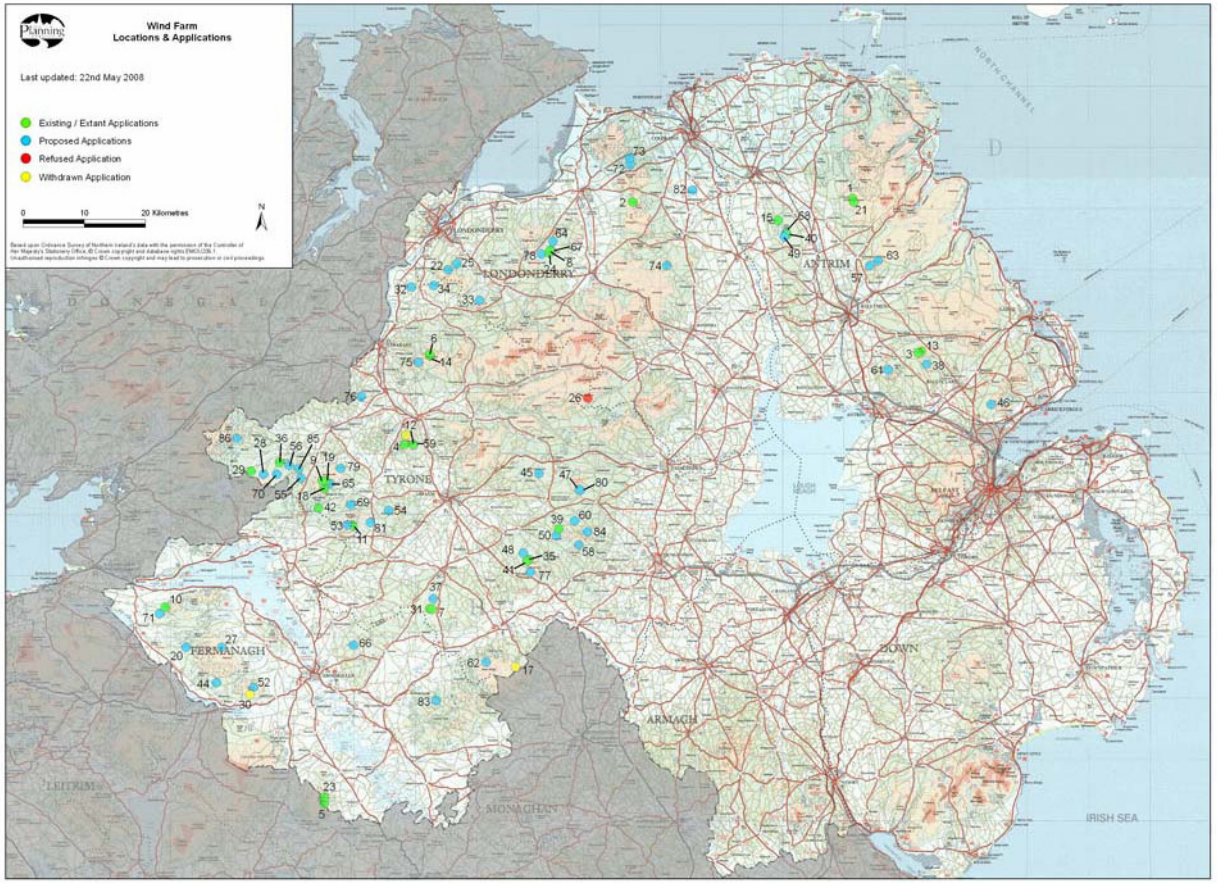
- Wind speed
- Access to grid
  - Distance
  - Cost
  - Legal Framework
- Planning restrictions
  - National Parks
  - Too close to buildings
  - Bird migrations
  - Airports

AONBs in Northern Ireland



Source: DoE NI

Wind farm Applications in Northern Ireland



Source: NI Planning Service

Technical Considerations

- Wind resource
  - Azerbaijan wind map
  - Anemometer
- Site survey
  - Access
  - Ground conditions
  - Foundations
  - Grid connection issues
  - Temporary storage
  - Underground cabling

Technical Considerations cont.

- **Electricity output**
  - kWh per annum
- P = C x LF x 8760

Where P = Power generated (electricity) in kWh

C = Rated capacity of the wind turbine in kW

LF = Load Factor

8760 = number of hours in one year.

- Therefore, for a 1MW wind turbine

P = 1000 x 0.3 x 8670

= 2.6 GWh per year

Environmental Considerations

- **Is an environmental impact assessment needed?**
- **Physical characteristics of whole development**
  - Land-use, roads, storage, etc
  - Turbine characteristics
  - Emissions, water, air
  - Noise
- **Alternatives**
- **Impacts**
  - Social impacts
  - Fauna / Flora
  - Pollution
  - Landscape

Environmental Considerations cont.

- **Benefits to the environment**
  - Reduction in the use of natural resources
  - 1MW turbine = 500,000 litres oil; 457,000 m3 gas; 650 tonnes coal per annum
- **Reduction in GHGs**
  - 2250 tonnes CO_2; 26.3 tonnes SO_2; 7.9 tonnes NO_X per annum

Financial Considerations - Costs

Capital / Installation

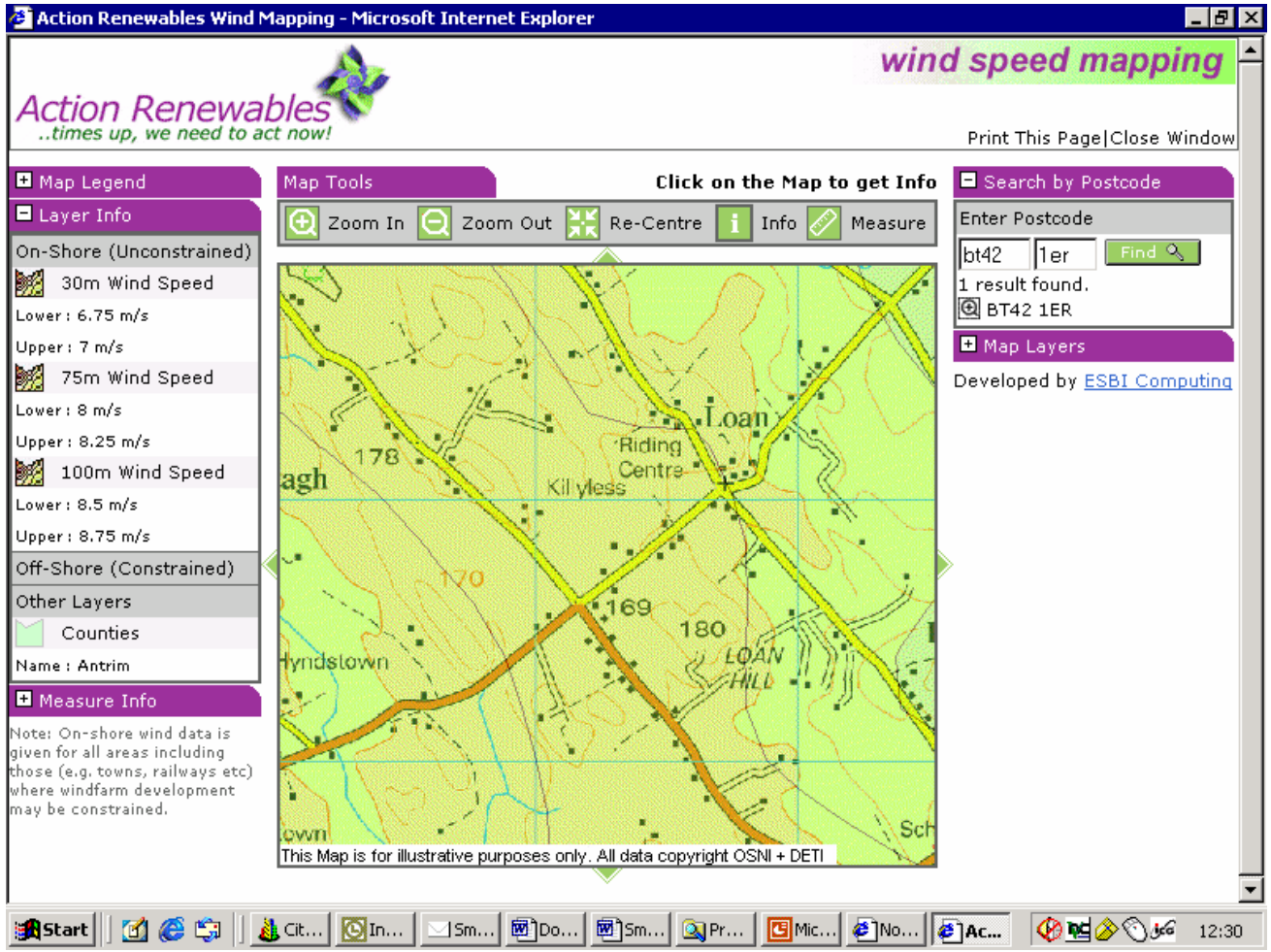
- Purchase of Generator / Prime mover
- Auxiliary Equipment
- Civil Works – access roads, etc
- Installation of Electrical Equipment
- Grid Protection (Installation & Commissioning)
- Grid Connection and Metering Costs
- Planning and Environmental Impact
- Contingency

Operational

- Insurance
- Maintenance Costs
- Availability of Spares
- Admin / Accountant
- Rates / Taxes
- Land Lease / Rental

Financial Considerations - Opportunities

- Promoting the development of wind-generated electricity and other renewable energy technologies, reduces the demand for electricity supplied by natural gas
- Wind energy could save 457,000 m3 of gas per MW installed, per year
- Approximate export value of $300 per 1000m3 for natural gas
- If 5000 MW of wind was installed in Azerbaijan, the value for exporting gas is about $685.5 million per year


Action Renewables Wind Mapping - Microsoft Internet Explorer
Action Renewables
..times up, we need to act now!
wind speed mapping
Print This Page|Close Window
Map Legend
Layer Info
On-Shore (Unconstrained)
30m Wind Speed
Lower : 6.75 m/s
Upper : 7 m/s
75m Wind Speed
Lower : 8 m/s
Upper : 8.25 m/s
100m Wind Speed
Lower : 8.5 m/s
Upper : 8.75 m/s
Off-Shore (Constrained)
Other Layers
Counties
Name : Antrim
Measure Info
Note: On-shore wind data is given for all areas including those (e.g. towns, railways etc) where windfarm development may be constrained.
Map Tools
Click on the Map to get Info
Zoom In
Zoom Out
Re-Centre
Info
Measure
Loan
Riding Centre
Killyless
178
169
180
LOAN HILL
Hyndstown
This Map is for illustrative purposes only. All data copyright OSNI + DETI
Search by Postcode
Enter Postcode
bt42
1er
Find
1 result found.
BT42 1ER
Map Layers
Developed by ESBI Computing
Start
12:30

Installing – 2.5kW Proven

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Installing a large scale wind turbine

Ireland's first offshore wind farm

- Arklow Bank – 10km offshore from Wicklow
- Airtricity and GE Wind
- 7 x 3.6MW GE Wind Turbines
- The world's largest offshore wind turbines when installed
- 25MW capacity – enough to power 15,000 homes

Source: Airtricity

Onshore wind turbines arriving in port

Offshore wind

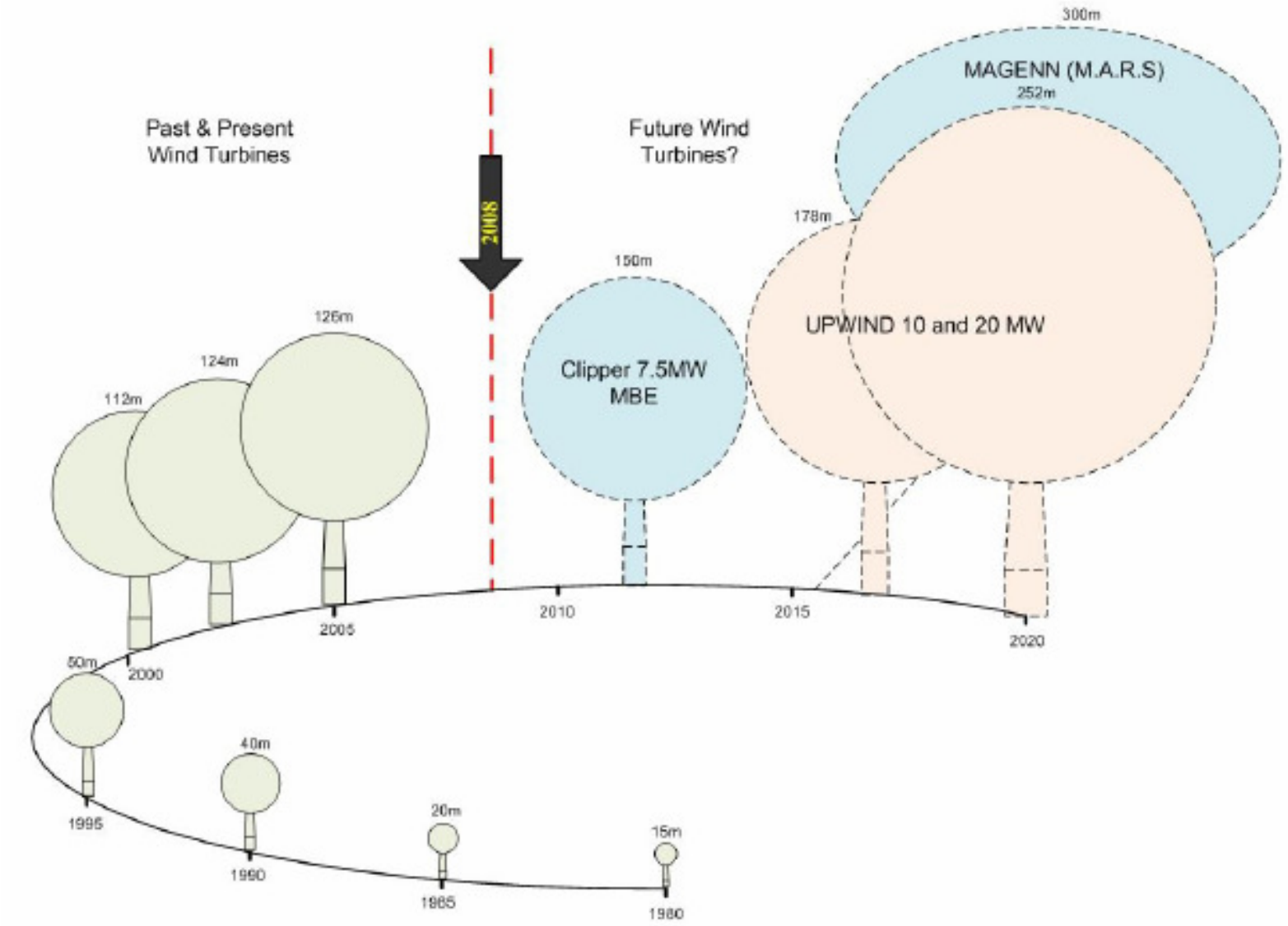
- UK now global leader in offshore wind installations
- Builds on experience in offshore gas and oil industry


GROVE

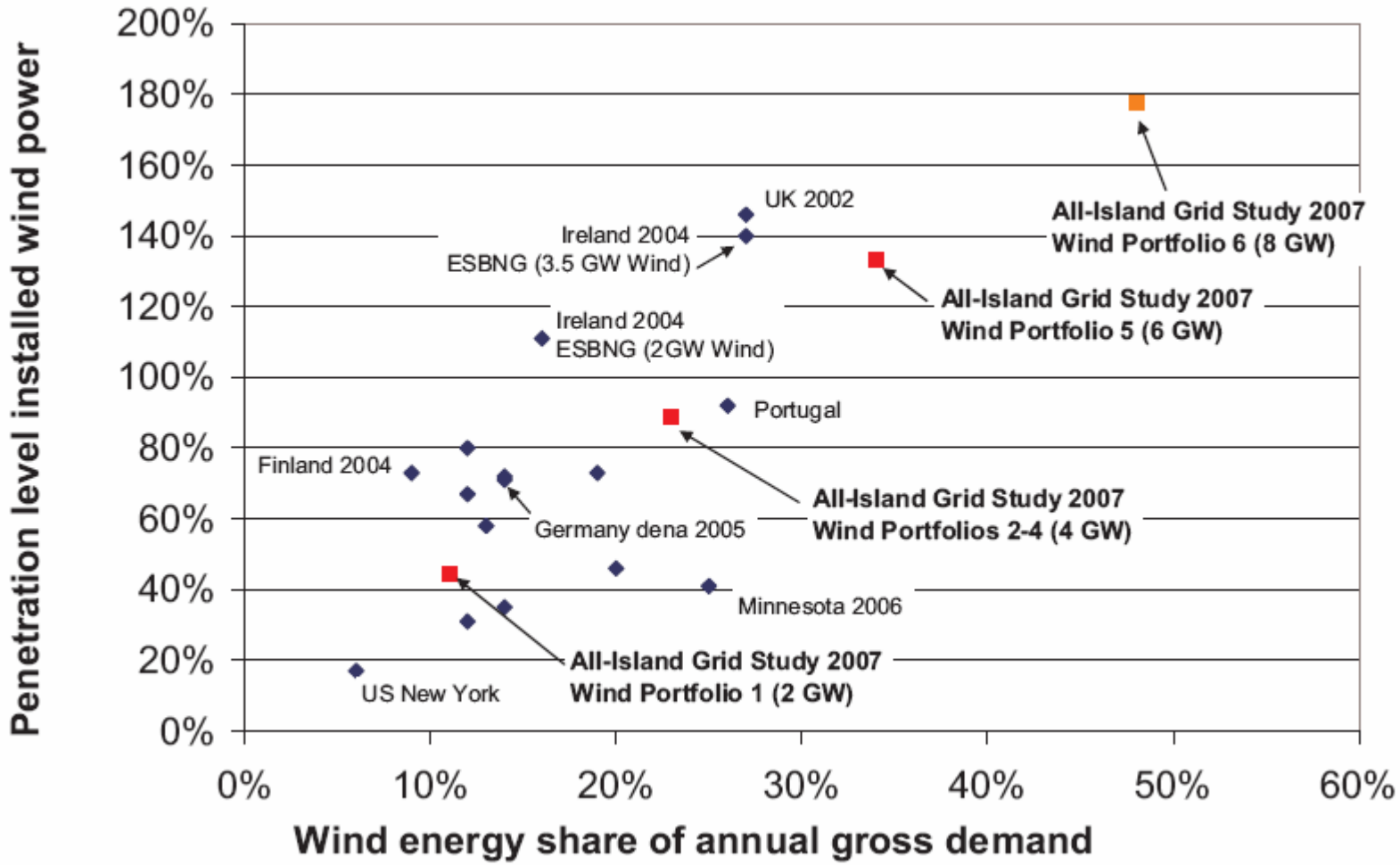

H & W

Trends

- Wind turbines are getting larger
- 6MW turbine installed in Germany
- Progress within the last ten years means that a wind farm of 10 x 500kW turbines could now be replaced by a single 5MW turbine
- Typical installation sizes are now in excess of 2MW turbines
- Studies show that wind can supply up to 35% of a country's electricity consumption
- More can be accommodated if excess generation from wind can be stored or exported


Past & Present
Wind Turbines
Future Wind
Turbines?
2008
300m
MAGENN (M.A.R.S)
252m
178m
UPWIND 10 and 20 MW
150m
Clipper 7.5MW
MBE
126m
124m
112m
50m
40m
20m
15m
1995
1990
1985
1980
2000
2005
2010
2015
2020

Comparison of wind penetration levels in various studies



Enercon wind turbines in Germany

Wind Energy in Summary

- A mature technology
- One of the most economic renewable energy technologies
- High levels of penetration in many countries
  - In 2008, 21% of Denmark's electricity demand was met by wind; 12% and 7% in Spain and Germany respectively
- EU target for 2020 is 34.8% of renewable electricity supply met by wind – about 12% – 14% of EU electricity demand
- Grid integration must be managed