Catching the wind

and

Basking in the sun

Catching the wind

But not too much

Remember 16th October 1987 !

Michael Fish – forecast on 16th October

Michael Fish – forecast on 16th October

In 1987, despite major advances, we had very limited satellite information compared with the present day

Marine traffic provided most of the up to date forecasts of incoming weather

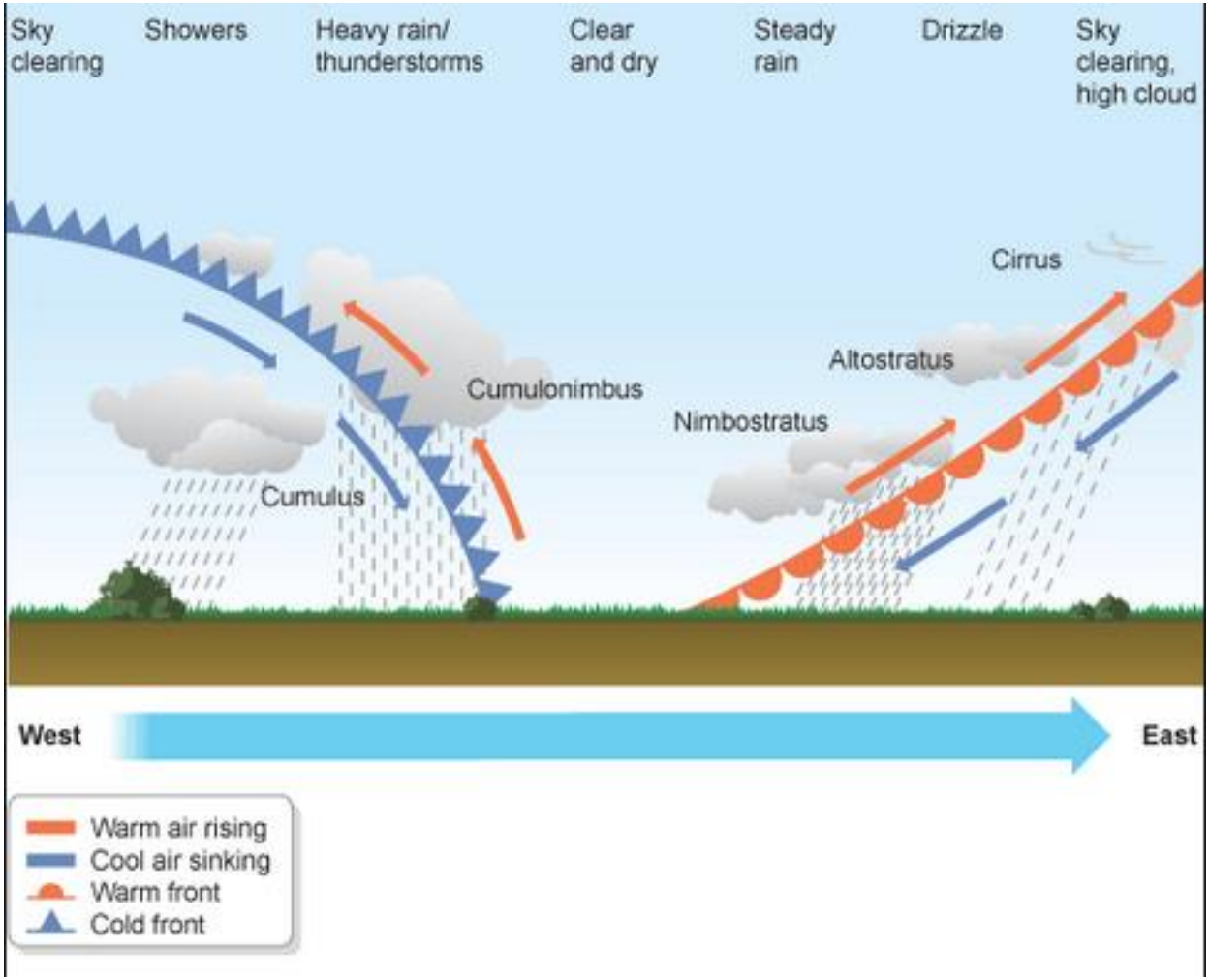
All the ships in the Atlantic had moved away from the storm area. So we were effectively blind…

The British Isles sit in the "latitude of storms"

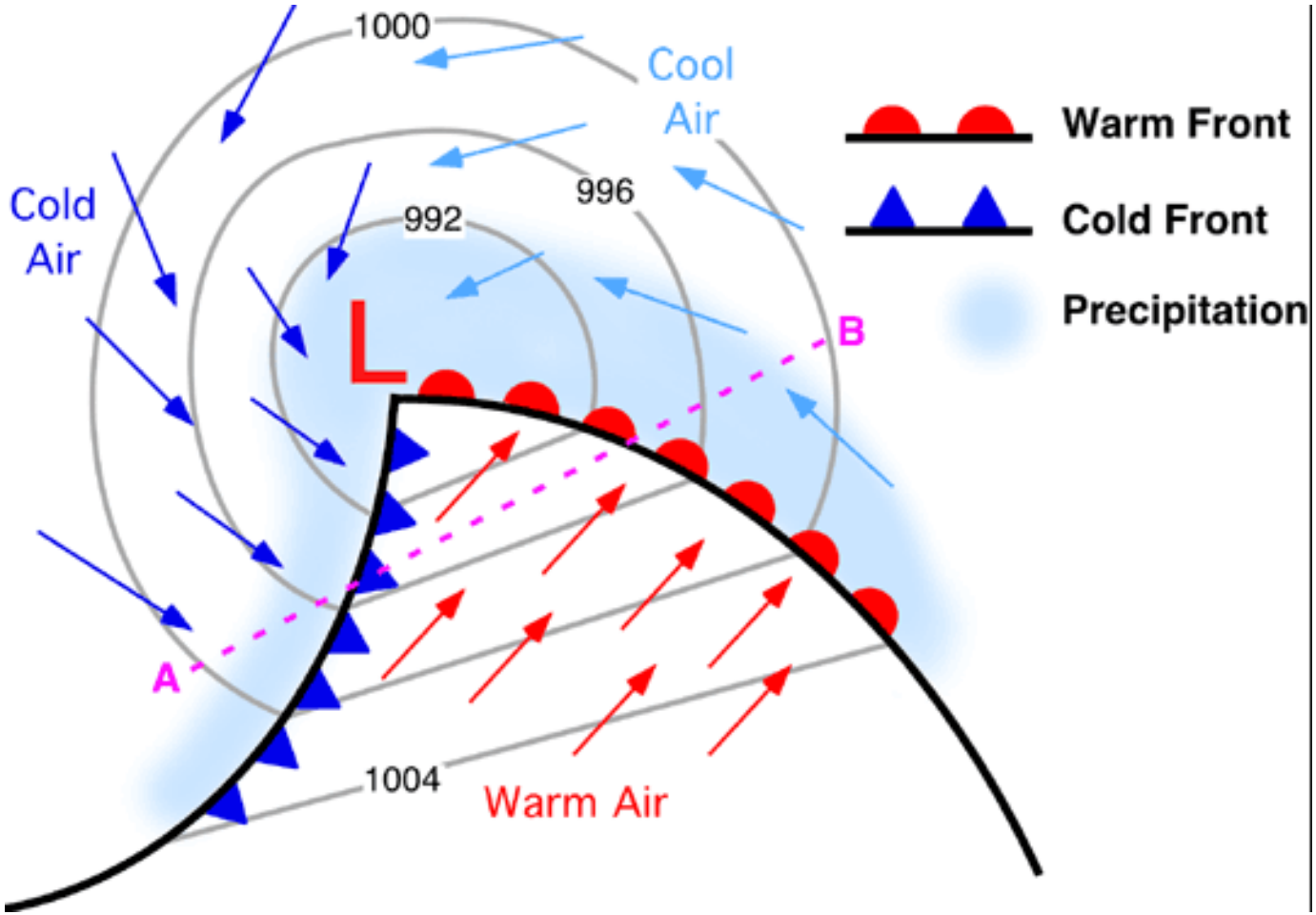
Cold dry polar air meets moist warm tropical air

RESULT: A depression

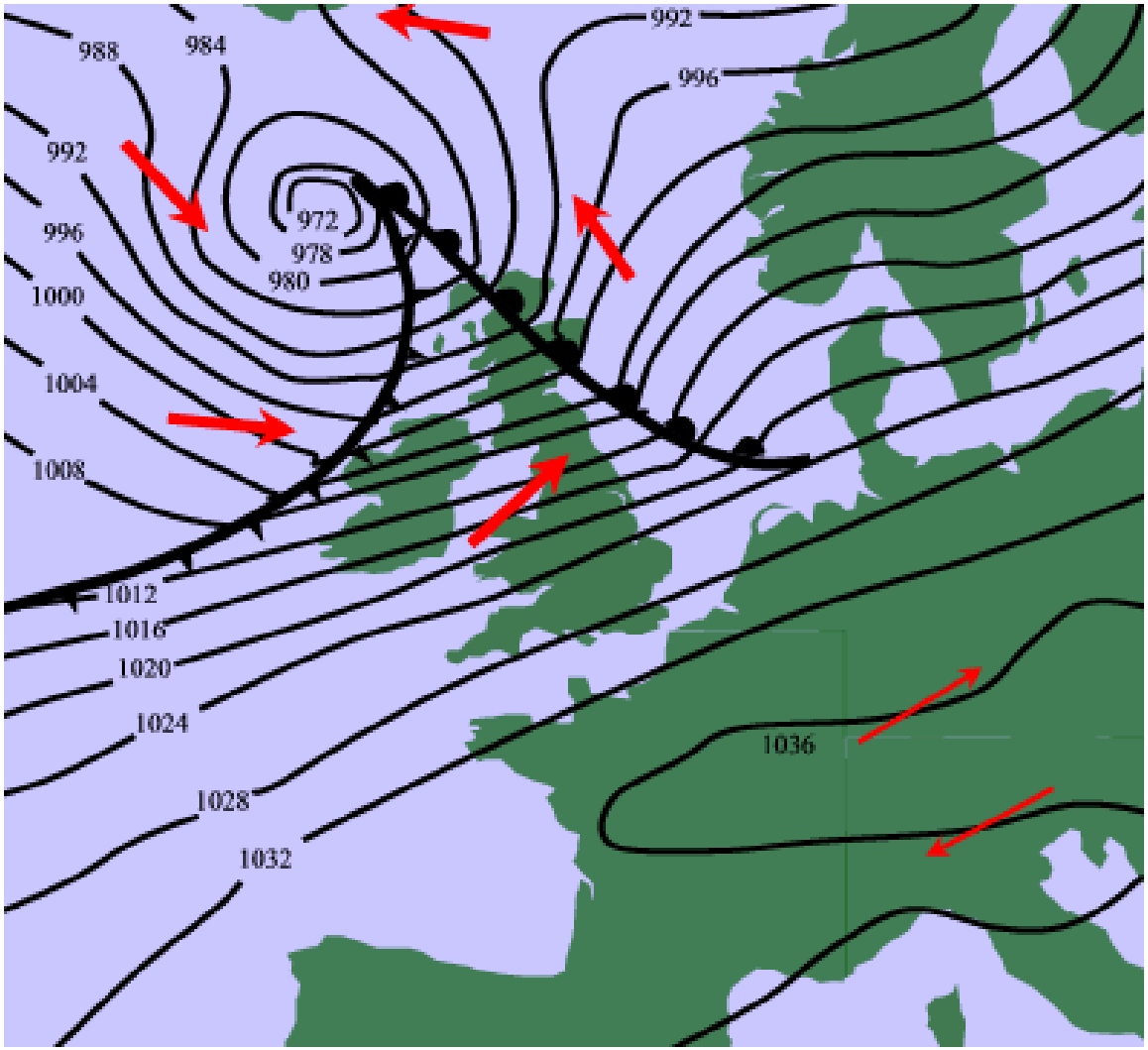
Vertical section through a depression



The wind strength and direction inside a depression



The wind strength is directly proportional to the isobar spacing

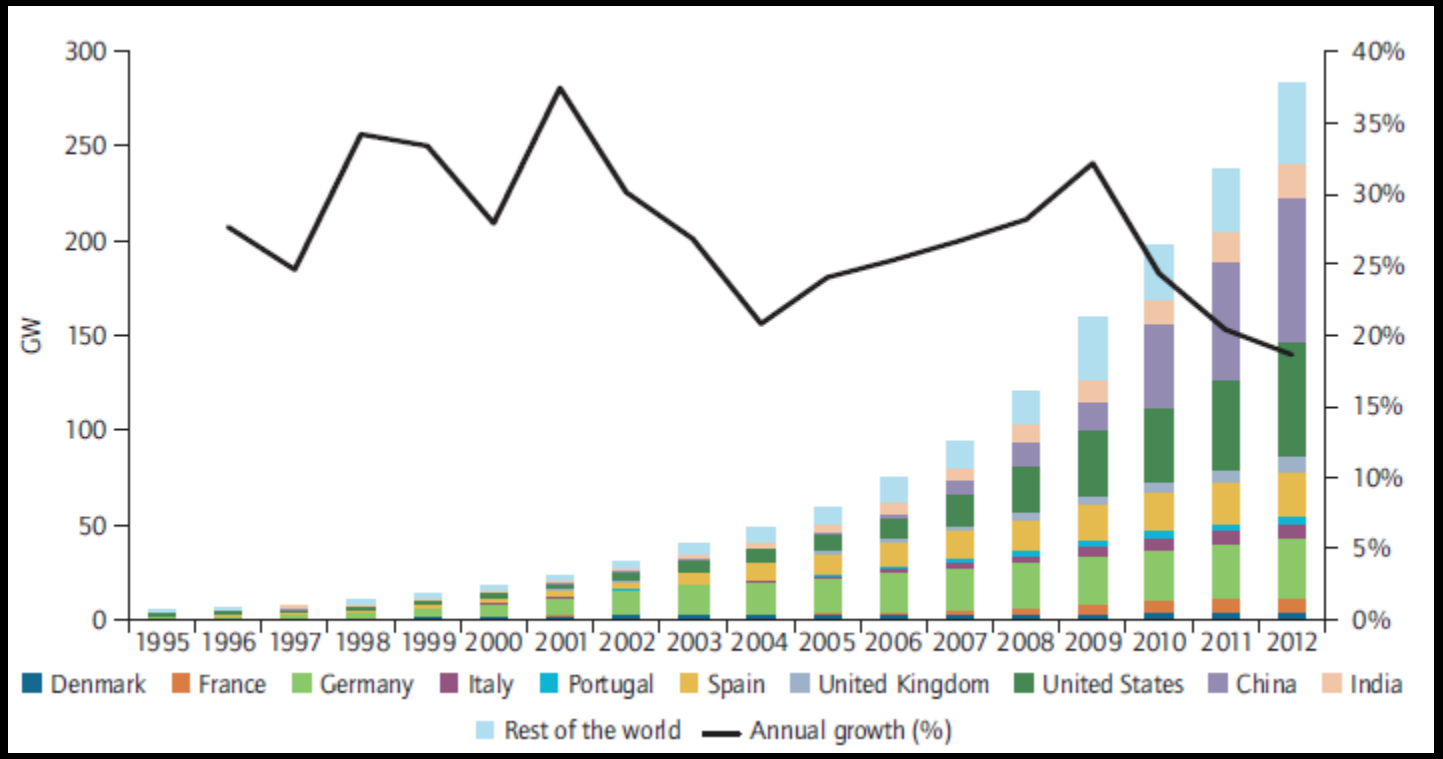


Wind Turbines

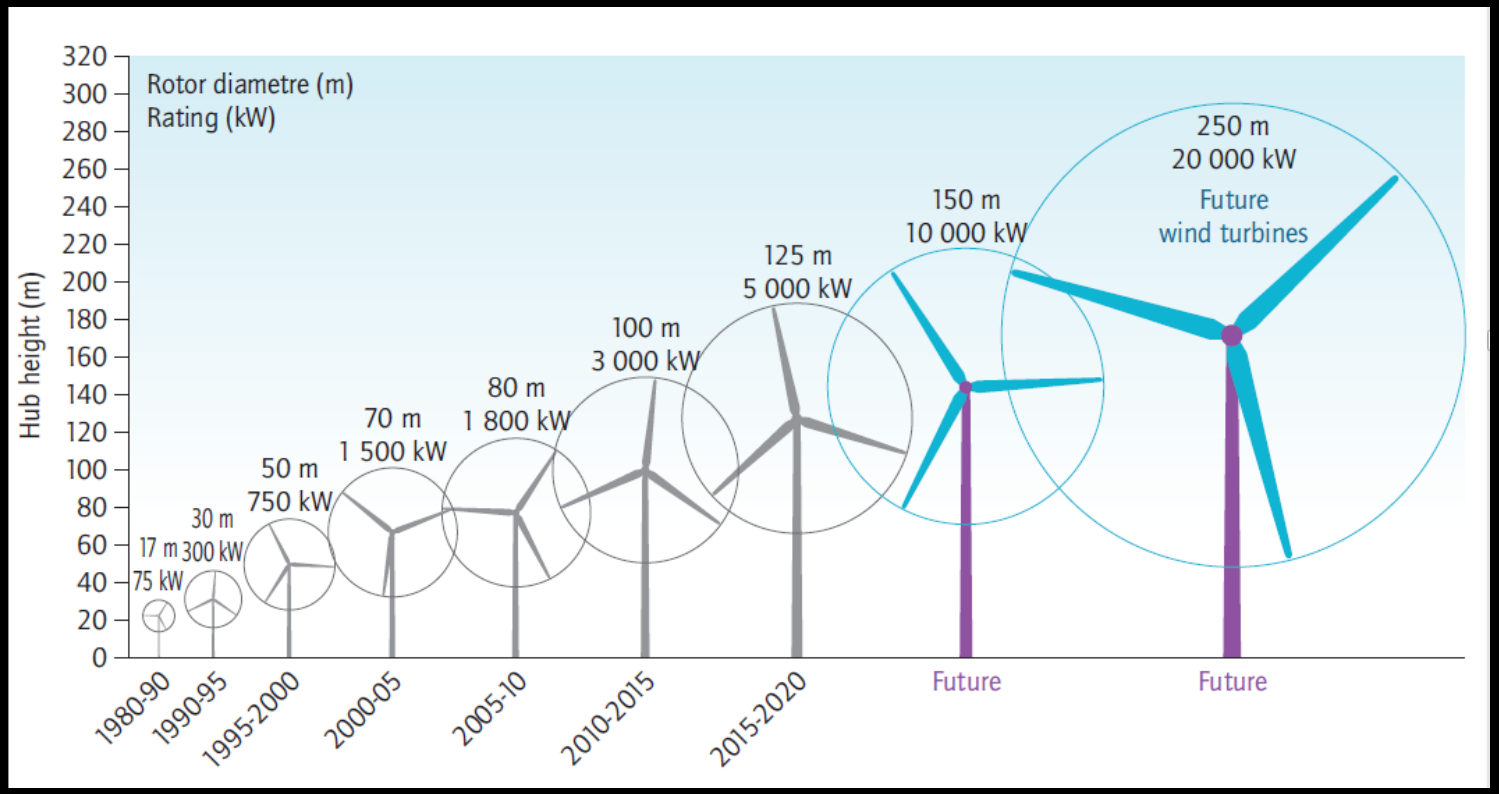
Breath of life……

……Or kiss of death ?

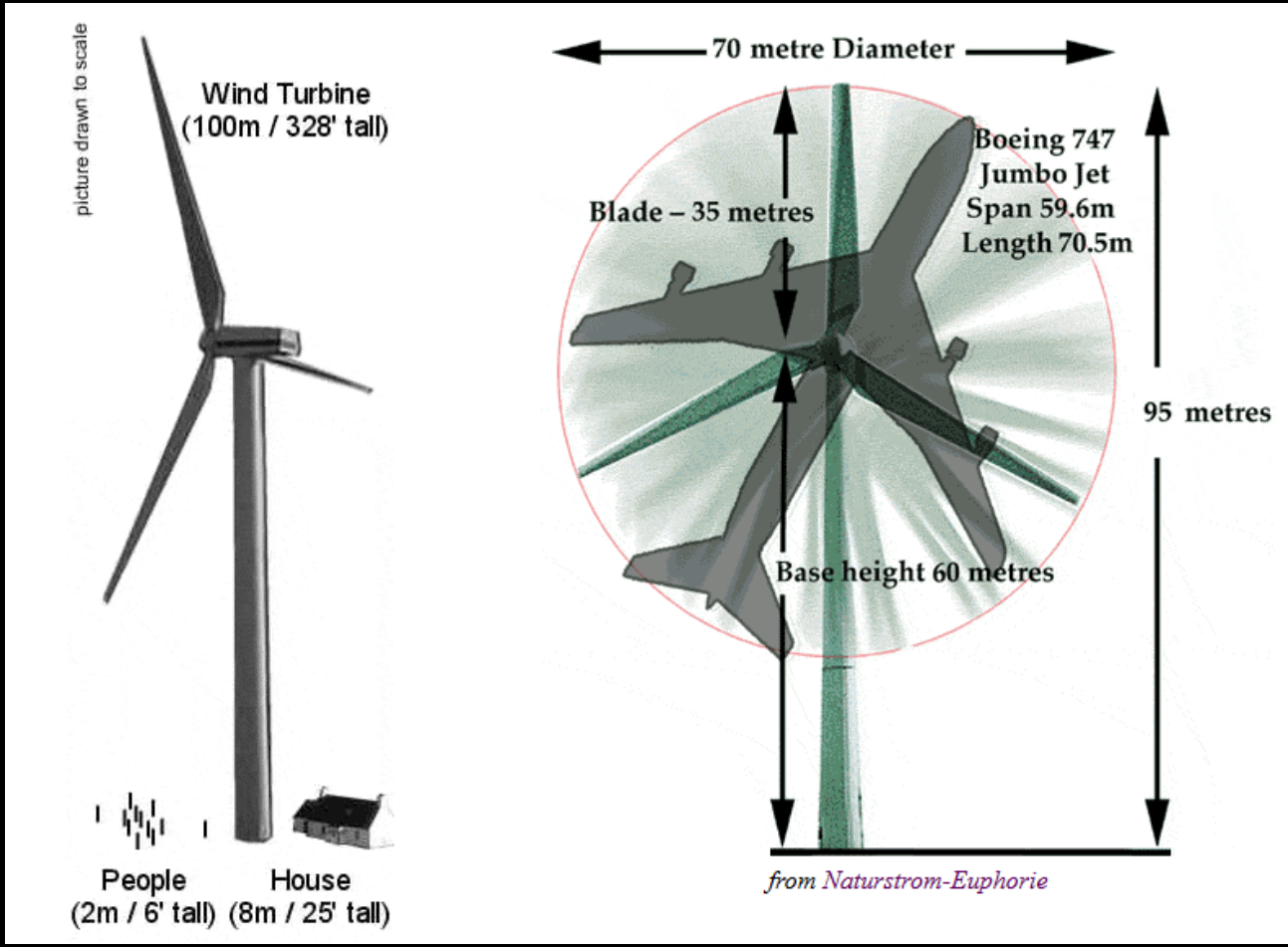
World growth of wind power 1995-2012



And the 2009 forecast of turbine size



Comparative size – 2MW turbine and a Jumbo 747

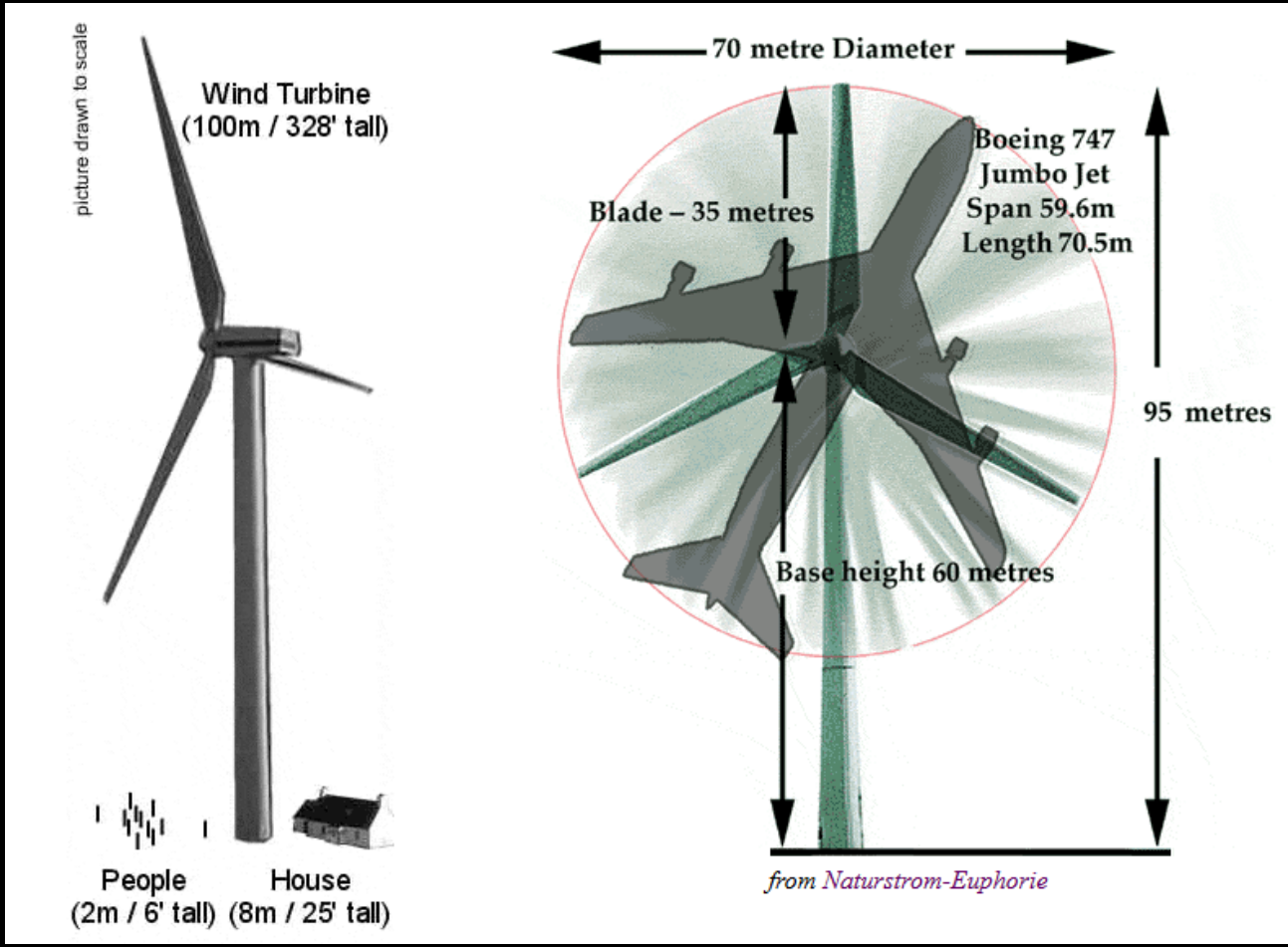


In 2014 the largest turbine is the Vestas V164-8.0.....

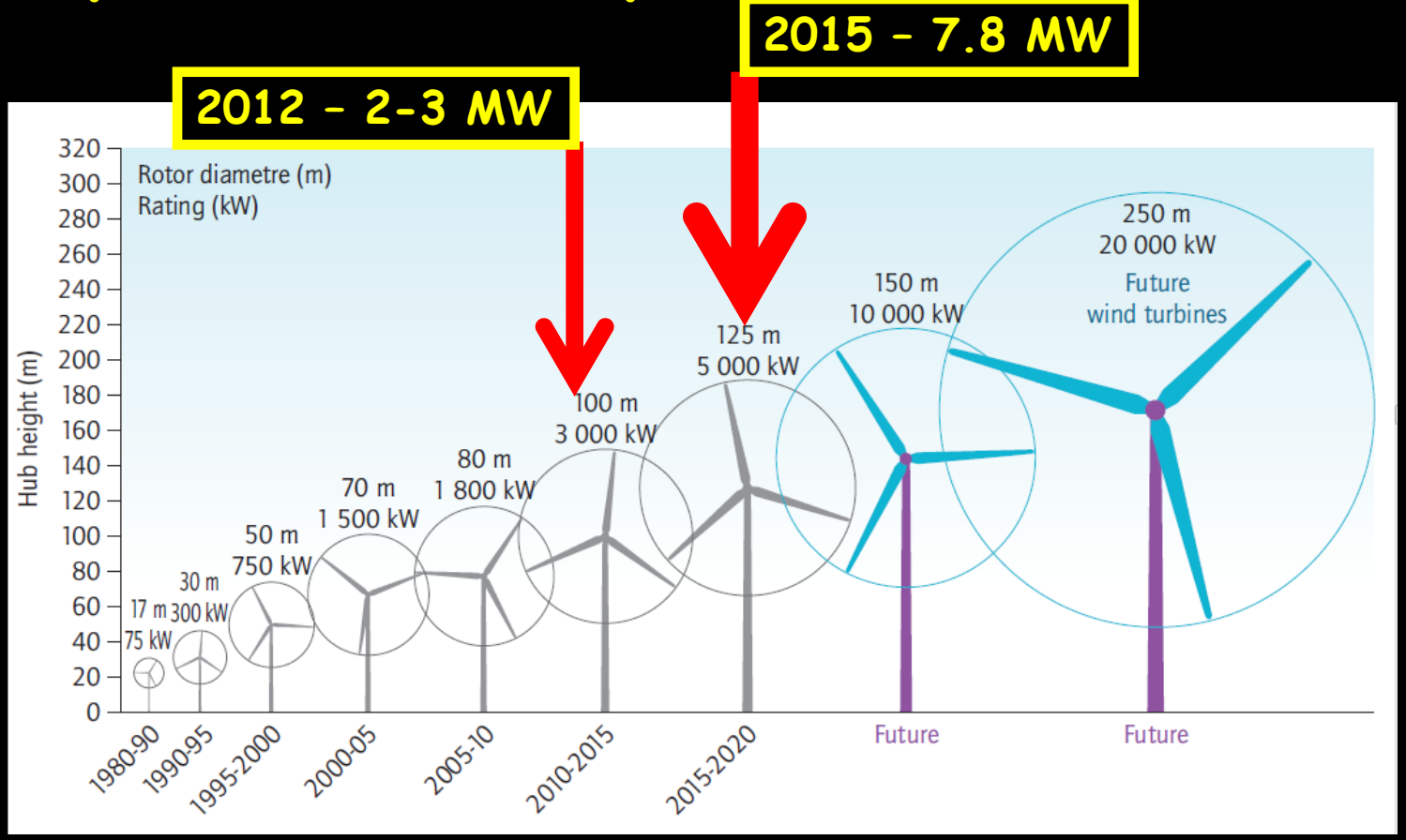
- Tower height: 140-metres
- Blade length: 80 metres
- Tip height: 220 metres
- Swept area: 21,000 m^2

Rated output 8MW

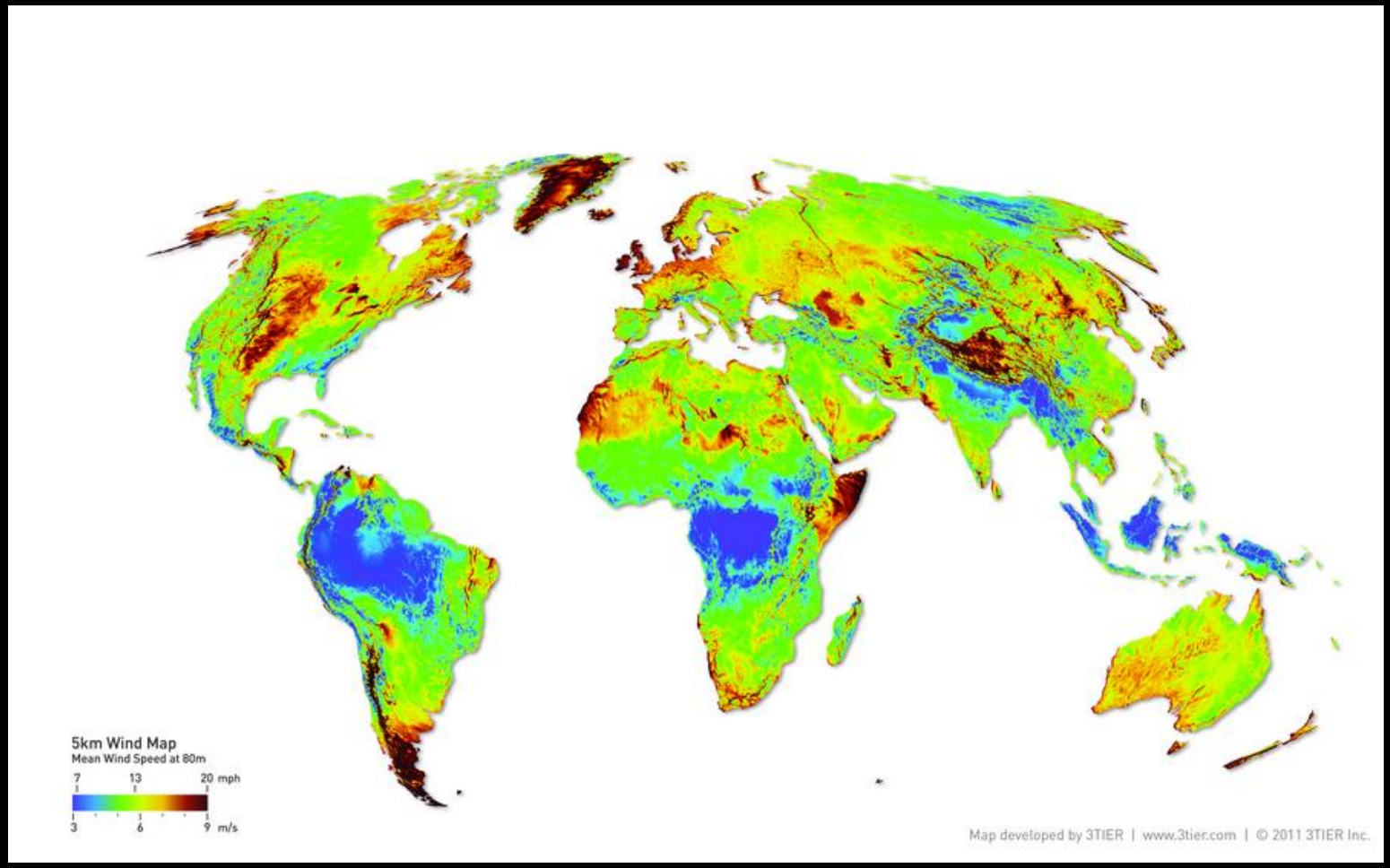
Comparative size – 2MW turbine and a Jumbo 747



Remember the 2009 forecast of turbine size?



The global mean wind speed at 80 metres



There is a very good reason why we the UK are building wind turbines

Impact of wind turbines on land

Visual intrusion on landscape

Low frequency turbine noise

Flicker effect at low sun elevation

Headache

Pollution

Fire

Nausea

Depression

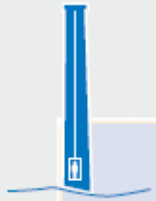
Birds and bats killed by sweeping blades

Anxiety

Relative component values

How a wind turbine comes together

A typical wind turbine will contain up to 8,000 different components. This guide shows the main parts and their contribution in percentage terms to the overall cost. Figures are based on a REpower MM92 turbine with 45.3 metre length blades and a 100 metre tower.



Tower — 26.3%

Range in height from 40 metres up to more than 100 m. Usually manufactured in sections from rolled steel; a lattice structure or concrete are cheaper options.

Rotor blades — 22.2%

Varying in length up to more than 60 metres, blades are manufactured in specially designed moulds from composite materials, usually a combination of glass fibre and epoxy resin. Options include polyester instead of epoxy and the addition of carbon fibre to add strength and stiffness.

Rotor hub — 1.37%

Made from cast iron, the hub holds the blades in position as they turn.

Rotor bearings — 1.22%

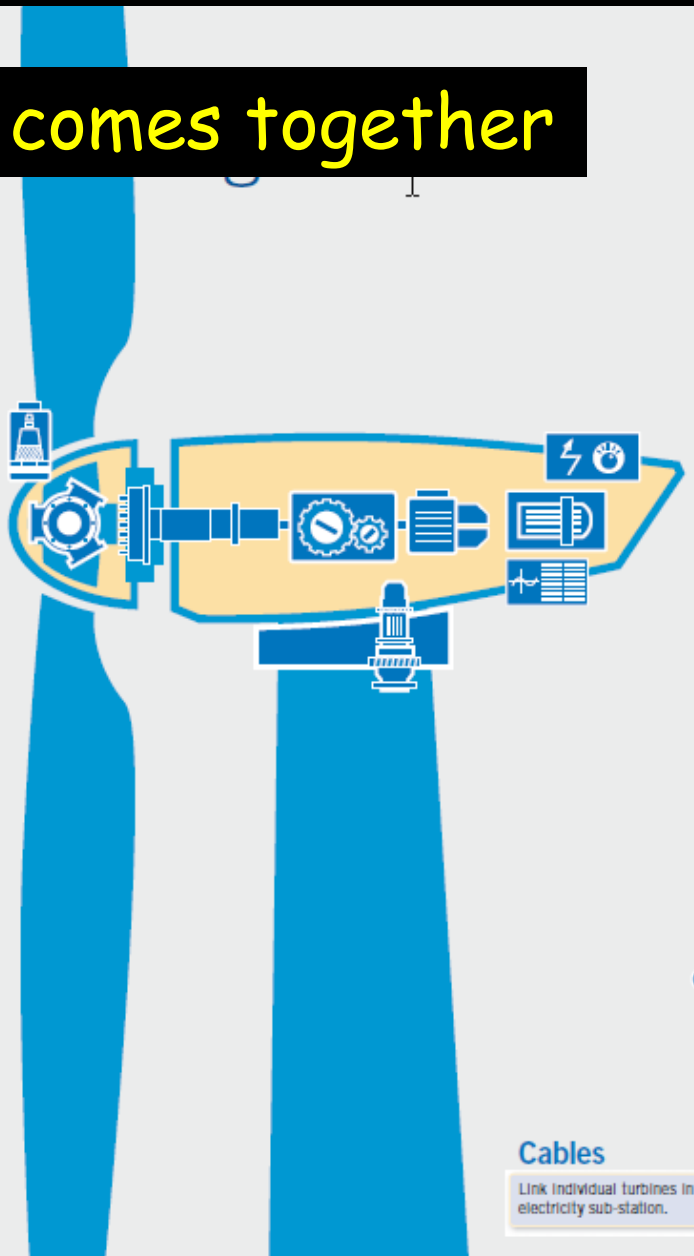
Some of the many different bearings in a turbine, these have to withstand the varying forces and loads generated by the wind.

Main shaft — 1.91%

Transfers the rotational force of the rotor to the gearbox.

Main frame — 2.80%

Made from steel, must be strong enough to support the entire turbine drive train, but not too heavy.



Gearbox — 12.9%

Gears increase the low rotational speed of the rotor shaft in several stages to the high speed needed to drive the generator

Generator — 3.44%

Converts mechanical energy into electrical energy. Both synchronous and asynchronous generators are used.

Yaw system — 1.25%

Mechanism that rotates the nacelle to face the changing wind direction.

Pitch system — 2.66%

Adjusts the angle of the blades to make best use of the prevailing wind.

Power converter — 5.0%

Converts direct current from the generator into alternating current to be exported to the grid network.

Transformer — 3.59%

Converts the electricity from the turbine to higher voltage required by the grid.

Brake system — 1.32%

Disc brakes bring the turbine to a halt when required.

Nacelle housing — 1.35%

Lightweight glass fibre box covers the turbine's drive train.

Cables — 0.96%

Link individual turbines in a wind farm to an electricity sub-station.

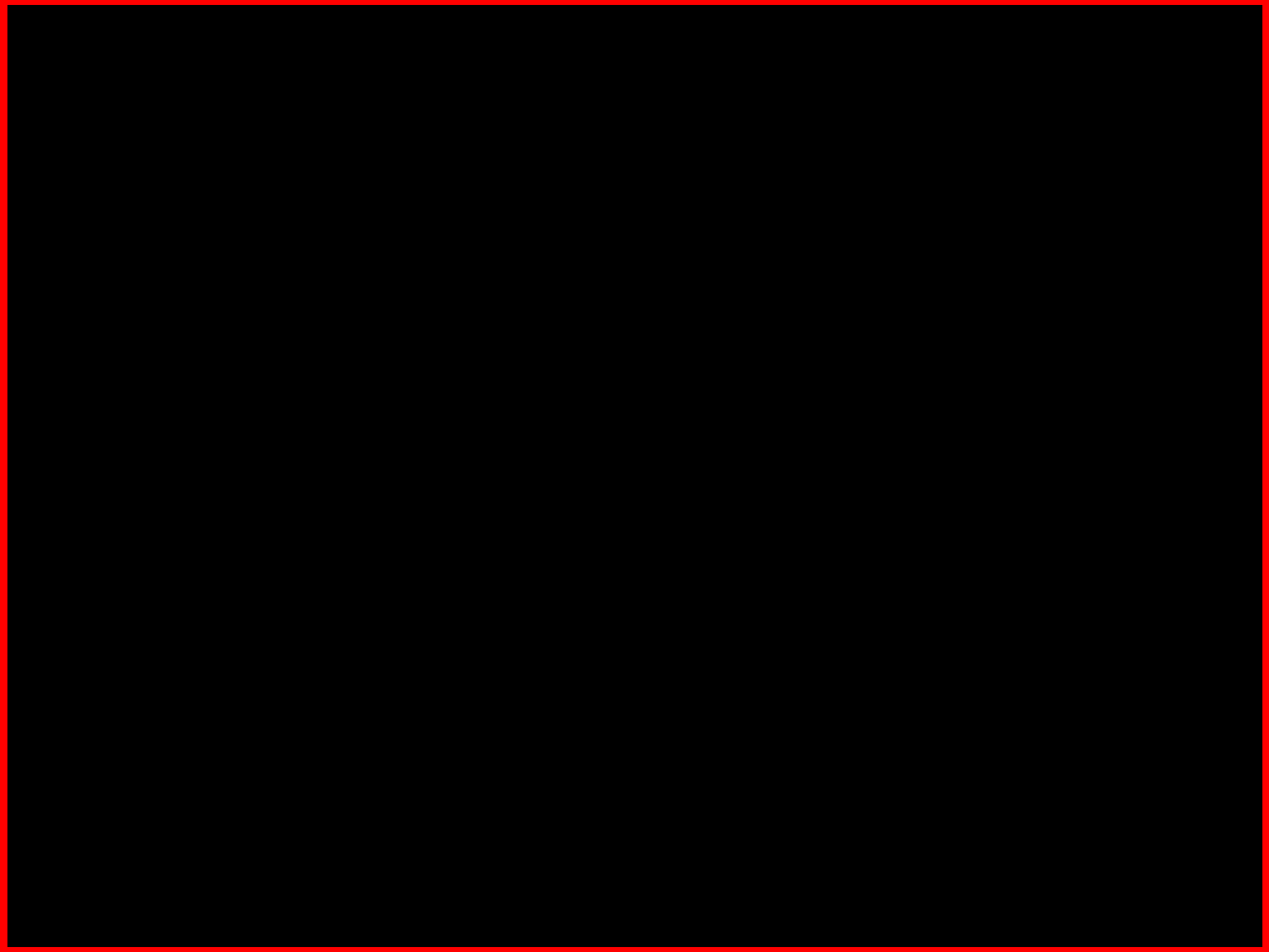
Screws — 1.04%

Hold the main components in place, must be designed for extreme loads.

What's inside a wind turbine

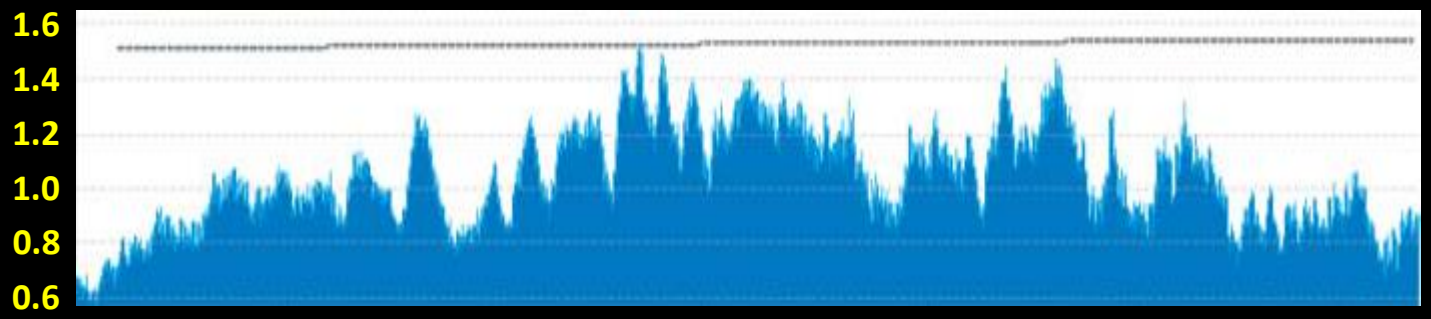
Out of control wind turbine

Wind turbine fire



Normalised output from 15 turbines

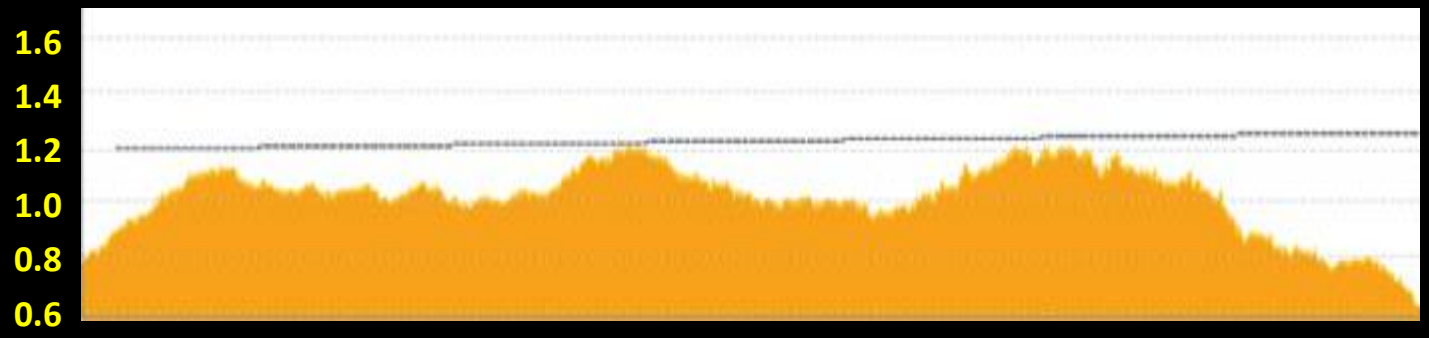
- Variability about the norm
- Standard deviation/mean 1.84



← **9 hours** →

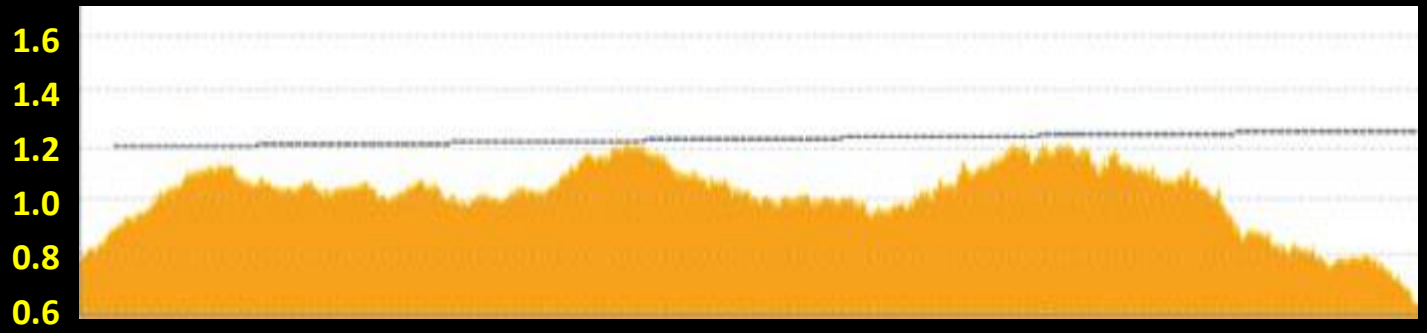
Normalised output from 200 turbines

- Variability about the norm
- Standard deviation/mean 1.26

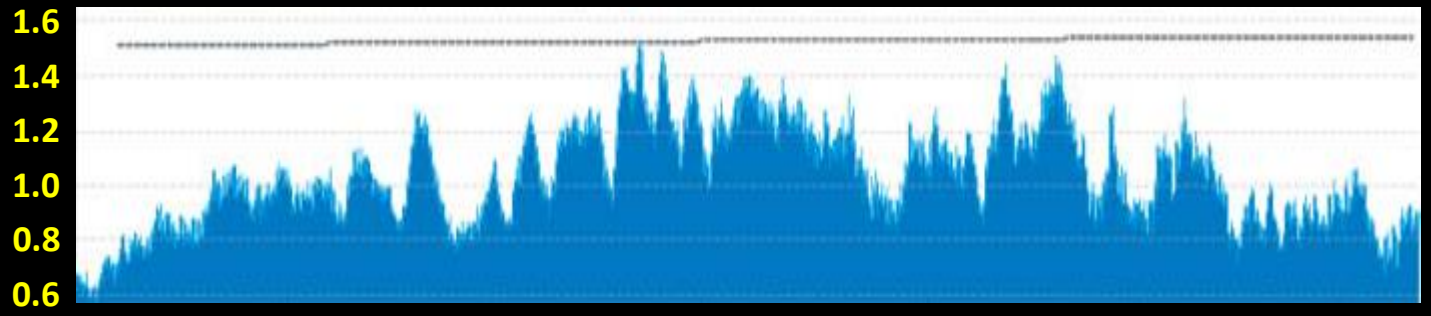


← **9 hours** →

Comparing the two situations



← **9 hours** →



Catching the wind

and

Basking in the sun

Basking in the sun

.....When it shines

Solar PV and three years' Personal experience

solar panels

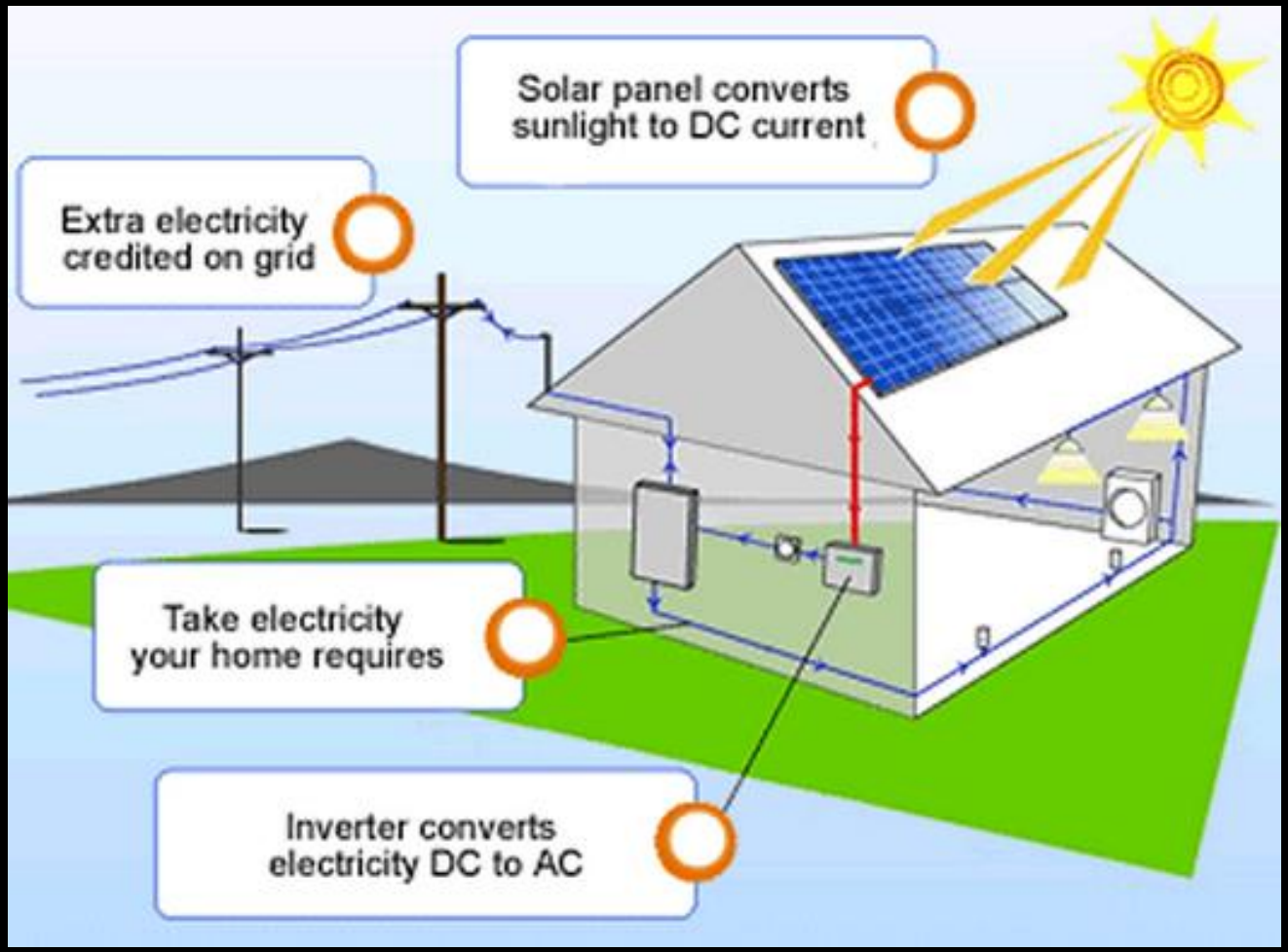
The average energy flux striking the Earth's surface is 175 W/sqM

We could supply all the world's energy needs from a solar farm covering the area of a small country

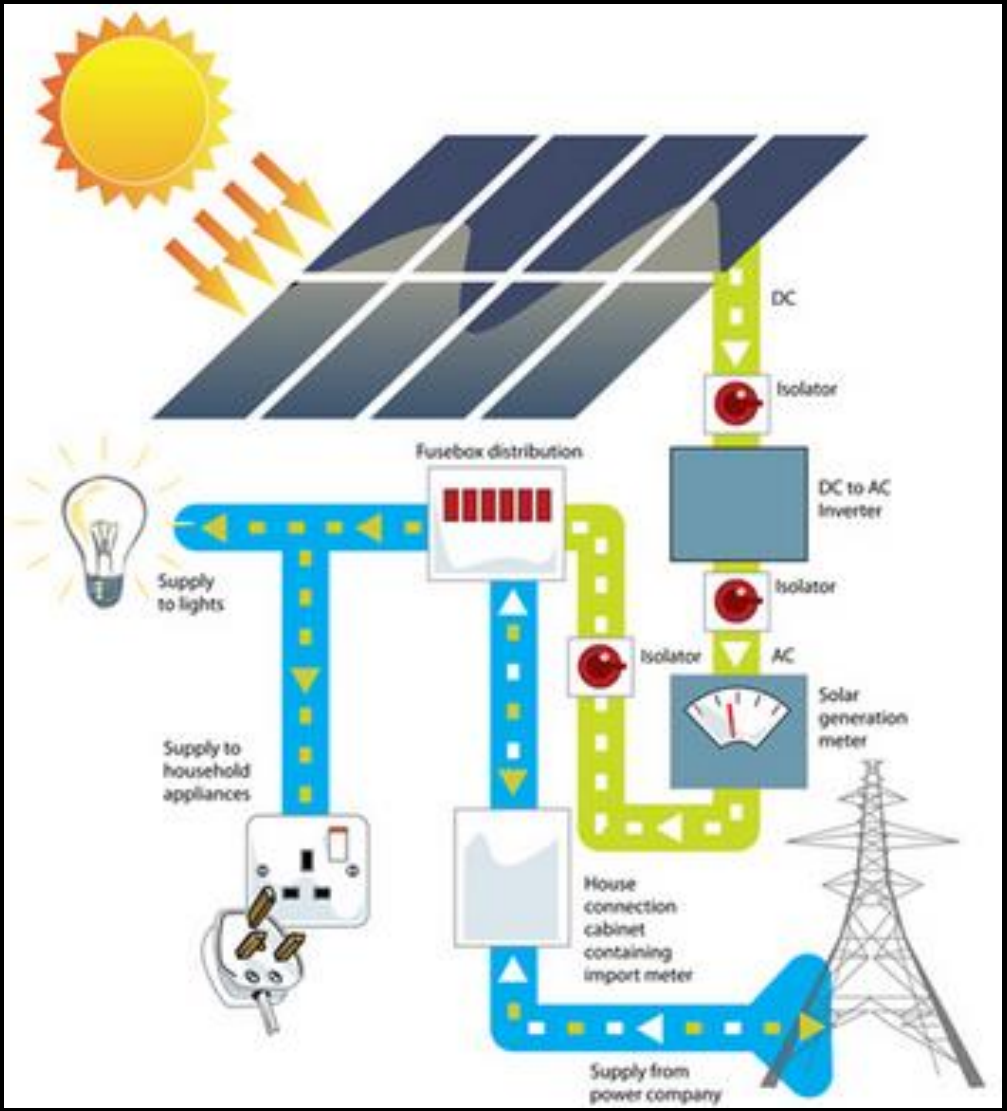
Solar panels convert sunlight to electricity with an efficiency of around 15%

A typical domestic installation

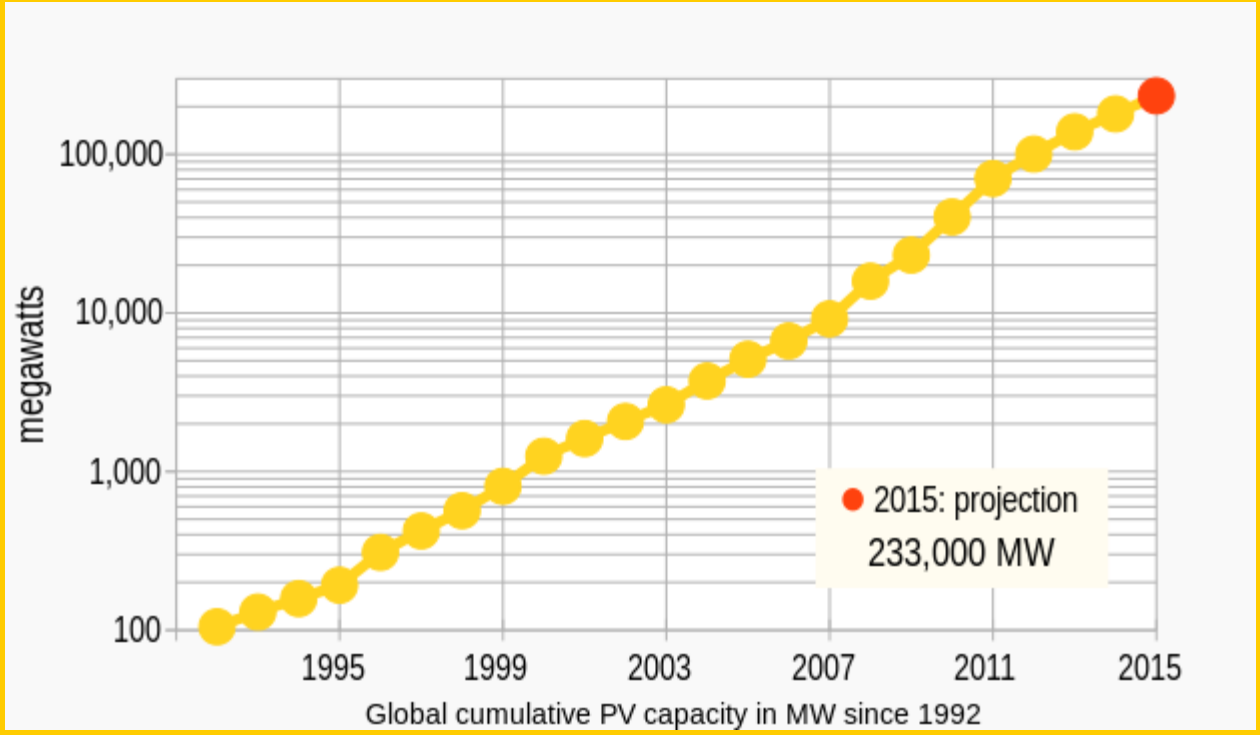
The basic principle



Simplifed schematic diagram



Worldwide growth of PV



Eight of our 16 250w panels

The other eight panels

Some like it hot – and some do not!

Electronic equipment tends to get less efficient and more prone to fail at higher temperatures

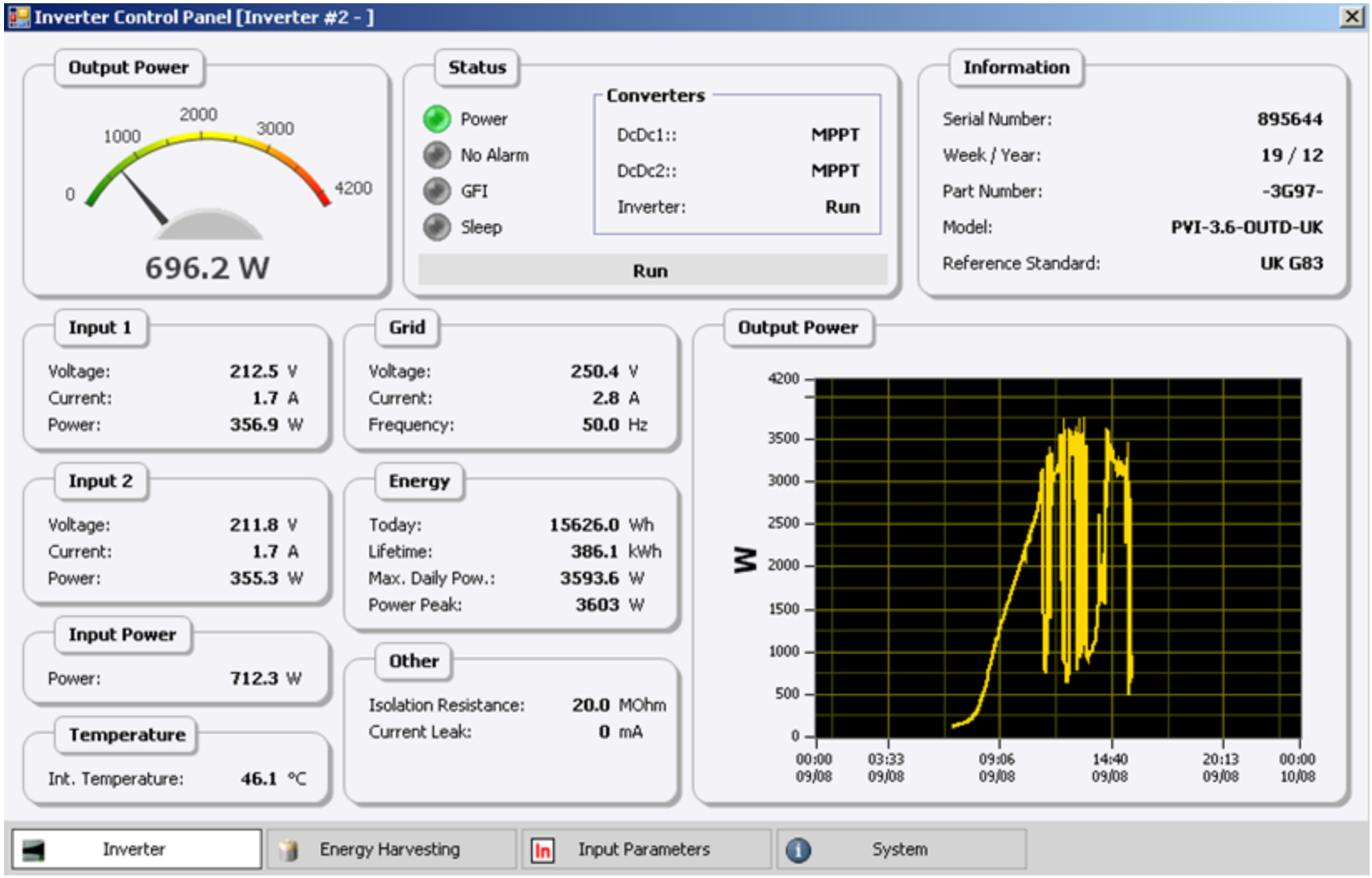
The inverter is typically mounted in an unventilated roof space or a garage. The roof space warms up very quickly on sunny days

On sunny days the solar panels generate up to 4 kilowatts at DC

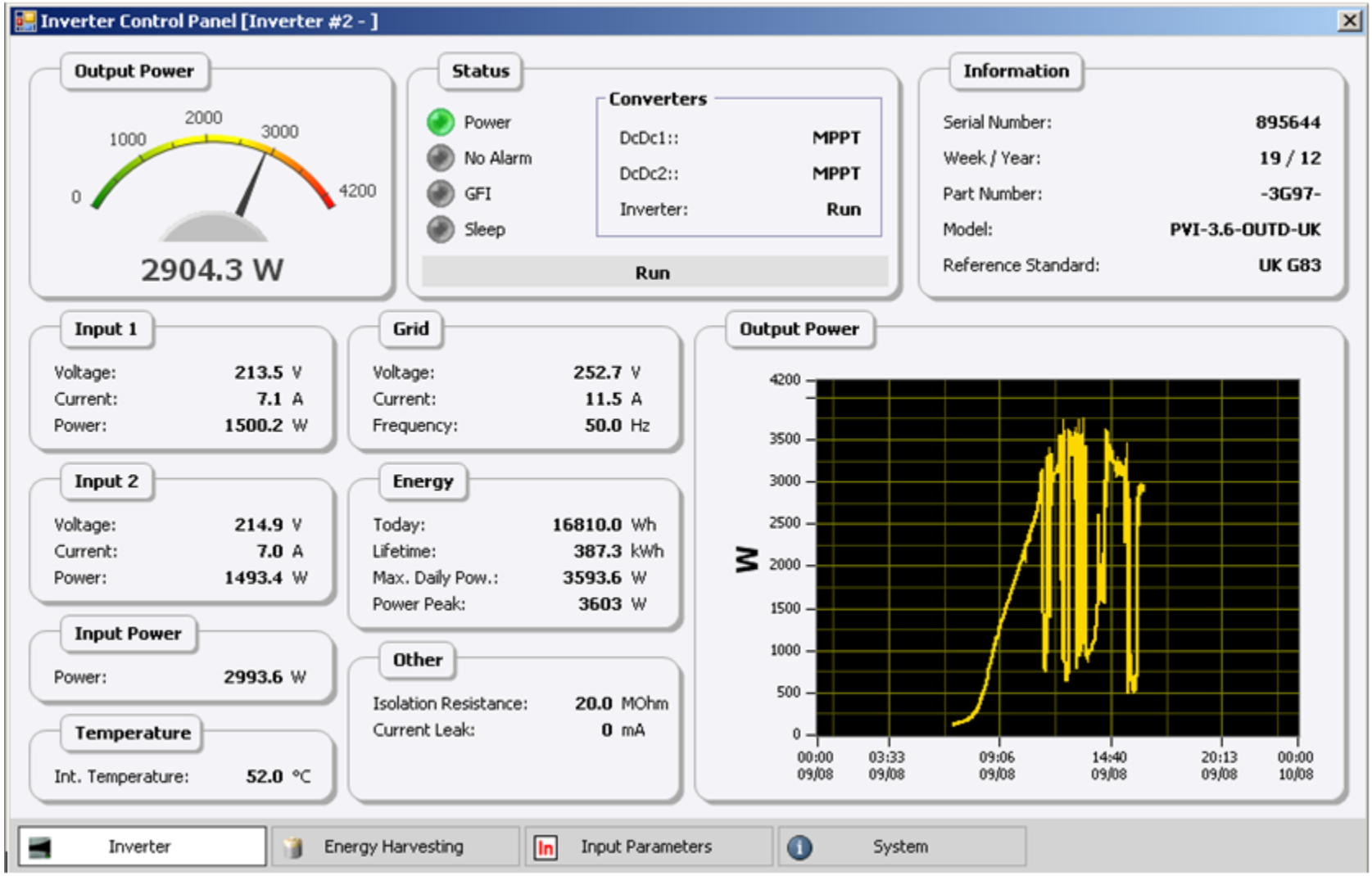
The inverter consequently gets substantially warmer than the already warm roof space!

It has an internal cooling system with a large finned heat sink, but it needs a bit of help!

A warm sunny day with passing cumulus clouds



A few minutes later the cloud has passed



This is my Aurora 3.6 Kw inverter, mounted in the roof space

The elephant's trunk is my own very special adaptation

Note the two isolators. My system has two groups of 8 panels and each can be isolated

A hot water cylinder thermostat has a SPCO switch so I used it in reverse!

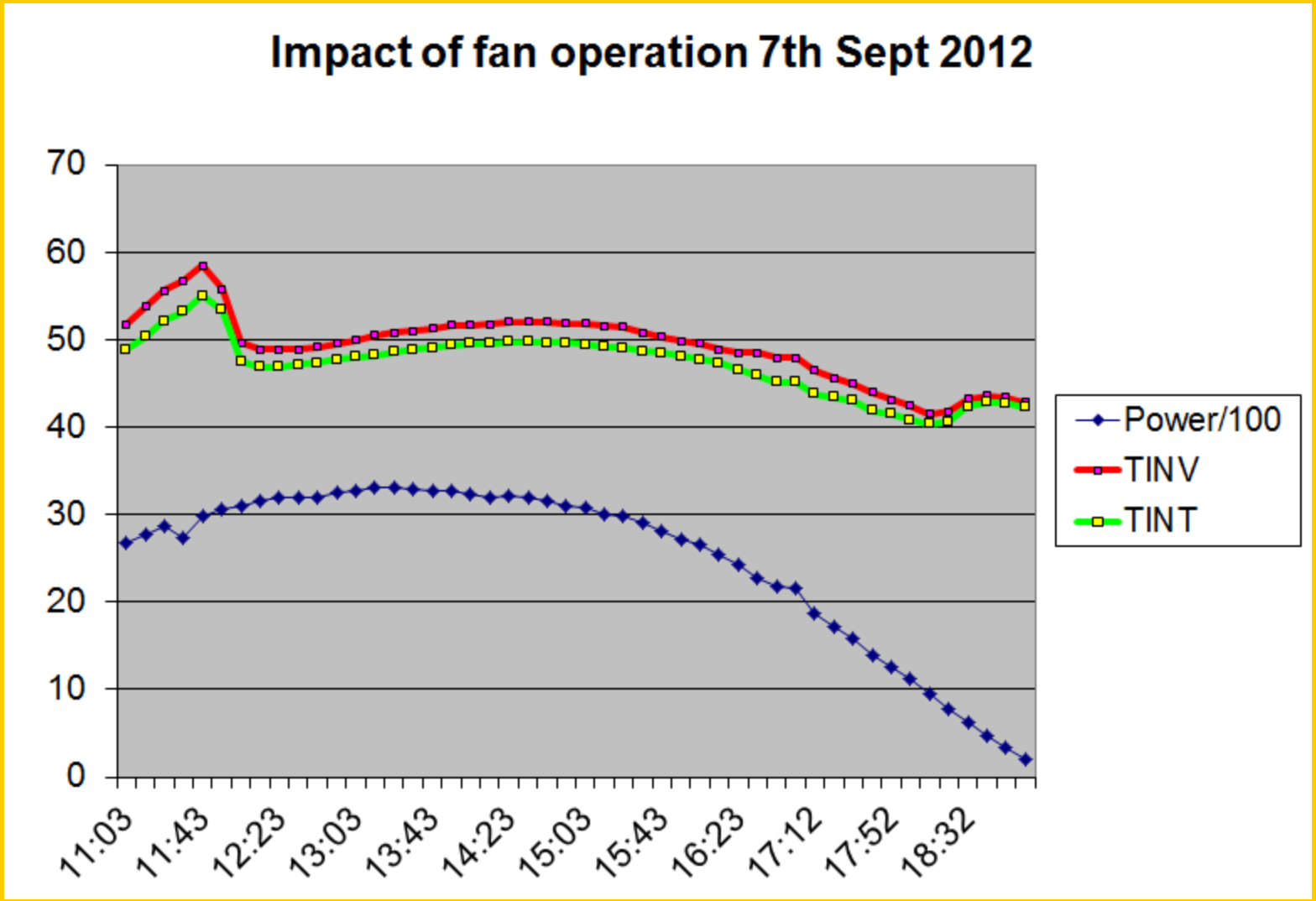
When the inverter gets too hot it switches on an inline fan

The temperature drops immediately by about 10 degrees

Air is drawn in from a nearby bedroom when the temperature rises to about 55 degrees

The cool air is blown vertically through the finned heat sink

Some like it hot – and some do not!



Basking in the sun

.....When it shines

Solar PV and three years' Personal experience

Was it a good investment?

Solar PV and three years' Personal experience

An unqualified YES!

Assuming only 10% of the electricity generated is used

Initial cost was £8,500

Forecast power generation was 3,700 kwh

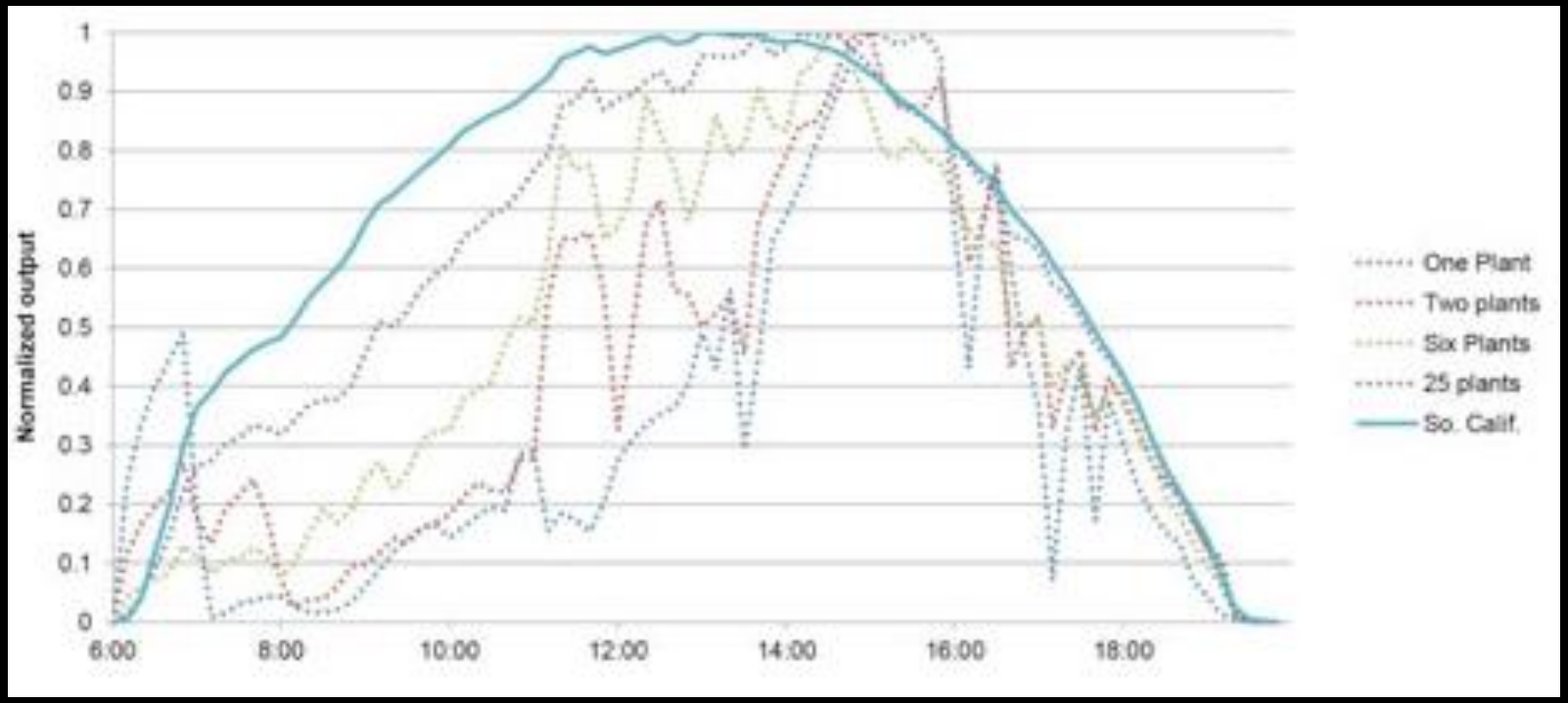
After three years' experience:

- M.A.T. power generated was 4,300 kwh
- F.I.T. payment £932
- Electricity sold to grid £128
- Reduced electricity from grid saves £52
- FORECAST TOTAL ANNUAL RETURN £1,112
- Equal to 13.1% tax free
- Equal to 16.4% at 20% tax rate
- Or even 21.8% at 40% tax rate

Three years actual payments made by EDF

Solar generation payments					
Date	FIT payment	Deemed generation	Total	MAT Total	Equiv @40%
19/11/2012			£97.27		
19/12/2012			£57.12		
20/12/2012			£253.54		
04/03/2013	£61.76	£8.68	£70.44		
27/03/2013	£216.32		£216.32		
			£267.17		
11/09/2013	£354.63	£27.03	£381.66		
02/12/2013	£153.72	£11.72	£165.44		
31/03/2014	£100.89	£7.69	£108.58		
04/06/2014	£304.57	£23.22	£327.79		
03/09/2014	£348.12	£26.54	£374.66	£976.47	£1,627.45
03/12/2014	£164.28	£12.53	£176.81	£987.84	£1,646.40
10/03/2015	£102.70	£7.83	£110.53	£989.79	£1,649.65
10/06/2015	£344.86	£26.27	£371.13	£1,033.13	£1,721.88
04/09/2015	£297.96	£22.69	£320.65	£979.12	£1,631.87
RUNNING TOTAL	**£2,449.81**	**£174.20**	**£3,299.11**		**£5,498.52**

Daily normalised output from Solar PV

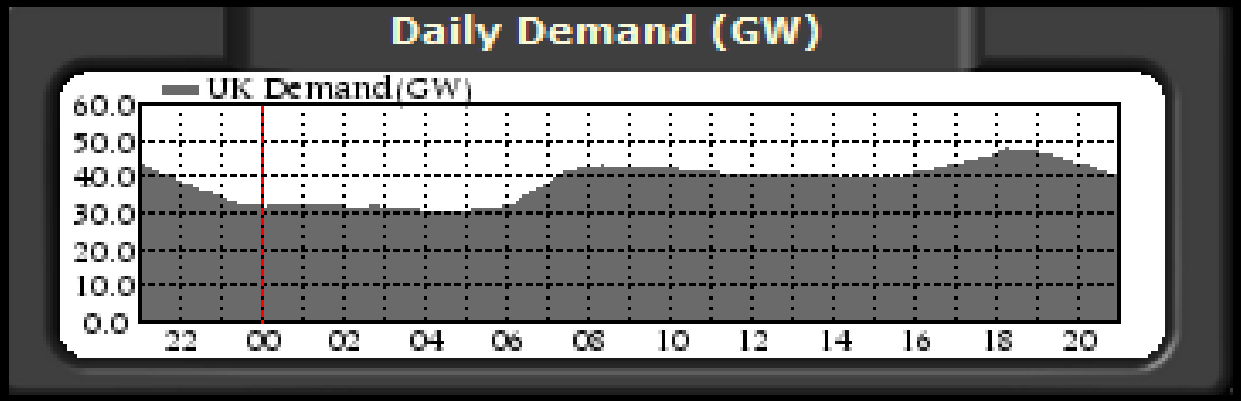


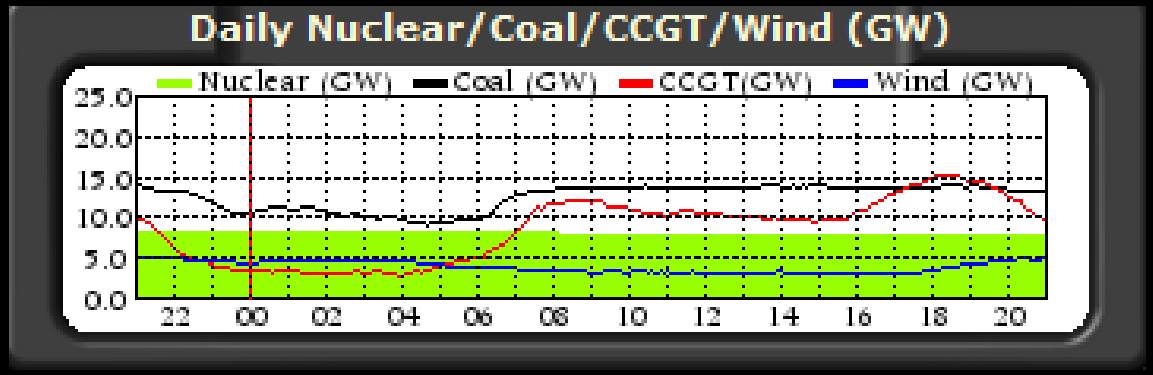
But what happens when the entirety of Europe sits under a large midwinter anticyclone with little sun showing through the clouds?

NO solar PV

NO wind turbines moving

Demand and Supply 27th February 2015





We need to store the energy created earlier

Storage technology	Typical round trip efficiency (%)	Typical capacity
Pumped hydro	80	100 – 1000 MW
Compressed air	75	50 – 100 MW
Flywheel	90	1 kW – 50 kW
Conventional battery	50 - 90	1 kW – 10 MW
Flow battery	70	~ 15 MW
Hydrogen fuel cell	40	50 kW – 1 MW