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zero energy design
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feasibility studies
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RT+40 Years of Wind Power

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+

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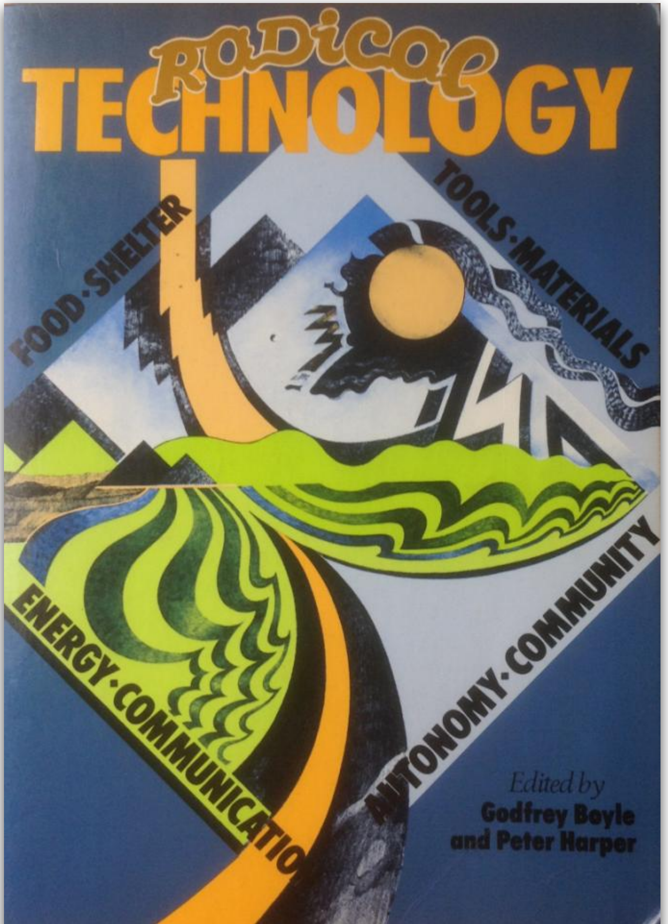
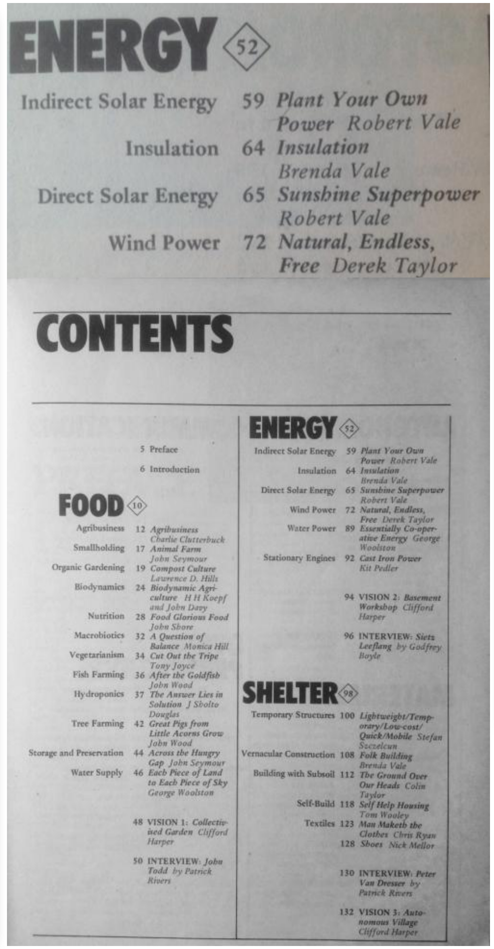
RT 1.0 ‘*Wind Power : Natural, Endless, Free*’ by Derek Taylor 1976





ENERGY 52

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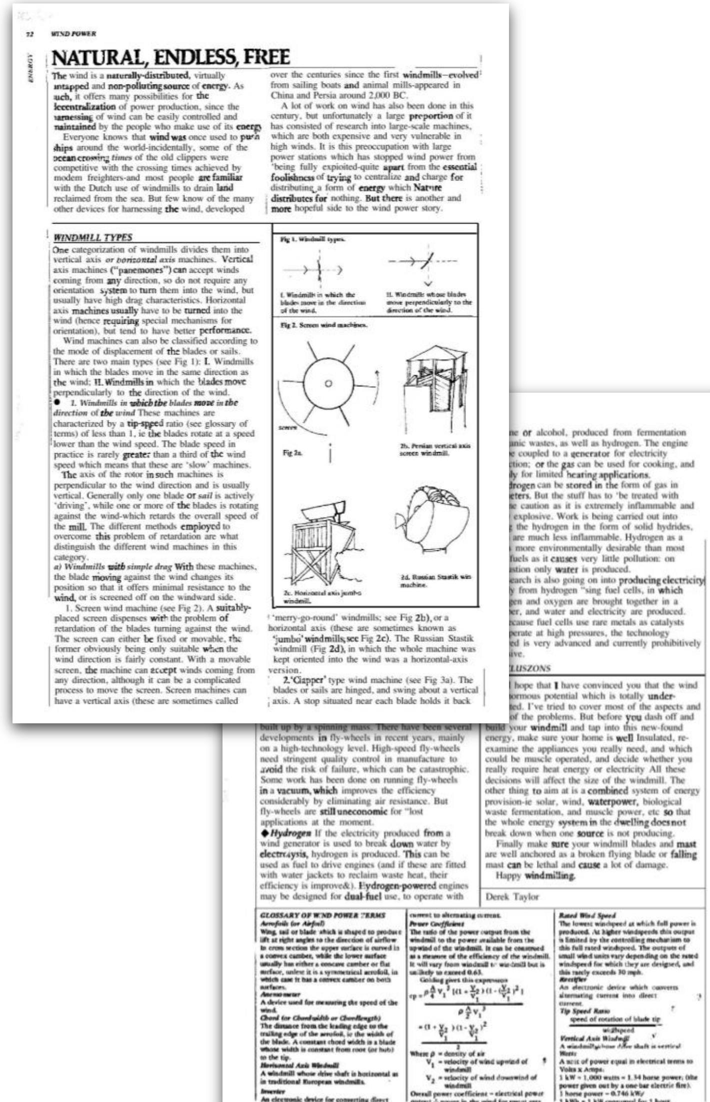

ENERGY

NATURAL, ENDLESS, FREE

The wind is a naturally-distributed, virtually untapped and non-polluting source of energy. As such, it offers many possibilities for the decentralization of power production, since the harnessing of wind can be easily controlled and maintained by the people who make use of its energy.

Everyone knows that wind was once used to push ships around the world-incidentally, some of the ocean crossing times of the old clippers were competitive with the crossing times achieved by modem freighters-and most people are familiar with the Dutch use of windmills to drain land reclaimed from the sea. But few know of the many other devices for harnessing the wind, developed over the centuries since the first windmills–evolved from sailing boats and animal mills-appeared in China and Persia around 2,000 BC.

A lot of work on wind has also been done in this century, but unfortunately a large proportion of it has consisted of research into large-scale machines, which are both expensive and very vulnerable in high winds. It is this preoccupation with large power stations which has stopped wind power from 'being fully exploited-quite apart from the essential foolishness of trying to centralize and charge for distributing a form of energy which Nature distributes for nothing. But there is another and more hopeful side to the wind power story.

WINDMILL TYPES

One categorization of windmills divides them into vertical axis *or horizontal axis* machines. Vertical axis machines ("panemones") can accept winds coming from any direction, so do not require any orientation system to turn them into the wind, but usually have high drag characteristics. Horizontal axis machines usually have to be turned into the wind (hence requiring special mechanisms for orientation), but tend to have better performance.

Wind machines can also be classified according to the mode of displacement of the blades or sails. There are two main types (see Fig 1): I. Windmills in which the blades move in the same direction as the wind; II. Windmills in which the blades move perpendicularly to the direction of the wind.

● *1. Windmills in which the blades move in the direction of the wind* These machines are characterized by a tip-speed ratio (see glossary of terms) of less than 1, ie the blades rotate at a speed lower than the wind speed. The blade speed in practice is rarely greater than a third of the wind speed which means that these are 'slow' machines.

The axis of the rotor in such machines is perpendicular to the wind direction and is usually vertical. Generally only one blade or *sail* is actively 'driving', while one or more of the blades is rotating against the wind-which retards the overall speed of the mill. The different methods employed to overcome this problem of retardation are what distinguish the different wind machines in this category.

a) Windmills with simple drag With these machines, the blade moving against the wind changes its position so that it offers minimal resistance to the wind, or is screened off on the windward side.

1. Screen wind machine (see Fig 2). A suitably-placed screen dispenses with the problem of retardation of the blades turning against the wind. The screen can either be fixed or movable, the former obviously being only suitable when the wind direction is fairly constant. With a movable screen, the machine can accept winds coming from any direction, although it can be a complicated process to move the screen. Screen machines can have a vertical axis (these are sometimes called 'merry-go-round' windmills; see Fig 2b), or a horizontal axis (these are sometimes known as 'jumbo' windmills; see Fig 2c). The Russian Stastik windmill (Fig 2d), in which the whole machine was kept oriented into the wind was a horizontal-axis version.

2. 'Clapper' type wind machine (see Fig 3a). The blades or sails are hinged, and swing about a vertical axis. A stop situated near each blade holds it back

Fig 1. Windmill types.

I. Windmills in which the blades move in the direction of the wind.

II. Windmills whose blades move perpendicularly to the direction of the wind.

Fig 2. Screen wind machines.

Fig 2a.

2b. Persian vertical axis screen windmill.

2c. Horizontal axis jumbo windmill.

2d. Russian Stastik wind machine.

built up by a spinning mass. There have been several developments in fly-wheels in recent years, mainly on a high-technology level. High-speed fly-wheels need stringent quality control in manufacture to avoid the risk of failure, which can be catastrophic. Some work has been done on running fly-wheels in a vacuum, which improves the efficiency considerably by eliminating air resistance. But fly-wheels are still uneconomic for "lost applications at the moment.

◆ *Hydrogen* If the electricity produced from a wind generator is used to break down water by electrolysis, hydrogen is produced. This can be used as fuel to drive engines (and if these are fitted with water jackets to reclaim waste heat, their efficiency is improved). Hydrogen-powered engines may be designed for dual-fuel use, to operate with

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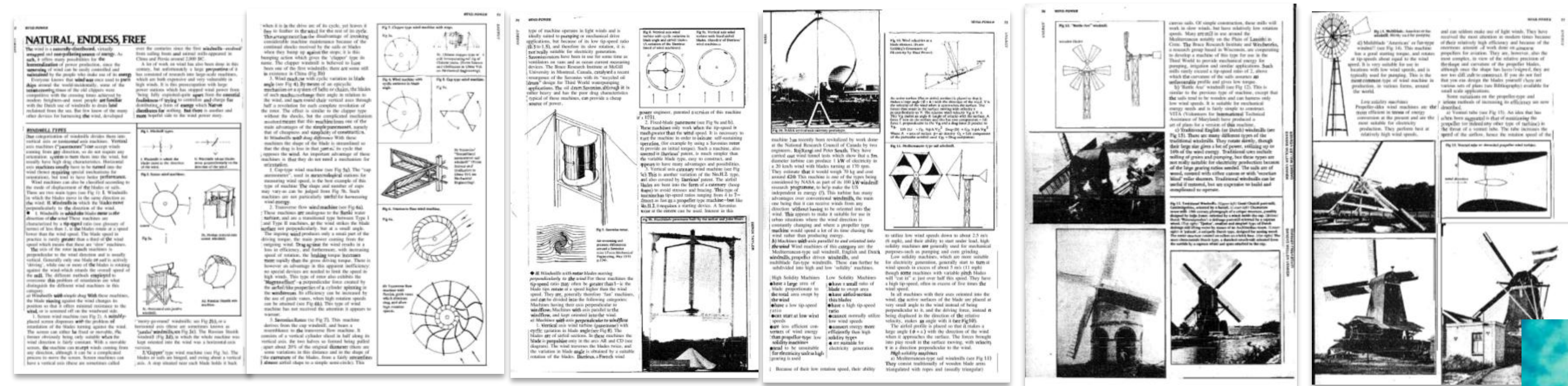
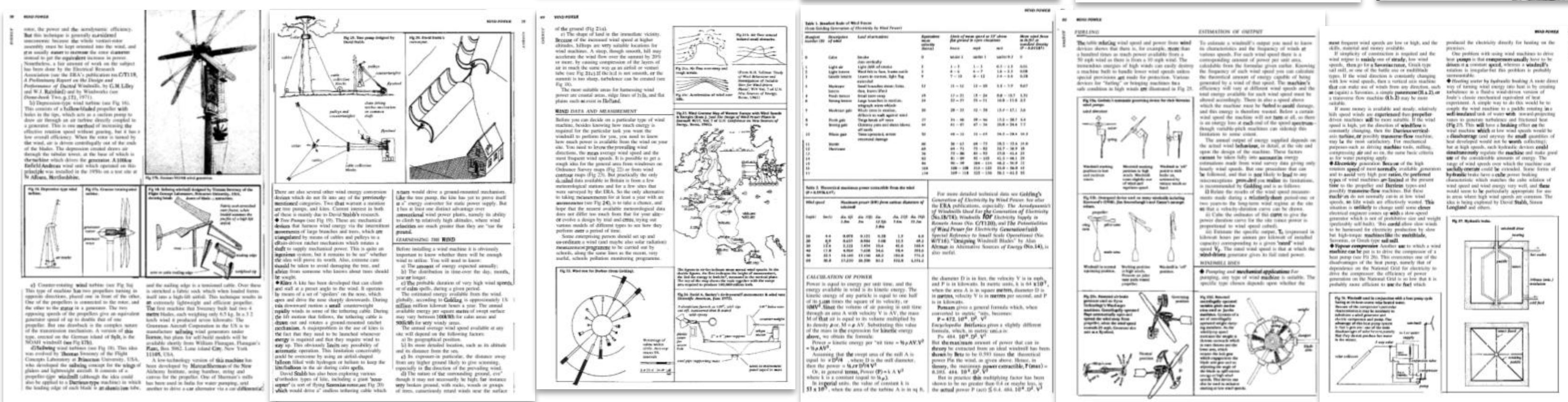
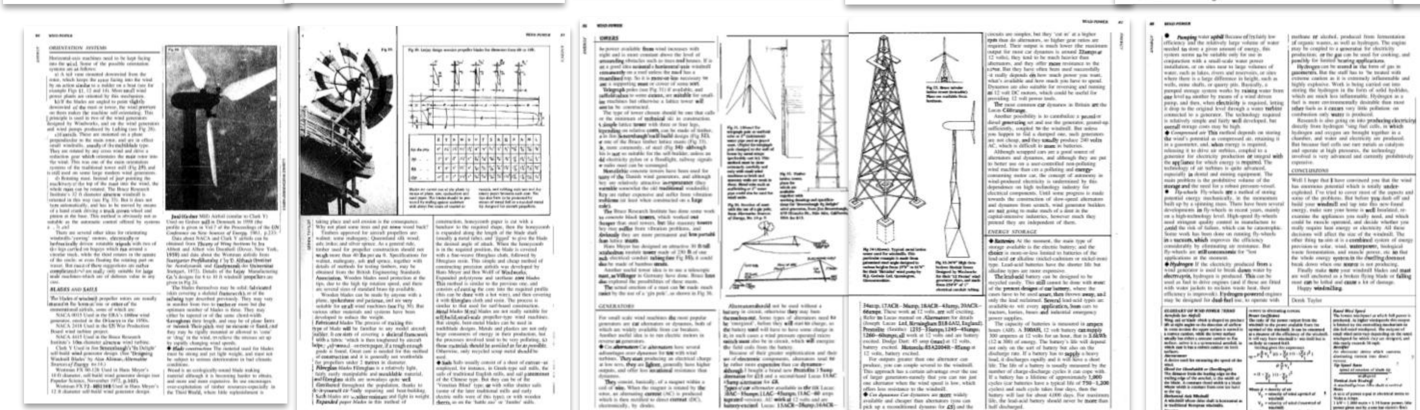
GLOSSARY OF WIND POWER TERMS







200 kW Gedser turbine by Johannes Juul in 1957.

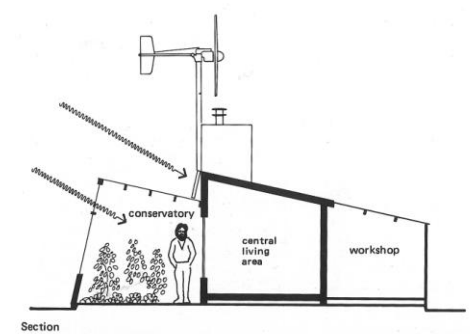
James Blyth built his first wind generator in 1887 at Strathclyde. This one at Marykirk operated > 20 years.

Some Wind Power Activities at The Architectural Association 1970s

Derek Taylor Sailwing design 1970s

Square VAWT by Derek Taylor & John Shore

StreetFarmers Sail turbine at Comtek 1970s



John Shore's design for wind turbine & his Integrated Solar Dwelling 1970s.

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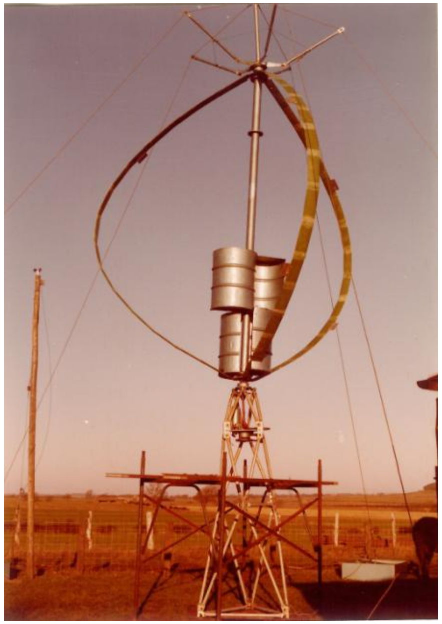
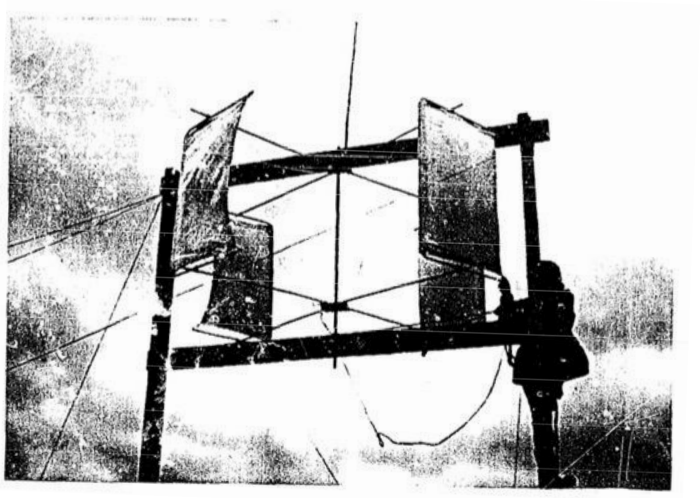
4m Dia ***SailFoil*** *HAWT* project at ATG Open University
Designed & Tested by Derek Taylor - 1980s



Dr Geoff Watson's
Maximill Darrieus
1970s at NEW.

Will Gryll's Cyclic Pitch VAWT
at Exeter University 1970s-80s

Dr Peter Musgrove's 1st Variable Geometry VAWT
Reading University 1970s.



Brian Hurley's Sailwing VAWT
Dublin 1970s.

The 1 MW TVIND turbine began producing electricity in march 1978.

The turbine was built by teachers and pupils at the schools, in an incredibly tough and long lasting working period.

This turbine was a beacon and a great inspiration for the early Danish wind power community.

The Tvind windmill, "Tvindkraft" was created during the years 1975-78, at the initiative of and financed by the teacher group of the schools at Tvind. The time was the time of the oil crisis, and the debate was for or against nuclear power - for or against wind power - nuclear power or wind power. The price of energy had multiplied, and something had to be done. The Danish industry was pressing on to introduce nuclear power as a cheap alternative to the expensive oil. A majority in the Danish Parliament was building up. At Tvind people were against the nuclear power, with its problems of nuclear waste and monopolization

Visionary American politicians opened a great marked for the worlds Wind Industry.
Also the Danes grabbed that opportunity.

In 1982/1983 the first Danish wind turbines were shipped to California. Until 1986 this Californian Wind Rush kept Danish companies busy, especially the last weeks of the year, as turbines should be commissioned, and on line before December 31st, in order to secure the investors their federal-, and state- tax credits.

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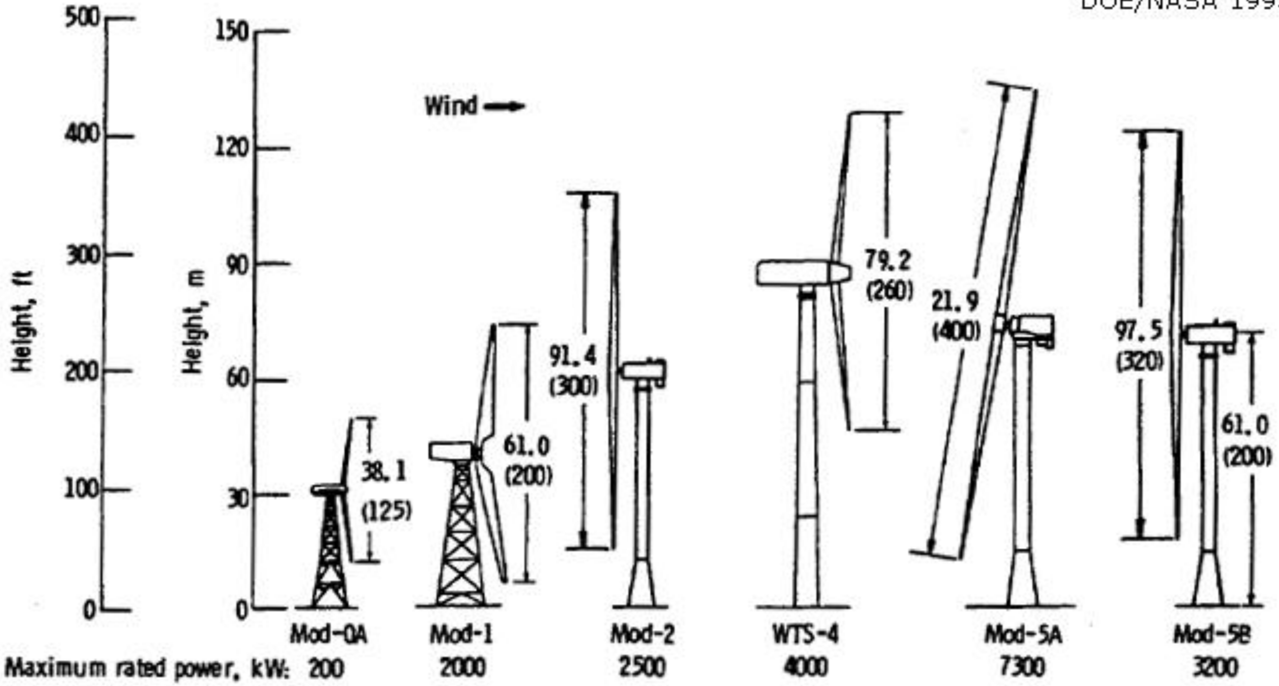
DOE/NASA 1995



Current Wind Power Capacity

RenewableUK - accessed August 2016

Onshore Wind Projects

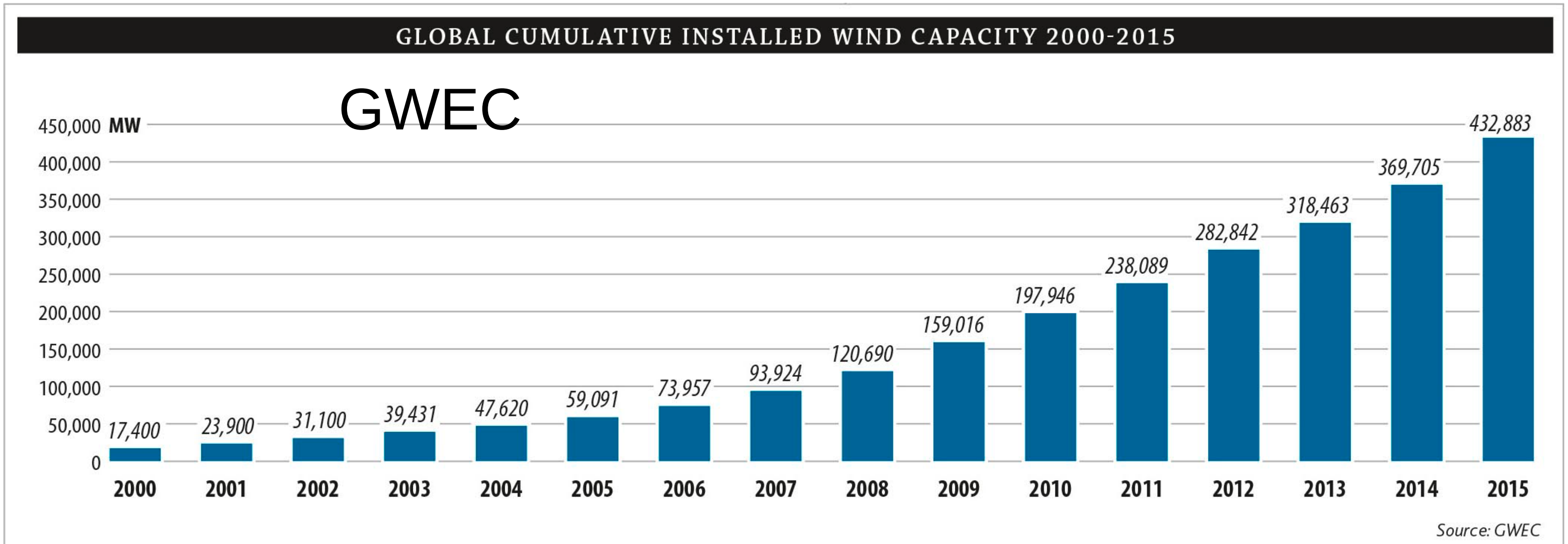
Onshore Turbines	5402	**Onshore Operational Projects**	1021	**Onshore Operational Capacity**	8871.825

Offshore Wind Projects

Offshore Turbines	1465	**Offshore Operational Projects**	28	**Offshore Operational Capacity**	5097.6

TOTAL

Total Operational Capacity	13969.425	**Energy Produced (MWh/p.a.)**	37201138
Homes Powered Equivalent (p.a.)	9446708	**CO2 reductions (pa) in Tonnes**	15996489



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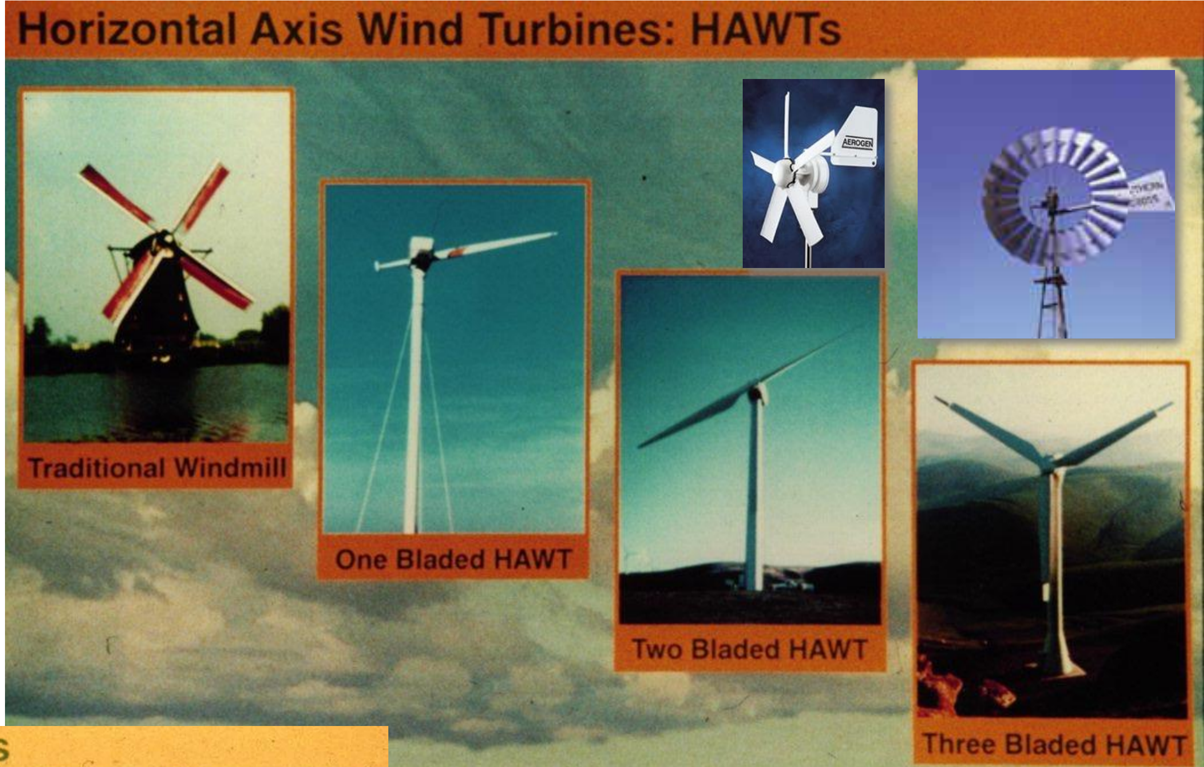
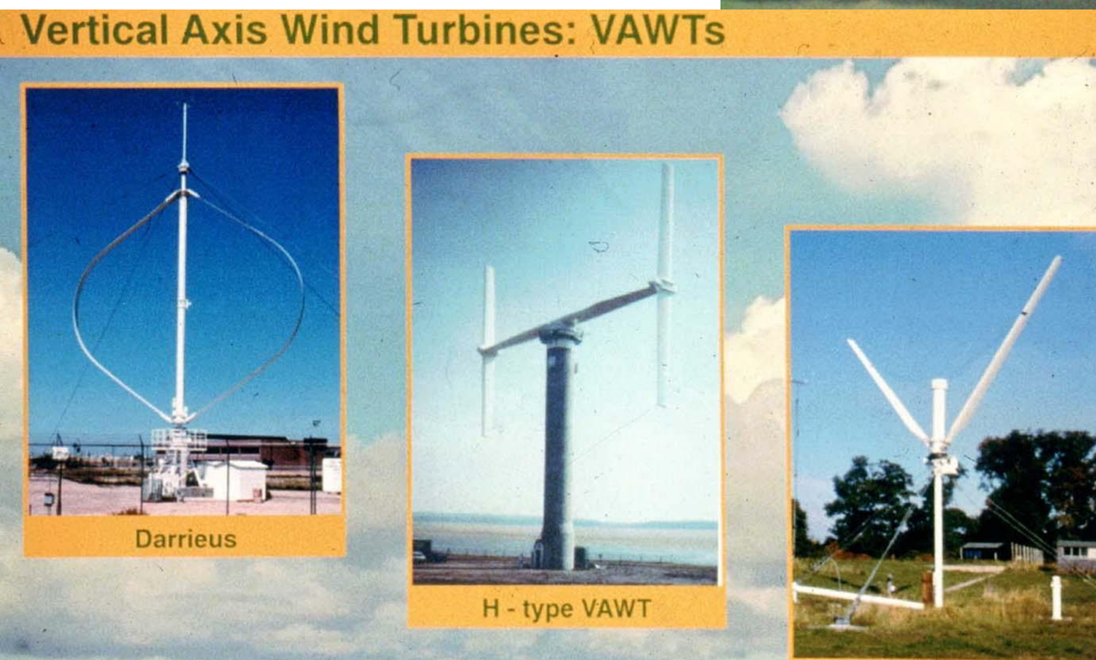
HAWTs



VAWTs



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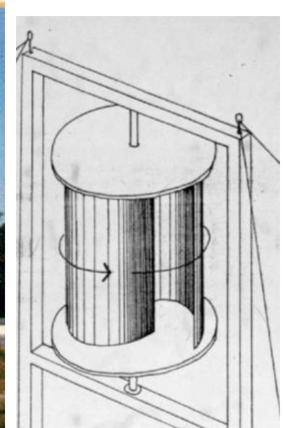

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Patented *Sycamore Rotor VAWT*™

FEATURES

- No yawing as able to use winds from all directions
- Reversing gravitational loads avoided
- Optimum swept area geometry - most at high level
- Short tower requirement
- Easy access to generating machinery
- Best VAWT blade length to swept area ratio
- Straight untwisted blades
- Blades can be folded down to ground level
- Low level blade installation without a tall crane
- Low level maintenance avoids climbing tall towers
- More feasible to install in difficult locations
- Easier to use direct drive low speed generators
- Blade operates at constant height
- Blade always in the higher power upper winds
- Minimal material content for a wind turbine
- Low visual impact in operation
- Only turbine able to be parked at/near ground level
- Almost zero visibility when blade parked
- Only turbine with no tower in swept area region
- Only VAWT with a teetering rotor.
- Low overturning moments
- Only VAWT with a single span cantilevered blade
- Novel design gives static & dynamic balance.
- Short rotation shaft
- Highly suited to off-shore operation
- Floating wind turbines more feasible

Multi-Megawatt Turbines

2.5 MW Wind turbine
80 m dia.

4.5 MW Wind turbine
112 m dia.

7.5 MW Wind turbine
126 m dia.

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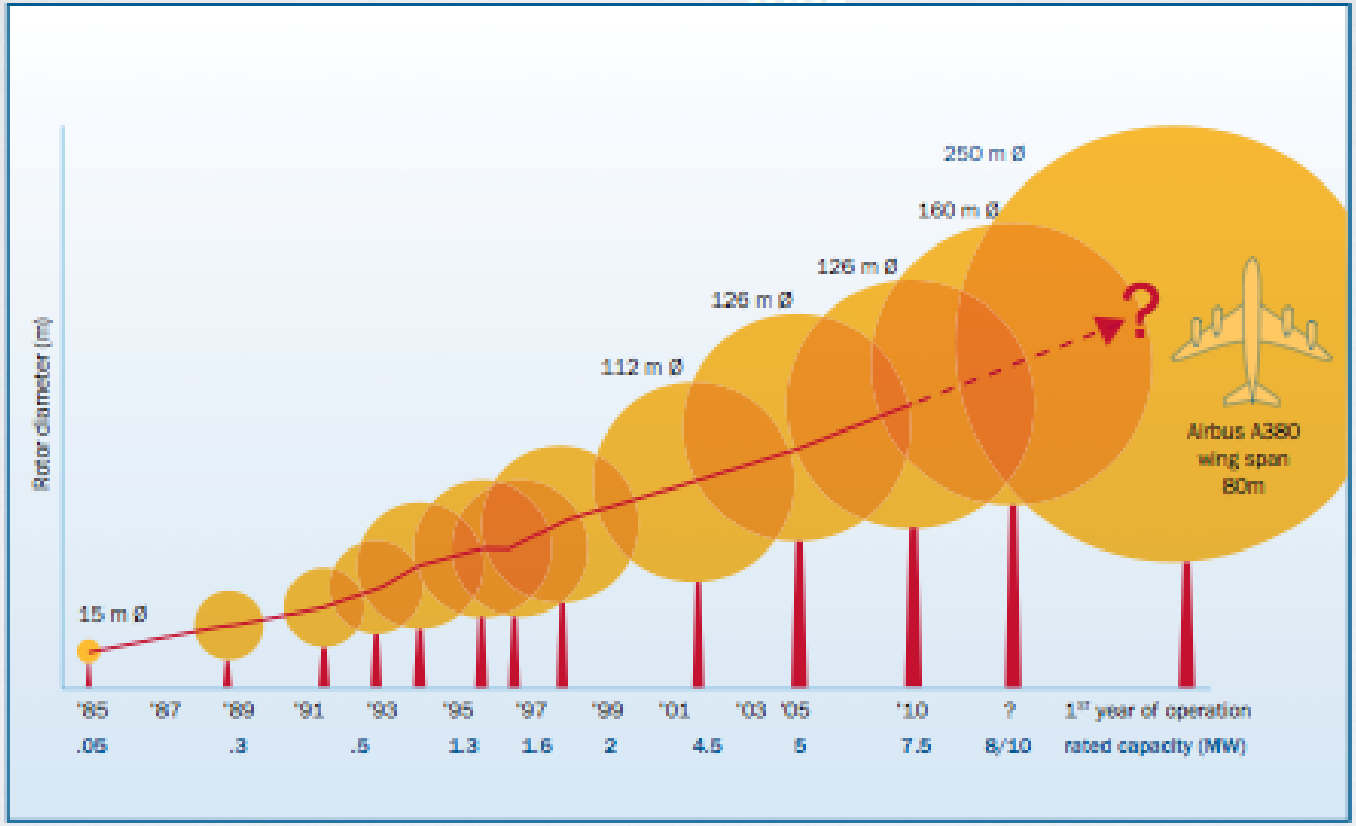
UPWIND PROJECT FOR 20 MW TURBINE



UPWIND PROJECT

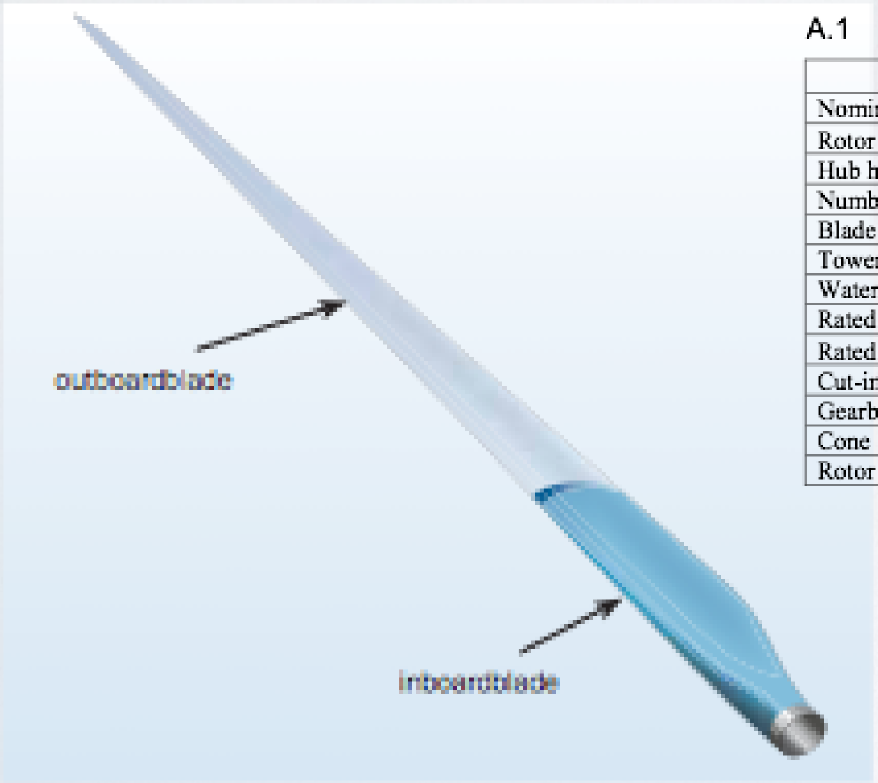


Figure 5: Sectional blade

A.1 General properties

Variable	Unit	5 MW ref turbine	20 MW ref turbine
Nominal power	MW	5	20
Rotor diameter	m	126	252
Hub height	m	90	153
Number of blades	-	3	3
Blade span	m	61.5	123
Tower height (incl. monopile)	m	107.6	168.2
Water depth	m	20	20
Rated tip speed	m/s	80	80
Rated rotor speed	rpm	12.1	6.05
Cut-in rotor speed	rpm	4.7	2.58
Gearbox ratio	-	97	194
Cone angle	°	-2.5	-2.5
Rotor tilt	°	5	5

a. Hermann Honnef's Wind Turbine

b. Three rotor Array Wind Turbine

c. Four rotor Array Wind Turbine

d. Three rotor Array Wind Turbine

e. Windship multi-rotor Wind Turbine

f. Four Rotor Array Wind Turbine

g. Octopus Wind Tech. 250MW Wind Turbine

h. Seven Rotor Array Wind Turbine

Fig.1 Co-planer Multi Rotor Wind Turbines

Multi rotor system concept

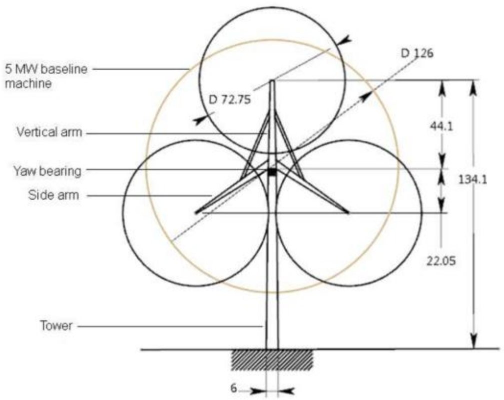
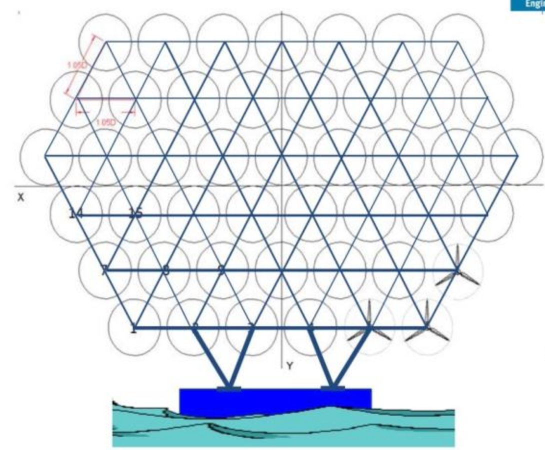
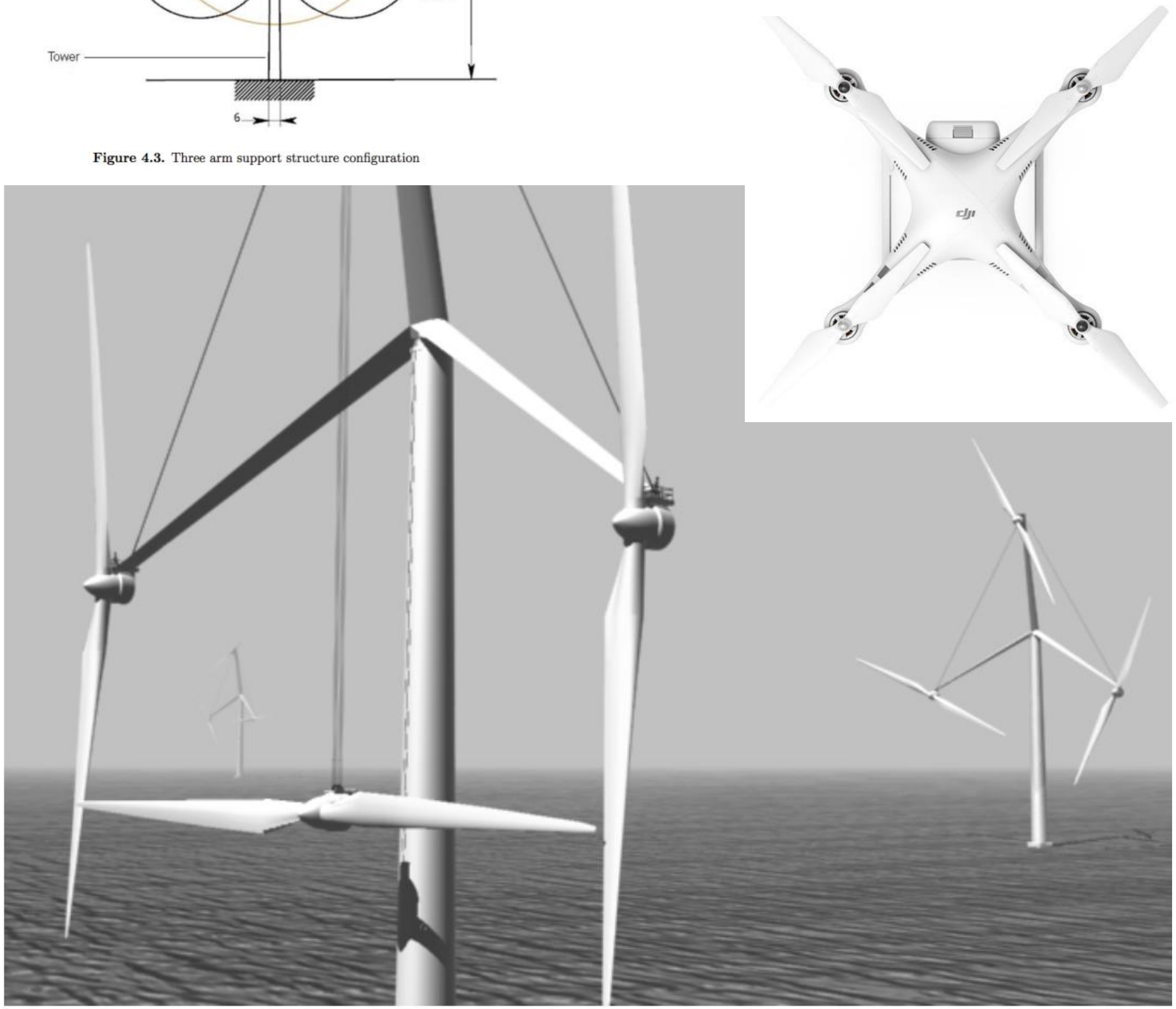
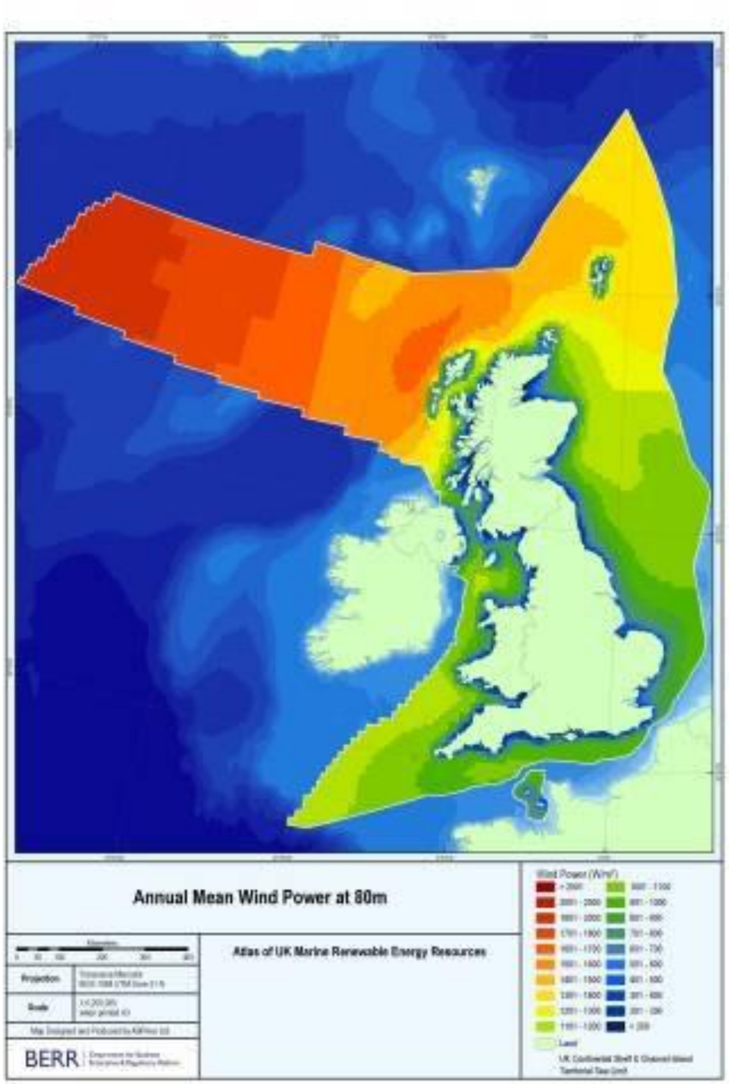


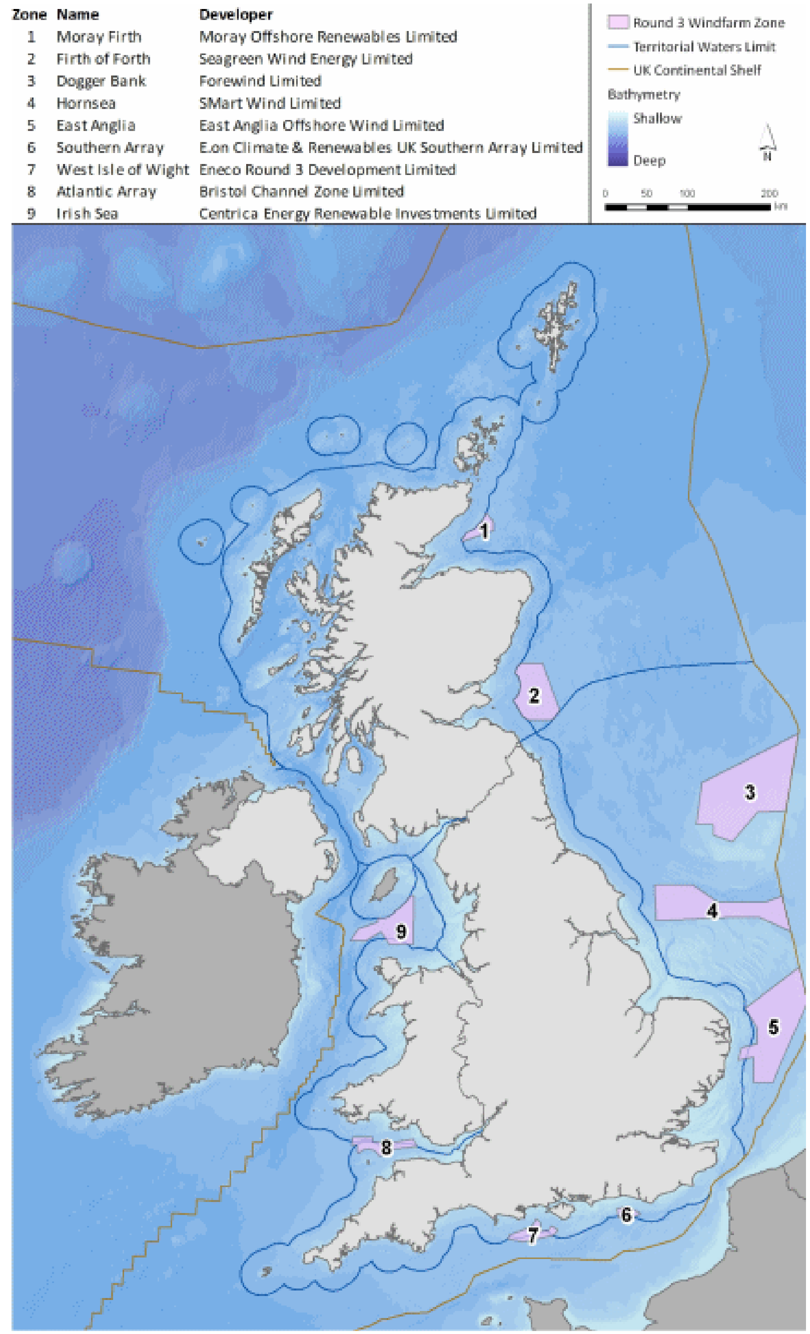
Figure 4.3. Three arm support structure configuration

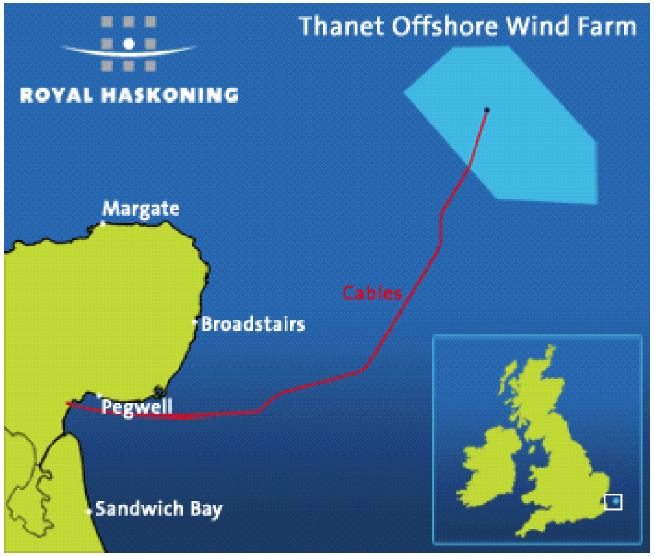


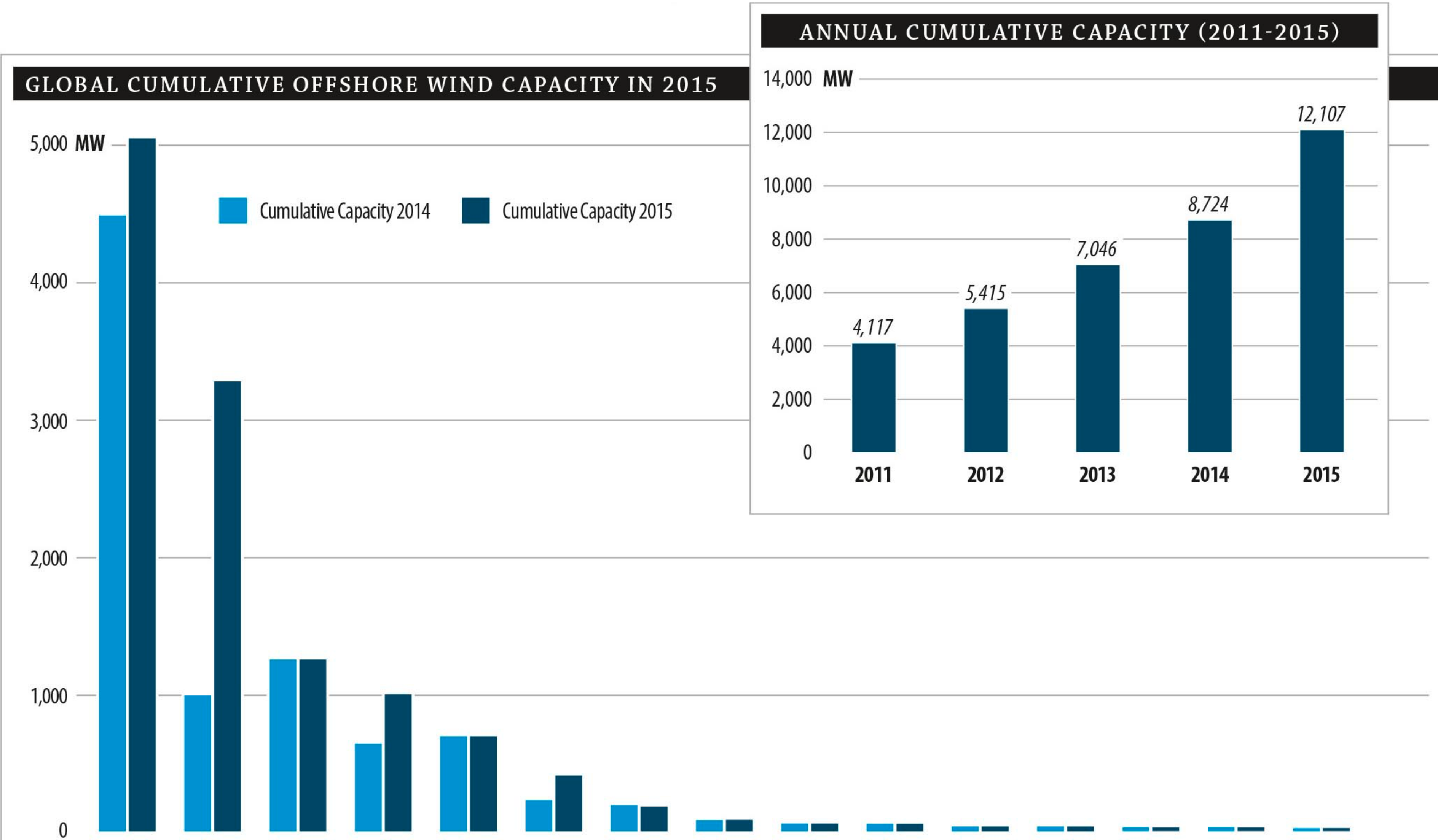




Zone	Name	Developer
1	Moray Firth	Moray Offshore Renewables Limited
2	Firth of Forth	Seagreen Wind Energy Limited
3	Dogger Bank	Forewind Limited
4	Hornsea	SMart Wind Limited
5	East Anglia	East Anglia Offshore Wind Limited
6	Southern Array	E.on Climate & Renewables UK Southern Array Limited
7	West Isle of Wight	Eneco Round 3 Development Limited
8	Atlantic Array	Bristol Channel Zone Limited
9	Irish Sea	Centrica Energy Renewable Investments Limited



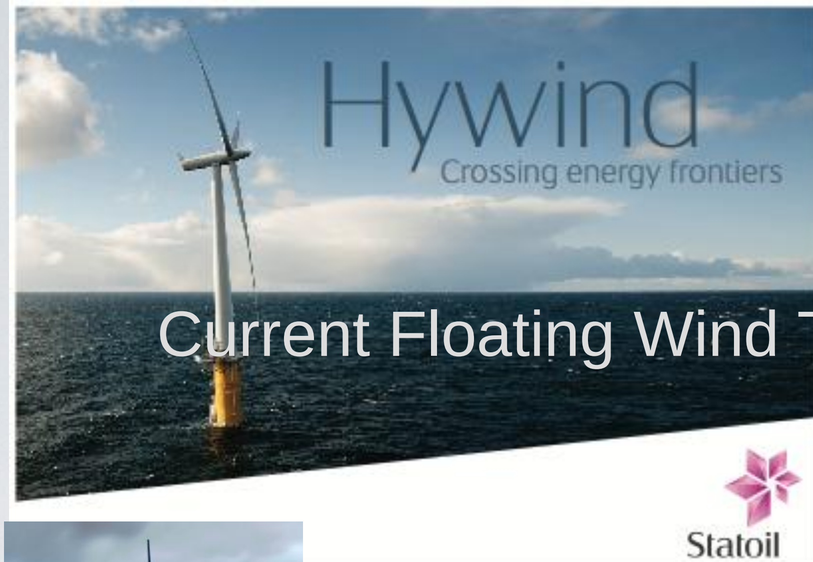

Thanet Offshore Wind Farm
ROYAL HASKONING
Margate
Broadstairs
Cables
Pegwell
Sandwich Bay

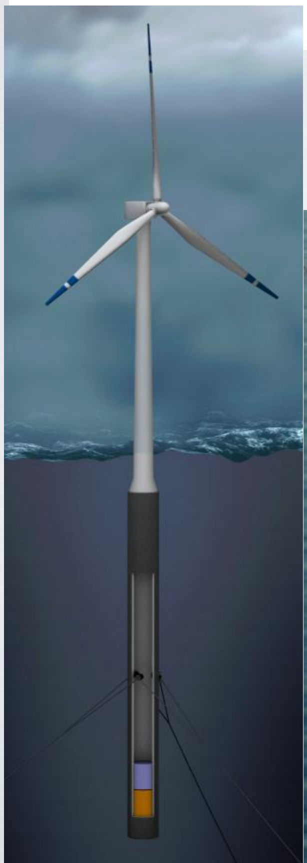


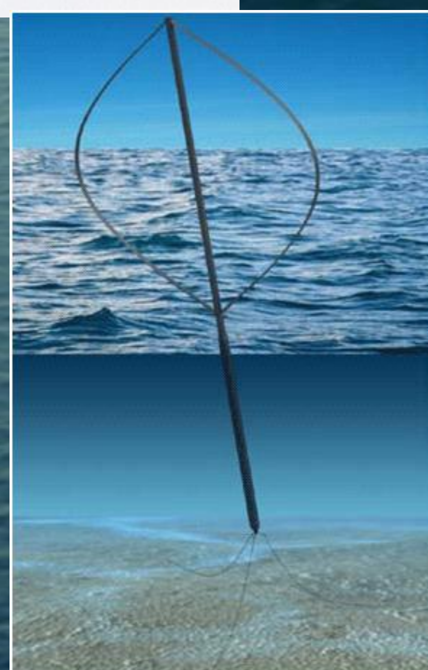
	UK	Germany	Denmark	PR China	Belgium	Netherlands	Sweden	Japan	Finland	Ireland	S Korea	Spain	Norway	Portugal	US	**Total**
Total 2014	4,500.4	1,012	1,271	654	712	247	212	50	26	25	5	5	2	2	0.02	**8,724**
New 2015	572.1	2,282.4	0	360.5	0	180	0	3	0	0	0	0	0	0	0	**3,398**
Total 2015	5,066.5	3,294.6	1,271.3	1,014.7	712.2	426.8	201.7	53	26.3	25.2	5	5	2.3	2	0.02	**12,107**

Source: GWEC, 2016

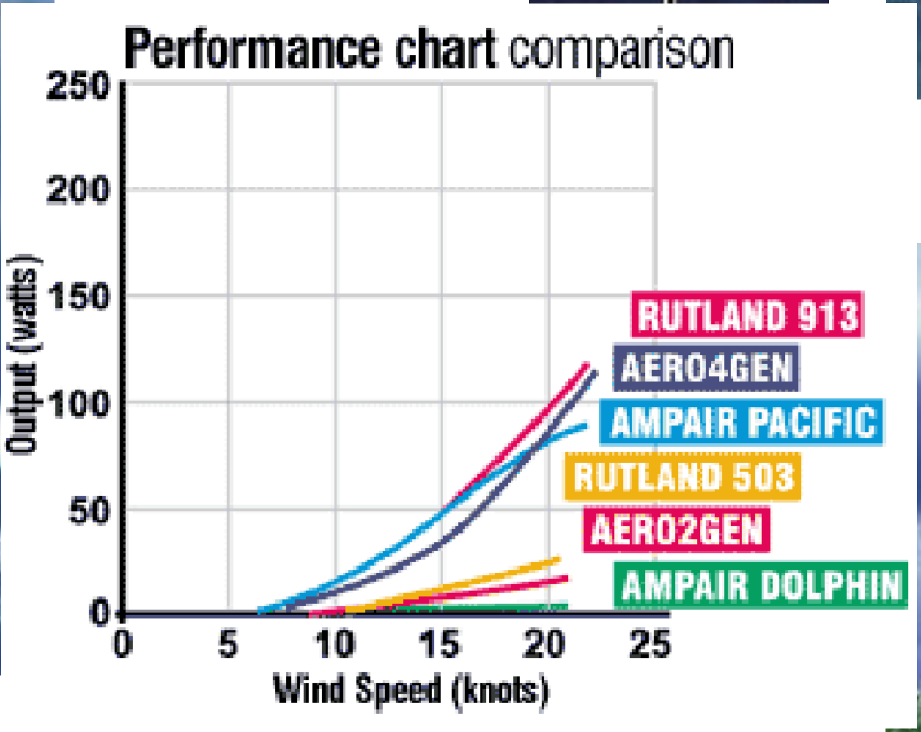
Current Floating Wind Turbines under development







MICRO wind turbines



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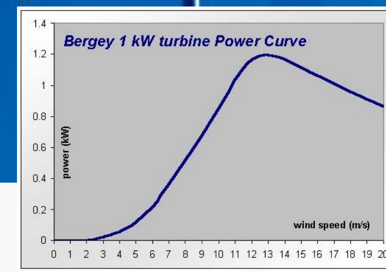
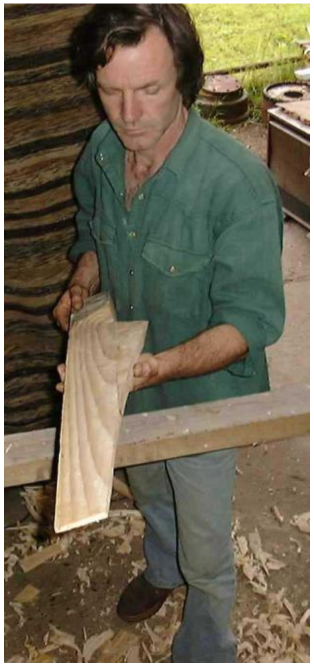
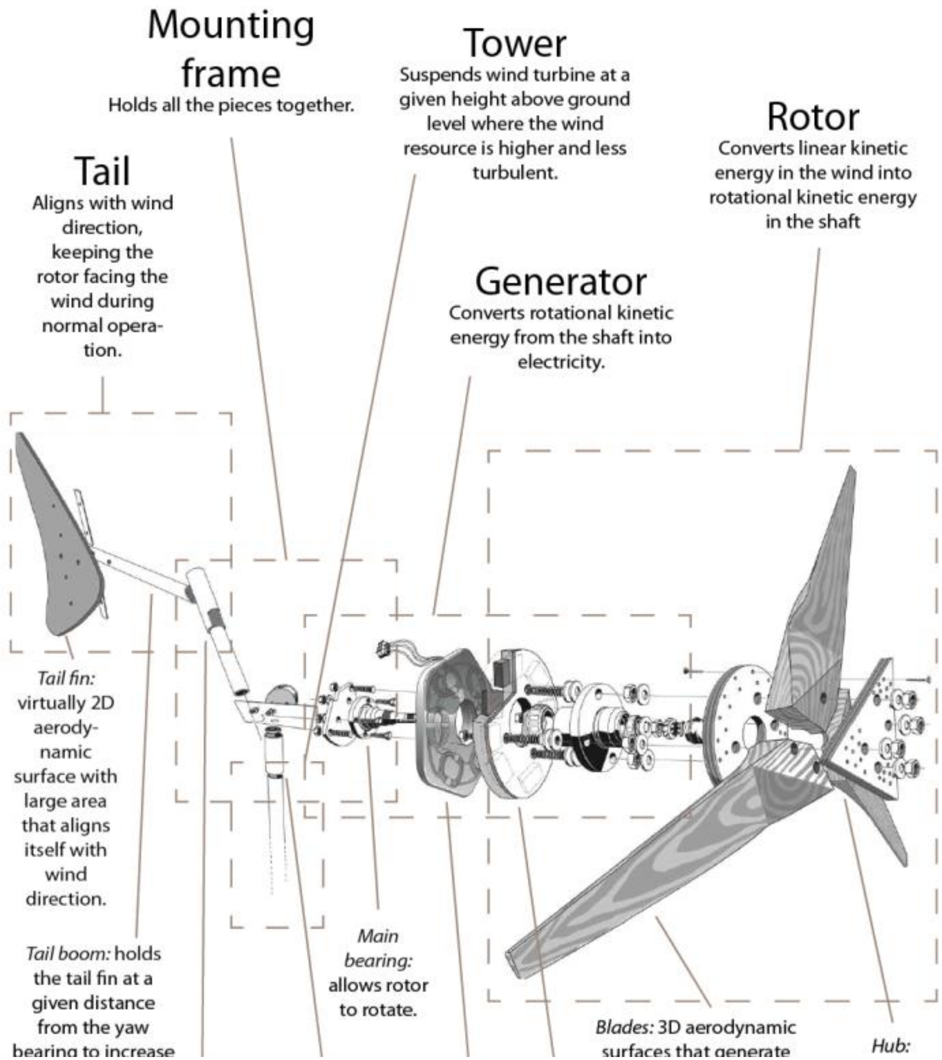
SMALL wind turbines



An American vision for small scale wind turbines.

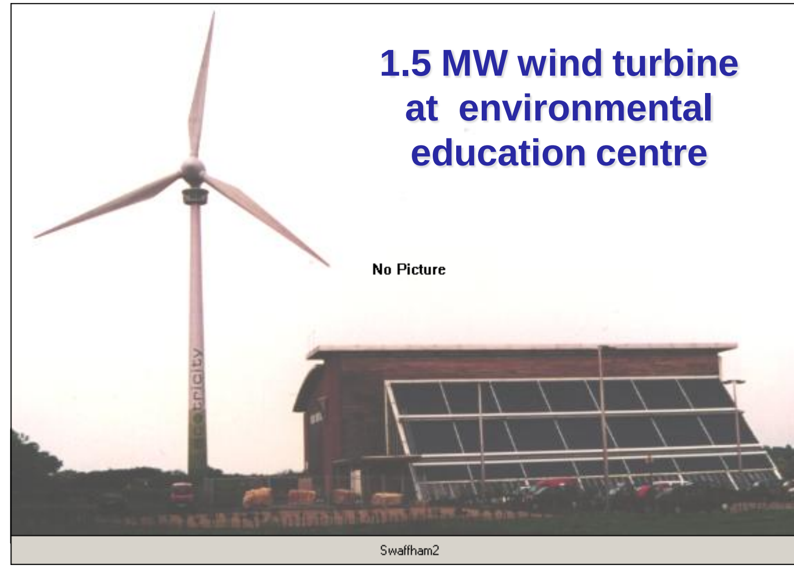
Hugh Piggot has enabled many to build their own small wind generator





www.scoraigwind.co.uk

Private + Community Wind Turbines



Single WTs for electricity saving, e.g.

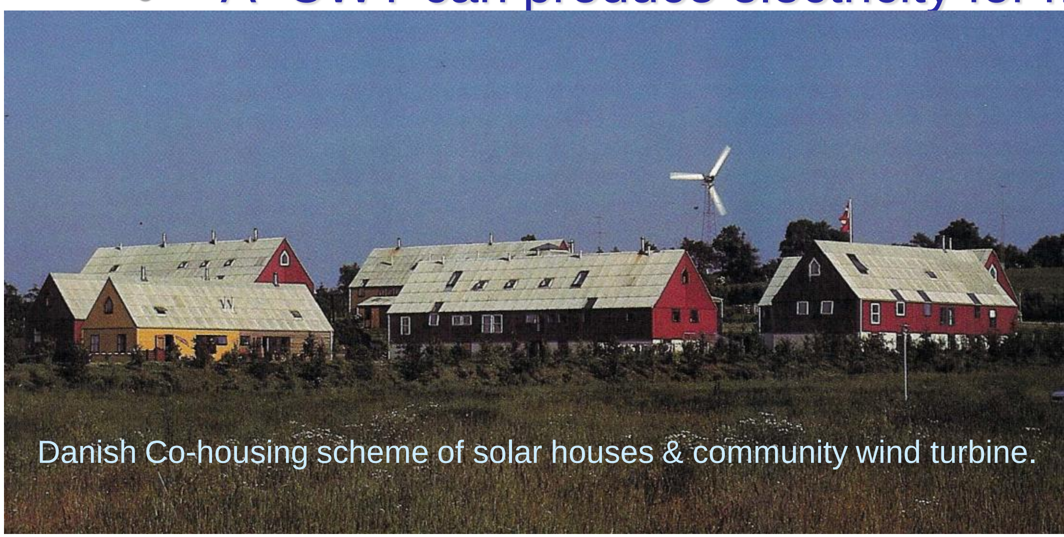
- medium size WT (200 - 600 kWp)
- large megawatt class machine

It is possible to sell the excess electricity to provide a revenue stream.

Over 38% of wind turbines in Denmark are owned by local co-operatives with support from banks & building societies.

Community Turbines for Housing

- On appropriate sites, Community WTs may be viable for housing.
- CWTs can provide electricity + heating via local heat stores.
- A CWT can produce electricity for many houses or a village.



Danish Co-housing scheme of solar houses & community wind turbine.

Hockerton Housing Association: Earth Sheltered zero energy houses & community wind turbines.

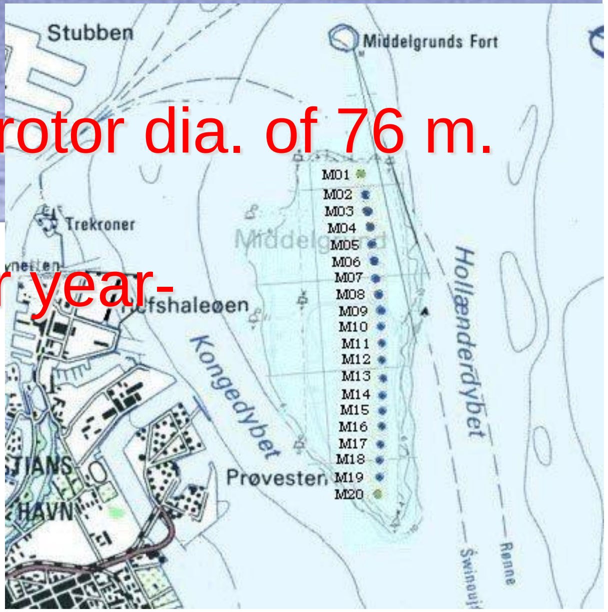
- Costs can be shared between several householders
- CWT can be operated by themselves or a management company.

1st Offshore Wind Power Co-op

The name of the partnership is Middelgrunden Wind Turbine Co-operative.

Ten Bonus 2 MW wind turbines.
Each of turbines hub height is 64 m & rotor dia. of 76 m.

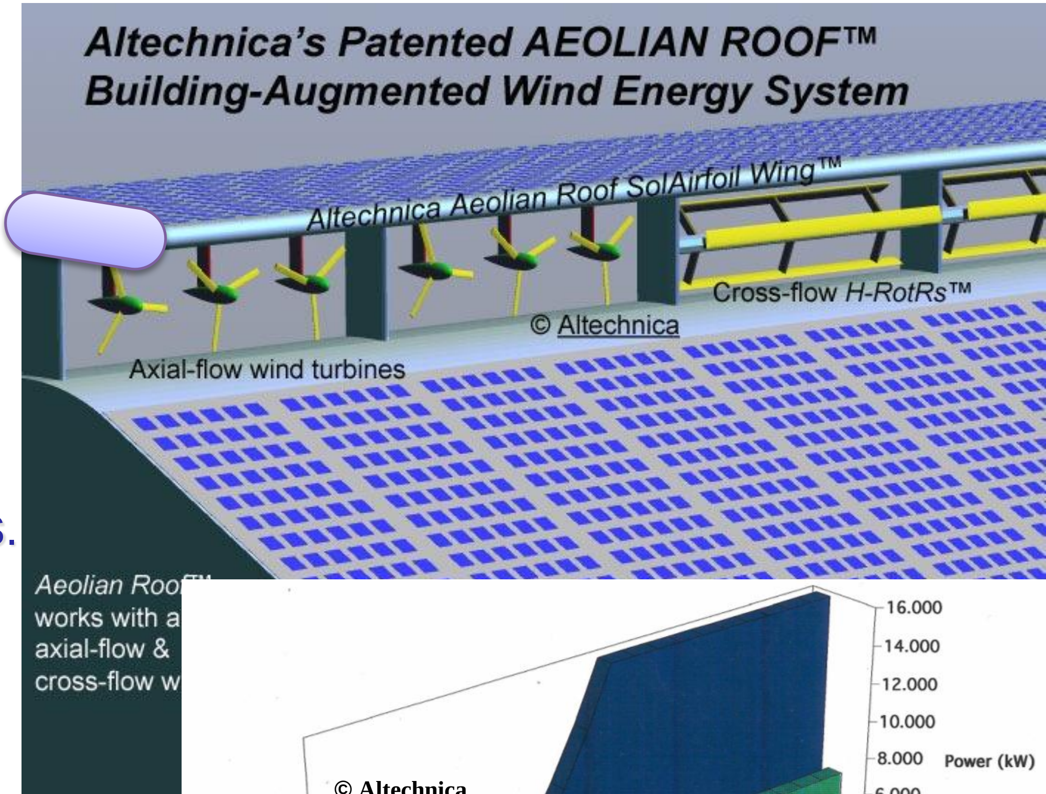
Estimated to generate 89,000 MWh per year- equiv to 3 % of the electricity consumed in Copenhagen.

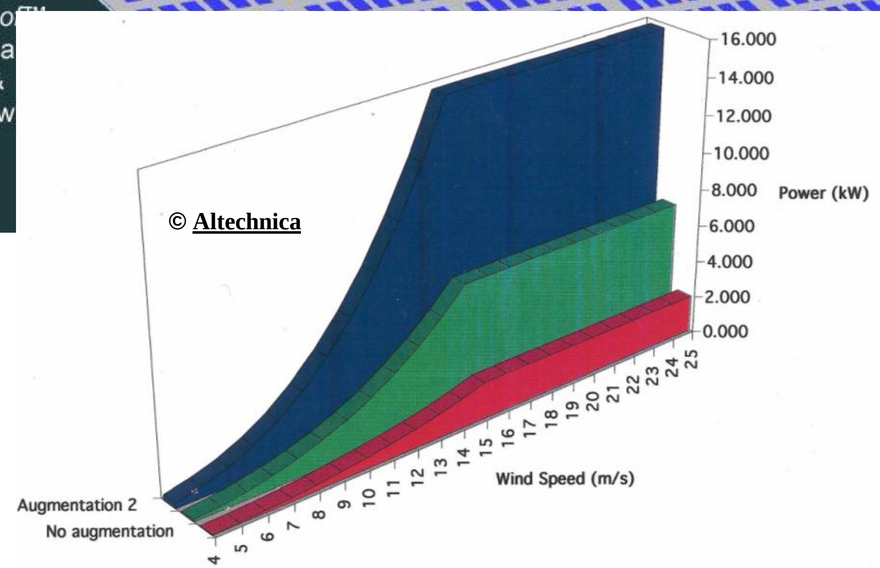


Middelgrunden Wind Co-operative Project - Copenhagen.

Altechnica *Aeolian Roof*™ + *SolAirfoil*™

- The patented ***Aeolian Roof***™ consists of a planar ‘wing’ concentrator above the highest region of a pitched or curved or membrane or vaulted roof.
- In the gap between the ‘wing’ & the ridge are located small cross or axial flow wind turbines.





Substantial potential for retrofitting *Aeolian Roof* + *SolAirfoil*™ hybrid wind & solar systems onto existing buildings.

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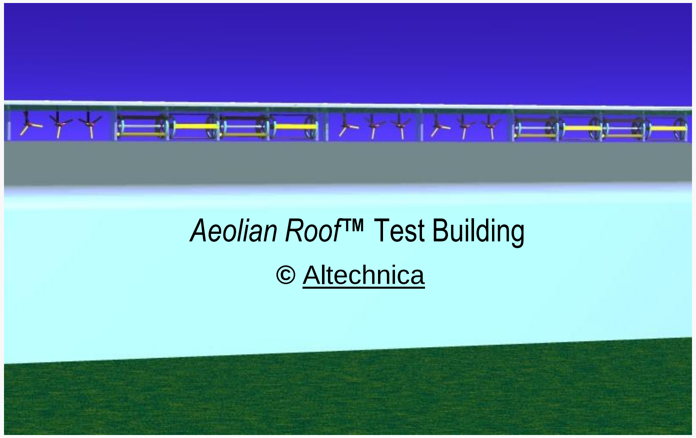
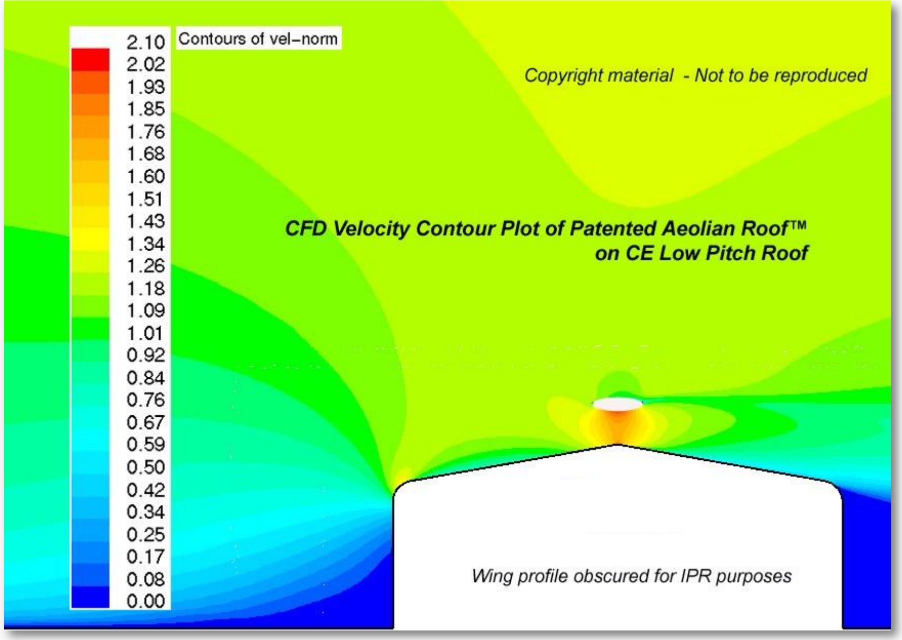
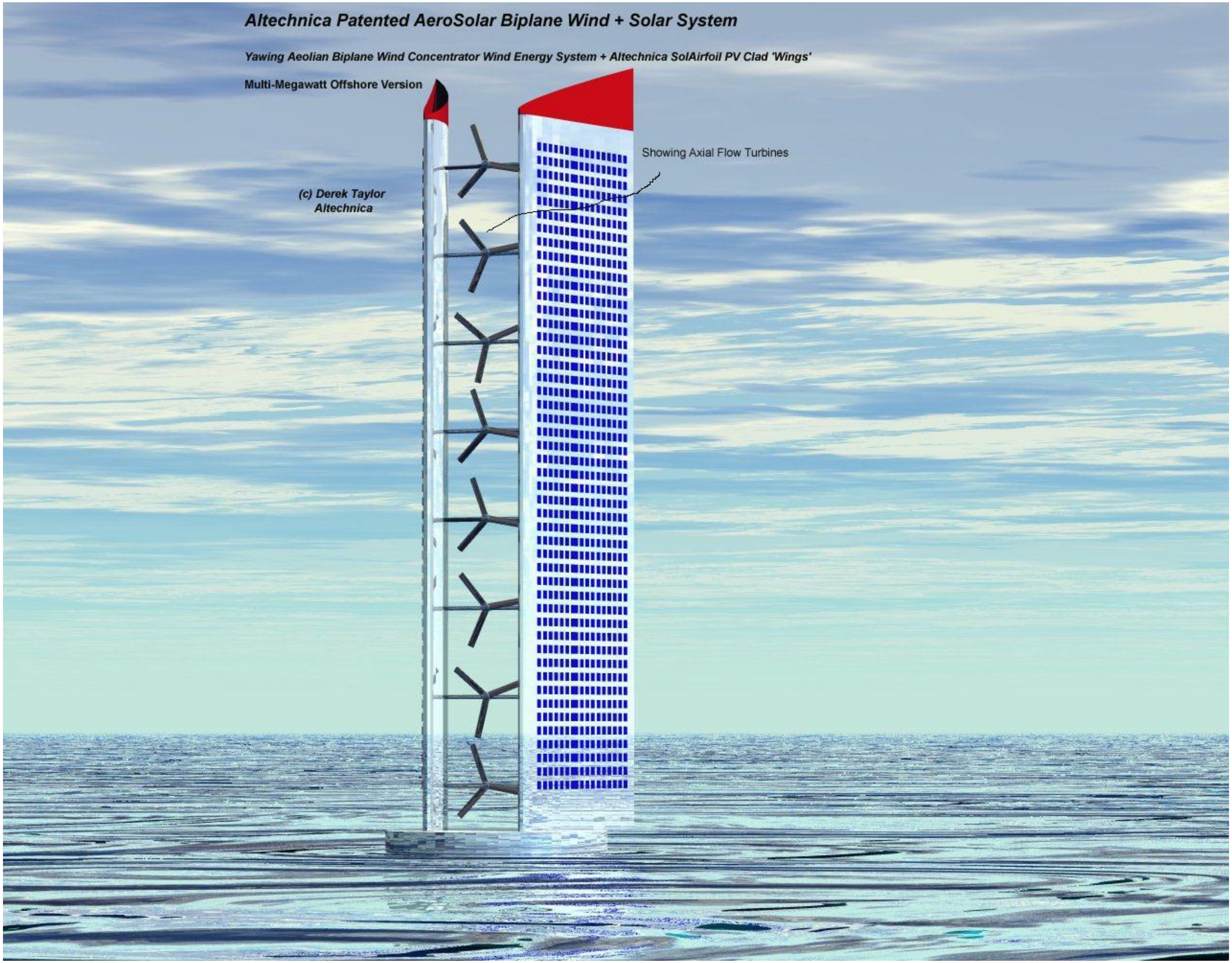
Aeolian Roof™ Prototype on Test Building







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Altechnica *AeroSolar*™ *DekHouse*

Engineered Design Approach facilitates *Super Insulation*, *Zero energy design, Energy Positif*□ & Integration of Renewables

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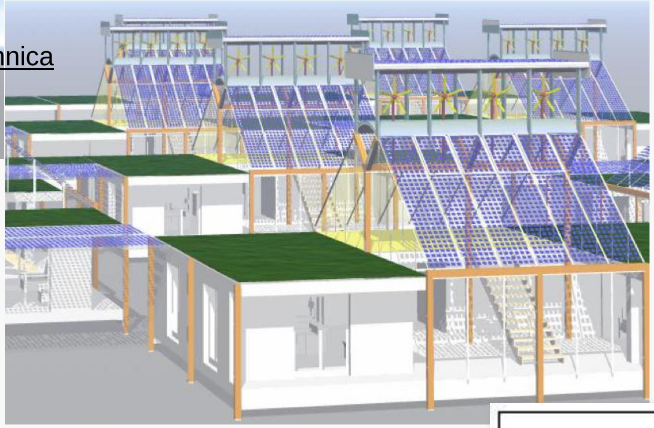
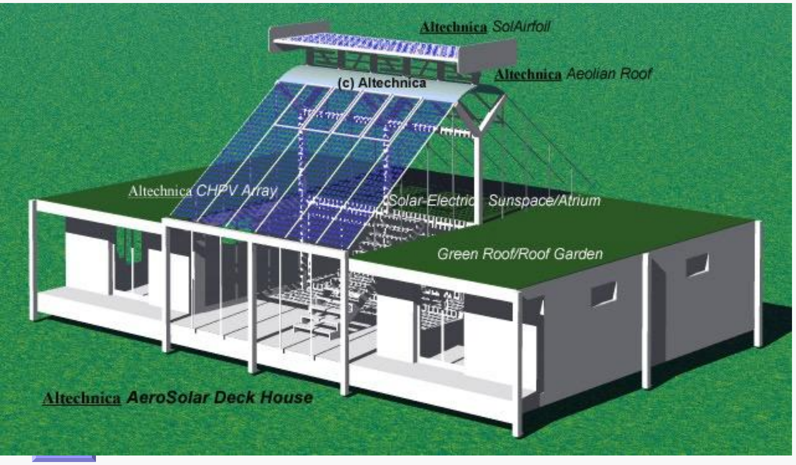


Stick + Panel™ Fabrication

- *Thin Super-insulated Walls*
- Super-Windows
- Structurally efficient
- Material efficient
- Lightweight
- Rapid fabrication
- Added thermal capacity
- Minimal foundations

CHPV for Elect. + Heat + Cool



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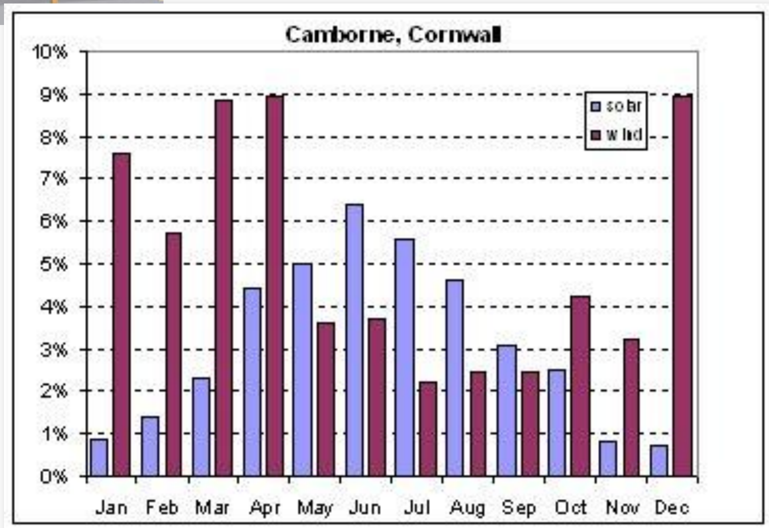
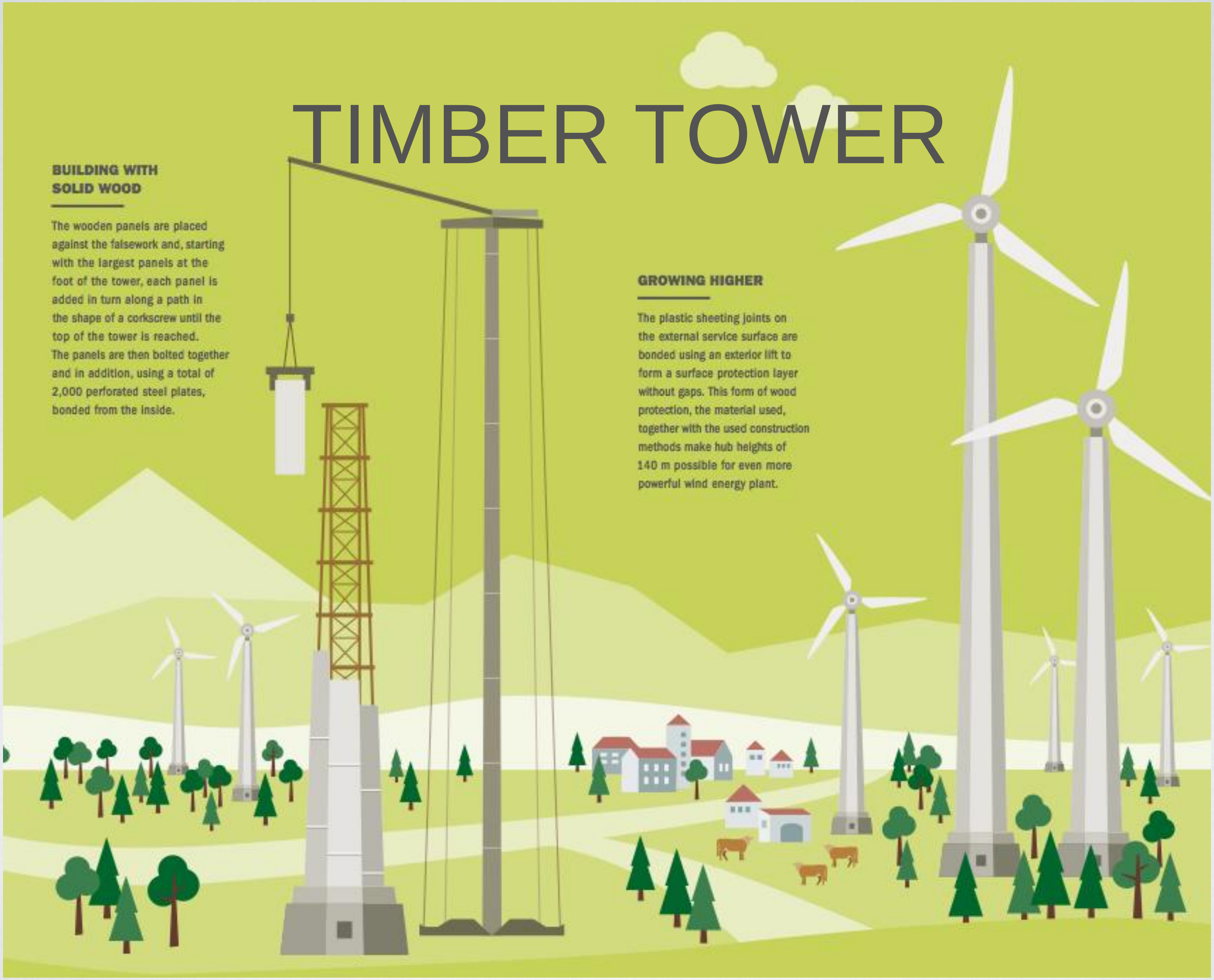
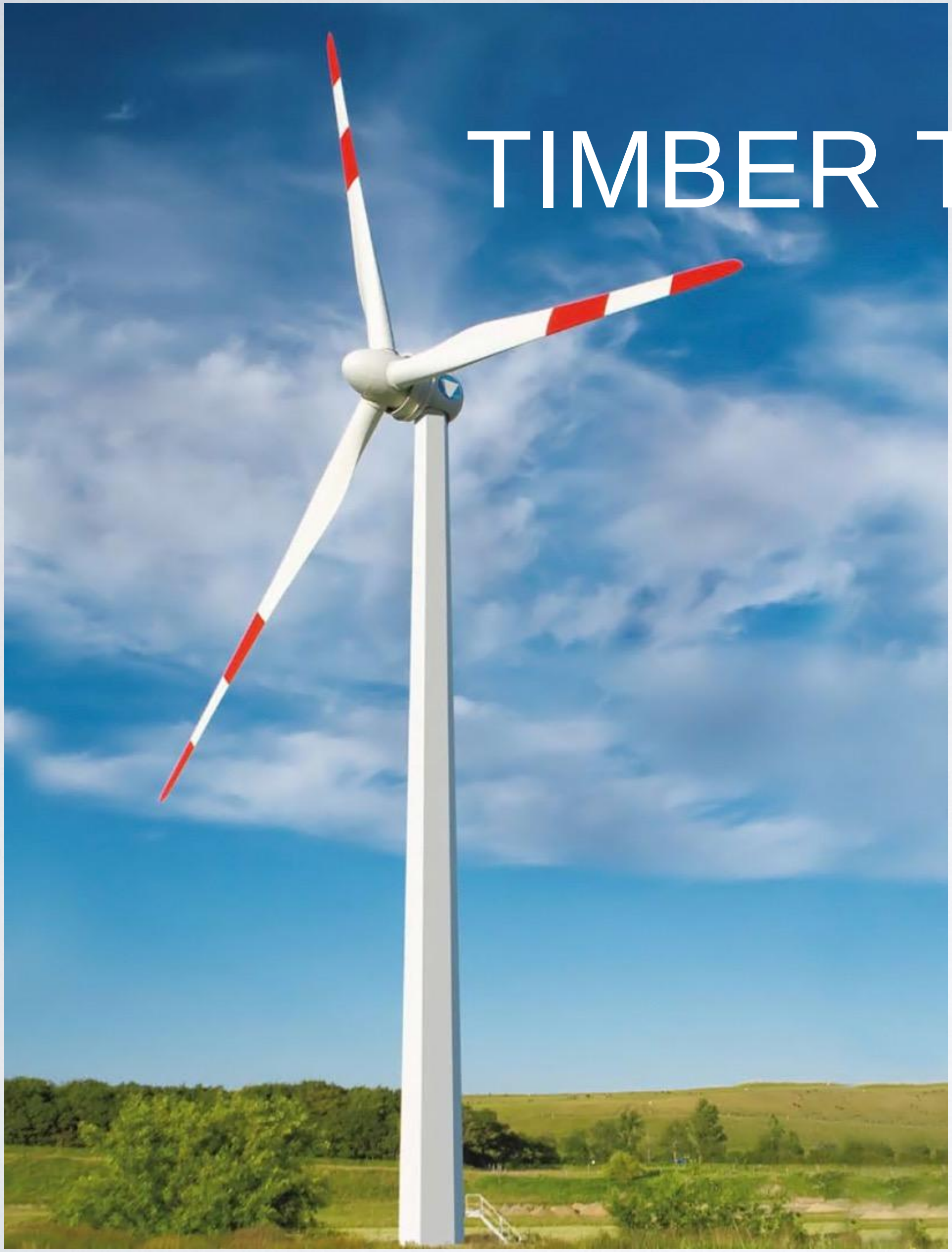


TIMBER TOWER



TIMBER TOWER



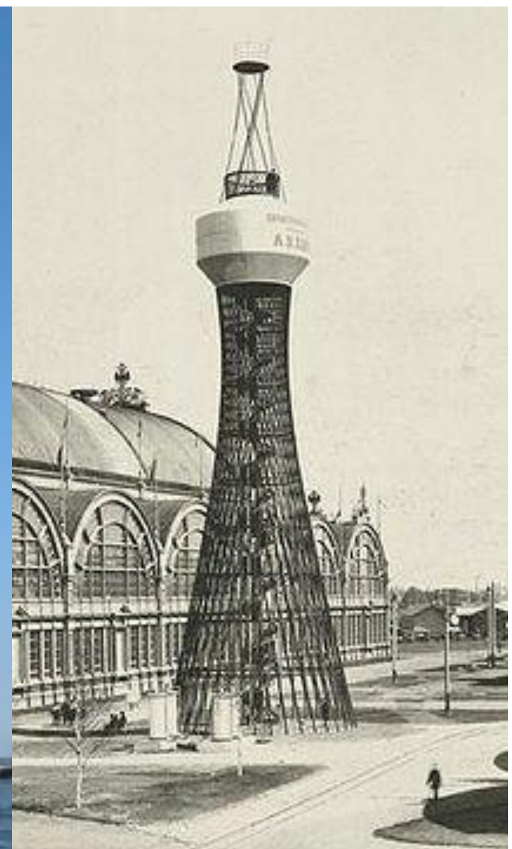
Solar Chimney Revisited

First *Solar Chimney* - Spain 1980s

AeroSolar Chimney - Wind Augmented

Altechnica design & shape of multifunctional wind+ solar chimney not shown here but based on hyperboloid grid tower & transparent collector with common features with these towers.
Designed to produce power + food + fresh water.
Can operate in deserts, arid & temperate sunny areas.

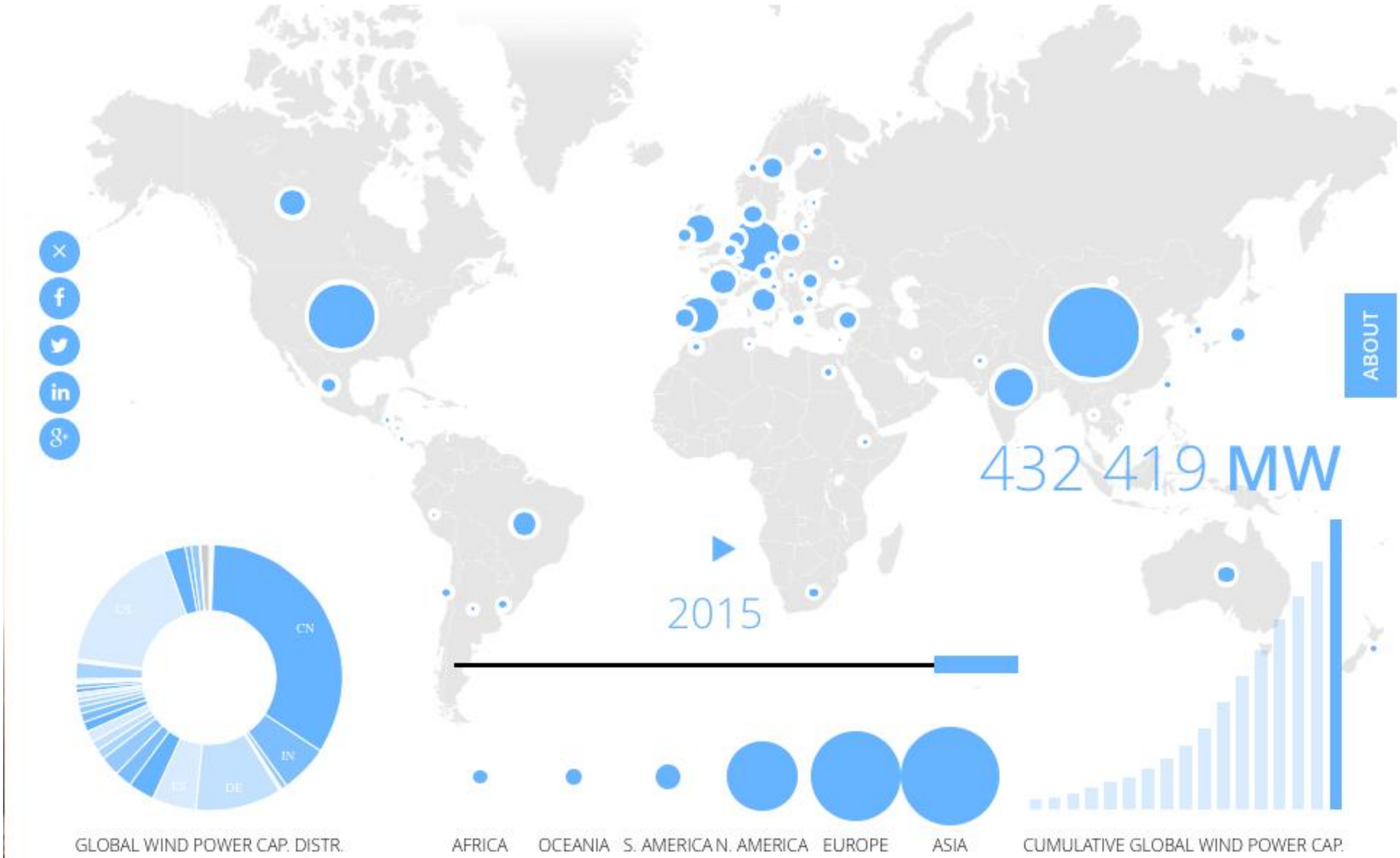
Unlike CSP etc does not need water for power



WIND IN NUMBERS

breeze

The Evolution of Wind Power



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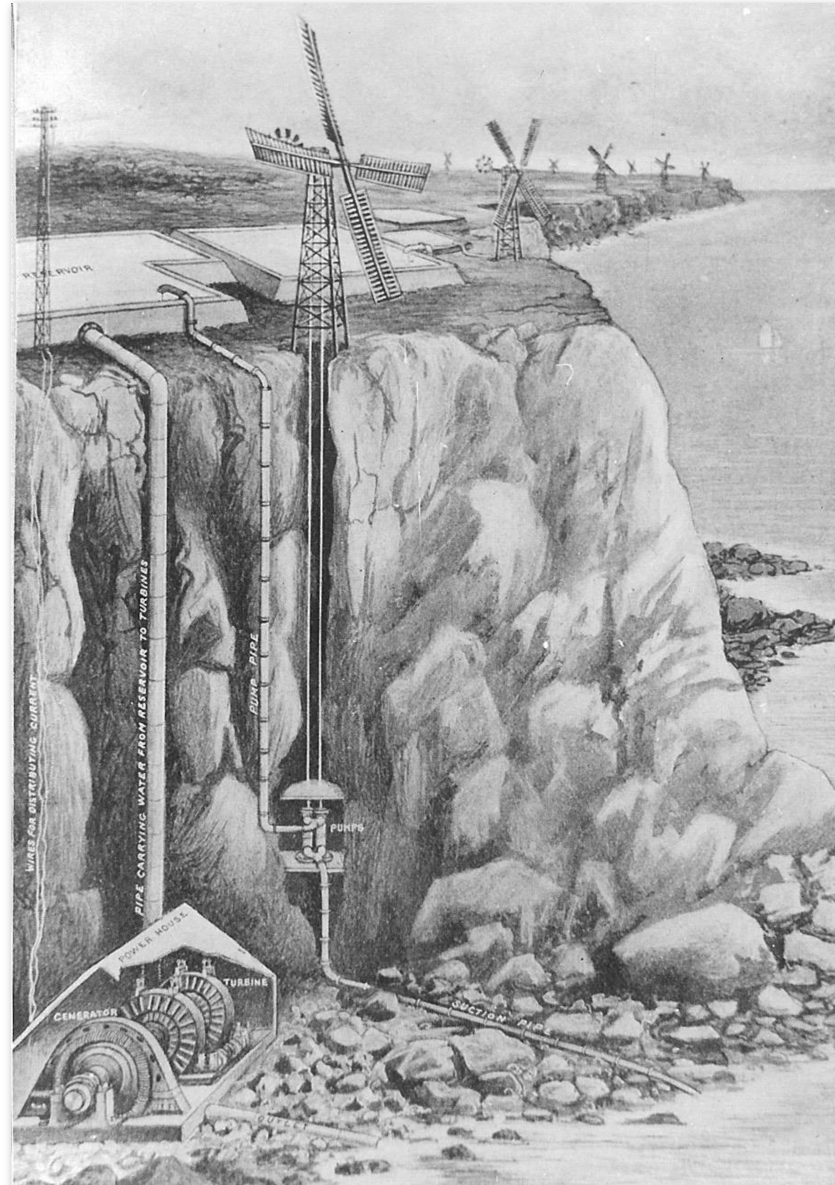
Wind Energy Storage

A number of promising options including:

- local pumped hydro
- wind-assist tidal power
- distributed H2 via eff. electrolysers
- *Power2Gas* > gas engine CHP
- Fuel Cells CHP/Trigen
- NH4 as H2 carrier
- *Power2Diesel* liquid fuels
- *Liquid Air* technologies & coolth
- Range of much more efficient batteries
- Interchange with EV/PHEVs & V2G
- Thermal stores via large heat pumps

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