

Renewable Wind Industry Challenges

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Rev - 2

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Challenges of Wind Power

Wind power must compete with other low-cost energy sources for long-term commercial viability. When comparing the cost of energy associated with new power plants, wind and solar projects are now more economically competitive than gas, geothermal, coal, or nuclear facilities. However, wind projects may not be cost-competitive in some locations that are not windy enough. Next-generation technologies, manufacturing improvements, and a better understanding of wind plant physics can help bring costs down even more.

Ideal wind sites are often in remote locations. Installation challenges must be overcome to bring electricity from wind farms to urban areas, where it is needed to meet demand. Upgrading the nation's transmission network to connect areas with abundant wind resources to population centres could significantly reduce the costs of expanding land-based wind energy. In addition, offshore wind energy transmission and grid interconnection capabilities are improving.

Turbines produce noise and alter visual aesthetics. Wind farms have different impacts on the environment compared to conventional power plants, but similar concerns exist over both the noise produced by the turbine blades and the visual impacts on the landscape.

Wind farms can impact local wildlife. Although wind projects rank lower than other energy developments in terms of wildlife impacts, research is still needed to minimize wind-wildlife interactions. Advancements in technologies, properly siting wind plants, and ongoing environmental research are working to reduce the impact of wind turbines on wildlife. [1]

The aforementioned challenges are the generally acknowledged ones currently facing the renewable wind industry.

However, there are a number of major problems that would appear to have either gone unnoticed or have been minimised by various bodies, and although they are covered under sections 1, 6, 9 & 10, it is worthwhile bringing them to the forefront of this document due to their gravity, as they could have apocalyptic consequences.

Despite what governments and various other bodies may think or say, current independent projections show that renewable wind, using current Wind Turbine designs will comprehensively fail to achieve the 2030/2050 global renewable wind energy targets.

**SOME RADICAL RETHINKING IS REQUIRED
and
WINDSTORM HAS RESPONDED**



Challenges and Ownership

Challenge	Owner
1. Increased Power Output	Turbine Supplier
2. Increased Turbine Size	Turbine Supplier
3. Increased CAPEX Costs	Turbine Supplier
4. Increased OPEX Costs	T/S & Wind Farm
5. Increased Maintenance Costs	T/S & Wind Farm
6. Increased Footprint	T/S & Wind Farm
7. Carbon Emission Reduction	T/S & Wind Farm
8. LCOE Reduction	T/S & Wind Farm
9. Turbine Build Capacity	Turbine Supplier
10. Wind Farm Site Capacity	Wind Farm
11. Wind Cut-In Speeds	T/S & Wind Farm
12. Increased Infrastructure	T/S & Wind Farm
13. Increased Radar Interference	T/S & Wind Farm
14. Increased Danger to Birds & Bats	T/S & Wind Farm
15. Increased Shadow Flicker	T/S & Wind Farm
16. Increased De-Forestation	T/S & Wind Farm
17. Increased Land Disturbance	T/S & Wind Farm
18. Increased Health & Safety	T/S & Wind Farm
19. Increased Noise Level	T/S & Wind Farm
20. Increased Visual Impact	T/S & Wind Farm
21. End-Of-Life	T/S & Wind Farm

1. Increased Power Capacity

Carbon emission reduction is one of our world's biggest challenges, but to achieve net zero emissions by 2050, global renewable wind capacity needs to increase from c.837 GW (2022) to c. 5900 GW. [2], [3]

Current Situation:

- ❑ DNV predicts capacity growing to 1 TW (2022), 2 TW (2029), 4 TW (2043) and 5.9 TW (2050). [2]
- ❑ At 837 GW (2022), wind energy is 163 GW (16.3%) below the 1 TW of growth requirement. [3]
- ❑ Growth required is c.140 GW/yr over next 20 years, then c.270 GW/yr over last 7 years
- ❑ C.94 GW installed in 2022 [4] = 46 GW (32.86%) below required growth of 140 GW/yr
- ❑ Turbines required = c.14,000/yr @ 10 MW for 20yr, then 27,000/yr @ 10 MW for 7yr
- ❑ Does not include any turbines at EOL requiring repowering. At 2030, c.2 TW near EOL

Issues:

- ❖ Currently, using standard Horizontal Axis Wind Turbines (HAWTs) we will have less than two-thirds of the wind energy capacity required by 2030. [3]
- ❖ Current growth needs to quadruple by the end of the decade to meet net zero 2050 targets. [3]
- ❖ End-of-Life requirements also need to be factored into the overall capacity projections

Challenges:

- To achieve both 2030/50 targets a seriously significant increase in the level of output from all of the turbine manufacturers is required, and required NOW
- Vastly increased capital investment on larger production facilities required
- Larger and more sophisticated parts result in longer lead times
- Larger and more sophisticated parts result in much slower production output

Windstorm Solution:

- ✓ Windstorm is using a bespoke Vertical Axis Wind Turbine (VAWT) system which is much smaller, modular, simpler and cheaper to build and install with much shorter lead times and faster production times
- ✓ The faster production times will allow the Windstorm system to better achieve the 2030 & 2050 targets

2. Increased Turbine Size

In response to the global demand for more clean energy, wind turbines have to produce more power, and since the early 2000s, wind turbines have grown in size, both in height and blade lengths, thus generating more energy.

Current Situation:

- ❑ Wind turbine power is limited by the Betz law, i.e., no turbine can capture more than 59.26% of the kinetic energy in wind, and is governed by the equation $P=0.5\rho C_p A V^3$
- ❑ HAWTs have increased their power output simply by using longer blades, hence increasing the swept area (A), but with much higher cut-in speed due to higher rotational inertia
- ❑ Turbine columns have had to increase in height to allow for these longer blades, thus also allowing access to higher wind speeds (V)
- ❑ As a result, wind turbines are just getting bigger and bigger, until a time comes when there wouldn't be enough extractable wind power (again due to higher inertia), at whatever height, that adequate power generation can be achieved

Issues:

- ❖ These large jumps in size will become slower as the structural limits of current blade technology are reached. [4]
- ❖ Increasingly large offshore wind turbines may not be adequately supported by their foundations. [38]
- ❖ Engineers currently rely on design codes borrowed from the oil and gas industry to determine the geometry and material properties of foundations. [38]
- ❖ Although the ever increasing size produces more power, it also brings many of its own challenges

Challenges:

- If the blade length is doubled, the mass increases eight times, but the stiffness increases just four times. When designing a big blade to ensure durability you effectively need to start from scratch and design a totally new geometric. [37]
- The larger the blade, the more important it is to focus on the weight, in order to reduce the stresses on the turbine during operation. [37]
- Wind imposed on such a large wind turbine may generate dominant design loads and significant vibrations, which may lead to damage and failure
- The biggest concern for offshore wind turbines is lateral loading and overturning moments - so the forces that try and topple the structure over - as opposed to the vertical deadweight forces that need to be designed against for oil and gas platforms. [38]

Windstorm Solution:

- ✓ Windstorm blades are of a simpler design and are more easily manufactured
- ✓ The system does not need to increase in size to achieve comparable power outputs as we are significantly increasing power output with the same sized turbine
- ✓ It is much smaller in height and diameter, so much less likely to suffer from structural failures, as compared to the large HAWTs

3. Increased CAPEX Costs

The dramatically falling costs of renewables are now a political, a media, and conversational cliché. However, the claim is demonstrably false. Audited accounts show that far from getting cheaper, wind power is actually becoming more expensive. [4]

Current Situation:

- ❑ The actual costs of onshore and offshore wind generation have not fallen significantly over the last two decades and there is little prospect that they will fall significantly in the next five or even ten years. [4]
- ❑ Far from falling, the actual capital costs per MW of capacity to build new wind farms increased substantially from 2002 to about 2015 and have, at best, remained constant. [4]
- ❑ With the ever increasing size, complexity of design, manufacturing and installation, as well as the increased infrastructure involved in installing these new turbines, costs are inevitably increasing

Issues:

- ❖ There is now a consensus that rising prices of materials such as steel and copper will have to be passed on to customers, driven in part by the war in Ukraine. [4]
- ❖ All new infrastructure investments including renewable generation will be subject to higher costs and possible supply chain disruptions. [4]

Challenges:

- Secure material supply if possible to stabilise raw material costs
- Simplify design and manufacture
- Reduce infrastructure costs

Windstorm Solution:

- ✓ This system will also be affected by rising prices, etc, but being much smaller it uses much less material, therefore costs are still comparatively cheaper than the larger HAWTs
- ✓ Windstorm is a less complex design, has less parts, is easier to manufacture, transport and installed at site
- ✓ Windstorm does not need to increase in size to achieve comparable power outputs
- ✓ Therefore costs should remain relatively stable
- ✓ Windstorm is much smaller in height and diameter, so does not incur the same infrastructure costs, as compared to the large HAWTs

4. Increased OPEX Costs

Far from falling, the operating costs per MW of new capacity have increased significantly for both onshore and offshore wind farms over the last two decades. In addition, operating costs for existing wind farms tend to increase even more rapidly as they age. [6]

Current Situation:

- ❑ The cost increase for new capacity seems to be due to the shift to sites that are more remote or difficult to service. [6]
- ❑ Much of the increase with age is due to the frequency of equipment failures and the need for preventative maintenance, both of which are strongly associated with the adoption of new generations of larger turbines – both onshore and offshore. [6]

Issues:

- ❖ Turbine manufacturers and wind operators appear to be relying on an increase in load factors via (i) an increase in hub heights to take advantage of higher wind speeds, and (ii) changes in the engineering balance between blade area and generator capacity. [6]
- ❖ However, the inferior reliability of new turbine generations leads to a more rapid decline in performance with age, so that the ultimate effect on average performance over the lifetime of new turbines is unclear. [6]
- ❖ More complex machinery and more parts

Challenges:

- Reducing the cost of energy to economically sustainable levels is the most important challenge facing the industry today. [41]
- Reduce complexity of the major parts
- Improve component reliability
- Improve system performance
- Develop appropriate condition monitoring and maintenance

Windstorm Solution:

- ✓ Windstorm has less parts
- ✓ HAWT's generally have about 16 major parts, Windstorm has about 4, all are smaller and less complex than the HAWTs, hence operation is much cheaper

5. Increased Maintenance Costs

Cutting costs by preventing failure instead of running wind turbines until they break, lies at the heart of a new approach to operations and maintenance. Robust operational data remains a relatively scarce commodity, and even expert technicians have been reliant on little more than anecdotal data regarding what component is likely to fail when on which turbine, or how trouble can be averted before it happens. [7]

Current Situation:

- ❑ Two components of the cost of operation and maintenance (O&M) of wind turbines are vitally important and need to be minimised - scheduled and unscheduled maintenance. [7]
- ❑ If component failures lead to unscheduled stoppages, then the additional cost of loss of electricity sales is introduced. That is why considerable efforts are being made to control and forecast such failures. [7]
- ❑ There are three ways of expressing O&M costs. The simplest way is to assume that the total annual charges represent a percentage of the installed cost, often quoted between 3% and 5%. [7]

Issues:

- ❖ The inexactitude of the science of calculating O&M costs begins with the variety of ingredients that make up the whole, in addition to scheduled and unscheduled maintenance. [7]

Challenges:

- Reduce complexity of the major parts
- Improve component reliability
- Improve system performance
- Develop appropriate condition monitoring and maintenance

Windstorm Solution:

- ✓ Windstorm has less complex parts
- ✓ HAWT's generally have about 16 major parts, Windstorm has about 4, all are smaller and less complex than the HAWTs, hence maintenance is simpler, faster and much cheaper
- ✓ Windstorm has all it's parts either on or within 16m of the ground, making maintenance much safer

6. Increased Footprint

Turbines extract energy from the wind and create an area of turbulence in the immediate area. Wind turbines that are spaced too closely will be less efficient, as they'll create erratic wind patterns, and there will be less kinetic energy available overall. Therefore, wind turbine spacing is a crucial aspect of planning a wind farm. But it's not all about efficiency. Wind turbines placed too close to one another can have several other adverse effects. The turbulence will cause the turbines to oscillate, increasing the wear and tear on the internal machinery, and thus reducing their lifespans. Crowded wind farms also make more noise, which can bother nearby residents. [8]

Current Situation:

- ❑ The ideal ratio for wind turbine spacing up and down stream, should be at least seven rotor diameters apart. This allows for ample space for turbulence to dissipate and wind speeds to recover. [8]
- ❑ Wind turbines laid out side-by-side can be closer together and should be at least three rotor diameters apart. These suggestions are the bare minimum. The more space between turbines, the better. [8]

Issues:

- ❖ Studies in onshore wind farms NREL researchers found a rough average of 4 MW / km². [9]
- ❖ Studies in European sea regions conclude that the capacity density is between 5 – 5.4 MW/km². [10]
- ❖ The simple fact is that due to the ever increasing length of rotor blades; required to increase the power output of the turbines, the distances between each turbine will have to increase

Challenges:

- Larger turbines mean larger footprints, but there is a limit to the amount of suitable land and sea available for wind farms
- By 2030, onshore requires 63,250 km², C.81.2% of area of Scotland [9], [17]
- By 2050, onshore requires 140,000 km², C.179.6% of area of Scotland [9], [17]
- By 2030, offshore requires <14,000 km², C.6.1% of available area of North Sea [10], [17]
- By 2050, offshore requires <76,000 km², C.33.33% of available area of North Sea [10], [17]

Windstorm Solution:

- ✓ The Windstorm (3 MW) system has a diameter of C.24m, which means the separation between each unit is very much smaller when compared to a 3MW HAWT
- ✓ The Whitelees wind farm near Glasgow covers C.55 km², has 215 turbines and produces 539 MW
- ✓ To produce the same amount of power, the Windstorm systems would require an area of less than 1% of 55 km² = < 0.55 km²

7. Carbon Emission Reduction

Carbon emission reduction is one of our world's biggest challenges, and reducing carbon emissions to levels consistent with the stabilization of greenhouse gas concentrations in the atmosphere will require enormous amounts of clean energy supplies to displace current fossil fuel combustion. Renewable energy supplies are one source of such clean energy. [11]

Current Situation:

- ❑ Building and erecting wind turbines requires hundreds of tons of materials — steel, concrete, fiberglass, copper, and more exotic materials like neodymium and dysprosium used in permanent magnets. All of it has a carbon footprint. [12]
- ❑ The construction process produces nearly 80% of a turbine's emissions. [12]

Issues:

- ❖ The steel tower makes up 30% of the carbon impact. [12]
- ❖ The concrete foundations account for 17%. [12]
- ❖ The carbon fibre and fiberglass blades account for 12%. [12]
- ❖ The transportation of materials and turbines additionally creates a sustainability challenge, generating 29% of all greenhouse gas emissions. [13]
- ❖ Over time, when combined with production pollution, turbines can generate a large carbon footprint. [13]

Challenges:

- As HAWTs get larger, so to the increase in carbon emissions from the resultant production processes of the larger and more complex components

Windstorm Solution:

- ✓ The 3 MW Windstorm system does not need to increase in size to achieve comparable power outputs, thus emissions from production are not increasing
- ✓ Windstorm is much smaller in height and diameter and so requires less material as compared to the large HAWTs
- ✓ HAWT's generally have about 16 major parts, Windstorm has about 4, all are smaller and less complex than the HAWTs, hence emissions from production are at least C.25% less than the larger HAWTs
- ✓ Carbon emissions from a 3 MW (onshore) HAWT with an average load factor of 33.3%, could produce C.40.6 Tonnes/Yr [43], a 3 MW Windstorm system could produce C.10.15 Tonnes/Yr

8. Levelised Cost Of Electricity (LCOE)

The Levelized Cost of Electricity or Energy (LCOE), is the sum of all the costs over a lifetime divided by the sum of all the revenue from the electricity produced over a lifetime. [14]

The LCOE is one way of determining whether or not a firm will build a project because if the project will not break even, then it will not be built. [15]

It includes the following:

Current Situation:

- Fuel expenditures for the year. [15]
- Electrical output for the year. [15]
- Discount rate. [15]
- The expected lifetime of the power system. [15]

Issues:

- ❖ Investment and Expenditures for the year. [15]
- ❖ Operational and Maintenance expenditures for the year. [15]

Challenges:

- The main challenge facing the offshore wind systems is the high Capex costs initially and then the high Opex cost during the service lifetime, resulting in a high Levelized Cost of Energy (LCOE). [42]
- In order to reduce the LCOE the capital cost of the wind turbine, structure and mooring systems will require to be considerably reduced. [42]

Windstorm Solution:

- ✓ As the CAPEX and OPEX costs will be much smaller than the larger HAWTs, the LCOE will be lower

9. Turbine Build Capacity

To achieve net zero emissions by 2050, global renewable wind capacity needs to increase from c.837 GW (2022) to c. 5,900 GW. [2]

Current Situation:

- ❑ DNV predicts capacity growing to 1 TW (2022), 2 TW (2029), 4 TW (2043) and 5.9 TW (2050). [2]
- ❑ Growth required is $5,900 - 837 = 5,163$ GW over 28 years
- ❑ Average annual growth required is $5,163 / 28 = \text{C.}184.4$ GW per year

Issues:

- ❖ C.94 GW installed in 2022 is c.90.4 GW (50.98%) below required growth of 184.4 GW/yr
- ❖ 2030 projection with current installation of C.94 GW/yr = C.1,589 GW, a shortfall of C.596 GW from C.2,185 GW (2030) target. Does not include any EOL pre 2010 turbines of C.200 GW. [16]
- ❖ 2030 shortfall is now projected to be C.796 GW
- ❖ 2050 projection with current installation of C.94 GW/yr = C.3,469 GW, a shortfall of C.2,431 GW from C.5,900 GW target. Does not include any EOL pre 2030 turbines of between 1,589 - 2,185 GW. [2]
- ❖ 2050 shortfall is now projected to be between 4,020 – 4,616 GW

Challenges:

- Current installation capacity is far short (C.49%) of the required target of 184.4 GW/yr
- Including EOL, we will have just less than 25% of the wind energy capacity required by 2030
- Including EOL, we will have just over 25% of the wind energy capacity required by 2050
- Current growth needs to quadruple by the end of the decade to meet net zero 2030 & 2050 targets. [3]
- To achieve both 2030/50 targets a seriously significant increase in the level of output from all of the turbine manufacturers is required, and required NOW

Windstorm Solution:

- ✓ HAWT's generally have about 16 major parts, Windstorm has about 4, all are smaller and less complex than the HAWTs, hence production is less complex and faster
- ✓ Windstorm is using a bespoke Vertical Axis Wind Turbine (VAWT) system which is much smaller, modular, less complex and more cost effective to build and install with much shorter lead times and faster production times
- ✓ The faster production times will allow the Windstorm system to better achieve the 2030 & 2050 targets

10. Wind Farm Site Capacity

Wind turbines create an area of turbulence in the immediate area, and if they are spaced too closely will be less efficient, as they'll create erratic wind patterns, and there will be less kinetic energy available overall. There are also various government site restrictions controlling the size and location, both on land and sea.

With a congested North Sea and the developments that can be seen on the horizon, Marine Spacial Planning (MSP) zones were implemented; basically "exclusion zones" that exist either for environmental reasons or because space is set aside for fishing, shipping and military activity. In at least 60% of the North Sea, it is not possible to build offshore wind farms today. [39]

Current Situation:

- ✓ In onshore wind farms NREL researchers found a rough average of 4 MW / km². [9]
- ✓ In offshore European sea regions studies show the capacity density is between 5 – 5.4 MW/km². [10]
- ✓ By 2030, the European Basin requires 253 GW (onshore) and 70 GW (offshore). [17]
- ✓ By 2050, the European Basin requires 560 GW (onshore) and 380 GW (offshore). [17]

Issues:

- ❖ By 2030, 253 GW equates to 63,250 km² (onshore) and 70 GW equates to between 11,667 – 14,000 km² (offshore)
- ❖ By 2050, 560 GW equates to 140,000 km² (onshore), 380 GW equates to 63,333 – 76,000 km² (offshore)

Challenges:

- Scotland covers C.77,933 km²
- By 2030, onshore requires 63,250 km², C.81.2% of area of Scotland (example)
- By 2050, onshore requires 140,000 km², C.179.6% of area of Scotland (example)
- North Sea covers C.570,000 km², approximately only C.40% is available to build wind farms, i.e., 228,000 km²
- By 2030, offshore requires <14,000 km², C.6.1% of available area of North Sea
- By 2050, offshore requires <76,000 km², C.33.33% of available area of North Sea

Windstorm Solution:

- ✓ As mentioned, the Windstorm systems would require an area of less than 1% of the HAWT wind farms.
- ✓ By 2030, Windstorm would free up C.62,617 km² of otherwise required land area
- ✓ By 2050, Windstorm would free up C.138,600 km² of otherwise required land area
- ✓ By 2030, Windstorm would free up C.13,860 km² of otherwise required North Sea
- ✓ By 2050, Windstorm would free up C.75,240 km² of otherwise required North Sea

11. Wind Cut-In Speeds

The cut-in speed is the wind speed required for a particular wind turbine to begin to generate electric power. The start-up speed is the wind speed at which the wind turbine blades will begin to rotate. The cut-in speed is always greater than the start-up speed.

A low start-up speed does very little to enhance the overall electric production of a wind turbine. A lower cut-in speed, however, can greatly increase electrical output in the long run by providing electrical power in a wider range of speeds. [18]

Current Situation:

- ❑ Average cut-in speed of a commercial HAWT is between 3.5m/s to 5m/s
- ❑ Average cut-in speed of a commercial VAWT is between 1.9m/s to 4m/s

Issues:

- ❖ UK average wind speed within cut-in speed range of 3.5 - 5m/s is C.44% of available wind [42]
- ❖ UK average wind speed above upper cut-in speed of 5m/s is C.56% of available wind [42]

Challenges:

- Best scenario is for the average wind speed to increase such as to give 100 % of turbine availability, which is not really possible with commercial HAWTs
- We have to produce more power from the actual available wind speeds

Windstorm Solution:

- ✓ The Windstorm system would be at the lower end of the commercial VAWT cut-in speed, i.e., 1.9 – 2m/s
- ✓ UK average wind speed now above the cut-in speed of C.2 m/s is now 100% of available wind [42]

12. Increased Infrastructure

In their continual quest to provide more cost effective power from larger wind turbines, both onshore and offshore wind farms are creating growing problems within their respective wind sector infrastructures.

Current Situation:

- ❑ This ever increasing turbine size requires larger and heavier foundations, and is directly responsible for the mounting issues for turbine build, delivery and installation in the wind farm, both onshore and offshore

Issues:

- ❖ Increased civil works, e.g., site surveys, access roads, foundations and drainage
- ❖ Transportation access difficulties through small towns
- ❖ Traffic disruption via roads and through aforesaid small towns
- ❖ Insufficient docks with suitable deep water, access and facilities

Challenges:

- Operating vessels require retrofit, and new ones built with increased lifting capabilities
- Greater deck space is required to ensure economic transportation and installation costs
- As projects continue to move into deeper waters, required lifting heights and crane capacities are also projected to increase
- Suitable ports will need expansion of their land area, quay reinforcement, storage for components, carrying capacity, cranes and other retrofits to host mass production of offshore and other turbine components

Windstorm Solution:

- ✓ The smaller dimensions of the Windstorm system, allows it to be transported to site or dock on a low loader
- ✓ Due to the helical screw piles, 1,000 tonnes of concrete per base is not required
- ✓ There are no transportation access difficulties through small towns
- ✓ There is no traffic disruption via roads or through aforesaid small towns
- ✓ Current operating vessels will be suitable to transport the Windstorm units
- ✓ Current dock facilities should be capable of loading the Windstorm system

13. Increased Radar Interference

Are wind farms an issue for radar systems? The UK Ministry of Defence (MOD) still seem to think so, and they haven't found a solution for the problem yet as they have released a call for further ideas to 'reduce and remove impact wind-farms have' on the air defence of the UK. [19]

Current Situation:

- ❑ Given that there is a drive for increased energy provision through sustainable sources, the balance of defence versus renewable energy growth is a delicate one if there are the problems that the research call seems to imply. [19]

Issues:

- ❖ Recent trials have shown that the moving turbine blades of a windfarm actually mimic the radar signature of fast moving aircraft, thus creating a background against which it is no longer possible to detect 'incoming, low flying, aircraft threats.' [19]
- ❖ Wind turbine blades have extremely large radar signatures, especially when grouped in a farm, and their movement creates doppler effects. [20]
- ❖ Reflection of the radar signal by one or more turbines – causes radar clutter for primary radar or bearing errors for secondary radar. [21]
- ❖ Shadowing reduces the radar's ability to detect aircraft beyond the wind farm. [21]

Challenges:

- Reflection impacts can be minimised by reducing turbine numbers and height. [21]
- Shadowing can be reduced by reducing turbine height. [21]

Windstorm Solution:

- ✓ The Windstorm system turbine blades are internal and therefore do not constitute any issue for aviation radar
- ✓ The smaller height of the Windstorm units negate both reflection and shadowing effects

14. Increased Danger to Birds & Bats

It's estimated that tens to hundreds of thousands die at wind turbines each year in North America alone. Unfortunately, it's not yet clear why this is happening. It's possible that wind turbines interfere with seasonal migration and mating patterns in some species of bats. [21]

Current Situation:

- ❑ In a recent Energy Science study, researchers found "no significant impact" from wind turbines as long as they were located 1,600 meters (about 1 mile) away from high-density bird habitats. [23]

Issues:

- ❖ Environmental assessments are now a key part of planning new wind farms, to assess bird and bat activity before deciding on turbine sites. [23]
- ❖ Most wind turbines are painted white or grey, an attempt to make them as visually inconspicuous as possible. But white paint can indirectly lure birds and bats, researchers found in a 2010 study, by attracting the winged insects they hunt. [23]

Challenges:

- Since bats use echolocation to navigate, sound might offer a way to repel them from wind farms. Ultrasonic "boom boxes," attached to turbines can emit continuous, high-frequency sounds between 20 and 100 kilohertz. [23]
- Researchers found that just making the turbines taller and the blades shorter reduces the impact on birds. [23]

Windstorm Solution:

- ✓ TRL5 field trials demonstrated that there were no deaths of birds or bats, either below or in the close vicinity of the Windstorm unit under test
- ✓ The Windstorm system turbine blades are internal, whilst the external surfaces of the unit are static and clearly visible, therefore it does not constitute any threat to birds or bats

15. Increased Visual Flicker

Shadow flicker is the flickering effect caused when rotating wind turbine blades periodically cast shadows through constrained openings such as the windows of neighbouring properties.

Current Situation:

- ❑ Shadow flicker occurs when a particular combination of conditions coincide in specific locations at particular times of the day and year. [24]
- ❑ It happens when the sun is low in the sky and shines on a building from behind a turbine rotor. When this is viewed through a narrow opening it is known as shadow flicker. [24]

Issues:

- ❖ When viewed from inside an affected building, as the turbine blades rotate they cast shadows that repeatedly cause a regular, intermittent light-dark-light-dark effect as they pass a window, door or other opening, and this is referred to as Shadow Flicker. [25]
- ❖ The effect would then only be observable through any particular window in that building for a limited number of minutes per day, as the sun rises or sets. [25]
- ❖ There was some concern that the pulsating effect of the light during shadow flicker could be a risk factor to people who suffer from any form of photo-epilepsy. [25]

Challenges:

- Ensuring wind turbines / farms are sited in rural areas, far from human habitation
- Increasing population and expansion of towns and small communities are making this more difficult

Windstorm Solution:

- ✓ The Windstorm system turbine blades are internal and therefore do not cast any intermittent shadows, hence no shadow flicker
- ✓ The smaller height and design of the Windstorm unit means they cast a much smaller and solid shadow which, if close to a building would not pose any risk

16. Increased Deforestation

Deforestation is the deliberate clearing of forest lands which includes the removal of trees.

Current Situation:

- ❑ While wind turbines are a renewable source of energy, the development of onshore wind farms and especially forest wind farms cause deforestation. [26]
- ❑ Ignoring this advantage will lead to severe impacts on the environment. [26]
- ❑ Wind farms will not positively impact the environment in the long run if it means deforestation is necessary. [26]

Issues:

- ❖ Climate change. [26]
- ❖ Soil erosion. [26]
- ❖ Loss of CO₂ absorption capacity. [26]
- ❖ Emission of greenhouse gasses. [26]
- ❖ Loss of biodiversity. [26]
- ❖ Flooding. [26]
- ❖ Statistics, released by Forestry and Land Scotland, show that 13.9 million trees have been axed to make way for 21 wind farm projects since 2000. [27]
- ❖ Hundreds of thousands of acres of ancient carbon-holding peat are also being dug up. [27]

Challenges:

- Onshore wind farm NREL researchers found a rough average of 4 MW / km². [9]
- Onshore wind farm of 1 GW would require 250 km² which equates to 61,776 acres

Windstorm Solution:

- ✓ As mentioned, the Windstorm systems would require an area of less than 1% of the HAWT wind farms.
- ✓ By 2030, Windstorm would free up C.62,617 km² of otherwise required land area. [17]
- ✓ By 2050, Windstorm would free up C.138,600 km² of otherwise required land area. [17]
- ✓ The smaller dimensions of the Windstorm system mitigates the negative impact on the forest
- ✓ The smaller dimensions of the Windstorm system, also allows it to be transported to site on a low loader, hence access roads are not as intrusive
- ✓ Due to the helical screw piles, which are drilled directly into the ground, 1,000 tonnes of concrete per base is not required

17. Increased Land Disturbance

Wind turbine projects require the removal of considerable areas of upland habitat. This is cleared for turbines, construction areas and infrastructure (such as roads, drainage ditches, buildings, distribution lines, etc.).

Current Situation:

- ❑ Review of development proposals and actual sites indicates that the habitat destruction and land take, for a 16 to 53 wind turbine installation, is 6.57 to 44.16 hectares. [28]

Issues:

- ❖ The modification of natural drainage by the construction of turbine infrastructure could cause impacts over a much wider area of upland habitat. [28]
- ❖ Modification of peatland drainage by the use of ditch systems associated with wind turbine developments is likely to lead to the drying of peatlands, ultimately resulting in erosion of habitats over a wide area. [28]

Challenges:

- Research indicates that peatlands impacted by construction lose 25 to 50% of the carbon that would normally be taken up each year "and so adds significantly to the potential impacts of climate change". [28]
- Unprotected upland areas are now at risk from damage or destruction, resulting in the loss of ecosystems which maintain our wilderness areas, provide habitat for wildlife and act as natural stores of carbon stocks. [28]

Windstorm Solution:

- ✓ As mentioned, the Windstorm systems would require an area of less than 1% of the HAWT wind farms.
- ✓ By 2030, Windstorm would free up C.62,617 km² of otherwise required land area. [17]
- ✓ By 2050, Windstorm would free up C.138,600 km² of otherwise required land area. [17]
- ✓ The smaller dimensions of the Windstorm system mitigates the negative impact on the land
- ✓ The smaller dimensions of the Windstorm system, also allows it to be transported to site on a low loader/container lorry, hence access roads are not as intrusive
- ✓ Due to the helical screw piles, which are drilled directly into the ground, 1,000 tonnes of concrete per base is not required

18. Increased Health & Safety Issues

Construction, operation, maintenance and decommissioning of wind farms, be that offshore or on, present significant challenges and multiple hazards, in conditions that are often arduous and unpleasant. These have led to a number of high-profile incidents in recent years. [29]

Current Situation:

- ❑ Standards have generally improved over the past decade, as the industry matured and learned from the experience and knowledge of other sectors, be that other forms of energy generation or, in the case of offshore renewables in particular, oil and gas. [29]
- ❑ But in more recent years worrying evidence has emerged that this is tailing off, perhaps even going backwards. [29]

Issues:

- ❖ According to the industry's own figures, in 2020 the rate of lost time to injuries in UK offshore renewables was four times as high as in offshore oil and gas, itself a high hazard industry.
- ❖ While the rate in onshore renewables was far better, it was still higher than in the offshore oil industry. [29]

Challenges:

- The HSE outlined a series of concerns, including fatigue, cost reductions, training and supervision, and inspections of work equipment. [29]
- Extended working in confined spaces, electrical hazards, turbine hazards. [29]
- Fall hazards from working at extreme heights at an average of 280 feet. [29]

Windstorm Solution:

- ✓ There are no confined spaces in the Windstorm system
- ✓ The Windstorm system is 16m from ground level to top of unit, so is a lot smaller than the commercial HAWTs, hence safer
- ✓ The vast majority of the maintenance will be carried out at ground or close to ground level, making it a safer unit to maintain

19. Increased Noise Level

The two main sources of wind turbine noise are mechanical noise from components, such as gearboxes and generators, and aerodynamic noise from the blades. [30]

Current Situation:

- ❑ Wind turbines emit a relatively weak but characteristic noise. The noise is mainly generated by the movement of the blades through the air. This produces a swishing sound in rate with the rotation of the blades. [30]
- ❑ There is also the noise from the turbine machinery. Machine noise can have a tonal character which is particularly annoying. [30]

Issues:

- ❖ The greater the wind speed, the faster the blades spin, and the louder the aerodynamic noise will sound. [31]
- ❖ The loudness of the aerodynamic noise is related to how fast the tip of the blades are spinning, the size of the blades, and the wind speed. [31]

Challenges:

- The longer the blade, the faster the blade tip spins and the noisier the turbine
- VAWT's turn at comparatively lower rpm than HAWT's, thus producing less vibration and noise. [32]
- Most VAWT manufacturers quote noise levels of less than 40 dB at a distance of less than 20 ft/6m, while the few HAWT builders that offer such measurements often report 50 to 60 dB or more at much greater distances. [32]

Windstorm Solution:

- ✓ The Windstorm system is based on a VAWT, so the noise level will be lower than a HAWT
- ✓ As the Windstorm system turbine blades are internal, this will also reduce the emitted noise level

20. Increased Visual Impact

Although many of us consider wind turbines to be visually acceptable and in some cases even nice to see, how many of us would seriously like one of these placed a few hundred meters from our homes? Wind turbines can be anywhere from a few meters to a hundred meters high depending on the scale of the project. Having a wind turbine tower over their home is the last thing any resident wants. [40]

Current Situation:

- ❑ It is generally accepted that the impact of wind parks that are further away than 30km will be negligible, as the human eye will not register them in the field of view from that distance. The perceptibility of a wind farm is not just affected by distance, but also by the angle of the light, the contrast, visibility and the movement of the blades. [33]

Issues:

- ❖ Land-based wind turbines can be visually degrading for the environment, especially for those who live within the vicinity of a wind farm. [26]
- ❖ However, because beauty is usually in the eye of the beholder, this type of pollution is mainly subjective. This means that what one person finds aesthetically (dis)pleasing will differ from another. [26]

Challenges:

- To reduce the cumulative impact of wind farm development on landscape and visual amenity by the attention to the following
- The overall character of the landscape and its sensitivity to wind farms. [34]
- The siting and design of the wind farms themselves. [34]
- The way in which the landscape is experienced. [34]
- The distance between individual wind farms (or turbines). [34]
- The distance over which they are visible. [34]
- One measure that has been taken to ensure that wind turbines appear less visible is to paint them white. This is done to help them blend in with the skyline, but this is only effective when the turbines are seen from afar. [26]

Windstorm Solution:

- ✓ The Windstorm system is much smaller, therefore less visible and intrusive from a distance
- ✓ The system can be painted in a fashion to blend in with the background, i.e., camouflaged

21. End-Of-Life

Product End of Life (EOL), is when a product is retired from the market. Retirement can involve completely pulling the product from the market without replacing it or, in many cases, replacing it with a new version.

Current Situation:

- ❑ Modern wind turbines are designed to last 20 years and with proper monitoring and preventative maintenance two to three times per year (increasing with frequency as the turbine ages) their lifetime can be extended to 25 years. [35]

Issues:

- ❖ By 2030 half of all UK wind farms will be over 20 years old. Not only will the wind turbines have reached the end of their design life after 20 years, but the projects' leases, planning permission and other contracts will have been structured around this 20 year period. [36]
- ❖ Currently, old turbine blades which are non-recyclable are being consigned to landfill, which causes vast areas of land to be used solely for this potentially harmful environmental and wasteful practice

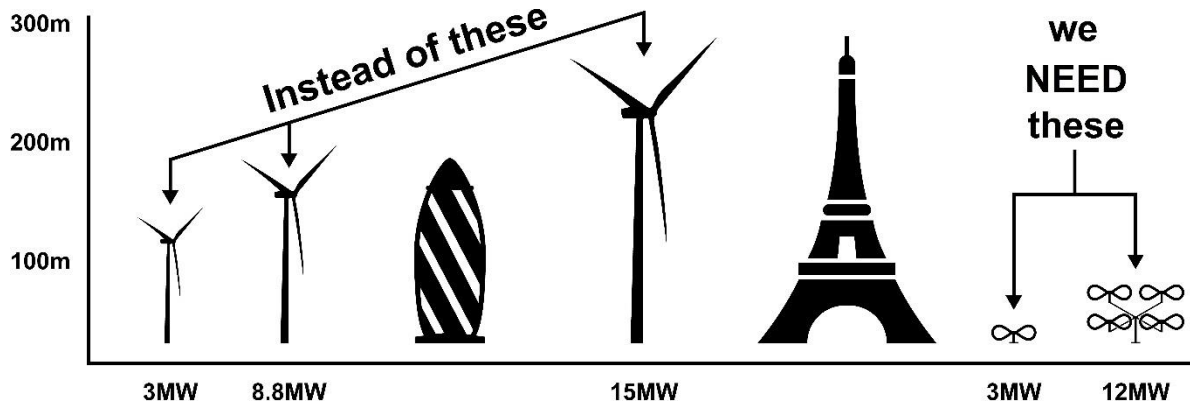
Challenges:

- Extend the life of the installation by fitting new key components into the existing equipment. [36]
- Dismantling and replacing the old equipment. [36]
- The default position will be to dismantle the installation, remediate the site and to restore it to its former use. [36]
- Eradicate use of non-recyclable materials

Windstorm Solution:

- ✓ All parts of the Windstorm system can be recycled
- ✓ Due to less parts and being smaller units, it is much easier and cheaper to refurbish the EOL unit

22. The Windstorm Solution



When the fully developed commercial Windstorm system is compared to Horizontal Axis Wind Turbines, they will be...

- Much smaller
- Less complex design
- Less complex build allowing mass production
- Less complex installation
- Comparable efficiency
- Comparable power output
- More cost effective
- Greener
- Has a lower environmental impact
- Cheaper CAPEX and OPEX

The market sectors the system can operate in...

- Onshore
- Offshore
- Sub-sea
- Marine
- Decommissioning
- Offshore O&G Assets (Powering & Conversion)
- Disaster areas
- Remote communities
- Green Hydrogen production

The Windstorm system delivers all the advantages of a commercial HAWT and more, whilst eliminating the current drawbacks.

It's a Game Changer In Wind Power.

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