## 7.1 Current state of the art

Our proposal directly affects the following 2 areas of wind turbine technology:

**Area Swept Out and Energy Generated for varying Blade Lengths:**

At present there is an aerodynamic limit on power extraction (Betz Limit) for a given area swept out. In reality there is no scope for major improvements and little scope for minor improvements in turbine efficiency for an area of sky swept. This had lead to turbine manufacturers building larger structures for more power per unit or looking for ways to reduce the costs of turbine construction and maintenance. The following 2 examples show that there is little difference in power generated per unit area swept out even when the turbines are of very different sizes:

| *Turbine* | *Blade Length* | *Area Swept Out* | *Power Rating* | *Energy Generated/m²* |
|---|---|---|---|---|
| *Enercon E-30* | *15m* | *707m²* | *300kW* | *0.42kW/m²* |
| *Enercon E-112* | *57m* | *10207m²* | *4500kW* | *0.44kW/m²* |

**Offshore Wind Generation in Depths greater than 15m**

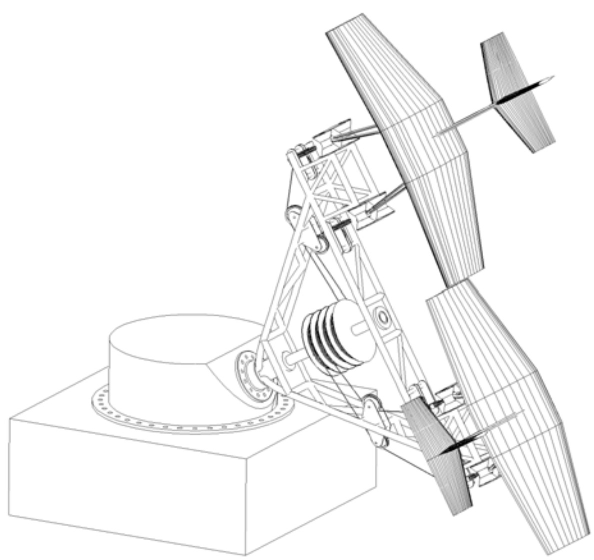
The present economic limit within the industry is approximately 15m water depth. Beyond this depth there are significant costs of putting in static piles or of adapting modern turbines to go on floating platforms. For floating turbines the problems come from having a weight on a high tower and trying to keep it from moving too much. If it does there will be problems with fatigue, basic controls and the alignment of components. To reduce this movement will require a substantial base, which at present makes it uneconomic.

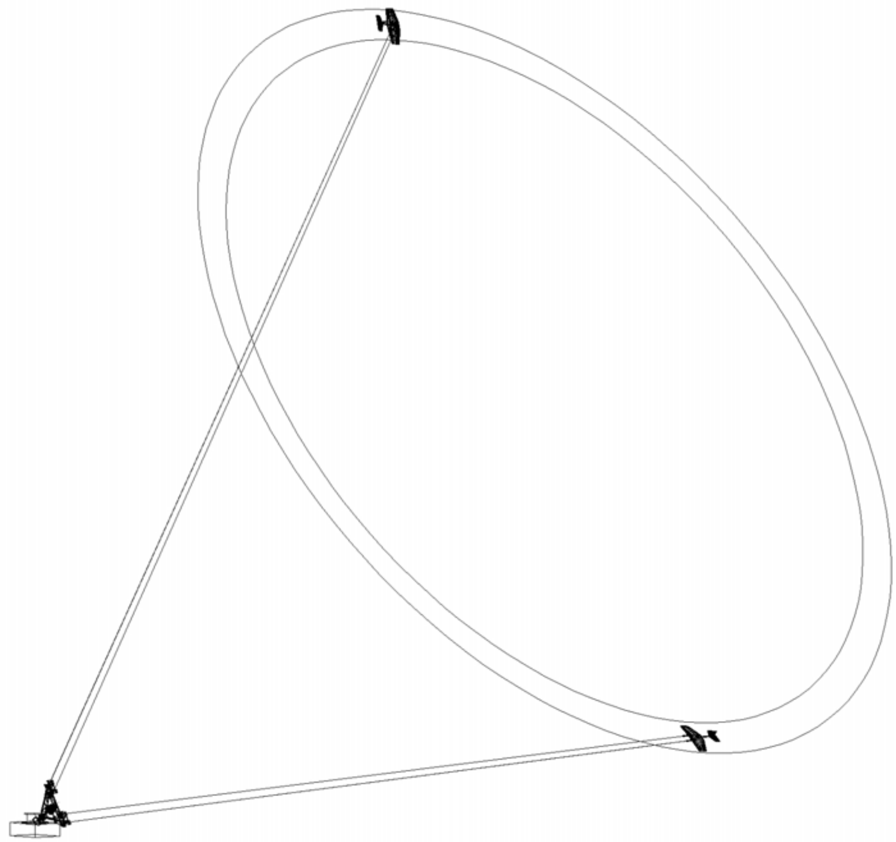
## 7.2 Technical description of the proposed innovation

**This work proposes a wind turbine utilising a dynamically supported aerodynamic rig. This has been tested with both computer modelling and small scale models.** It consists of a pair of aerodynamic wings which provide a capturing surface. Instead of the wings being firmly attached to a fixed hub, as in a traditional turbine, they will be tethered by a cable. When there are no or only light winds the wings rest upon the generator arms. As the wind increases the arms start to turn and the wings are inclined towards the centre to counter centripetal forces. Energy can be generated at this point. However as the wind picks up the wings take off and the cable plays out until the appropriate length is reached.

When generating power, the cable can be taut at an extension of several hundred metres. The wings are effectively tethered gliders and describe circles downwind of the generator. The circles are very large, so although the capturing efficiency is not as great as a normal wind turbine, the area swept out is huge.

The tension in the cables transfers the rotational energy of the flying rigs to rotational energy of a drum housed in the turbine body. This rotational energy can be used to generate electricity using conventional means.





When the wind drops the rigs are automatically wound in. This also occurs when the wind is too high. At this point it is possible to wind in the rigs to a shorter distance, at which point the power, and hence the loads, drops. The only limitations to the maximum power generated will be structural ones.

We anticipate the base unit being mounted on a floating platform. Using normal anchoring techniques it will be possible to hold the platform in position in depths of up to 75m without any problems. The oil industry anchor in depths up to 1km deep, but in the short term this is unlikely to be economic for our application.

## 7.3 Technical and economic benefits

**Increased Power per unit or Decreased cost per MW**

For a 15m blade on a 150m wire we would expect to have an area swept out of approximately 1825m². This is approximately 3 times the area that an equivalent blade on a fixed hub can sweep out. While our efficiency per unit length of blade will be lower (end losses and cable drag) we benefit from a reduced Betz limit as the solidity of the swpet disk reduces, computer modelling predicts that we should see this unit generating about three times the Power Rating of the above E-30.

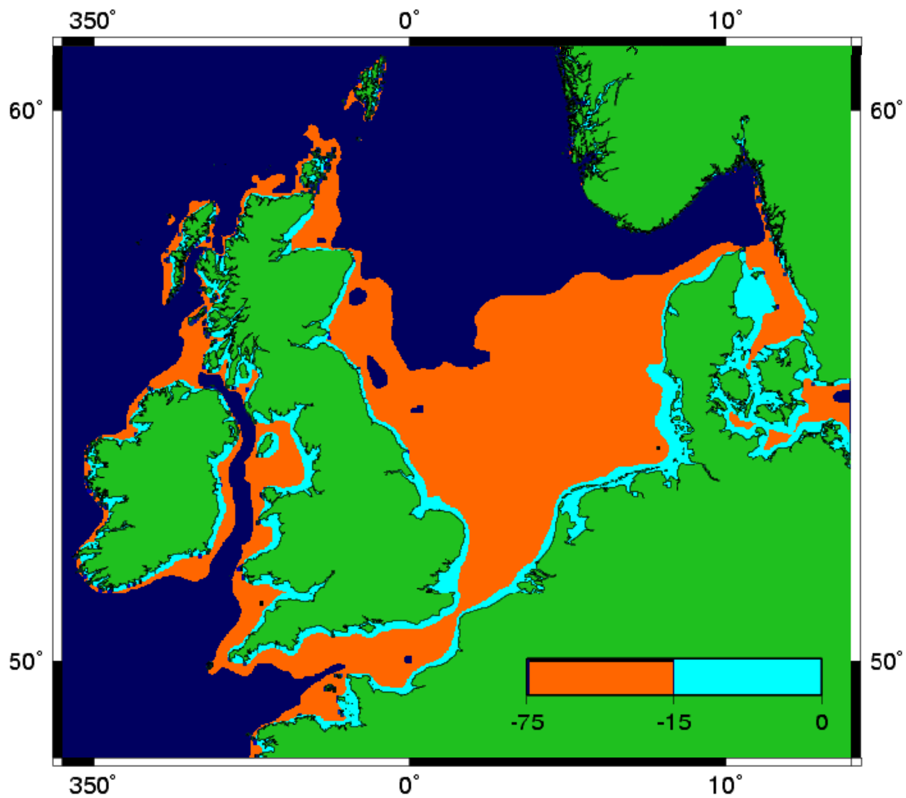
We estimate that one of our units equipped with two 15m rigs will have comparable costs to a normal turbine with 15m blades. With the greatly increased power output it will be possible to have the capital costs reduced to 1/3 of their present cost per MW. However the additional costs not related to the actual turbine will still remain.

It is not possible or necessarily realistic to give more detailed costings as the aim of this application is to produce a proof of concept and only then a pre-prototype.

**Minimal depth limitation for commercial exploitation of offshore wind.**

Our turbine can be mounted in any depth of water for virtually no cost differential apart from the cost of connection to shore. This is because our design has a very low overturning moment which means it can be mounted on a floating platform. All of the main items are at sea level so the centre of gravity is low. There is no need to keep the floating platform stable as the connecting wire and the rigs act as shock absorbers both with loads from the movement of the platform and from wind loads. For gust increase or direction variation the rigs and connecting wire can absorb these without significant transfer of loads or torques to the main structure. Consequently the cost of locating the structure will purely be the anchoring cost, which will not vary significantly with depths of up to 75m. The Chart on the next page shows how much more space will be opened up for offshore wind energy with the ability to exploit greater depths.

**Chart of Water Depths 0-15m, 15-75m and 75+m around the United Kingdom**




**Reduced cost of maintenance.**

The advantage of having a floating platform is that if repairs are required the platform can be towed back to port in a matter of hours. Repairs can be carried out swiftly and cheaply in a much less hostile environment. If there is a large storm at sea it is going to be virtually impossible to carry out repairs on a standard turbine until it passes.