2 MARCH 2012
www.rechargenews.com

The Netherlands Wind

Airborne giant could blow rivals out of the water

A 500MW high-altitude concept that could slash offshore costs is ready for small-scale testing, writes **Darius Snieckus**

Technology developer 500MW Wind Turbine has approached the operators of the Norway-to-Netherlands NorNed high-voltage direct-current (DC) subsea powerline with a view to wiring in a 1:100-scale prototype of its high-altitude generator.

The Dutch company's eponymous offshore concept is mind-boggling in size. More a power station than a machine, the 1.35km-diameter airborne turbine is made up of two vast concentric circular "flocks" of electricity-generating sail-wings designed to rotate thousands of metres up in the sky, sending electricity down hundreds of conductive tethers that double as its mooring spread.

The device, is a spin-out from civil engineer Bogey Venlo that is being developed to solve weight and cost issues faced by the wind industry as it attempts to scale turbines beyond the 10-15MW class.

"You get a limitation [as to how far you can scale up convention horizontal-axis designs] because of the forces working on the turbine — on the blades but particularly on the tower — and this is not much higher than 10MW, which is quite close already to the size we [as an industry] are designing them," says 500MW Wind Turbine director Sjef Beaujean. "So we have to look forward to what will have to be done when this limitation has been reached.

"Once you accept that high-altitude designs are the way forward, then you have to make everything lighter, and you discover that everything becomes much cheaper too. Going high in the air is technically possible and quite economic — by our calculations the fixed costs of [the 500MW Wind Turbine] will be competitive with those of present-day conventional 500MW power stations."

The 500MW sky-borne turbine is based around two arrays of 250 flexible polyamide sail-wings that are connected at either end to stationary rings (*see main picture*). Each set of sail-wings can be adjusted at a different "angle of attack", so that they are driven in opposite directions by the high-velocity winds streaming 1-2km above the Earth. This contra-rotation keeps the structure aloft in a way likened to a "hovering helicopter".

The sail-wings, which are "mechanically independent but electronically controlled", travel around the rings on a thin film of pressurised air, much like a disc on an air-hockey table, but the two arrays do not collide as they travel on separate tracks in the supporting rings.

Each sail-wing tip houses permanent magnets, which are electromagnetically charged to induce electrical energy as they move past stator coils embedded in the rings. This power is then flowed along the 2km-long high-tensile cables that tether the structure to the seabed with the help of five-metre-diameter "flat-pad" suction anchors.

"Each sail-wing's tip is like one rotor blade in a 500-blade-powered generator," says Beaujean. "At all times, for any individual coil, the effective inductivity [the electrical charge held in the magnet] is controlled. This control is used to harmonise the speed of all the wing tips and keep the induced voltage the same in all the coils [making for a smoothed output]."

Installation of the turbine would be a three-tug operation, with the two rings of sail-wings to be towed into position over the pre-installed mooring spread, where they would be mated with the cables and the floating reels that control them.

The outer ring of sail-wings would then be rotated so as to catch sea-surface winds — a minimum of five metres per second is needed — to allow the turbine to take off, with the second ring following suit. From float-out to switch-on, the operation is expected to take two weeks.

Ascent would be piloted by a sensor-driven, computerised control system, with the reel motors maintaining tension in the tethers. Once aloft, the two rings would be set in contra-rotation to begin power production.

The tether-and-reel structures would be under 500 tonnes of pull when in operation. Descent would be guided by adjustment to the angle of the sail-wings and activation of the reel motors.

The economics of this design point to "a cost of energy that is very low", says Beaujean, with early calculations suggesting one 500MW device could be built for the same price as a conventional three-bladed 5MW offshore machine.

The company is in negotiations with several third-party certification bodies to have them verify the 500MW Wind Turbine's energy-production modelling data.

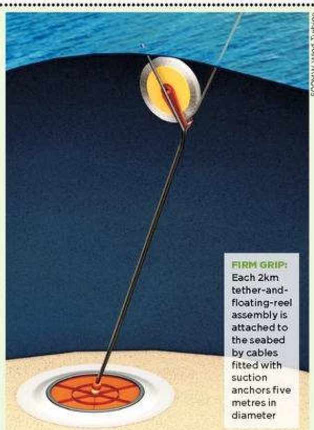
A first 5MW prototype is envisaged for hook-up to NorNed, the 580km 700MW underwater power cable connecting the Norwegian and Dutch grids (*see panel, right*). The concept will then be scaled up to a 25MW model, and then 50MW, before a full-size 500MW turbine is built.

"To test [our concept] we want to go offshore, and once you go offshore the major part of the cost is the connection to the mainland. If you have the cable in place — such as the NorNed — that part of the equation is sorted out. We are in discussions and we feel connection would be possible at a reasonable sum."

The long-term vision is impressive: by Beaujean's figuring, 3,200 of the devices dotted around the world could meet 20% of global electricity needs.

"Ultimately, the only solution in scaling up wind-power systems to hundreds of megawatts is to leave out the heavyweight parts — the blades and the tower, which are also the most expensive parts — and look at low-mass kite-sail ideas. We need a revolution in wind turbine design. High altitude must be the future."

> "Ultimately, the only solution to scaling up wind-power systems is to leave out the heavyweight parts — the blades and the tower"
>
> SJEF BEAUJEAN



500MW Wind Turbine

FIRM GRIP: Each 2km tether-and-floating-reel assembly is attached to the seabed by cables fitted with suction anchors five metres in diameter

How the turbine produces power

The 500MW Wind Turbine works as a giant permanent-magnet generator complex based around two vast polyamide "belts", one, for the outer ring, 3.8km long, and the other, for the inner ring (3.04km).

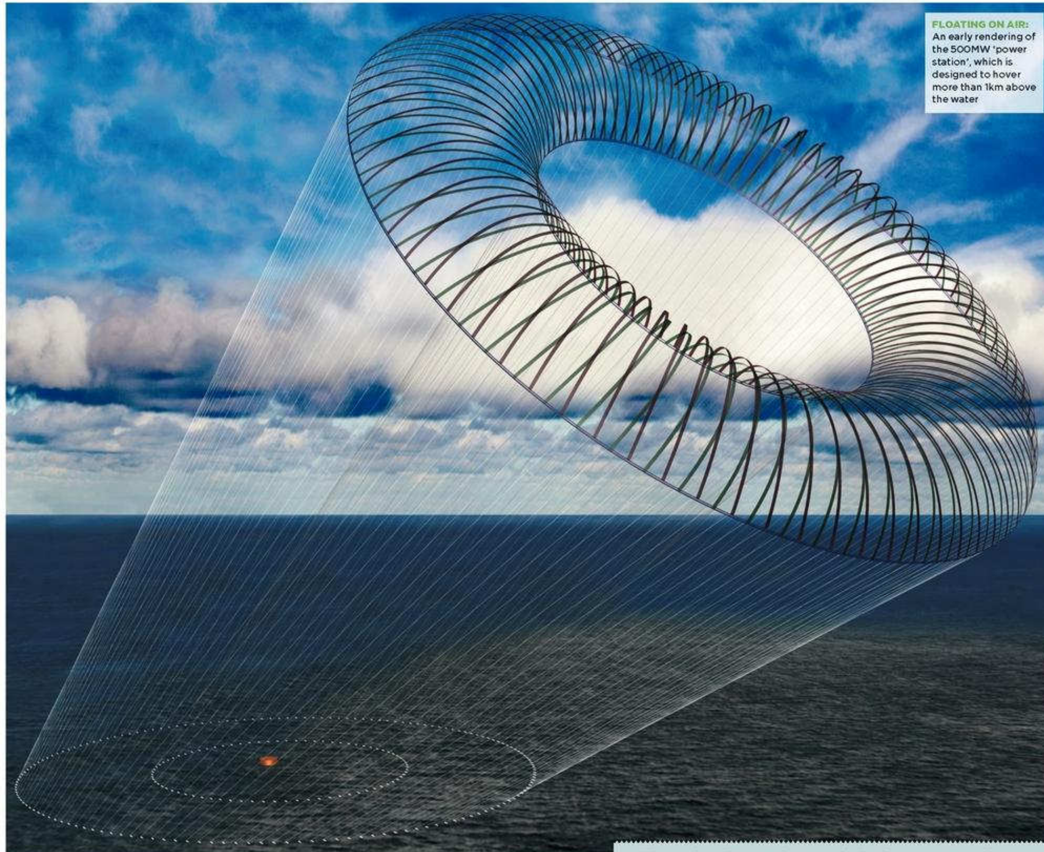
These function as the stators — the stationary part of a rotating generator system — while the rotor is made up of the 500 magnet-tipped sail-wings that flex between the rings.

At start-up, electrical current is fed into stator coils in the rings, creating an electromagnetic force on the rotor magnets, which are fabricated as corrugated polymer sheets filled with permanent-magnet particles.

As the sail-wings rotate and the turbine lifts "like a hovering helicopter", the electromagnetically charged wing tips induce electrical power in the stator coils.

With the sail-wings circling at a speed of 60 metres per second in contra-rotation, the magnets and the coils convert mechanical energy to electrical energy 5,000 times per second.

The alternating current generated is converted into direct current (DC) at each sail-wing tip by active switches that are controlled via electronic units on the stator ring. The DC runs down high-voltage cables to the central hub, and from there to shore and into the grid.



FLOATING ON AIR: An early rendering of the 500MW 'power station', which is designed to hover more than 1km above the water

500MW Wind Turbine

Plugging in to the world's longest undersea cable

NorNed Auction

CABLE GUYS: The NorNed project took four years to complete, with power flowing since 2008

The longest submarine power cable in the world, NorNed, flows high-voltage direct-current 580km between Norway and the Netherlands.

Work on the project began in 2005 and commercial operation on the €600m ($805m) link — built by grid operators Statnett and TenneT — started in 2008.

The director of 500MW Wind Turbine, Sjef Beaujean, says connection to the mainland is the major cost of the high-altitude concept, but, with NorNed in place, "that part of the equation is sorted out".