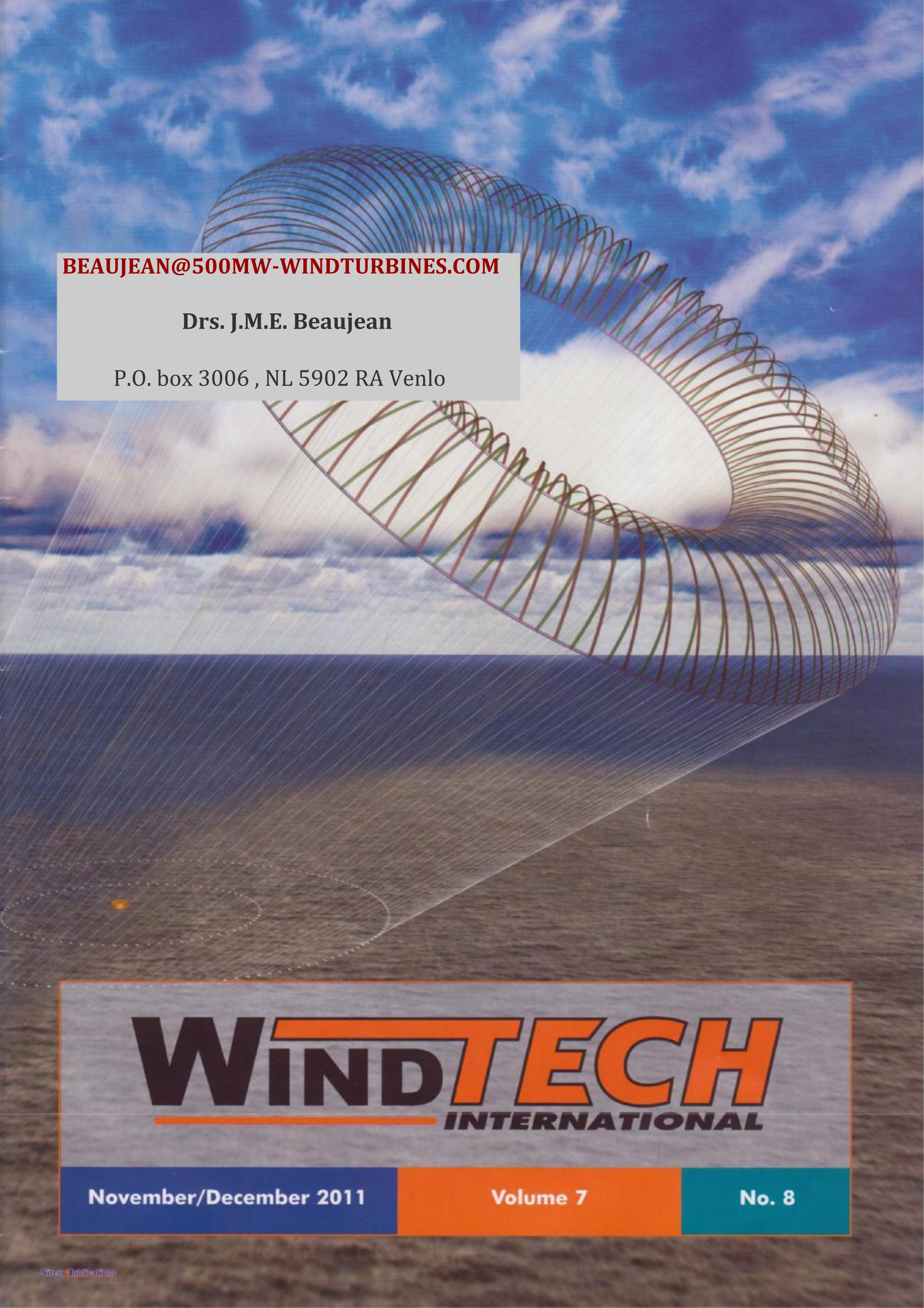
BEAUJEAN@500MW-WINDTURBINES.COM

Drs. J.M.E. Beaujean

P.O. box 3006 , NL 5902 RA Venlo



WINDTECH INTERNATIONAL

November/December 2011 | Volume 7 | No. 8

Wind turbines in use today are not able to catch the abundant flow of wind energy a kilometre or so above our heads. This article describes a design for a wind turbine of up to 500MW capacity that could be deployed at many places throughout the world.

By Dr J.M.E. Beaujean, Bogey Venlo BV, The Netherlands

500MW Wind Turbines

A Design Study

All over the world there is plenty of wind energy available. One kilometre above our heads wind energy flows at a density of kilowatts per square metre. That energy is free and green. However, present turbines are not high enough to reach this resource, making it difficult for them to compete with coal, oil, gas or nuclear fuel power stations.

At Bogey Venlo we are designing wind turbines for greater altitudes. We are giving them a capacity as large as that of conventional power stations. This will make it easier to incorporate them into electricity networks. Simply scaling up the conventional design of wind turbines is unfeasible. To give a single example of the difficulties, towers tall enough to reach the required altitudes are simply too expensive.

A paradigm shift in the approach to wind turbine design is needed. This is why our turbine is designed to hover high in the air, like a helicopter. This approach is not novel; it has been described before in general terms, but our development goes further. We have worked out a design for large, hovering turbines of up to 500MW power output in quite some detail. The scheme appears to be technically feasible, and economically attractive.

Design Basics

In our design these large turbines use two counter-rotating sets of sail wings. Their outer diameters can measure anything up to 1,350 metres. Their narrow sail wings, as shown in Figure 1, are much lighter than solid wings would be.

The wings are not interconnected mechanically. Their rapidly moving tips are kept in place by air bearings in wide support rings. These rings are held at altitude in the wind flow by 2,500-metre-long tethers, connected to winches floating in circles on the sea surface. These in turn are anchored to the seabed.

Via these winches and tethers the turbines can be directed to follow the wind. The turbines can also be tilted and so are able to vary the amount of the potential wind energy that is actually harvested. This harvesting is done by a combination of electric coils and sheet magnets. The sheets are mounted along each wing tip. The rapidly moving magnets induce electric power in the coils, which are held in the static bearing rings. The power is produced at a high voltage.

At all times, for any individual coil, the effective inductivity, and hence its reactive force, is controlled. This control is used to harmonise the speed of all the wing tips. By harmonising this speed the induced voltage is kept the same over all coils.

In each coil the induced current is rectified. The resulting direct current (DC) electrical charges are combined into one flow of energy. That combined flow is brought to the floating central hub and from there to the seabed, to reach the control station on shore via a subsea cable. In this control station the high voltage DC (HV-DC) electricity is converted to alternating current (AC) with the right specifications to be fed into the local power grid.

Alternatively, and advantageously, the station could be connected to an existing HV-DC line in the seabed. Such a combination would drastically reduce total capital costs. Wind energy and hydro energy could be combined successfully in this way.

The generating rig, while primarily acting as a turbine, also operates as an electrically driven helicopter. It rises from the sea surface into the air. By reversing the direction of rotation the turbine can be made to land for inspection and maintenance.

The fixed costs of these turbines will not be larger than those of existing 500MW power stations. As for the variable costs, the wind, the source of the energy, is free. As a result, the turbine should be able to deliver electrical energy to the power net at competitive prices.

We calculate that, spread over the world, some 3,200 such turbines could be implemented conveniently. These could potentially cover

20% of the local needs for electrical energy. If the turbines were interconnected via an HV-DC cable, the web of turbines could take care of even more than 20% of our electricity needs.

These qualities may open a great business opportunity for such 500MW wind turbines. Below we describe their technical elements in more detail.

Pilot Installation: Technical Details

It is envisaged that a prototype system will be installed near to the existing NorNed HV-DC line, connecting Norway's hydropower net with the electric grid in Western Europe. The following is a technical description of the proposed prototype. Intensive discussions are under way with potential partners to ensure harmonisation of the technical specifications.

Along the HV-DC line a suitable location for the turbine is being sought, outside the 12 miles zone. An important consideration is the presence of free air and sea traffic corridors, and another is the stability of the sea floor at the proposed installation site.

Anchoring

The suction pads that keep the turbine in position will probably be made on land. They will be transported to a suitable harbour, where floats will be applied, and the pads hoisted into the water. A small tugboat will tow a line of suction pads to the installation site. The pads will be positioned with the help of a GPS system. At the start just one pad is needed: to position the central hub.

Central Hub; HV-DC Line

The floating central hub will be constructed at a marine harbour. A short HV-DC cable will be attached to the hub and will act as the connection to the nearby HV-DC line. The specifications of the HV-DC connection point will be finalised following consultations with the authorities controlling the HV-DC line. The connector will need to be made compatible with the ultimate capacity of the line. This is 700MW for the NorNed connection.

The pad used to position the floating central hub will be hung from a cable below it, and will be transported to the anchorage point in this way. At the site, following the deployment of the short HV-DC cable, the suction pad will be lowered by a winch to the seabed, and the hub anchored in position.

Positioning of the Anchor Pads; Control Cables

The floating anchor pads will be towed in a string to the installation site. There the pads will be lowered to the seabed in a sequence using a winch and cable. Using a floating mud pump the mud below the pad will be pumped out, thus fixing it in the soft marine deposits.

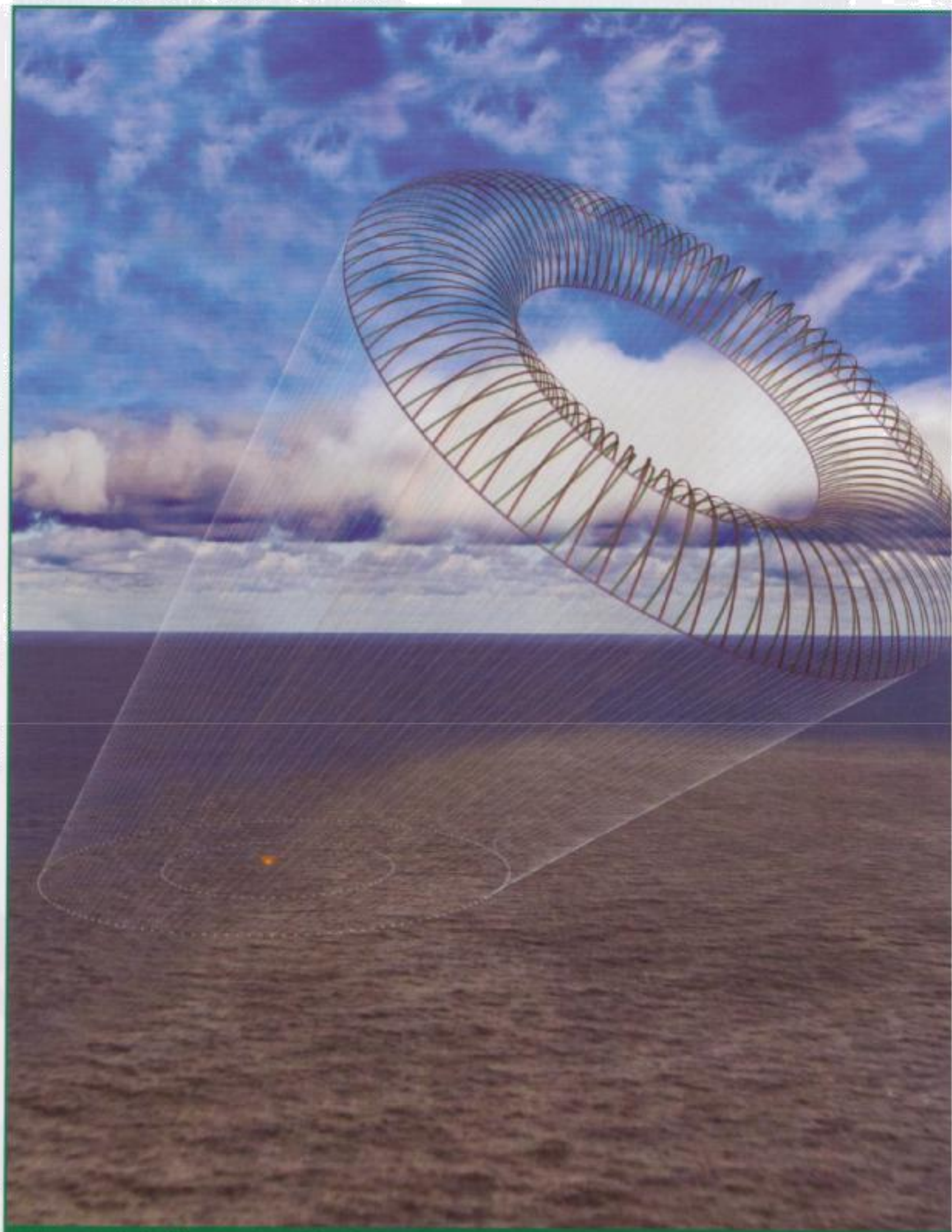


Figure 1. Artist's impression of the wind turbine, which would have up to 500MW capacity and an outer diameter of 1,350 metres

While the pads are being installed, they will also be electrically interconnected by a cable deployed with the help of a GPS. This interconnection will be needed to control the floating winches that operate the ribbon cables (see Figure 2); these will be used to position the turbine, which hovers in the air.

Figure 2. Parts of the proposed system: the suction pad with knuckle joint, tension cable with suction hose, and floating reel with ribbon cable

This electrical interconnection will be installed from winch to winch. The two circles of connecting lines for both circles of suction pads will also be connected to the central hub. That hub is connected to the HV-DC line, which provides the electric energy for the winches.

By changing the length of cable being deployed these computer-controlled winches will be able to alter the height and inclination of the power-generating 'sails' and the suspended turbine. The whole operation can be supervised from an on-shore control room.

Turbine

The turbine is likely to be assembled in a weather-proof facility near to where it is to be deployed. The wings and the rotors will both be made of flexible sheet materials, which could be transported to the site wound on bobbins. At the waterside the bobbins will be unwound and the ribbon sheets, which make up the wing of the turbine, will be processed to make the 3D curved sails.

Using a set of Zodiacs the sails and ribbons will be brought within the circle of the anchor pads. The stator ribbon cables will be unwound and consecutively connected to the anchored floats in the installation area.

During the process of creating the outer and inner rings of the turbine the wings will be supplied directly from the processing line. The wing tips will be inserted into the two double rings of the turbine. These double rings form the stators of the turbine.

When all the wings have been installed the floating turbine will be towed to the installation site, using tugs.

Connecting the Turbine

At the site, the turbine will be towed over the set of floating cable winches. The turbine will be positioned over the two circles of anchor pads, and then connected to the floating winches with their cables. The order in which the various cables are connected to the floating turbine will be tightly controlled in order to ensure a stable position for the turbine during its installation.

Take-Off and Landing

When the wind speed is at some 5 metres per second, the turbine will be activated to take off. First the upper set of wings will be activated. Using the great torque that can be made available from the turbine's generator as a motor, the upper wings should be easy to move.

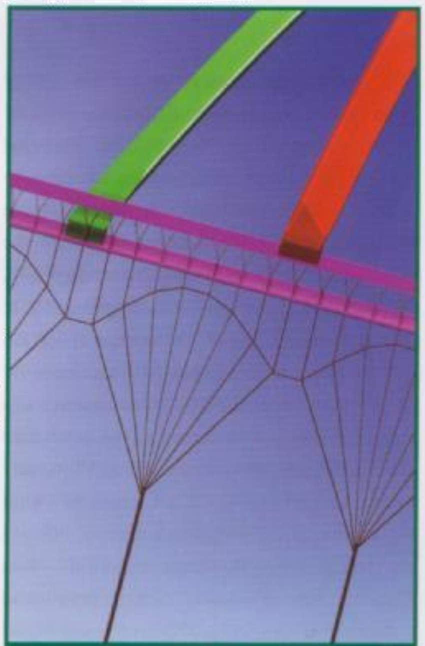


Figure 3. Other parts of the proposed system: the ribbon cable with spreaders, generator ring with bearing, and ribbon wings, counter-rotating

When the first set of rotating wings catches the wind, it should rise from the sea surface. Then the second set of wings can be activated using the same technique, but rotating in the opposite direction (see Figure 3). When the second set of wings catches wind too, the complete turbine will be made to rise vertically, controlled by computers, sensor feedback and the motors of the cable winches.

Once in the air at an operating altitude the turbine can be tilted and adjusted to harvest wind energy.

Pilot Installation Programme

The turbine components and the installation sequence have been described in detail as part of the pilot programme, which hopes to create and install a prototype. This detailed programme is being discussed with potential suppliers of components of the turbine. A public consultation exercise, encompassing as many interested groups as possible, will also be held.

Biography of the Author

Dr J.M.E. Beaujean has brought several industrial projects to the market. This 500MW wind turbine scheme can be seen as the pinnacle, both in respect to the potential outcome of the project as a whole as well as in the potential of possible spin-offs.

Affiliation

Dr J.M.E. Beaujean
E-mail:
beaujean@500MW-Windturbines.nl

Artist's impressions by ing J.J. Quak MBA of www.Quak-Equipment-Projects.com (E-mail : info@QuEP.nl)