THE WINDFLOW VENTURE: BRINGING IT TO LIFE

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Abstract

The Windflow design has been promoted for New Zealand manufacturing since 1991, first at 500 kW scale and recently at larger scale. In recent years promotion of the venture has been low-profile because of uncertainty about the market for wind energy here. However the fundamental advantages of the design have not diminished relative to the heavy European designs which have flourished in heavily subsidised markets. Indeed, as described at the last NZWEA conference, the advantages of the design are amplified as turbine sizes increase to 750-1000 kW or more. This paper gives a status report on the Windflow venture and describes recent work using computer animation to illustrate the Windflow technologies.

Introduction

The Windflow design combines two new technologies, the patented torque limiting gearbox (TLG) system of power control and the pitch regulated two-bladed teetering rotor. It has been described in other papers (Refs. 1, 2 and 3) so only a brief description of these two technologies will be given here.

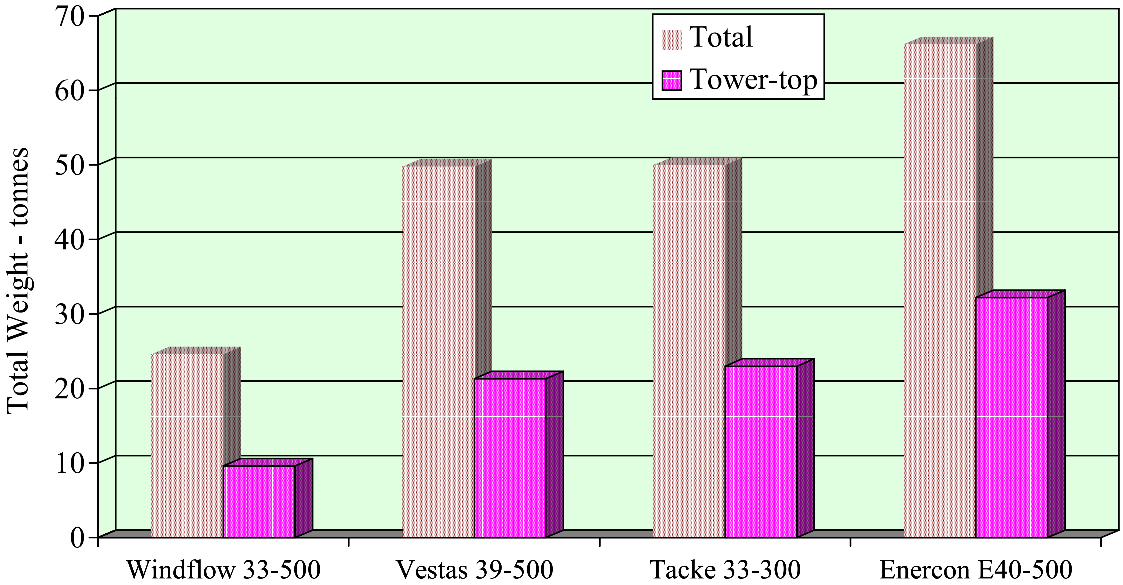
The TLG system is a hydraulic variable speed (VS) system. Like other VS systems it allows rotor speed to vary and as a result keep torque constant at rated power. This gives major savings in gearbox weight and cost. Unlike other VS systems:

- the hydraulic torque limitation enables the rating (and hence weight and cost) of the torque limiting hardware to be minimised. It also eliminates problems with generator-side harmonics and fault-condition transient torques which affect electrical VS systems
- rotor speed varies independently of the fixed generator speed, enabling the use of a light-weight, low-cost synchronous generator directly on line. This provides significant cost savings as well as superior electrical output characteristics.

In the two-bladed teetering design, the rotor is mounted on a hinge, allowing it to teeter back and forth as it rotates. Fixed-hub three-bladed turbines experience large overturning moments caused by asymmetrical rotor loading. These overturning moments are a major source of fatigue loads on the entire windmill structure. Teetering greatly reduces these fatigue loads allowing a significantly lighter design. The Windflow's "pitch-teeter coupling" feature ensures the advantage of teetering is not undermined by dynamic problems associated with other teetered rotor designs.

The combination of the TLG system and the two bladed teetering rotor results in weight reductions of more than 50% relative to comparable three-bladed designs as indicated by Figure 4, which shows the results of detailed design work for the Windflow at 500 kW scale. The right-hand bars show tower-top weight, i.e. nacelle plus rotor, but excluding the tower.

Figure 1 - Weight Advantage of the Windflow 500 Design



Both technologies have been proven in service. The TLG system was prototyped in 1990 in a 200 kW three-bladed windmill and ran very reliably for about six years before the unit was decommissioned. It is based on simple hydraulic components with a long track-record in general industrial applications. The two-bladed teetering rotor was used by a major British manufacturer for about 80 units of 33 m rotor diameter in UK wind farms since 1988. These units, which are about 30-40% lighter than comparable three-bladed units, are achieving wind farm availabilities in excess of 98%.

Until recently it seemed likely that windmills of 30-40 m diameter (about 500 kW rating) would be the optimum. For this reason the Windflow design, which was developed for New Zealand manufacture and optimised for New Zealand wind conditions, was set at 33 m, 500 kW. Costing studies and a detailed business plan showed that a profitable manufacturing business could be established based on this design, provided that long-term power purchase contracts could be obtained in the 5-6 c/kWh range.

As described in Ref. 1, our current thinking is that a rotor size comparable to those coming out of Europe, (40-50 m, rated at 600-1100 kW) may be optimal, and indeed this should give greater economies with the Windflow design than it does with European designs.

Background to the Windflow Venture

Wind Torque Ltd (WTL) was established in late 1990 to promote the Windflow venture. Two years later Aeolian Property Company Ltd (APCL) was established as an associated company to purchase a 240 block of land on North Range Rd, Palmerston North. This has an outstanding wind resource, and should be able to be developed as a 50 MW wind farm. In the meantime it is being leased out for grazing.

In the early 1990's WTL promoted the Windflow design by seeking funding (unsuccessfully) from a number of corporate sources including the Foundation for Research Science and Technology, ECNZ and other energy companies. At the same time WTL played a pioneering

role in promoting wind energy as a low-cost, environmentally desirable and technologically mature alternative to gas-fired generation.

As it transpired, in the 1990's wind energy was not able to overcome the institutional inertia behind gas-fired power. And at the same time it became clear that the Windflow enterprise needed a more optimistic outlook for the future of wind power in New Zealand. It does not make sense to invest millions in a pre-production unit if there is a poor chance of achieving ongoing domestic sales. Therefore in the late 1990's the Windflow venture adopted a relatively low profile, with promotional efforts focussing on the political changes needed to create a stable market for wind energy.

At the same time promotion of the technology continued in the USA. The Windflow design was the subject of a concept design study in early 1995 funded by the National Renewable Energy Laboratory of the US Department of Energy (NREL) under their Advanced Wind Turbine programme. At present our US agent is submitting the TLG system as part of two proposals to NREL for funding under their Wind Partnerships for Advanced Component Technologies (WindPACT) programme, focussing on Advanced Drive Train Components for Utility Scale Wind Turbines.

Current Status

The promoters have decided that the time is now ripe to proceed with the Windflow venture by issuing a prospectus to raise $3 million to fund the development of a pre-production unit. The Windflow prospectus is currently being finalised and is expected to be issued within the next two months.

While the market for wind power in New Zealand remains uncertain, there are several aspects of "silver lining":

- the new government creates a greater expectation of progress towards a sustainable energy future
- the weak NZ dollar reduces the viability of imported windmills and strengthens the case for local manufacturing
- the end of the Maui gas take-or-pay agreements is nearly in sight
- the over-supply of generation is temporary. New generation is expected to be required within 3-5 years.

There is therefore a 3-5 year "window of opportunity" in which to establish this venture and build up a track record before the NZ market for wind power recovers. In order to capture this “silver lining”, our 3-5 year development programme must commence at once. Otherwise, even with our technology edge, it will be difficult to compete with the established overseas manufacturers when the market redevelops.

Once the present generating surplus is taken up, investments of $100-200 million annually will be needed to meet electricity demand growth, currently about 2% per annum. This equates to about 150 MW of wind power. In the intervening period, the Company will seek to capitalise on the exciting developments taking place in Australia due to its 2% target. After the pre-production unit (to be installed in New Zealand), it is expected that sales will build up gradually in demonstration projects in Australia as well as New Zealand.

Computer Animation

Recent work has focussed on using computer animation to explain how the Windflow technologies eliminate fatigue loads. A combination of software packages was used:

- AutoCad 2000 and Mechanical Desktop 4 for geometry creation
- 3D Studio Max for geometry creation, animation and rendering
- DPS Perception Software for conversion of the rendered jpeg files to video format
- Adobe Premiere 5.0 for editing the video files, adding soundtracks and recording to tape.

Three video animations were produced:

- an overview of the Windflow turbine as it starts up from stationary
- the pitch-change mechanism inside the hub, showing the pitch-teeter coupling
- the internals of the TLG showing the differential action and a schematic rendering of the flow in the hydraulic circuit.

Figures 2, 3 and 4 show still images from these animations. The video animations have been very helpful in explaining the Windflow technologies, as they allow the dynamic effects of pitch-teeter coupling and torque limiting to be visualised.

Summary

The Windflow design combines two technologies which have independently been demonstrated (in Britain) to reduce fatigue loads and hence machine weight without compromising reliability. The design has been optimised for New Zealand's high wind conditions and holds promise for achieving significant economies, not only at 500 kW scale but also 1000 kW and above.

A prospectus is being finalised to enable funds to be raised for the development of a pre-production Windflow unit, to be released as soon as the legal review, audit and registration process is complete. Apart from prospectus preparation, recent work has focussed on computer animation of the Windflow design. This is a particularly powerful tool which has been very helpful in explaining the Windflow technologies.

REFERENCES

1. Henderson, G.M. 1999: - "Potential for Reducing Cost of Energy by Scaling Up a Low-Mass Wind Turbine Design", *Proceedings of NZWEA Conference '99*, EECA, Palmerston North

2. Henderson, G.M. 1993: - "Wind Energy at 2.5 c/kWh: a Challenge met by the Windflow 500" *Proceedings of Windpower '93*, AWEA, San Francisco

3. Henderson, G.M. 1996: - "Pitch-Teeter Coupling and the Torque Limiting Gearbox: Cost-Effective Methods of Fatigue Load Reduction" *Proceedings of 1st NZWEA Conference*, EECA, Wellington

Figure 2 – The Windflow 500

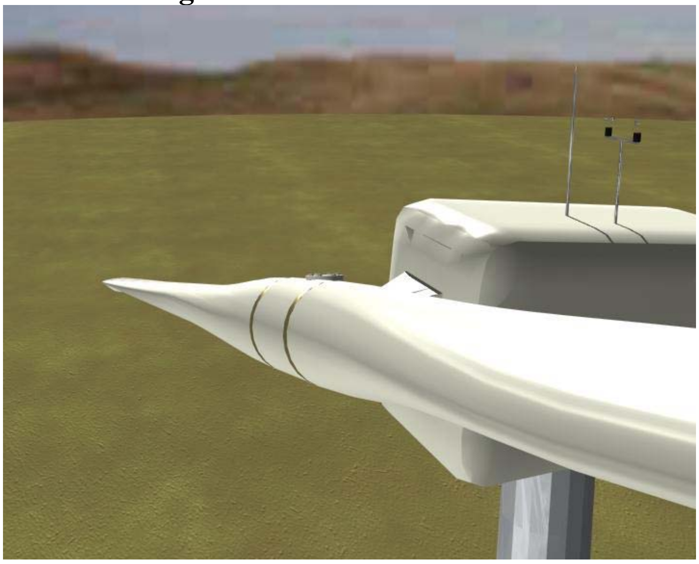


Figure 3 – The Windflow Pitch Change Mechanism, showing Pitch-Teeter Coupling

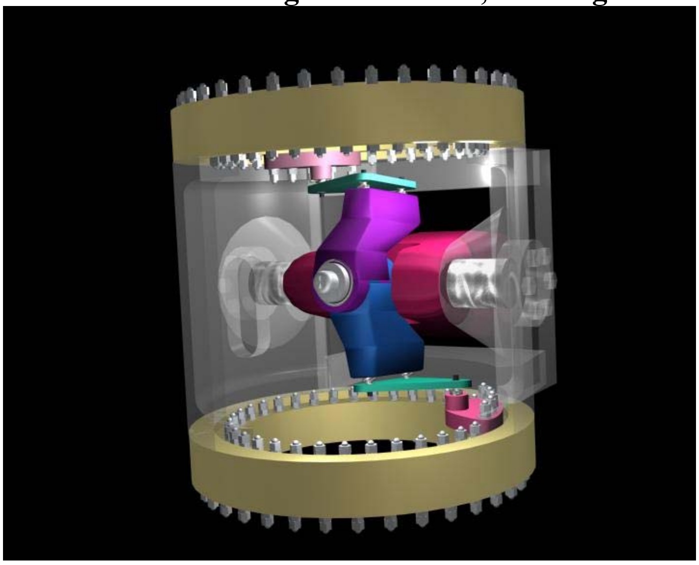


Figure 4 - The Torque Limiting Gearbox (patented in the US and other countries)