THE WINDFLOW SOLUTION

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ABSTRACT

Internationally, wind power has had the largest growth in the power generation industry for the last few years, despite this New Zealand is yet to embrace wind power at the same rate. This is largely due to the historically low cost of Maui gas (taxpayer susbsidised), which has undercut other forms of power in the last ten years. By contrast wind power has been unsubsidised in New Zealand, whereas overseas the cost of wind turbines has been padded by generous subsidies to reflect its environmental values.. As gas supplies are becoming less reliable and hydro storage reaching frighteningly low levels with some regularity, power prices continue to rise and wind power is becoming economically viable. With financial benefits from the ratification of the Kyoto protocol and new thinking from some of the lines companies, the gap is rapidly closing.

The Windflow technology is designed specifically for N.Z. use and is overall a cheaper, more reliable and more efficient wind turbine. With these attributes the Windflow wind turbine is set to become part of the solution to the impending security of supply problems soon to be faced in the N.Z. power supply industry.

1. INTRODUCTION

In New Zealand, wind power generation accounts for only a very small percentage of the total annual energy production, which seems unusual for a country with one of the world's best wind resources. New Zealand is yet to embrace wind power at the same rate as other first world countries. This is most likely due to the luxury of having abundant generation for so many years, variability in the electricity supply industry in recent times and the comparatively low cost of gas-fired power (with historical subsidies in the form of the original take-or-pay contracts, which were transferred to the private sector at discounted values). Many of these factors have now changed especially with the uncertainty of gas supplies, low hydro storage levels with more regularity and the continuing decrease in the cost of wind power as technology advances and competition grows.

There is no quick fire solution to the current energy "crisis" as no major generation development has been scheduled (in-fact our only generation project has been held back due to concerns of security of fuel supply). This has now brought wind power to the fore and it is now being considered as a serious option.

Windflow Technology Ltd (WTL) is a newly formed New Zealand company with the goal to manufacture grid connected wind turbines using primarily New Zealand sourced labour, expertise and materials. At the time of writing WTL is nearing completion of the first turbine, a prototype 500 kW generator called the Windflow 500 (W500). The WTL turbine utilises technology not found in other commercially available wind turbines making the WTL turbine more economically viable, reliable and better suited for New Zealand conditions.

This report will detail the mechanical and electrical advantages of the W500 itself as well as wind power in New Zealand in general. Then the current status of WTL will be described, followed by a brief outline of WTL's future plans.

2. MECHANICAL ADVANTAGE

The W500 combines two non-standard technologies for the first time; the torque limiting gearbox (TLG) and the teetering 2-bladed rotor with pitch-teeter coupling. These technologies in combination provide for a more economical, reliable and overall superior wind turbine.

THE TLG

The TLG is an invention of WTL director Geoff Henderson, who holds the NZ, Australian and US patents. Above rated wind speed, the TLG provides constant input and output torque, and allows the input speed to vary while the output speed is held fixed by the AC grid. By doing this, mechanical loading is decreased allowing for improved reliability and reduced weight (and hence cost).

A constant output speed enables the use of a synchronous generator, which is cheaper and more flexible in operation than the more typical induction generator.

An advantage of the TLG which is just come to light is that of "referred generator inertia" as it affects electrical variable speed (VS) systems. This is a phenomenon that increases loading on the gearbox due to the inertia of the generator rotor. An inertia that is referred through a gearbox is multiplied by the square of the gearbox ratio. Thus a relatively small inertia becomes a significant part of the total. While the turbine rotor is still the largest inertia, the generator, being on the non-drive end of the gearbox, can impose significant inertial torques and thus significant stresses on the gearbox during wind gusts. With the TLG system, the generator speed does not vary, therefore the inertia of the generator rotor is not reflected through the gearbox during torque transients.

Fig. 2.1, depicts the torque fluctuations for varying wind turbine systems with the TLG system displaying smooth torque along the whole drive train.

PITCH-TEETER COUPLED BLADES

An inherent problem with wind turbines is that there is always asymmetric loading across the rotor due to turbulence, wind shear and tower shadow. With 3-bladed fixed-hub rotors this imposes a significant and continuously fluctuating overturning moment on the low speed shaft, tower and machine as a whole.

To avoid the loading problem, the Windflow's 2-bladed rotor is allowed to "teeter" on a hinge connecting it to the low speed shaft. Pitch-teeter coupling means that as the rotor teeters, the pitch on the blades passively changes also. This lets the rotor teeter without any of the dynamic problems associated with other 2-bladed teetering rotors.

This relatively simple and cost effective solution allows for a wind turbine to be built with good reliability with less weight and expense when compared to 3-bladed machines. Not only is there a saving because there is one less blade, but the reduced fatigue loads enable further weight savings.

3. ELECTRICAL ADVANTAGE

Synchronous Generator Utilisation

As described previously, the TLG enables the use of a synchronous generator. This is not the norm with more typical wind turbines which use either asynchronous or permanent magnet direct drive generators and have the power factor problems associated with these topologies.

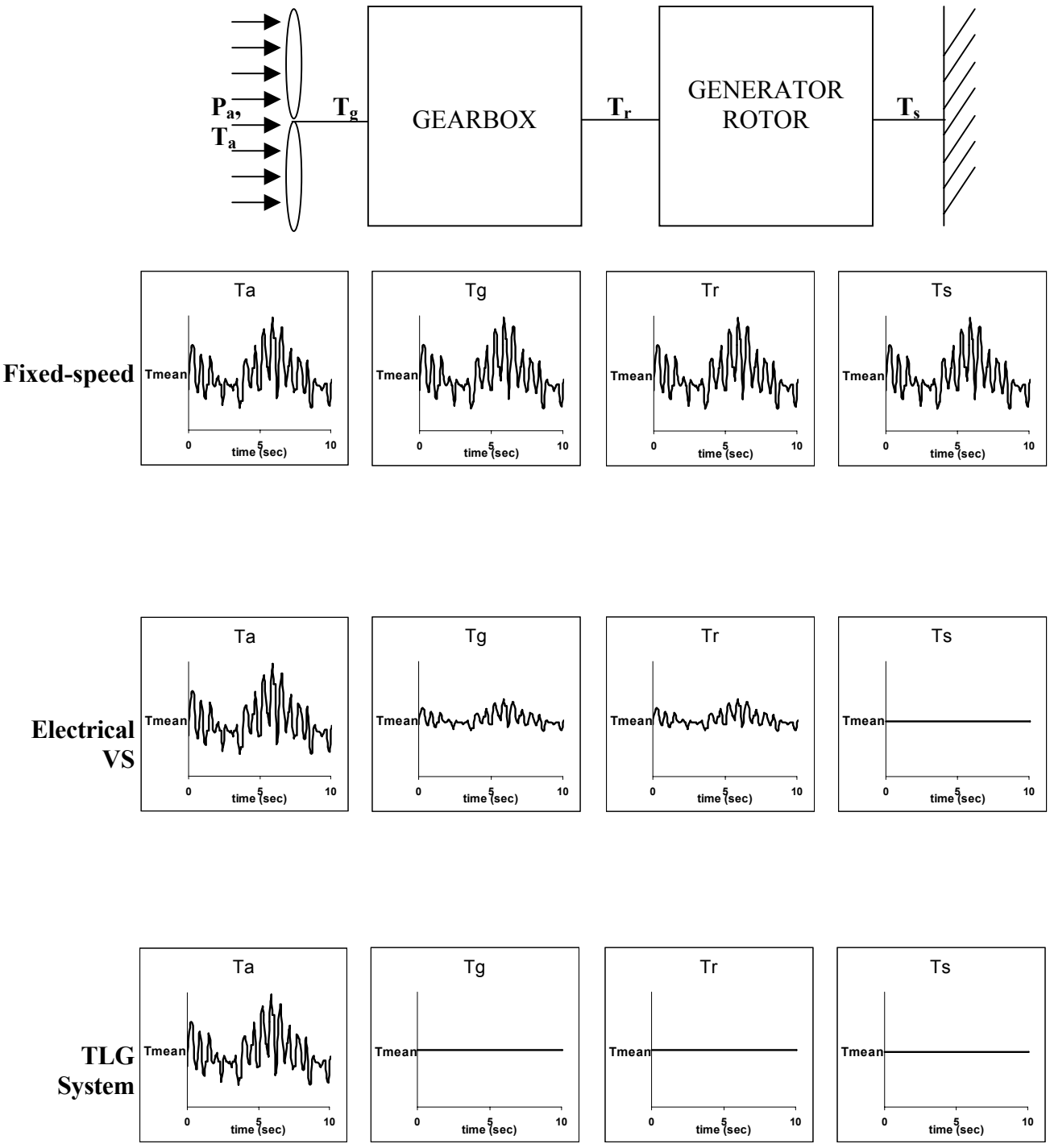

Fig. 2.1: Comparison of torque fluctuations through the drive-train.[1]

By using a synchronous generator the W500 has power factor control capability. This can be advantageous for a lines company that has poor power factor in a part of the network that the wind turbine feeds. With the purchase of some additional electronics, power factor (or kVAr) control can be implemented when desired. For example, Orion Ltd will pay for leading kVAr generation under periods of high load (called control demand periods or CDP's) on their network as signalled by ripple control. As a result the W500 has been equipped with a pony motor so that the generator can be put on line during an Orion CDP, if the wind is not blowing, and leading kVAr generation initialised. The pony motor and associated power kVAr control electronics are expected to pay for themselves in the first year. This sort of incentive provides for a symbiotic relationship between the lines company and the generator as the generator gains by direct payment and the lines company gains by deferring capital expenditure (more on this later).

Depending on the point of connection, point of metering and lines company pricing methodology, power factor control can be financially beneficial for a business with a large load and generation behind the meter. If however the lines company that supplies that load has a kVAr incentive plan the point of connection and/or metering will need to be carefully considered so that full financial benefit is realised.

Distributed Generation

With the infrastructure that exists in New Zealand at both the transmission and distribution level and the geographical load profile, interest in distributed generation is increasing. Wind power lends itself well to distributed generation due to its modular nature and likelihood of being located in "remote" areas. It is also easy to increase the capacity of a wind farm by simply adding more wind turbines when needed at reasonable expense due to the low installation cost.

By geographically distributing generation, the generation source is situated closer to the load thus reducing transmission losses by lowering load on the lines. This has advantages for lines companies (and/or Transpower) as they can then defer capital expenditure on any line upgrades thus effectively increasing the useful lifetime of that line. This financial benefit is now being realised by some lines companies.

4. WTL CURRENT POSITION

At the time of writing WTL is ready to commission the first W500 on site. All of the mechanical and electrical design is complete, the assembly of the nacelle was completed in May and the turbine installed on site at Gebbies Pass. At present the control system is being commissioned and verified. In the factory at the nacelle-assembly stage, the system was put through 48 hour and 24 hour on-load running-in tests, where the turbine was driven by a 75 kW induction motor via a variable speed drive. Using this system an average of 35 kW was generated and fed back into the drive motor creating a closed system with only losses supplied from the grid. These two tests proved successful, and should enable a relatively short commissioning period on site.

Following commissioning, detailed testing and monitoring will be conducted. WTL intend to obtain international certification and hence a comprehensive monitoring system is being designed so that the certification criteria may be verified.

Fig. 4.1: The W500 during a rotating test.

5. WTL FUTURE PLANS

Once the prototype W500 has been installed and commissioned WTL will launch the next round of capital raising, the method of which is yet to be announced. This capital will be used to fund the building of ten further W500's which will most likely be installed on a piece of land near Palmerston North that WTL has rights to develop and which has been proven as a suitable wind farm site.

It is likely that WTL will promote the formation of a wind farm company to develop this and other sites over the next few years. In addition WTL will be marketing the W500 and other turbines it intends to develop to third-party customers.

6. CONCLUSION

There is an impending power crisis in New Zealand and wind power is one form of generation that should not be overlooked. It is the fastest growing form of generation world-wide, and New Zealand is the windiest country in the world. Wind power can be installed quickly, and in relatively small increments so that it suits the scale of the NZ electricity system. When the distributed nature of wind power and the power factor benefits of the W500 are considered, wind power has more to offer than just being an environmentally friendly and sustainable form of generation.

WTL is a company that believes that there is a future for wind power generation in New Zealand and as a result has taken the step of setting up local manufacturing to provide an economically viable wind turbine suited for New Zealand conditions using technologies that will give the W500 advantages over foreign units.

7. REFERENCES

1) Henderson G.M.: "Referred Generator Inertia: a new and decisive advantage for the Torque Limiting Gearbox (TLG) system", Proc. 6th NZWEA, Wellington, 2002.