AUTHOR: **Tim Armitage** (BE, CPEng, MIPENZ, IntPE (NZ))

Presenter: **Tim Armitage**

Title of Paper: **Sustainable Wind Energy Projects for New Zealand**

Contact information:: Tim Armitage
Position: Quality Manager
Organisation: Windflow Technology Ltd
Postal Address: PO Box 42-125, Christchurch 8149
Telephone: 03 365 8960
Email: tim@windflow.co.nz

Abstract

New Zealand is at a turning point as it sets out to achieve the target in the New Zealand Energy Strategy of 90% renewable electricity by 2025. Wind energy is one of the most favoured technologies in terms of its relatively low impact, speed of installation and range of project sizes. It is also one of the more cost-effective electricity generation options and is becoming part of most electricity generator and distribution companies' portfolios.

The way in which New Zealand develops its wind energy resource is also at a turning point as the different players involved have different ideas on what is the best option – a small number of very large wind farms connecting to the transmission grid or a higher number of smaller wind farms distributed around the country and supplying local communities.

This paper discusses the economic, social and environmental benefits of the 'smaller and smarter' Distributed Generation approach to wind farms compared to the recent trend towards very large wind farms. Examples are used to show that the 'smaller and smarter' approach to wind energy is the most sustainable.

Introduction

New Zealand has some of the best conditions for wind energy in the world with very strong and consistent winds, yet in July 2008 only 2.6% (approximately 322 MW) of the electricity came from wind energy, (NZ Wind Energy Association, 18 July 2008 and The National Business Review, 14 July 2008). Wind energy has the potential to play a big role in achieving the target set out in the New Zealand Energy Strategy of having 90% renewable electricity by 2025. There are no technical reasons why wind could not provide up to 30% of New Zealand's electricity needs.

Wind power, people, and place (a report published in 2006 by the Parliamentary Commissioner for the Environment) recommended further investigation of measures to encourage investment in smaller-scale, distributed wind farms and turbines (page 114). The following attributes were identified for smaller-scale wind farms (page 113):

- Have less concentrated impact on localities and communities
- May not create the same tensions as larger-scale wind farms
- Can be sited in locations that would be inappropriate for large-scale wind farms

- Add to local energy security by strengthening local electricity networks
- Can increase public acceptance of wind farms
- Can retain economic benefits within the district or region

New Zealand wind resources

Initially wind farms build in New Zealand were of modest capacity with medium-sized turbines. However, tables 1, 2 and 3 show that New Zealand wind energy is increasing in size by having a few very large wind farms using big wind turbines.

Table 1: List of current wind farms

Name	Operator	Commission date	Region	No of turbines	Turbine capacity	Project capacity
White Hill	Meridian	2007	Southland	29	2.0 MW	58.0 MW
Tararua 3	TrustPower	2007	Manawatu	31	30.0 MW	93.0MW
Te Rere Hau*	NZ Windfarms	2006	Manawatu	5 (of 97)	3.0 MW	2.5 MW
Te Apiti	Meridian	2004	Manawatu	55	500 kW	90.8 MW
Tararua 2	TrustPower	2004	Manawatu	55	1.65 MW	36.3 MW
Hau Nui 2	Genesis	2004	Wairarapa	8	600 kW	4.8 MW
Tararua 1	TrustPower	1999	Manawatu	48	660 kW	31.7 MW
Hau Nui 1	Genesis	1996	Wairarapa	7	550 kW	3.9 MW
Single turbine projects	-	-	-	3	-	825 kW
TOTAL	**-**	**-**	**-**	**241**	**-**	**321.8 MW**

* The total project capacity for Te Rere Hau will be 48.5 MW when all of the turbines have been installed.

Table 2: Wind farms under construction

Name	Operator	Commission date	Region	No of turbines	Turbine capacity	Project capacity
Te Rere Hau*	NZ Windfarms	2008-9	Manawatu	60	500 kW	30.0 MW
West Wind	Meridian	2009	Wellington	62	2.3 MW	142.6 MW
TOTAL	**-**	**-**	**-**	**122**	**-**	**172.3 MW**

* The total project capacity for Te Rere Hau will be 48.5 MW when all of the turbines have been installed.

Table 3: Wind farm projects that have applied for resource consent

Name	Developer	Notified	Region	Project capacity
Mt Cass	MainPower	June 2008	Hurunui	Up to 69 MW
Mill Creek	Meridian	April 2008	Wellington	Up to 71 MW
Kaiwera Downs	TrustPower	Nov 2007	Gore	Up to 240 MW
Waverley	Allco WindEnergy	Oct 2007	South Taranaki	Up to 135 MW
Horseshoe Bend	Pioneer Generation	Aug 2007	Central Otago	Up to 1.8 MW
Te Uku	WEL Networks	Jul 2007	Waikato	Up to 84 MW
Mahinerangi	TrustPower	Nov 2006	Clutha	Up to 200 MW
Project Hayes	Meridian	Nov 2006	Central Otago	Up to 630 MW
Motorimu	Allco WindEnergy	Aug 2006	Manawatu	Up to 110 MW
Te Waka	Unison/ Roaring 40s	Jan 2006	Hastings	Up to 102 MW
Hawkes Bay	Hawkes Bay Wind Farm	May 2005	Hastings	Up to 225 MW
Titokura	Unison/ Roaring 40s	Apr 2005	Hastings	Up to 48 MW
Taharoa	Taharoa C / PowerCoast		Kawhia	Up to 100 MW
Taumatatotara	Ventus		Waikato	Up to 20 MW
Awhitu	Genesis	Apr 2004	Franklin	Up to 18 MW
TOTAL				**2,054 MW**

The move to large wind farms using big turbines is increasingly leading to the environmental benefits associated with harnessing wind power and renewable energy being undermined by major resistance from local communities and environmental groups. The opposition are against the industrialisation of landscapes that previously remained in splendid isolation. Environmental groups, many with high level professional associations, are questioning more and more the overall benefits of 'big' and the new linkage is more with 'bad' than 'better'. (Save Central, 29 September 2008 and Upland Landscape Protection Society, 29 September 2008)

Economic impacts

Megawatt wind turbines are very capital intensive. Major construction projects with a life of two years or more are required to to build the wind farms. Roads and other infrastructure development becomes a sub-project in itself and impacts can be quantified by such diverse measures as employment spikes with the disruptions to local community economies, transport and logistics issues such as bridge or road closures. Furthermore it also leads to major impact on site ecology through roads and foundation development and the visual impact of these structures.

As wind farm opposition groups become polarized around these issues the difficulty of gaining resource consents is also intensified. It can therefore be argued that medium size turbines with between 100 and 1000 kW capacity provide numerous benefits. Surveys have shown that there is more public acceptance towards smaller wind farms than bigger wind farms. (Barry, page 34-36)

Smaller-scale wind farms such as distributed generation facilitate community ownership because they are more affordable than large projects. Community ownership has several advantages such as increased public acceptance and provision of local economic benefits and additional capital. This will help the wind industry grow faster. In wind energy rich countries such as Denmark, Germany and the USA, community ownership (and farmers) has played a significant role in the development of the industry. (Barry, page 36-40)

Medium size turbines can be located much closer to end users reducing the demand for transmission lines and upgrades. Medium sized turbines can also use embedded networks and can be sited closer to demand sites thereby achieving a much greater level of community buy in. They provide a cost efficient alternative and potentially a better use of capital given that the medium size turbines can be up and running within in much shorter timeframe. (Barry, page 74)

Bigger wind farms and big imported European turbines affect the New Zealand trade deficits, because of the size of the investments. This was seen both in 2004 and 2006 when the Hau Nui, Tararua and Te Apiti wind farms were build. (New Zealand Trade and Enterprise and Statistics New Zealand)

Environmental and social impacts

The Windflow 500 turbine is one such medium sized turbine with an output of 500 kW. It has two blades, as opposed to most other turbine designs in the world which are comprised of three blades. Having two blades allows the blades to teeter and thus reduce the fatigue loads on the bearings and the rest of the turbine. Two blades also make it lighter and the combination means the turbine is light weight compared to most other turbines relative to power output.

Table 4 shows an example comparing the Windflow 500 wind turbine and the Vestas V80. It is supported with figure 1 to show how the square-cube law works in on wind turbines. If you double the size of the turbine, you do get the four times the output, however, the weight is multiplied by eight!

Table 4: Comparing Windflow 500 and V80

	WF 500	V80	Multiplier
Hub Height	30 m	60 m	2.0
Blade Diameter	33.2 m	80 m	2.4
Nominal Output	500 kW	2000 kW	4.0
Nacelle/Rotor Weight	13 metric ton	104 metric ton	8.0
Tower Weight	16 metric ton	130 metric ton	8.1

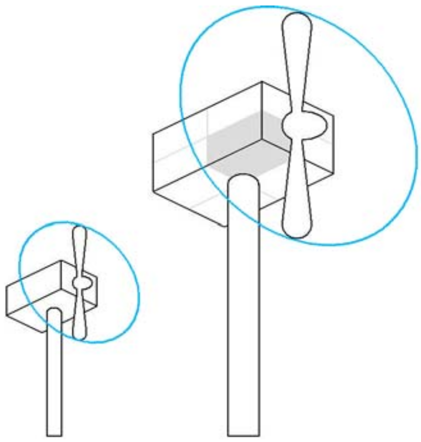

Figure 1: Square cube law

A light-weight design reduces the amount of steel required in the production, and with rising steel prices, this makes the Windflow 500 even more cost efficient. The turbine fits onto standard size trucks and normal roads and hence does not disrupt communities as much as when over-sized trucks and pilot vehicles for big wind turbines are being transported to a wind farm site. (Connell Wagner, page v)

Medium-sized turbines have a smaller environmental impact than big turbines, which require extensive earth works in regards to both roads and foundations. This is especially true for landscapes of ecological values. Such wind turbines' footprint and roads only take up 3-4% of the land in a wind farm and the rest can be used for normal agricultural use. (NZWEA Fact Sheet 5 - Siting, page 4)

Smaller-scaled wind farms spread around the country also have lower environmental impacts than large wind farms clustered in few geographical areas as the development in New Zealand has been. This distributed generation can open up for a whole range of rural land use throughout the country and people would get more used to wind turbines in general and learn that the actual impacts are not as high as perceived.

Medium sized turbines are much less obtrusive in the landscape. Wind turbines are most often situated on ridgelines and hills and this makes the visual impact even larger. Big turbines rise to 160 m high and on a 400 m high hill they will look even bigger, as shown in figure 2. The Windflow turbine is only 47 m tall and thus does not stand out as much on a ridge top as big turbines (figure 3).

Figure 2: This photo shows a ridge with 26 turbines which are 125 m tall.

Figure 3: This photo shows a ridge with 83 turbines which are 47 m tall.

It seems reasonable to expect that one would not get as much output per area from a medium-sized turbine compared with big turbines. However, this is not correct in all cases and it depends on the wind farm site.

Table 5 shows how many Windflow 500 and V90 (Vestas) turbines will fit into an area. If there is only room for one row of turbines, yes, then the Windflow 500 turbine will only put out 38% of what the bigger ones would. However, if you have a square area, the output would be almost identical (2% difference). A standard of 3 rotor diameters' distance between each turbine in a row and 10 rotor diameter's distance between each row has been used for this calculation.

Table 5: Installed MWs per area

	WF500	V90	WF500	V90
	Single Row Ridge		Multiple Rows	
Blade Diameter (m)	33.2	90	33.2	90
Output MW	0.5	3.0	0.5	3.0
Annual Output (kWh at 10 m/s)	1,930,087	13,582,266	1,930,087	13,582,266
Ridge Length (km)	10	10	10	10
Ridge Depth (km)	0.1	0.1	10	10
Turbines Along Ridge	101	38	101	38
Turbine Rows	1	1	31	12
Turbines Total	101	38	3131	456
Output Total (MW)	194,939	516,126	6,043,103	6,193,513
		38%		**98%**

Discussion

There are numerous advantages with distributed generation and smaller-scale wind farms. The main argument is that it would help to secure the supply for New Zealand's future demand. Distributed generation would help grow the wind industry in New Zealand. Distributed generation does not compete with large wind farms, on the contrary, they complement each other. A few turbines here and there make them more visible to everyone and more acceptable and thus ease resource consent for all wind farms.

Conclusion

Distributed generation definitely seems a logical way forward for New Zealand's wind industry. New Zealand has such rich wind resources and it would be a waste not to make the best of them. Distributed generation offers an alternative to the trend of bigger wind farm with bigger wind turbines. Mid-sized turbines on small-scale wind farms spread around the country have various benefits such as: smaller environmental impact, strengthening of local electricity networks, increased public acceptance, local community ownership and local economic benefits.

Literature list:

Barry, Martin, (2007) Distributed Small-Scale Wind Energy in New Zealand: Advantages, Barriers and Policy Support Instruments, Victoria University of Wellington

Connell Wagner (2008), Transmission to Enable Renewable Economic wind resource study for the Electricity Commission, Revision B Final.

New Zealand Trade and Enterprise (2007), Seasonally Adjusted Trade Deficit Grows. Retrieved on 18 July, http://www.nzte.govt.nz/section/14600/16533.aspx

New Zealand Wind Energy Association. (2008), Current wind farms, projects under construction, projects for which resource consents have been applied and potential future developments. Retrieved on 14 July 2008, http://www.windenergy.org.nz/FAQ/proj_dom.htm

New Zealand Wind Energy Association. (2008), Fact Sheet 5 - Siting. Retrieved on 29 September 2009, http://www.windenergy.org.nz/documents/2005/050825-NZWEA-FactSheet5Siting.pdf

Parliamentary Commissioner for the Environment. (2006), Wind power, people, and place. Wellington: Parliamentary Commissioner for the Environment

Save Central (2008), About Wind Power. Retrieved on 29 September 2008, http://www.savecentral.org/aboutus3.aspx

Statistics New Zealand (2004), Overseas Merchandise Trade (Imports) May 2004, Commentary. Retrieved on 18 July, http://www2.stats.govt.nz/domino/external/pasfull/pasfull.nsf/84bf91b1a7b5d7204c256809000460a4/4c2567ef00247c6acc256ebe000d5d03?OpenDocument

The National Business Review (2008), Wind contributes more to power supply. Retrieved on 18 July, http://www.nbr.co.nz/article/wind-contributes-more-power-supply-32711

Upland Landscape Protection Society (2008), Don't Trust Power & Feedback. Retrieved on 29 September 2008, http://uplandlandscapeprotection.org/index.html and http://uplandlandscapeprotection.org/feedback.html