Wind Power – is it a viable, renewable source of electricity for Australia and will it reduce our carbon emissions? : Environmental and economic impacts.

By Geoffrey Harold Clark

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Executive Summary

Wind farms cause considerable visual and noise (among other) impacts on the local environment. Meteorological conditions such as wind speeds, directions and the temperature profiles above the ground influence the propagation of noise to nearby receptors. Under stable, night-time conditions it is possible to have calm, low background noise conditions at ground level but strong winds aloft leading to turbine operations and a high potential for production of noise there. The impacts of such turbine noise can be considerable. The average capacity factors (efficiency) are usually less than 30% of the rated electricity output of the wind farms. The output of individual, and a network, of wind farms is also highly variable and effectively presents an injection of random noise into the national electricity distribution system. Therefore, another compensating, rapid output response electricity generation system (e.g. open-cycle gas turbine station) would be required to generate the required smooth base-load electricity. This would increase the cost of electricity and not provide any significant improvement in terms of carbon emissions over a simple installation of say, the gas turbine station in the first place. All energy options for Australia should be considered in terms of their environmental, economic and carbon reduction impacts.

1. Senate Inquiry Terms of Reference

The social and economic impacts of rural wind farms, and in particular:

(a) Any adverse health effects for people living in close proximity to wind farms;

(b) Concerns over the excessive noise and vibrations emitted by wind farms, which are in close proximity to people's homes;

(c) The impact of rural wind farms on property values, employment opportunities and farm income;

(d) The interface between Commonwealth, state and local planning laws as they pertain to wind farms; and

(e) Any other relevant matters.

I will be addressing some aspects relating to points (b), (d) and (e) above.

2. Introduction:

In order to consider the question of whether wind power is a viable, renewable source of electricity for Australia and if it will reduce our carbon emissions there are three major issues to be addressed:

1. The environmental impact of wind farms.
2. The performance of wind farms in delivery of electricity to the national grid.
3. The economic aspects and the reduction of green house gases delivered by wind farms.

2. **Some aspects of the environmental Impact of wind farms:**

Wind farms present an obvious significant visual impact on the environment, usually in undisturbed rural areas. In addition, there can be impacts on the local ecology both during the construction and operating phases. There is increasing evidence that wind farms generate noise from their turbine operations which cause significant disturbance on nearby residents (e.g. Punch, James and Pabst 2010; Pierpont 2009). Local meteorological influences can also lead to noise impacts beyond these nearby residents to distances of several kilometres (e.g. Berg van den 2006). My experience in analysing meteorological data collected to support noise analyses associated with a wind farm has shown the following:

1. Wind data used for an impact assessment are frequently unsuitable in that they have been collected to assess the wind potential of a site and not the impact itself i.e. a profile of wind speeds is necessary through the full sweep volume of the turbine blades to avoid false general assumptions required to extrapolate lower measurements. Under stable, night-time conditions of near calm winds at ground level can be accompanied by much stronger winds aloft, leading to potentially significant turbine noise generation. The influence of this "wind-shear" on wind turbine performance has also been discussed in some detail by Wharton and Lundquist (2010). They found at one site that power output could vary by up to 20% depending on the atmospheric stability and turbulence prevailing with a particular wind speed. This emphasizes the need for more local, specific and detailed meteorological measurements at potential wind farm sites.

2. The propagation of sound through the lower atmosphere is influenced by many factors such as the prevailing wind speeds, directions and temperature profiles, the complexity of the terrain, vegetation and soil types, and the frequencies of the sound sources. Estimation of noise impacts in areas of complex terrain (e.g. coastal regions, hills, valleys, etc.) requires wind measurements at a number of locations in order to identify areas of variable wind speeds and in particular calm regions (with low background noise) where wind farm noise impact conditions could be worse(van den Berg 2007). Alternatively, sophisticated wind/noise field modelling over the region covering nearby residents should be required (Blanc-Benon and Juve 2004; Klinkby 2002). Such analyses would allow planners to minimise impacts but currently they are not required by legislation. As a result, over recent times there have been numerous articles in the media on noise impacts and other impacts of existing wind farms. Politicians will ignore these protests at their peril!

3. **The performance of current wind farms:**

With a proliferation of wind farms across south-eastern Australia there is an increasing database of performance statistics. Proponents of the technology state that by separating these farms over significant distances (say of the order of 100s to 1000s of kilometres) integration of the outputs will produce a smooth supply of electricity to the national distribution grid. This claim can be demonstrated to be false (see Miskelly 2010 for daily and monthly performance statistics – the data are based on 5 minute values). See also the accompanying paper (Miskelly & Quirk 2009). There is also considerable overseas evidence (see for example Oswald et al 2008). In Figure 1 there is an example of the variability of the output of the grid of wind farms during a period of light winds across southern Australia. With stronger winds shown on July 10, 2010 shown in Figure 2 there is still

significant variability in the integrated output of generated electricity. There are several important points to make about these and the daily wind farm output data:

- The output of wind farms can vary rapidly on short time scales e.g. less than 15 minute periods.
- The capacity factors are frequently well below 100% and on average below 30%.

Electricity distributors make decisions about where to source electricity on a short term basis (typically every 15 minutes) and ideally need to supply smooth outputs to the electricity retailer companies. At present it is impossible for models to forecast wind speeds at specific locations every 5-15 minutes without large errors so that the distributor could plan for a smooth electricity supply (Kay et al 2009). In any case, it would be necessary to have an alternative generator (e.g. gas fired power station with capacity to cover the total network of wind farm outputs) to compensate for the variability/intermittency in the wind generated electricity. Therefore, one should ask, what are the environmental and economic benefits of having a network of wind farms compared to more simply a network of gas fired power stations?

4. **Some economic aspects and the reduction of green house gases delivered by wind farms:**

Others have addressed the economic aspects with the conclusions being that wind energy is heavily subsidised and causes significant price distortions in the electricity purchase markets (e.g. McGill 2010 – sees high prices as an incentive for more wind farm company investment! ; White 2004; Nicholson et al for an excellent assessment of the relative costs of different technologies useful for providing low carbon, base-load electricity; Lang 2010a who estimates the cost of a wind-gas system to be $126 per MWh vs. $51 for a closed-cycle gas system).

However, it is the environmental aspect in terms of green house gas emission improvements which will be discussed here. An independent report in Colorado (Bentek 2010) has stated that " Integrating erratic and unpredictable wind resources with established coal and natural gas generation resources requires PSCO to cycle its coal and natural gas-fired plants". (PSCO – the Public Service Company of Colorado, is the dominant electricity utility in Colorado USA). By cycling coal fired power stations, ironically there can be increased emissions of SO_2, NO_x and CO_2 and decreased efficiency of the station output. In the UK context, White (2004) similarly concluded that if coal fired power stations were used to support the highly variable wind generated electricity then "operating fossil capacity in this mode generates more CO_2 per kWh generated than if operating normally". The practicalities in the same UK context are addressed in some detail in the above-referenced Oswald et al (2008) paper. Lang (2010a) is quoted as saying the cost of avoiding each tonne of carbon emissions using wind with gas turbine back-up is $1149 compared to carbon capture and storage ($56), more efficient combined cycle gas turbines ($33) and nuclear ($22). Lang (2010b) has also described both the environmental and economic alternatives in shutting down a large coal fired generator such as the Hazelwood power station in Victoria. He comes to the conclusion that there would only be a minimal increase in savings of CO_2 emissions of a combined wind-gas system versus gas system only. The gas only option would be much cheaper than the gas-wind option, therefore, do away with the wind option completely!

5. **Summary:**

The above discussion and cited references show wind farms will not produce electricity to replace the base-load electricity generated by coal-fired power stations. As Robert Bryce says in his latest book *Power Hungry* , "we don't have control over the wind or the sun and we won't have until we are able to have large-scale energy storage... that is ultra cheap, ultra-reliable, ultra-widespread". "He argues that if policymakers are going to agree that carbon dioxide is a problem, then nuclear

power should be central to the solution" (ABC 2010). Nicholson et al (2010) also conclude "nuclear power to be the standout solution for low emissions base-load electricity, in terms of cost and ability to meet the timetable for GHG (GreenHouse Gas) abatement". In conclusion, eminent scientist, James Lovelock, states in the European context, "I know that wind-farms are no answer to global warming". Will the same conclusion be drawn for Australia following an objective study?

6. **Recommendations:**

1. In preliminary impact studies there should be a requirement for short term simultaneous measurements of background noise, wind speed, direction and temperature profiles through the sweep volume of the turbines to be used to calibrate the wind/noise field modelling across the region where the wind farm is to be located. In that way the full impact of the wind farm can be more accurately estimated using the long term meteorological dataset. The meteorological dataset used for the impact assessments needs to be detailed and specific to the local site and not just that collected for wind energy potential studies.
2. A full audit of the economics, carbon reductions and environmental impacts of various power generation and emission strategies in Australia is required before there is further expansion of the wind energy industry.

7. **References**

ABC 2010: ABC Radio National program Counterpoint interview, October 11.

Blanc-Benon, P., Juve, D. 2004: Outdoors sound propagation in complex environments: recent developments in the PE method. At Website:
http://www.ia.csic.es/sea/sevilla02/osp01003.pdf

Bryce, R. 2010: Power Hungry. Published by Public Affairs a member of the Perseus Books Group, New York

Hittinger, E., J.F. Whitacre, J.F., Apt, J. 2010 Compensating for Wind Variability Using Co-Located Natural Gas Generation and Energy Storage. Carnegie Mellon Electricity Industry Center CEIC-10-01.

Bentek 2010: How Less Became More: Wind, Power and Unintended Consequences in the Colorado Energy Market. Prepared for Independent Petroleum Association of Mountain States. The 77-page report is available at: http://www.wind- watch.org/documents/wp- content/uploads/BENTEK- How-Less- Became- More.pdf,,
with a useful summary at: http://www.masterresource.org/2010/05/wind- integration- realities-the- bentek- study- for- colorado- part- iii/

Berg, Godefridus Petrus van den 2006: The Sounds of High Winds The sound of high winds: the effect of atmospheric stability on wind turbine sound and microphone noise. PhD dissertation Rutgers University, available at:
http://dissertations.ub.rug.nl/faculties/science/2006/g.p.van.den.berg/

Kay, M.J., Cutler, N., Micolich, A., MacGill, I., Outhred, H. 2009 Emerging challenges in wind energy forecasting for Australia. Australian Meteorological and Oceanographic Journal 58 (2009) 99-106.

Klinkby, J. 2002: NORD2000 vs. the existing nordic propagation models. At Website:
http://www.sp.se/Energy/acoustics/files/B-NAM%20paper%20revised%203%20Sep%202002.pdf

(see also the Website: http://www.lcpc.fr/en/presentation/moyens/slt/index.dml)

Lang, P. 2010a: Quoted in an article by Mr Graham Lloyd in The Weekend Australian newspaper. Inquirer Section page 2, November 27-28.

Lang, P. 2010b: Replacing Hazelwood Power Station – Critique of Environment Victoria report http://bravenewclimate.com/2010/05/29/replacing-hazelwood-coal/

McGill, I. 2010: Some experience to date with wind integration in South Australia… *and some emerging issues Challenges and Opportunities for Renewable Energy in South Australia* – Renewables SA and CEEM Forum Adelaide, 17 May 2010

Miskelly, A. 2010: See the websites: http://www.landscapeguardians.org.au/data/aemo/ and http://windfarmperformance.info/

Miskelly, A. & Quirk, T. 2009: Wind Farming in South East Australia. Energy & Environment **20** #8 2009/**21** #1 2010 Multi Science Publishing. Available from: http://multi-science.metapress.com/content/j2l218v143733536/

Nicholson, M., Biegler, T., Brook, B.W. 2010: How carbon pricing changes the relative competitiveness of low-carbon baseload generating technologies. In Press. Energy

Oswald, J., Raine, M., Ashraf-Ball, H. 2008: Will British weather provide reliable electricity? Energy Policy **36,** 3202– 3215

Pierpont, N. 2009: Wind Turbine Syndrome: A Report on a Natural Experiment. Publisher: K-Selected Books.

Punch, J., James, R., Pabst, D. 2010: Wind-turbine noise – what audiologists should know. Audiology T oday JulAug2010.

Van den Berg, F. 2007: Wind profiles in complex terrain. Second International Meeting on Wind Turbine Noise. Lyon France, Sept. 20-21.

Wharton, S. And Lundquist, J.K. 2010: Atmospheric Stability Impacts on Power Curves of Tall Wind Turbines – An Analysis of a West Coast North American Wind Farm. Lawrence Livermore National Lab. Report LLNL-TR-424425

White, D. 2004: Reduction in carbon dioxide emissions: estimating the potential contribution from wind-power. A Report by David White, BSc, C Eng, F I Chem E Commissioned andpublished by the Renewable Energy Foundation.

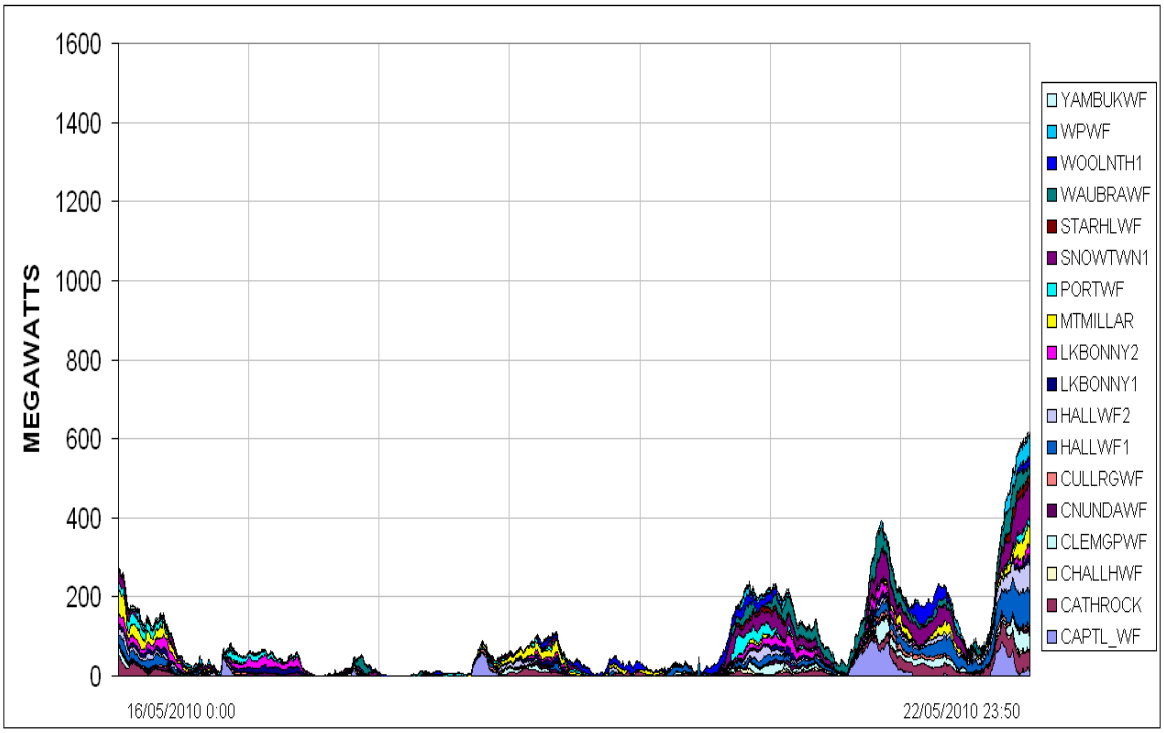
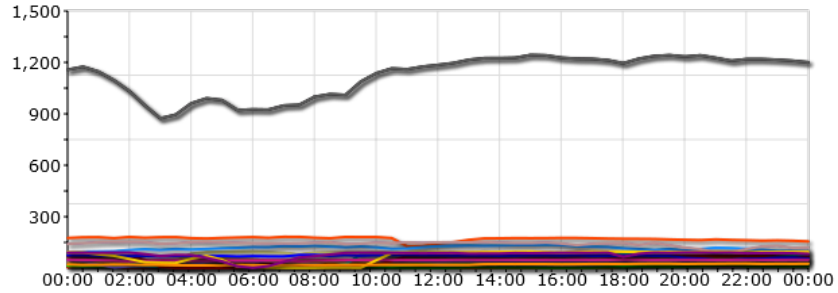
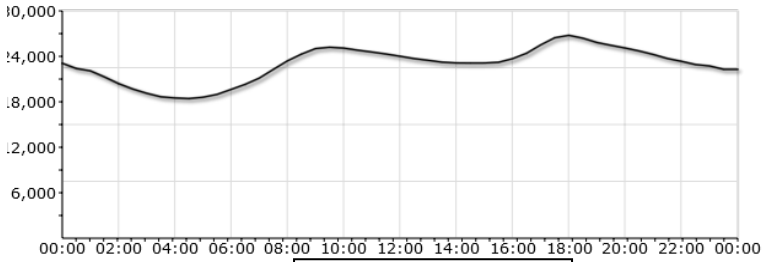


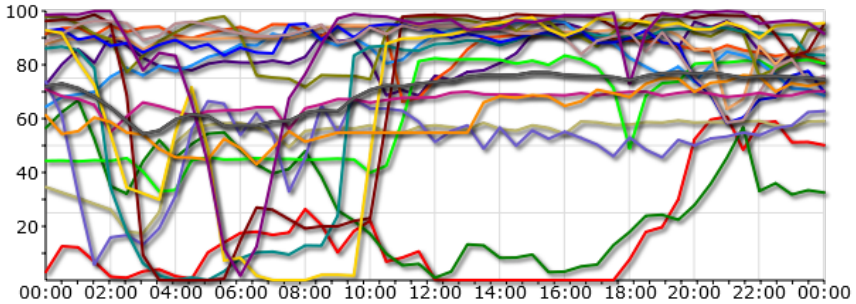
Figure 1 Total electricity generation by the present 18 windfarms connected to the eastern Australian grid for the period midnight-to-midnight 16 May 2010 – 18 May 2010; see the map below. The total installed capacity of these windfarms is 1611 MW. The legend shows the windfarms by the abbreviated name by which they are registered with the AEMO. For part of the period the output was not only zero, but negative. (All windfarms require operational power.) Source: AEMO published data, available at http://windfarmperformance.info.



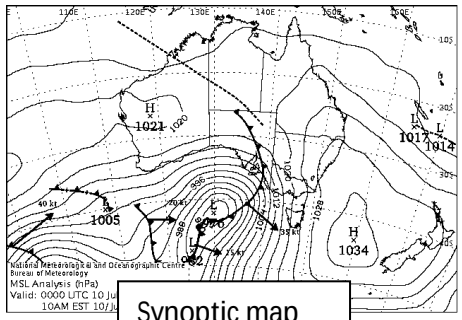
Grid/Station Output (MW)



Power demand (MW)



Capacity Factors (%)



Synoptic map

Wind farm performance and electricity demand data during strong regional winds on July 10, 2010

Figure 2

Curriculum Vitae

Geoffrey Harold Clark

Date of Birth : November 21, 1946.

Place of Birth : Melbourne, Victoria.

Nationality : Australian.

Academic Qualifications :

B.Sc. (Hons) Meteorology, M.Sc. Meteorology, University of Melbourne.

Employment History :

Joined the Australian Atomic Energy Commission (later renamed Australian Nuclear Science and Technology Organisation - ANSTO) in 1970.

Current Employment :

I retired from ANSTO in December 2004. I continued as a Consultant to the International Atomic Energy Agency (IAEA) on a Regional Co-operative Project involved in Environmental Risk Assessment with specific responsibility for meteorological studies and atmospheric dispersion methodology.

Background :

The following is a synopsis of activities associated with environmental impact assessments of uranium mining, the nuclear industry and general industrial release of air pollutants.

General Experience and Expertise :

1. Atmospheric transport modelling :
   - 2 & 3 dimensional wind field analyses (e.g. CALMET [USA]; LINCOM [Denmark]; TAPM [Australia]).
   - including plume and puff models (CALPUFF [USA]; RIMPUFF [Denmark]; EXPRESS [Japan]).
2. application of unique atmospheric tracer technology (using perfluorocarbon chemicals) to air pollution problems and model validation.
3. Installation, calibration and use of a wide range of meteorological instrumentation. Working to ISO9001 standards.
4. Collection, statistical analysis and interpretation of high quality meteorological data, both coastal and inland, urban and rural, including :
   - wind speed and direction, stability and turbulence categorisation.
   - radiation, rainfall, temperature, humidity and evaporation.
   - acoustic sounder data analysis.
   - tethered and free flying balloon supported transducers.
5. I made an Expert Witness submission to the NSW Land and Environment Court in relation to the meteorology and noise impacts of a proposed wind farm at Taralga,

NSW (Court Proc 11216 of 2007).

6. Project Management skills – I have lead a project aimed at certification of the ANSTO environmental management system to ISO 14001 standards. This involved a multi-disciplinary team of 20 people (in the atmospheric, biological, hydrological, ground water and environmental risk management areas).

Work History :

I was involved in leading the meteorological research and monitoring program for ANSTO for 34 years. This principally has been focused on support of operations at the Lucas Heights nuclear facilities and also those at the National Medical Cyclotron site in the Sydney-city area. In addition I have interacted with industry through conduct of meteorological and atmospheric tracer studies. These studies included the uranium mining, aluminium smelting and refining, and the oil shale refining industries. My specific expertise is in the meteorology of complex terrain including wind flow patterns and the daytime evolution of temperature inversion/stability conditions. I have written many ANSTO and commercial reports and have presented results at both International and local Australian conferences.