Review of Wind Energy Utilization in Australia

Alireza Bahadori[1,*] and Chikezie Nwaoha[2]

[1]*Southern Cross University, School of Environment, Science and Engineering, PO Box 157, Lismore, NSW, 2480, Australia*
[2]*Independent Consultant, 10a Lake Nwaebere Street, Aladinma, Owerri, Nigeria*

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Abstract: Energy production processes that use fossil fuels as an energy source release greenhouse gases (GHGs) that cause global warming and climate change. However, in recent years, concerns over this climate change have prompted Australian policymakers to seek ways to increase the proportion of emissions-free renewable energy, such as wind energy. Wind energy is a renewable, sustainable, and environmentally friendly energy source. In Australia, the wind power industry is expected to grow rapidly over the next decade, primarily due to the national renewable energy target (RET), which will mandate that renewable sources provide approximately 20% of Australia's electricity production by 2020. The objective of this article is to identify and analyze issues that are imperative for successful acceptance of wind energy in Australia.

Keywords: Australia, greenhouse gases, renewable energy target, wind energy

1 Introduction

According to the Australian Government Department of Energy and Resources (2011), the wind energy industry is the fastest-growing renewable energy (RE) source in many countries, and is expected to continue to grow rapidly until 2030. Wind power will undoubtedly play a significant role in the drive toward decarbonizing global energy systems [1]. Wind power has a significant contribution to make in efforts to abate CO_2 emissions from global energy systems.

Wind energy is a proven and mature technology with low operating costs. Both the size of turbines and the size of wind farms have increased, with farms of more than 100 MW combined capacity now common, and substantially larger wind farms proposed [2].

**Corresponding author*: alireza.bahadori@scu.edu.au

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The increasing negative effects of fossil fuel combustion on the environment, in addition to limited stock of fossil fuel, have forced many countries to inquire into and change to environmentally friendly alternatives that are renewable to sustain the increasing energy demand [3]. Energy policy plays a vital role to mitigate the impacts of global warming and crisis of energy availability.

The Australian Government Department of Energy and Resources (2011) forecasts that the world's wind energy resource is estimated to be around one million gigawatts (GW) for total land coverage. Assuming only 1% of the area is utilized and allowance is made for the lower load factors of wind plant, the wind energy potential would correspond to around-the-world total electricity generation capacity [4]. The windiest areas are typically coastal regions of continents at mid-latitudes to high latitudes and mountainous regions.

The world outlook for electricity generation from wind energy will be strongly influenced by government climate change policies and the demand for low-emission RE at affordable prices. In the latest Australian Bureau of Agricultural and Resource Economics (ABARE) long-term energy projections that include a 5% emissions reduction target, wind electricity generation in Australia is projected to increase sharply, from 4 TWh in 2007–2008, to 44 TWh in 2029–2030 (Fig. 1). The share of wind energy in total electricity generation is projected to increase from 1.5% in 2007–2008 to 12.1% in 2029–2030 [2].

In 2009, the Australian government legislated a renewable energy target (RET) of 20% by 2020 (i.e., approximately 45,000 GWh of RE-sourced electricity) in line with its national plan for a clean energy future [5]. While the plan is aimed at directly mitigating the impacts of climate change, the flow down of this target and the development of RE supply at the state, territory, and municipal levels of

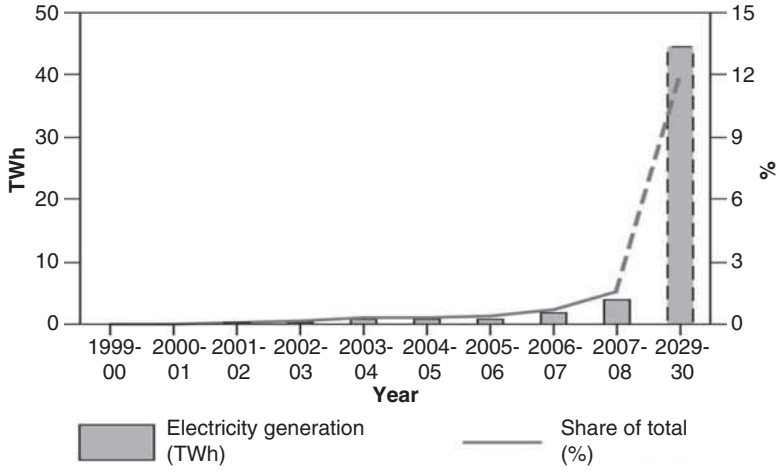

Figure 1 Australia's wind energy market in 2029–2030 (ABARE 2010 as cited in Australian Government Department of Energy and Resources, 2011)

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government present a significant challenge [6]. Accordingly, the impositions of a poor RE development framework for RE asset construction and deployment may render the national RET unachievable in the remaining time frame [6].

These policy opportunities that have been canvassed by various researchers and RE advocates provide a series of policy prescriptions and actions that support the achievement of the RET and any state-level targets [6]. These initiatives can take various forms, including RE Portfolio Standards (RPS), government tendering of RE projects, tax benefits for RE assets purchase and depreciation, and voluntary green power markets [6]. However, the selection of RET enabling actions, commencement of the Australian carbon pricing legislation in mid-2012, and the relatively short 10-year time frame for meeting the national RET present some immediate challenges for domestic governments [7].

2 Australia's Wind Energy—An Overview

Australia has one of the highest per capita greenhouse gas emissions levels in the industrialized world [8]. This is partly due to its large domestic reserves of coal, which have kept electricity prices low and attracted energy-intensive industry.

Currently, coal-fired power provides more than 75% of domestic electricity generation (Fig. 2) [3]. However, in recent years, concerns over climate change have prompted Australian policymakers to seek mechanisms to increase the proportion of emissions-free RE, such as wind energy.

Currently, wind accounts for almost 22% of total clean energy generation. In the past year, wind power generated over 6400 GWh of electricity, which was enough to power over 900,000 homes [9].

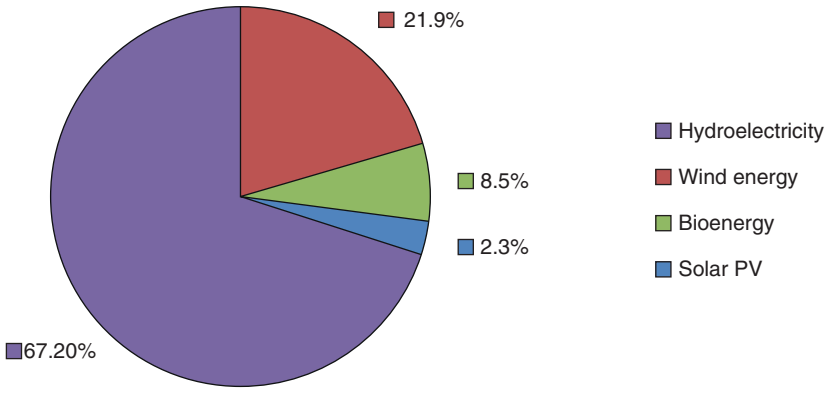

Figure 2 Australia's estimated percentage contribution of each technology to renewable generation (Clean Energy Council, 2011, p. 6)

Note: Solar thermal (0.015%), geothermal (0.002%), and marine energy (0.003%) are not inclusive in the data above.

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The Clean Energy Council (2011) stated that Australia has 1,188 wind turbines and 57 operating wind farms, including one small wind farm located in the Australian Antarctic Territory. The amount of wind power in Australia has grown by an average of 35% per year over the past 5 years, and the efficiency and power output of turbines are evolving quickly [9].

A report prepared by Garrad Hassan for the Clean Energy Council in 2011 predicted that there would be approximately 6.9 GW of wind power built under the RET by 2020. This would be delivered from approximately 2000 to 2500 wind turbines, depending on their size and power output [9]. Acciona's Waubra Wind Farm, northwest of Ballarat in Victoria, is currently the largest in the country, with 128 turbines spread out over 173 km^2 [9].

Australia has some of the best wind resources in the world, primarily located in western, southwestern, southern, and southeastern coastal regions, but extending hundreds of kilometers inland and including highland areas in southeastern Australia (Fig. 3). There are large areas with average wind speeds suitable for high-yield electricity generation [2].

This includes the coastal regions of western and southern Australia [2]. These regions are generally characterized by high, relatively constant wind conditions, with average wind speeds in excess of 6 m/s and, in places, more than 9 m/s [2].

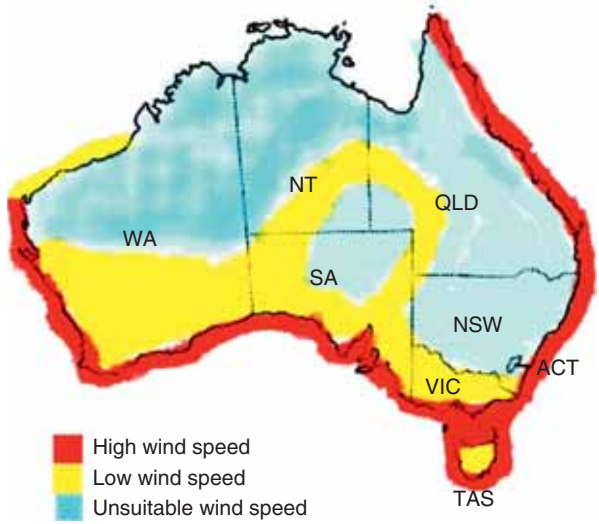

Figure 3 Australia's potential wind speed (Department of Resources Energy and Tourism, 2009 as cited in Yusaf, Goh, and Borserio, 2011) [10].

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However, making comparisons between wind and other sources of energy can be difficult because of the cost profiles associated with wind developments. The vast majority of the costs associated with wind developments are upfront capital costs. The operating costs are relatively low, with each additional unit of wind power costing very little to produce. By comparison, conventional gas and coal developments have large capital costs as well as significant operating costs.

The difference in cost profiles creates difficulties when trying to compare the cost of alternative energy sources [11]. Despite these complexities, most of the data indicate that wind energy is one of the most cost-efficient sources of RE, and that when the costs associated with pollution are factored in, it is competitive with coal- and gas-fired power stations [11].

3 Wind Energy and Gains

Wind is a vast potential and sustainable source of RE. Winds are generated by complex mechanisms involving the rotation of the earth, the heat capacity of the sun, the cooling effect of the oceans and polar ice caps, temperature gradients between land and sea, and the physical effects of mountains and other obstacles [2]. Wind energy is generated by converting wind currents into other forms of energy using wind turbines. Turbines extract energy from the passing air by converting kinetic energy from rotational movement via a rotor. The effectiveness of this conversion at any given site is commonly measured by its energy density or, alternatively, as a capacity factor [2]. Wind energy is primarily used for electricity generation, both onsite and for transport to the grid. Wind energy is also used to pump bore water, particularly in rural areas. See Figure 4 for Australia's wind energy supply chain.

In the electricity market, wind energy is automatically dispatched, meaning that the wind electricity must be consumed before other, more controllable sources are dispatched. Since March 2009, new wind generators greater than 30 MW must be classified as "semi-scheduled" and participate in the central dispatch process [12]. Electricity produced from the individual turbines is stepped up by means of a transformer and high-voltage switch and collected in the central switchyard of the wind farm. It is then fed to the electricity transmission grid substation with further transformers and switchgear.

The electricity is distributed to the industrial, commercial, and residential markets in the same manner as electricity generated from any other source. Small wind turbines (typically less than 10 kW) are commonly used in remote locations isolated from the grid for a variety of industrial, commercial, and household needs, usually in conjunction with some form of storage [2].

As an additional gain, according to the Clean Energy Council (2011), wind energy will account for the most number of new employees in the RE industry (Fig. 5).

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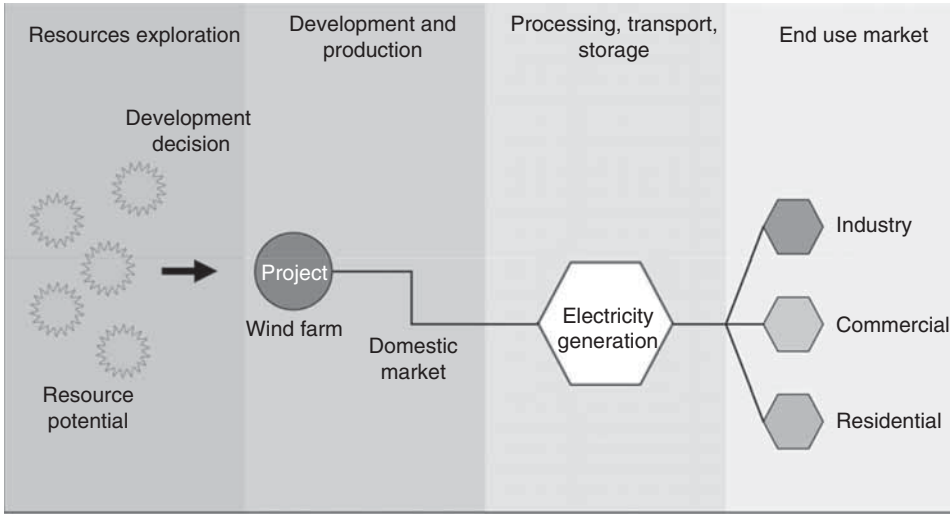

Figure 4 Australia's wind energy supply chain (ABARE and Geoscience Australia as cited in Australian Government Department of Energy and Resources, 2011)

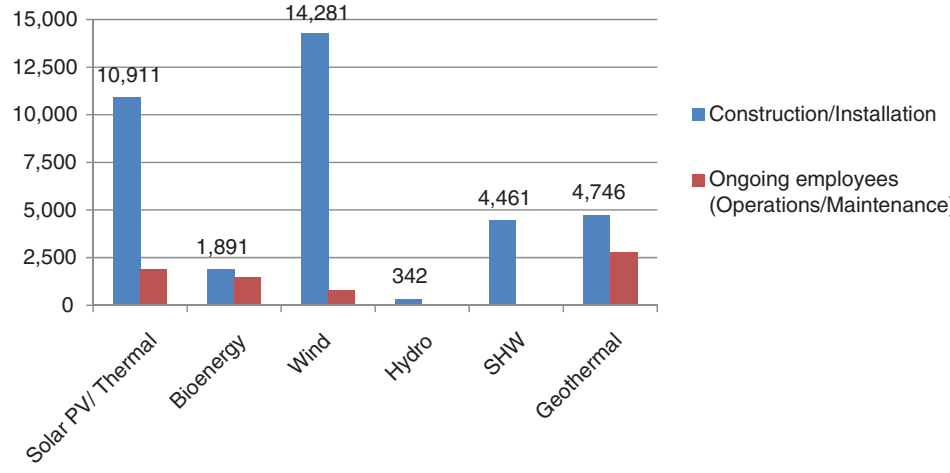

Figure 5 Estimated numbers of new jobs created in the renewable energy industry by 2030 (Clean Energy Council, 2011)

4 Challenges

First, the main issue affecting the wind energy industry is its reliance on government-enforced RETs. However, a large reliance on the mandatory RET (MRET)

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scheme implies that the wind power industry is at risk of facing dormancy again when the target is met, or if there is a change in the government support for the MRET scheme. For this reason, it would be better to implement alternative economic incentive mechanisms to make the industry an attractive ground for investment regardless of the MRET scheme [11].

Second, according to Kuwahata and Monroy (2011), there were no taxpayer subsidies for the wind energy industry in Australia. The developer must carry the entire financial liability for a project, which may cost anywhere from AU$100 million to AU$400 million, without government funding. Investors are faced with a high capital cost, inhibiting growth of this technology. Therefore, it would make sense to implement a system that reduces the initial capital required. Rather than direct subsidies that are likely to be costly for the government, some form of tax exemption strategy such as accelerated depreciation, similar to those that benefit coal-fired power generators, could be applied. A more unique solution to the industry would be to encourage the establishment of wind turbine manufacturing in Australia. According to Kuwahata and Monroy (2011), there are no facilities for manufacturing large wind turbine systems in Australia at the moment, so most components are imported from Europe or China, which incurs additional cost for transportation.

Third, another challenge with wind power is grid constraints—lack of capacity or availability. This may limit further growth of wind energy in some areas with superior wind resources, particularly in South Australia. In such areas, upgrades and extensions to the current grid may be required to accommodate significant further wind energy development. Elsewhere, current grid infrastructure should be adequate for the levels of wind energy penetration projected for 2030 [2].

For new systems, extra distribution and transmission networks need to be built, and being at the ends of a long and stringy grid system, unpredictable intermittency generation can result in major frequency oscillation problems [11]. These types of technical barriers must be addressed to allow for the sustainable growth of wind power generation, which means investing in research and development (R&D) for intermittency-related grid connection issues and to encourage construction of transmission network infrastructure [11].

However, despite all, it is still worrisome to see that achieving the 2020 target is so dependent on the accurate implementation of policies, particularly when the time frame for taking action against global warming and climate change is so limited [13]. State policies must be streamlined with the federal government's initiatives to attract more investment in renewable-based power technologies, and the people of Australia must be prepared to change in the way they use energy [13].

5 Conclusion

Wind turbines sustain the environment by producing no greenhouse gas emissions, while emissions involved in the development stage are low when compared

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with electricity generation from other fossil and nonfossil sources. With Australian Government policies, particularly the RET, wind energy will be greatly sustained to boost the future energy demand of Australia. In addition, to accelerate the technical development of wind energy, funding toward R&D, pilot projects, and support for international collaboration projects must be encouraged. Finally, it is essential to ensure that wind power projects are developed in the most economically optimal approach.

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