***COSTS OF GRID INTEGRATION OF WIND ENERGY IN THE AUSTRALIAN NATIONAL ELECTRICITY MARKET***

Hue T.T. Nguyen, The University of Western Australia, +61 437 412 428, 21415271@student.uwa.edu.au

Chunbo Ma, The University of Western Australia, +618 6488 2534, chunbo.ma@uwa.edu.au

Morteza Chalak, The University of Western Australia, +618 6488 5508, morteza.chalak@uwa.edu.au

Atakelty Hailu, The University of Western Australia, +618 6488 2538, atakelty.hailu@uwa.edu.au

## Overview

Australian federal government committed to achieve 20 per cent of total electricity generation comes from renewable sources by 2020 under the Large-scale Renewable Energy Target (LRET) scheme that mainly aims to encourage the additional generation of electricity from renewable sources and reduce emissions of greenhouse gases in the electricity sector. Increasing wind power production, therefore, will play a vital role in this scheme to meet the government’s target. Indeed, the LRET requires 41,000 GWh of electricity be sourced from renewable energy sources by 2020 but only 18,200 GWh are generated by renewables today. That means electricity to be generated by renewables will grow double during the period of 2013-2020, and wind energy is projected to account for the majority of this growth, representing 14% of total electricity generation by 2035.

Increasing the penetration level of renewables to produce electricity implies a cost to the system, which is called “integration cost”. In other words, the integration of wind energy into power system results in additional costs at the system level such as increasing cost of balancing services, reserve capacity, and more cycling and ramping of conventional plants (Hirth, 2012). Surveyed results from the literature showed that integration costs of wind energy could be significantly varies from €15-€35/MWh at 20-25% share of wind in some countries in Europe and can become an economic barrier to deploying wind power at higher shares (Ueckerdt et.al, 2012). The magnitude of integration cost of wind energy in the National Electricity Market (NEM) in Australia is projected to be higher due to the fact that NEM is designed to predominantly deliver electricity from large-scale thermal power plants, and areas with high wind potential located far from major demand centres. Moreover, the transmission system of the NEM covers a very large and long distance and has a relatively week interconnection between states.

Given the magnitude of integration costs of wind power, this could be a burden to the Australian investors, and unfortunately none of the studies have been found to estimate additional costs of wind integration on the NEM system in a comprehensive approach to the best of my knowledge. This research will therefore be the first study in Australia, aiming to quantify this cost eventhough the integration costs could be indicative numbers, but the result of this study provide an exhaustively and comprehensive method to quantify the cost to help Australian government to shape the wise and stable future energy direction in Australia.

## Methods

There are a number of methods available to estimate the cost of grid integration of wind generation, however this research selected a methodology that comprehensively used in EU countries in GreenNet-EU27 project ([Diesendorf, 1998](#_ENREF_2); [EIE, Auer, Obersteiner, Weissensteiner, & Resch, 2005](#_ENREF_3); [Strbac, 2002](#_ENREF_4)). This methodology uses system cost top-down approach that allows analysing and decompositing integration costs into three cost components: (1) additional system capacity cost and balancing cost, (2) additional grid reinforcement/extension cost, and (3) grid connection cost.

**Integration costs = Additional system capacity cost and balancing cost + additional grid reinforcement/extension cost + grid connection cost**

Integration costs of wind power in this study is calculated from empirical market data. Details of the empirical approach are described in the following steps:

1. To estimate additional system capacity cost, this research uses real data of wind generation in the NEM (5’ interval dispatch) to run simulation to estimate capacity credit of wind generation. Capacity credit of wind is calculated by determining the reductions of installed conventional power capacity so that the probability of loss of load (LOLP) in peak period is maintained. Once capacity credit of wind generation is calculated, additional system capacity requirements are estimated by assuming that the amount of wind generation could be replaced by thermal generation (CCGT) at 83% load factor. Balancing cost is estimated around 50% of system capacity cost similarly to the EU countries.
2. Grid connection cost is split into two: the costs for the local electrical installation, and the costs for connecting the wind farm to the electrical grid. The costs for local electrical installation are technology specific and has been incorporated into the Levelised cost of electricity (LCOE), and therefore this research focus on estimating the cost of connecting the wind farm to the electrical grid alone. Findings from the literature show that grid connection cost of on-shore wind farm depends on the size (installed capacity of wind turbine) and votage level of grid connection. In the case of Australian NEM network, most of the existing and proposed new wind farms will be connected to the medium to high voltage level. The additional 8.8GW of new wind generation has average installd capacity above 150MW. The average grid connection cost of wind energy accounts for about 25% of installed capacity equivalents to $0.63/MW installed.
3. Grid extension/reinforcement cost: This research used the findings from ([Buckman & Diesendorf, 2010](#_ENREF_1)) for grid extension/reinforcement costs. More than 10 billion dollars will be invested in the NEM to extend and augument the transmission lines (>27,500km) under the commitment of the government. This equals to $25.2/MWh investment for grid extension/inforcement due the length and aged characteristics of NEM transmission lines.

## Results

## This research estimates the integration costs of wind generation using two scenarios: with and without wind dispersion factor. This factor reflects the flunctuation and variability of wind energy across NEM region.

## Results of this study show that in both scenarios with the low penetration level of renewables, the integration cost of wind energy is about $27/MWh – $37/MWh respectively. Grid extension and system capacity costs are the largest driver of integration cost which accounts for about 54% and 37% respectively.

Renewable energy penetration increases up to 20% by 2020 as targeted, the integration costs are projected to be much higher which is above $40/MWh depends on the location of the wind farms and season (winter or summer)..

## Conclusions

The estimation of system integration cost is complex and requires a sophisticated model and/or reliable market data. Projecting these costs for the Australian NEM is even more difficult because until now there has been very little research or publicly available detailed data on how the variable nature of sunshine or wind flows affects electricity networks, and research done in other countries is not entirely relevant to the Australian context. The values in this paper, therefore, should be taken as indicative of the order of maginitude of the likely integration costs. However, this study finds that the integration cost is significant if the government aims to target 20% of the renewables to produce electricity for the country. A careful consideration from policy planners are recommended to design an electricity market for facilitating the integration of wind energy in Australia. Higher penetration wind generation will impact severely on the electricity prices on those days that weather condition is not in favour to produce wind energy.

## References

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