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Australian evidence on the role of interregional flows, production capacity, and generation mix in wholesale electricity prices and price volatility

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ABSTRACT

This paper examines the impact of interregional flows, production capacity and generation mix, encompassing both fossil fuels (black and brown coal and natural gas) and renewables (hydropower and wind power), on daily wholesale electricity price volatility across the five regional electricity markets in the Australian National Electricity Market from January 2006 to June 2012. One objective is to examine the volatility impacts of daily interregional energy flows when regions are exporting and importing electricity and daily slack (excess daily capacity) produced by differences in generation capacity and actual generation. Another is to gain insights into the emergent effects of policy and industry developments regarding the choice of generation on price volatility. Using Student panel common and fixed-effects generalized autoregressive conditional heteroscedasticity (GARCH) specifications, we find that the type of generation exerts a strong influence on prices and price volatility, with prices increasing for open-cycle gas turbine and hydro generation and decreasing for black coal generation. We also find increasing price volatility for black coal, open-cycle gas turbine, and hydro generation, and decreasing price volatility for combined-cycle gas turbine generation. Interregional flows appear to exert no significant influence on prices or price volatility, while generation slack tends to reduce prices, but has no effect on price volatility.

1. Introduction

In just over a decade, the electricity industry in Australia has experienced rapid and far-reaching changes in market structure, operations, competitiveness, ownership, and efficiency. Once characterized by large vertically integrated state government-owned entities operating in distinct regional markets, it now features the separation of generation, transmission, and distribution functions across a relatively large number of competing commercialized, privatized, and private companies with strong interregional linkages. A small but growing literature has examined price behaviour in these markets, including Higgs and Worthington (2005, 2008), Worthington et al. (2005), Chan and Gray (2006), Becker et al. (2007) and Higgs (2009).

Alongside these developments have been important changes in the technologies used to produce and distribute electricity in Australia. Obviously, the high-voltage interconnectors between the state-based regions in the national

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electricity market have been critical, with Tasmania physically joined to the mainland market through an unregulated interconnection with Victoria (Basslink) and regulated interconnectors between the four mainland states. In addition, electricity generation capacity has also increased significantly in all regions and across all technologies over time. Even during the relatively short period since the creation of the National Electricity Market (NEM) in 1998, yearly electricity generation in Australia increased by some 35,411 GWh (22%). However, of late and for at least the next few years, there has been a continuing slide in electricity demand, with both falling industrial demand resulting from the closure of aluminium smelters and manufacturing operations and softening retail demand associated with household solar generation. The current situation is of oversupply in the NEM, even beyond the 15%–20% reserve margin commonly set to ensure continuity in supply.

Endowed with substantial reserves of black and brown coal, for much of its history and today, the Australian electricity industry has drawn on solid fossil fuels to provide most of its capacity and generated electricity, especially base load production. For instance, of the 195,525 GWh of electricity generated in Australia in 2013, black and brown coal accounted for 97,509 GWh (50%) and 47,255 GWh (24%), respectively (AEMO, 2015). While the share of coal in total generation has clearly declined over time, down from 88% for both black and brown coal in 1998, it is still up by 3,573 GWh in volume during our chosen sample period.

More recently, the development of sizeable gas reserves, both natural and coal seam gas (CSG), in South Australia, Queensland, NSW, and elsewhere has widened the choice of fossil fuels in use, especially in peaking plants, such that it now accounts for 22,693 GWh (12%) of total electricity generation. This is a nearly ninefold increase from the bare 2541 GWh of gas-fired electricity generation in 1998, which at the time accounted for less than 2% of total electricity production. With emissions of greenhouse gases (GHGs) less than half those from brown and black thermal coal, gas has lower capital costs than coal-fired plants, but higher fuel costs. During the period of our analysis, growth in gas-fired electricity generation surged alongside the discovery of new and larger gas reserves, though the discovery of new reserves has now slackened with gas-fired generation itself expected to soften alongside electricity demand (Fleming and Measham, 2015).

Lastly, renewable energy production of all types has also increased in volume and share, but rather more moderately, from 15,861 GWh (10%) in 1998 to 28,068 GWh (14%) in 2013 (an increase of 76% over the past 17 years). In practice, this is mostly hydropower from the Snowy Mountains Hydroelectric Scheme (about 55% of hydropower production) and Tasmania (an additional 29%), with smaller-scale operations in some of the other states. However, wind power has recently emerged as a primary and growing source of renewable energy in Australia, primarily in South Australia and Victoria. While relatively insignificant at the national level, South Australia now has wind energy production comparable to Denmark and exceeding that of Spain and Germany. In fact, on a number of occasions, wind (along with solar) electricity production in South Australia has exceeded its own regional demand.

In terms of other renewable sources of wholesale electricity, the first commercial-scale photovoltaic (PV) solar power plants opened outside the NEM in Western Australia and the Northern Territory in the early 2010s, with commercial-scale plants within the NEM (at Nyngan and Broken Hill) coming online in the second half of 2015. Of course, while not part of the NEM, the huge expansion in household PV solar systems (currently in excess of one million domestic household installations and nearly 4 GW of installed capacity) has already had a significant impact on the wholesale market, in terms of reducing electricity demand and delaying the development of large-scale generation capacity. A number of renewable technologies also show future promise (though none are presently commercially viable) as potential wholesale suppliers of electricity in Australia, including tidal/wave, bioenergy, and geothermal generation. There are currently no plans for nuclear generation in Australia.

However, apart from the existing and newly discovered natural resource endowments that have done much to foster the existing generation mix in the Australian electricity industry, the pattern of generation technologies is also evolving in response to climate change policy. Most notable of these is the Commonwealth government's primary emissions reduction policy in the form of a national renewable energy target (RET) scheme intended to deliver a 20% share of renewable energy in Australia's generation mix by 2020 through the requirement for electricity retailers to source a proportion of their electricity from renewable sources developed after 1997.

More recently, July 2012 saw the introduction of a carbon tax of $23 per ton of emitted CO_2 on fossil fuels consumed by major industrial emitters as a complement to the RET. This fixed price was to increase by 5% per year until transitioning to a flexible-price emissions-trading scheme (ETS) in 2015/16 when the permits available would be set in line with a pollution cap. While the carbon tax was abolished on 1 July 2014 by the current Liberal–National government, it was replaced by a so-called 'direct action plan' comprising an emissions reduction fund intended to provided financial incentives for polluters to reduce GHG emissions.

While the effects of these changes remain contentious, it was generally accepted that the RET and the carbon tax then direct action, would continue to drive the development of low-emission renewable generation at the expense of high-emission fossil-fuel generation. However, there is substantial uncertainty over the timing and technical and economic feasibility of these changes with it being likely that coal will remain the dominant baseload generation type for at least the next decade, and gas increasingly, and almost paradoxically, called upon to complement the variable and intermittent output from wind as the primary renewable after hydropower. It is clear that while wholesale prices are now stable and not directly accountable for recent large increases in retail prices – Simshauser and Nelson (2013) provide a useful analysis of the causes and past and immediate impacts – they will respond to the varying cost structures of the different technologies, combined with the impact of generation capacity and regional interconnection.