Emission Intensities in the Australian National Electricity Market – An Econometric Analysis

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Overview

This study analyses the evolution of CO2 emission intensity of the electricity sector within the National Electricity Market (NEM) in Australia during the period 2010-2019. The role of demand, changes in generation fossil fuel mix, the closure of coal-fired plants and fuel efficiency on emission intensity have been examined using the daily data. Particular emphasis is placed on the assessment of any potential association between the examined driving factors and the major climate and energy policies, more specifically the Carbon Pricing Mechanism (CPM) and the Renewable Energy Target (RET) implemented during the examined period. The model developed to identify factors impacting on emission intensity of power sector across NEM is based on Simultaneous equations model. Logarithmic mean Divisia index methodology is also applied to analyze the drivers of carbon emissions intensity. The obtained results show that changes in renewable deployment was the principal factor affecting the emission intensity of the NEM. Moreover, the fossil fuel mixture effect (reduction in coal-fired generation combined with the increase in generation from gas) was responsible for reducing the emission intensity of the power sector. However, other drivers, such as CPM and fuel efficiency, were not as influential.

Data for the NEM show that the emission intensity of electricity generation has fallen over the past few years. However, the emission intensity of power sector in Australia is still higher than most OECD countries. In Australia, stationary energy is the largest source of CO2 at around half of total emissions (Treasury, 2017), of which more than two-thirds come from electricity generation (i.e. electricity generation accounts for 35 per cent of all CO2 emissions in Australia). In Australia, the main source of electricity supply is from fossil fuel generators (mainly coal-fired plants). The brown coal-fired power stations (with the highest emission intensities) have dominated the bottom of the merit order producing around 25 per cent of electricity, followed by black coal-fired stations which generate about 52.4 per cent of electricity (AEMO, 2018). Gas generates around 10 per cent of electricity, and finally renewable energy sources (with zero emission intensities) have a 12.6 per cent share of the generation mix, and are located higher in the merit order (AEMO, 2018). Thus, any changes in the power structure and in the share of fossil fuel generation could significantly impact the average emission intensity of the sector. Therefore, this paper assesses how the potential shift between fossil fuels (mainly between coal and gas) and renewables could affect emission intensity. In other words, it measures, for example, if and by how much gas has replaced coal and what has been its impact on emission intensity.

This paper also attempts to relate each driving factor to existing energy and climate policies in Australia in order to assess the impact on the emission intensity of the power sector and each factor's overall effectiveness. Australia's principal climate change policies in recent years have been the Australian Government's Renewable Energy Target (RET) scheme (launched in 1999 and amended several times), Carbon Pricing Mechanism (CPM, 2012–14), and Direct Action (launched 2014). Alongside these schemes, State governments have operated feed-in tariff schemes that have subsidised solar PV generation as well as the Emission Reduction Fund (ERF) crediting and purchasing mechanism. As Australia transitions to a lower emissions economy, the focus is shifting to gas and renewables generation. Therefore, this paper takes into consideration the potential impacts of the CPM and the RET as the main climate and energy policies putting these in context with the dominant factors impacting the power sector's emissions. Changes in electricity generation emission intensity could be also attributed to changes in the carbon intensity of each fuel type as well as the fuel efficiency of power plants.

Methods

This study will be one of the first studies to identify factors impacting the emission intensity of power sector within the NEM. In order to investigate and quantify the factors driving emission intensity for each major regional market within the NEM individually (i.e. New South Wales (NSW), Queensland (QL), Victoria (VIC), and South Australia (SA)) as well as nationally, both a Simultaneous equation model and the Logarithmic mean Divisia index methodology are employed. The dataset is constructed on a daily basis from 1 July 2010 to 30 December 2019. Following a procedure similar to that of Shrestha et al. (1996), and Karmellos et al. (2016), this paper assumes that changes in emission intensity of the power sector can be predominately attributed to the following: changes in the fossil fuel mix generation; the quality of fuel (i.e. type, heat value, and carbon content) used to generate the electricity within each fuel type; and the generation efficiency of thermal power plants. In addition to these key factors, the impact of the demand for electricity and the implementation of climate and energy policies addressing emission intensity, are also taken into consideration over the period investigated. Moreover, the withdrawal of coal-fired plants with very high emission intensities that has occurred over the past few years (more specifically in 2016 and 2017), which consequently retired significant coal-fired capacity from the market, is considered one driver behind a reduction in the average emission intensity of the power sector. For the purpose of robustness check, we also use an alternative multivariate linear model to quantify the contributions of each driver.

Results

Our findings demonstrate that for all states considered renewable deployment and changes in the fuel mix (i.e. the increased share of gas) are the principal factors explaining the reduction in emission intensity. It should be noted that the increase in share of gas maybe influenced by the intensification of the efforts of the Australian government to curb carbon emissions mainly through the CPM, as well as by changes in gas prices, the market maturity and diffusion of low carbon technologies. Regarding the CPM, the results show a relatively limited contribution to the reduction of emission intensity of the power sector. It seems that uncertainty about the CPM affected investor confidence, resulting in a relatively small reduction in carbon intensities through the generation mix effect. This slight reduction appears to have occurred mainly through switching from coal-fired electricity generation to gas (due to carbon price-induced cost increases for coal-fired generators), rather than from increased renewables deployment. Therefore, the carbon-induced effects on emissions intensities for all states considered are of little importance. Based upon this analysis, the temporary or the permanent closure of some coal-fired plants across the NEM played an important role in decreasing the emissions from the power sector over the period investigated through the removal of significant coal capacity from the market. For instance, the closure of Alinta's Northern Power Station in May 2016 which marked the end of coal fired electricity generation in South Australia, removing 546 megawatts (MW) of capacity from the NEM, resulted in a significant drop in emission intensity in SA. Moreover, the closure of Engie's Hazelwood power station in VIC in March 2017 which removed another 1600 MW of brown coal generation from the NEM, had a great share of responsibility for the recorded emission reduction in VIC as well as in the NEM. The findings also reveal that across the NEM emission intensities are strongly influenced by demand for electricity.

Conclusions

This paper finds that the main reasons for the decline in the emission intensity of power sector have been an increase in renewable deployment and a shift in the fossil fuel mix effect. It seemed that the RET was a significant driver behind a fall in the emission intensity across the NEM. CPM has limited effects in changing the merit order and the dispatch of power stations during the first two years of its operation due to its uncertainty. These findings could be crucial for policymakers to make better-informed regulatory decisions when designing climate policies to reduce domestic emissions and support international efforts and, more specifically, when considering a transition to an emissions trading scheme under the Liberal-National coalition government.

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