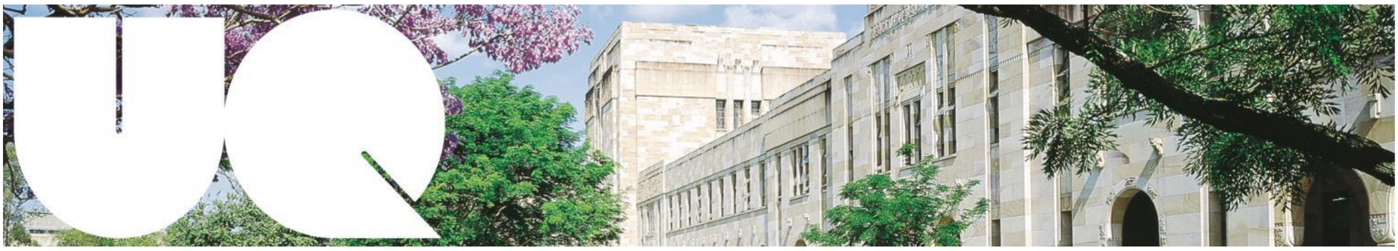

The effect of increasing the number of wind turbine generators on generator energy in the Australian National Electricity Market from 2014 to 2025

EEMG Working Paper 6-2015 - Version 09

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As part of the project:

ARC Linkage Project (LP110200957, 2011-2014) - An investigation of the impacts of increased power supply to the national grid by wind generators on the Australian electricity industry

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Preface

This report investigates *'The effect of increasing the number of wind turbine generators on generator energy in the Australian National Electricity Market (NEM) from 2014 to 2025'*. The report is part of research project titled: *An investigation of the impacts of increased power supply to the national grid by wind generators on the Australian electricity industry: ARC Linkage Project (LP110200957, 2011-2014).*

The aim of the project is to discover the most economical and effective way to accommodate large increases in wind power into the national grid and to understand the effects on the national electricity market. This is crucial to ensure stability of electricity supply and affordable prices in the transition towards a low carbon economy.

Significant increases in Australian power generation using wind are planned for the coming years. This project answers urgent questions concerning the capability of the existing power grid to cope with a volatile source of supply, required grid modifications, impacts on the national electricity market (NEM), the optimal placement of wind farms and the Large-scale Renewable Energy Target (LRET). This is, necessarily, an interdisciplinary project involving economists, electrical engineers and climate scientists with very strong support from the wind generators. A coherent government policy to phase in renewable energy in a cost effective manner will not be possible without high quality research of this kind.

The project's electricity market modelling tool is the *Australian National Electricity Market (ANEM) model version 1.10 (Wild et al. 2015). Wild et al. (2015)* provides extensive details of the version of the ANEM model used in this project. Table 1 provides a list of the project's publications.

Table 1: The project's publications

Journal publications:

Bell, WP, Wild, P, Foster, J, and Hewson, M (2015), Wind speed and electricity demand correlation analysis in the Australian National Electricity Market: Determining wind turbine generators' ability to meet electricity demand without energy storage, *Economic Analysis & Policy*, vol. 48, no. December 2015, doi:10.1016/j.eap.2015.11.009

Wild, P, Bell, WP and Foster, J, (2015) Impact of Carbon Prices on Wholesale Electricity Prices and Carbon Pass-Through Rates in the Australian National Electricity Market. *The Energy Journal*, vol. 36, no 3, doi:10.5547/01956574.36.3.pwil

Final reports:

Wild, P, Bell, WP, Foster, J, and Hewson, M (2015), *Australian National Electricity Market Model version 1.10*, EEMG Working Paper 2-2015, The University of Queensland, Brisbane, Australia.

Bell, WP, Wild, P, Foster, J, and Hewson, M (2015), *The effect of increasing the number of wind turbine generators on transmission line congestion in the Australian National Electricity Market from 2014 to 2025*, EEMG Working Paper 3-2015, The University of Queensland, Brisbane, Australia.

Bell, WP, Wild, P, Foster, J, and Hewson, M (2015), *The effect of increasing the number of wind turbine generators on wholesale spot prices in the Australian National Electricity Market from 2014 to 2025*, EEMG Working Paper 4-2015, The University of Queensland, Brisbane, Australia.

Bell, WP, Wild, P, Foster, J, and Hewson, M (2015), *The effect of increasing the number of wind turbine generators on carbon dioxide emissions in the Australian National Electricity Market from 2014 to 2025*, EEMG Working Paper 5-2015, The University of Queensland, Brisbane, Australia.

Bell, WP, Wild, P, Foster, J, and Hewson, M (2015), *The effect of increasing the number of wind turbine generators on generator energy in the Australian National Electricity Market from 2014 to 2025*, EEMG Working Paper 6-2015, The University of Queensland, Brisbane, Australia.

Bell, WP, Wild, P, Foster, J, and Hewson, M (2015), *NEMLink: Augmenting the Australian National Electricity Market transmission grid to facilitate increased wind turbine generation and its effect on transmission congestion*, EEMG Working Paper 9-2015, The University of Queensland, Brisbane, Australia.

Bell, WP, Wild, P, Foster, J, and Hewson, M (2015), *NEMLink: Augmenting the Australian National Electricity Market transmission grid to facilitate increased wind turbine generation and its effect on wholesale spot prices*, EEMG Working Paper 10-2015, The University of Queensland, Brisbane, Australia.

Interim reports:

Wild, P, Bell, WP and Foster, J (2014*), Impact of Transmission Network Augmentation Options on Operational Wind Generation in the Australian National Electricity Market over 2007-2012*, EEMG Working Paper 11-2014, School of Economics, The University of Queensland

Wild, P, Bell, WP and Foster, J (2014)*, Impact of increased penetration of wind generation in the Australian National Electricity Market,* EEMG Working Paper 10-2014, School of Economics, The University of Queensland

Wild, P, Bell, WP and Foster, J (2014), *Impact of Operational Wind Generation in the Australian National Electricity Market over 2007-2012*. EEMG Working Paper 1-2014, School of Economics, The University of Queensland.

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Abstract

This report investigates the effect of increasing the number of wind turbine generators on energy generation in the Australian National Electricity Market's (NEM) existing transmission grid from 2014 to 2025. This report answers urgent questions concerning the capability of the existing transmission grid to cope with significant increases in wind power and aid emissions reductions. The report findings will help develop a coherent government policy to phase in renewable energy in a cost effective manner.

We use a sensitivity analysis to evaluate the effect of five different levels of wind penetration on energy generation. The five levels of wind penetration span Scenarios A to E where Scenario A represents 'no wind' and Scenario E includes all the existing and planned wind power sufficient to meet Australia's 2020 41TWh Large Renewable Energy Target (LRET). We compare the relative effect of five different levels of wind penetration on energy generation to the effect on emissions. We also use sensitivity analysis to evaluate the effect on energy generation of growth in electricity demand over the projections years 2014 to 2015 and weather over the years 2010 to 2012. The sensitivity analysis uses simulations from the 'Australian National Electricity Market (ANEM) model version 1.10' (Wild et al. 2015).

We find NSW, QLD and SA experience a larger decrease in percentage emissions than in percentage decrease in energy. The converse is true in TAS and VIC. In the NEM overall, there is a larger percentage decrease in energy than in emissions. TAS has the largest percent decrease in generation owing to its gas fleet that is readily displaced by wind power penetration and hydro-generation that is similarly displaced. However, TAS has the largest difference between percent energy decrease and percent emissions decrease that means reducing energy in TAS is most ineffective at reducing emissions. This is owing to TAS relatively large displaced gas fleet that produce relatively few emissions and the displaced hydro-generation that produces no emissions. In contrast, Victoria having the largest brown coal generation fleet in the NEM has the lowest percent decrease in energy in the NEM and an even lower percent decrease in emissions. This situation is suboptimal for the NEM because brown coal produces more carbon dioxide emissions per unit of electricity. Wind power via the merit order effect displaces the more expensive fossil fuel generators first in the order gas, black coal and brown coal. Reintroducing the Carbon Reduction Pricing Scheme would address this inefficiency. In addition, introducing a 100% RET would help reduce investment uncertainty both for wind turbine and fossil fuel generators and aid fossil fuel staff in their decisions to transition to the renewable energy sector. Refurbishing the old coal generators remains a viable option without a commitment to a higher RET. Such refurbishment detracts funds from a more sustainable future.

In further research, we (Bell et al. 2015d, 2015e) investigate augmenting the NEM's transmission grid to reduce transmission congestion across the NEM and address the price differential between states under increasing wind power penetration. This augmentation will affect both emissions and energy generations.

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Abbreviations

ABS	Australian Bureau of Statistics
AC	Alternating Current
ACF	Annual Capacity Factor
AEMC	Australian Electricity Market Commission
AEMO	Australian Energy Market Operator
AGL	Australian Gas Limited
ANEM	Australian National Electricity Market Model (from EEMG)
ARENA	Australian Renewable Energy Agency
BREE	Bureau of Resources and Energy Economics
CCGT	Combined Cycle Gas Turbine
CER	Clean Energy Regulator
DC OPF	Direct Current Optimal Power Flow
EEMG	Energy Economics and Management Group (at UQ)
ESO	Electricity Statement of Opportunities
GHG	Green House Gas
GJ	Gigajoule
ISO	Independent System Operator
LCOE	Levelised Cost of Energy
LMP	Locational Marginal Price
LNG	Liquid Natural Gas
LRET	Large-scale Renewable Energy Target
LRMC	Long Run Marginal Cost
LSE	Load Serving Entity
MVA	Megavoltamperes
MW	Megawatt
MWh	Megawatt hour
NEFR	National Electricity Forecast Report

NEM	National Electricity Market
NSP	Network Service Provider
NSW	New South Wales
NPV	Net Present Value
OCGT	Open Cycle Gas Turbine
PPA	Power Purchase Agreement
PV	Photovoltaic
QLD	Queensland
SA	South Australia
SRMC	Short Run Marginal Cost
LRMC	Long Run Marginal Cost
TAS	Tasmania
TMM	Typical Meteorological Month
TMY	Typical Meteorological Year
UQ	University of Queensland
VIC	Victoria
VO&M	Variable Operation and Maintenance
VOLL	Value-of-Lost-Load
WTG	Wind Turbine Generator

1 Introduction

This report's primary aim is to investigate *'The effect of increasing the number of wind turbine generators on generator energy in the Australian National Electricity Market from 2014 to 2025'.* The report is part of the research project titled *'An investigation of the impacts of increased power supply to the national grid by wind generators on the Australian electricity industry'.* The sensitivity analysis in this report uses simulations from the *'Australian National Electricity Market (ANEM) model version 1.10' (Wild et al. 2015)* to model the effect of five different levels of wind penetration on generator energy. The five levels of wind penetration span Scenarios A to E where Scenario A represents 'no wind' and Scenario E includes all the existing and planned wind power sufficient to meet Australia's 2020 41TWh Large Renewable Energy Target (LRET). Wild et al. (2015) provide a comprehensive explanation of the both the ANEM model and the five levels of wind penetration.

Bell et al. (2015f) analyses wind speed and electricity demand correlation to determine the ability of wind turbine generators to meet electricity demand in the Australian National Electricity Market (NEM) without the aid of energy storage. They find the most advantage from the lack of correlation between wind speed between the NEM's peripheral states including QLD, SA and TAS. Additionally, the correlation between electricity demand and wind speed is strongest between these states. Similarly, they find the most advantage from the lack of correlation between electricity demands in each of these states. However, the NEM requires sufficient transmission capacity through VIC and NSW to maximise the benefit of wind power in the peripheral states and the NEM generally. To that end, this report examines the change in generation patterns induced by higher penetrations of wind power displacing fossil fuel generation and any potential transmission constraints through VIC and NSW as well as between other States impeding fossil fuel displacement.

Section 2 discusses the methodology for the sensitivity analysis and provides an extremely brief outline of the *ANEM model (Wild et al. 2015).* Section 3 presents the results from the sensitivity analysis. Section 4 discusses the results and Section 5 concludes the report.

2 Methodology: a sensitivity analysis using five levels of wind penetration

Wild et al. (2015) provides a detailed description of the ANEM model, justification for the five levels of wind penetration and the incrementing of the baseline electricity demand profile years 2010 to 2012 to form three demand projections from 2014 to 2025. This section provides a brief outline of the ANEM model, the five levels of wind penetration and the demand profiles before presenting the sensitivity analysis results in the next section.

2.1 Australian National Electricity Market Model

The following description provides a simplified computer input-output overview of the ANEM model.

The inputs of the ANEM model are:

- half hourly electricity "total demand" for 50 nodes in the NEM;
- parameter and constraint values for 68 transmission lines and 330 generators, albeit incorporating the de-commissioning of generation plant occurring over the period 2007-2014;
- carbon price, which is assumed zero in this project;
- fossil fuel prices; and
- network topology of nodes, transmission lines and generators.

The outputs of the ANEM model are:

- wholesale spot price at each node (half hourly),
- energy generated by each generator (half hourly),
- energy dispatched (sent out) by each generator (half hourly),
- power flow on each transmission line (half hourly), and
- carbon dioxide emissions for each generator (daily).

2.2 Five levels of wind penetration

We group existing and planned windfarms into five levels of wind power penetration.

a. No wind generation
b. Operational and under construction
c. Advanced planning *(+all the windfarms above)*
d. Less advanced planning *(+all the windfarms above)*
e. Least advanced planning *(+all the windfarms above)*

Details of the windfarms within the five groups are in the project report *'ANEM model version 1.10'* (Wild et al. 2015, tbls. 4 & 5).

2.3 Baseline years 2010-12 and projections years 2014-25

The project uses electricity demand profiles from three calendar years 2010, 2011 and 2012. Using the demand profiles from these three calendar years reduces the chances of modelling an unrepresentative weather year. Additionally, these weather years provide half-hourly correspondence between electricity demand for each node on the NEM and wind power generated for the five levels of wind power penetration for each node on the NEM. The wind power generated is calculated from half-hourly wind climatology results for the years 2010 to 2012 (Wild et al. 2015).

The demand profiles in the three baseline-years are incremented to form projections for the years 2014 to 2025, making three projections. We simulated the five levels of wind penetration for each projection base year, making fifteen projections in all to allow sensitivity analysis.

Examining the three baseline years 2010 to 2012 considers the effect of differing annual weather systems on the dynamics of the NEM and the generator energy. In contrast, the projections years 2014 to 2025 consider the effect of growth in electricity demand on the dynamics of the NEM and the generator energy.

3 Results

This section presents the results of the generator energy sensitivity analysis. The structure of this report parallels the project's carbon dioxide emissions report (Bell et al. 2015a) to allow easy comparison. For the most part, carbon emissions parallel the energy generation but the report highlights the more interesting aspects where the rates of decrease in emissions and energy generation differ. Additionally, the results highlight when the States' rate of decrease in energy differs from the NEM's average.

3.1 Inter State comparison of wind power, weather and growth effects

Table 2 presents the average hourly generator energy by State in MWh excluding wind power. We examined system wide patterns using the lowest and highest wind penetration scenarios, A and E, and the first and last projection years, 2014 and 2025 for each of the baseline weather years 2010 to 2012. Three effects can explain the change in generator energy.

- Wind penetration effect shown between scenario A and E
- Weather effect shown between the baseline years 2010 to 2012
- Growth in demand effect shown between the projection years 2014 to 2025

The following three sections discuss these effects using data from Table 2. The ANEM model (Wild et al. 2015) calculates half hourly generator energy for each generator in the NEM. Table 2 shows the average hourly generator energy by State excluding wind power.

Table 2: The average hourly generator energy for wind penetration scenarios A and E, the projection year 2014 and 2025 and baseline years 2010 to 2012 (MWh)

Wind penetration effect	Weather effect	Growth in electricity demand effect						
Wind scenario	Baseline Year	Projection Year	NSW	QLD	SA	TAS	VIC	NEM
a	2010	2014	8,230	7,392	1,324	1,028	6,574	24,548
a	2010	2025	8,901	8,277	1,428	1,344	6,670	26,620
a	2011	2014	7,691	7,312	1,277	955	6,560	23,794
a	2011	2025	8,326	8,213	1,372	1,292	6,622	25,825
a	2012	2014	8,410	7,481	1,454	1,119	6,601	25,065
a	2012	2025	9,015	8,351	1,597	1,440	6,770	27,174
e	2010	2014	6,067	6,737	1,076	446	6,358	20,685
e	2010	2025	6,686	7,675	1,019	601	6,431	22,413
e	2011	2014	5,497	6,672	1,064	396	6,309	19,938
e	2011	2025	6,039	7,606	997	522	6,392	21,556
e	2012	2014	6,159	6,823	1,080	395	6,392	20,848
e	2012	2025	6,805	7,762	1,025	553	6,472	22,617

3.1.1 Wind penetration effect shown between Scenarios A and E

Figure 1 and Table 3 show the average hourly generated energy excluding wind power by State for the wind penetration Scenarios A and E. Scenario A is no wind generation. In contrast, Scenario E contains all existing and planned wind generation that would meet the 2020 LRET. Figure 1 and Table 3 are the average hourly energy generated excluding wind power by State averaged across the baseline weather years 2010 to 2012 and the projection growth years 2014 and 2025. Victoria's (VIC) generation remains the least affected by wind power penetration with wind power inducing a 4% decrease in other forms of VIC's generation. Section 4 discusses VIC's generator energy unresponsiveness to wind power in more detail.

The States most responsive to wind power's induced reductions in other forms of generation by percentage are Tasmania (TAS), South Australia (SA) and New South Wales (NSW). All three States have relatively large wind power deployments compared to their demand for electricity. In contrast, Queensland (QLD) has a much smaller percentage reduction. Table 4 shows that NSW has the largest cumulative wind power in Scenario E in the NEM. The merit order effect of wind on the NEM would displace NSW's relatively more expensive gas and black coal generators before affecting VIC's cheaper brown coal generators. TAS shows the largest rate of decrease disparity between carbon emissions and energy generated. Section 4 discusses TAS in more detail.

The wind penetration effect is by far the largest of the three effects for energy generated. The wind penetration effect is also the largest of the three effects for transmission line congestion, wholesale spot prices and carbon dioxide emissions (Bell et al. 2015a, 2015b, 2015c).

Figure 1: Comparing the average hourly generator energy between wind power scenarios A and E

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Table 3: Average hourly generator energy for each State for the wind power scenarios A and E (MWh)

States	a	e	% decrease energy	% decrease emissions*
NSW	8,429	6,209	26	27
QLD	7,838	7,213	8	8
SA	1,409	1,043	26	27
TAS	1,196	486	59	23
VIC	6,633	6,392	4	3
Average	5,101	4,269	16	13

(* Source:Bell et al. 2015a, sec. 3.1.1)

Table 4: NEM Windfarms added each scenario by State

State/Scenario	No of WTG	Capacity (MW)	Average Capacity Factor	Annual Production (GWh)
NSW	**1,670**	**4,517**	**0.38**	**15,001**
b	350	666	0.36	2,090
c	329	915	0.39	3,137
d	580	1,722	0.39	5,964
e	411	1,215	0.37	3,810
QLD	**328**	**936**	**0.41**	**3,497**
b	20	12	0.36	38
c	25	75	0.40	263
d	208	624	0.44	2,407
e	75	225	0.40	789
SA	**1,152**	**3,052**	**0.38**	**10,885**
b	649	1,473	0.36	4,883
c	193	579	0.41	2,149
d	134	402	0.43	1,522
e	176	598	0.44	2,331
TAS	**323**	**923**	**0.42**	**3,324**
b	118	308	0.42	1,134
d	45	135	0.42	492
e	160	480	0.40	1,698
VIC	**1,471**	**3,784**	**0.39**	**13,201**
b	592	1,223	0.38	4,072
c	415	1,245	0.40	4,401
d	464	1,316	0.40	4,728
Total	**4,944**	**13,212**	**0.39**	**45,907**

(Source: Wild et al. 2015, tbl. 5)

3.1.2 Weather effect shown between the baseline years 2010 to 2012

Figure 2 and Table 5 show the average hourly generator energy excluding wind power by State for the baseline years 2010 to 2012. We attribute most of the variation in demand in the years 2010 to 2012 to variation in weather between these years. Figure 2 is the average across the wind scenarios A and E and the projection growth years 2014 and 2025. NSW's generator energy is the most affected by changes in weather and wind speed climatology in quantity of energy generated. However, Table 4 shows the weather effect on generated energy by percentage standard deviation. This provides a more suitable measure for comparison between States. The weather effect on generated energy combines weather induced changes in demand and weather induced changes in wind power. The rank order from most susceptible to least susceptible to the weather effect is TAS, NSW, SA, QLD and VIC. The merit order effect of wind power on the NEM would displace TAS's gas generation and NSW's gas and black coal generation before VIC's cheaper brown coal generation. The weather effect is the smallest effect of the three for generator energy.

Figure 2: Average generator energy for each State for the baseline years 2010 to 2012

Table 5: Average hourly energy generated for each State for the baseline years 2010 to 2012

States	2010	2011	2012	Std. Dev.	% Std. Dev. Energy	% Std. Dev. Emissions*
NSW	7,471	6,888	7,597	309	4.2	4.3
QLD	7,521	7,451	7,604	63	0.8	1.0
SA	1,212	1,177	1,289	47	3.8	3.9
TAS	855	791	877	36	4.3	2.6
VIC	6,508	6,471	6,559	36	0.6	0.5
NEM	23,567	22,778	23,926	479	2.0	1.9

(* Source:Bell et al. 2015a, sec. 3.1.2)

3.1.3 Growth in electricity demand effect shown between projection years 2014-25

Figure 3 and Table 6 show the average hourly generator energy for the projection years 2014 and 2025. We model the demand for electricity to grow from 2014 to 2025. Hence, a growth effect can account for the change in average generator energy. Figure 3 is the average across the wind scenarios A and E and baseline years 2010 to 2012. We would expect the growth in demand to put upward pressure on generator energy, which is evident in all the States of the NEM. VIC's brown coal generation is some of cheapest in the NEM, so most of VIC's fleet is already dispatched in 2014. There is little spare capacity to accommodate the increase in demand in 2025. TAS, QLD and NSW experience the largest increases in generator energy as a proportion. This reflects the more bullish projection assumptions for QLD and NSW's demand compared with the other states. The growth effect is the second largest of the three effects for generator energy. Once again, TAS continues to shows the largest rate of increase disparity between carbon emissions and energy generated. Section 4 discusses TAS in more detail.

Figure 3: Average generator energy for each State for the projection years 2014-2025

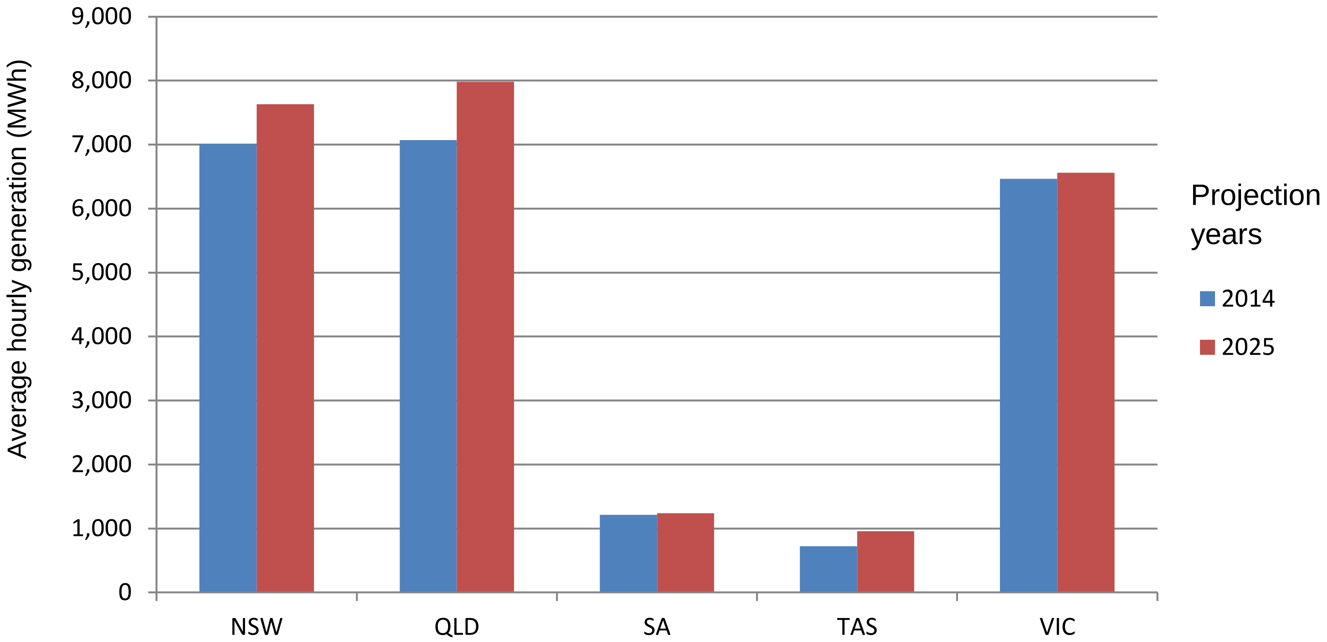

Table 6: Average hourly generator energy for each State for the projection years 2014-2025

States	2014	2025	% increase Energy	% increase Emissions*
NSW	7,009	7,629	8.8	8.5
QLD	7,070	7,981	12.9	11.0
SA	1,212	1,240	2.3	1.4
TAS	723	959	32.6	11.5
VIC	6,466	6,559	1.4	0.5
NEM	22,480	24,367	8.4	5.9

(* Source:Bell et al. 2015a, sec. 3.1.3)

3.2 Comparing the three effects on generator energy in individual States

This section compares the effect of wind power, weather and growth in electricity demand on generator energy in each State and the NEM in total. The “energy generated” in both the figures and tables in this section refers to energy generated from sources other than wind power, unless otherwise stated.

3.2.1 Comparing the three effects on the NEM

Figure 4 and Table 7 shows the effect of wind power, weather and demand growth on generator energy in the NEM. Table 8 shows the percentage decrease in generator energy from Scenario A. The increase in wind power from Scenario A to E shows a steady decrease in ‘non-wind’ forms of generator energy for all weather and growth Scenarios that are years 2010-2012 and 2014-2025 respectively. The NEM’s emissions and energy follow a similar pattern. However, the overall percentage decrease in energy is 16.3% compared to the percentage decrease in emissions 13.1% (Bell et al. 2015a, sec. 3.2.1). Section 4 discusses this disparity in rates.

Figure 4: Comparing wind power, weather and growth effects on the NEM’s average hourly generator energy

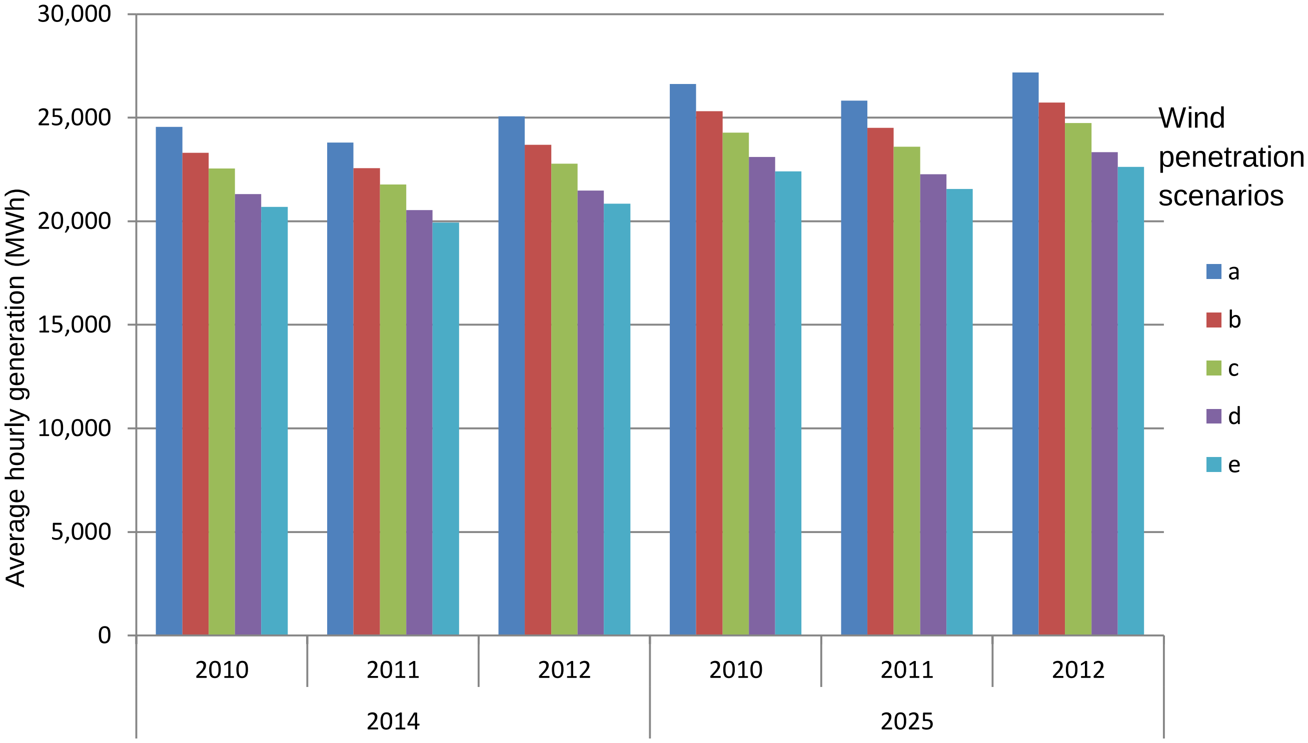

Table 7: Comparing wind power, weather and growth effects on the NEM's average hourly generator energy

NEM	a	b	c	d	e	Average
Average	**25,504**	**24,185**	**23,283**	**22,005**	**21,343**	**23,264**
2014	**24,469**	**23,183**	**22,362**	**21,112**	**20,490**	**22,323**
2010	24,548	23,310	22,539	21,307	20,685	22,478
2011	23,794	22,558	21,769	20,543	19,938	21,720
2012	25,065	23,681	22,777	21,485	20,848	22,771
2025	**26,540**	**25,187**	**24,204**	**22,898**	**22,195**	**24,205**
2010	26,620	25,318	24,278	23,104	22,413	24,346
2011	25,825	24,510	23,601	22,260	21,556	23,550
2012	27,174	25,735	24,733	23,331	22,617	24,718

Table 8: Comparing wind power, weather and growth effects on the NEM's % decrease in average hourly generator energy

NEM	a	b	c	d	e
% decrease	**0.0**	**5.2**	**8.7**	**13.7**	**16.3**
2014	**0.0**	**5.3**	**8.6**	**13.7**	**16.3**
2010	0.0	5.0	8.2	13.2	15.7
2011	0.0	5.2	8.5	13.7	16.2
2012	0.0	5.5	9.1	14.3	16.8
2025	**0.0**	**5.1**	**8.8**	**13.7**	**16.4**
2010	0.0	4.9	8.8	13.2	15.8
2011	0.0	5.1	8.6	13.8	16.5
2012	0.0	5.3	9.0	14.1	16.8

(Percentage decrease in energy from Scenario A)

3.2.2 Comparing the three effects in NSW

Figure 5 and Table 9 shows the effect of wind power, weather and demand growth on generator energy in NSW. Table 10 shows the percentage decrease in 'non-wind' generator energy from Scenario A. The increase in wind power from Scenario A to E shows a steady decrease in this generator energy for all weather and growth Scenarios that are years 2010-2012 and 2014-2025 respectively. The wind power induced generator energy reduction rate in NSW is about 10% higher than that of the NEM. NSW's emissions and energy follow a similar pattern and the rates are similar. The overall decrease in NSW's energy is 26.4% compared to the decrease in emissions at 26.8% (Bell et al. 2015a, sec. 3.2.1).

Figure 5: Comparing wind power, weather and growth effects on the NSW's average hourly generator energy

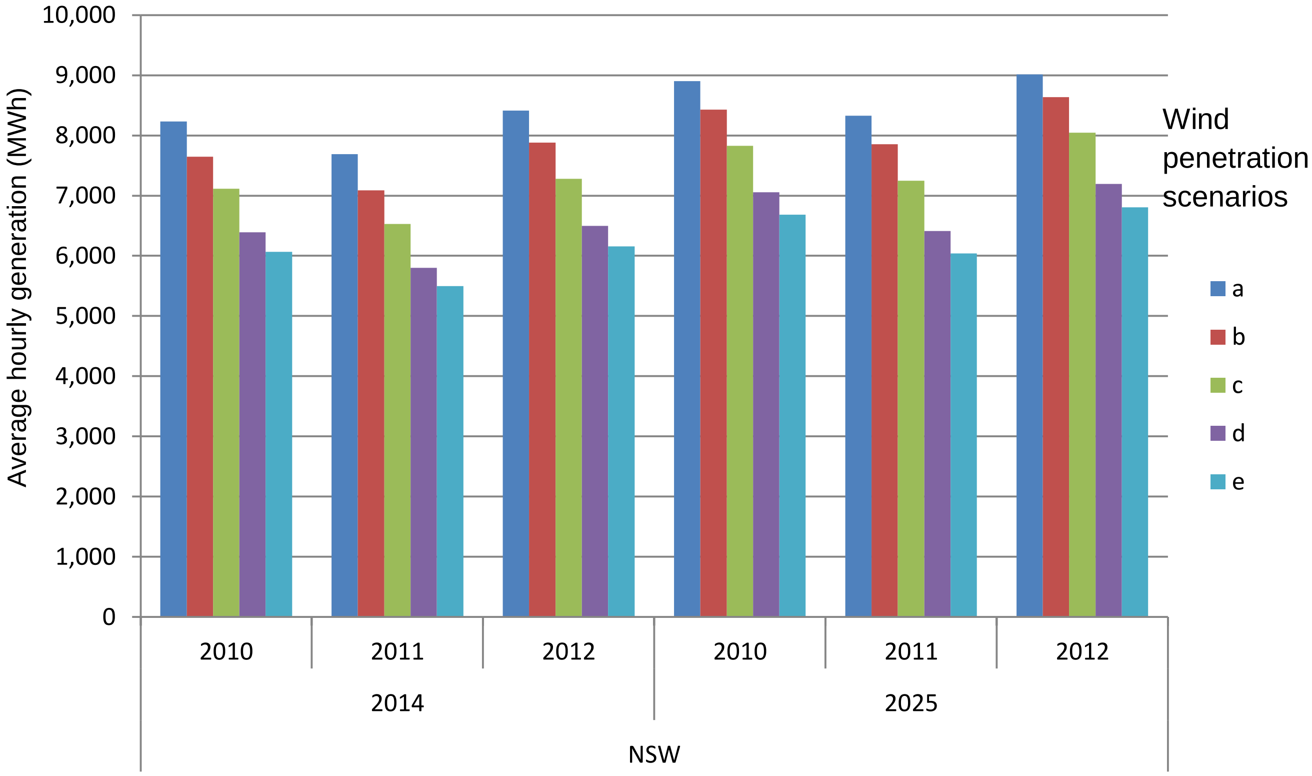

Table 9: Comparing wind power, weather and growth effects on the NSW's average hourly generator energy (MWh)

NSW	a	b	c	d	e	Average
Average	**8,429**	**7,924**	**7,340**	**6,559**	**6,209**	**7,292**
2014	**8,110**	**7,539**	**6,974**	**6,230**	**5,908**	**6,952**
2010	8,230	7,648	7,112	6,391	6,067	7,090
2011	7,691	7,088	6,529	5,799	5,497	6,521
2012	8,410	7,882	7,281	6,499	6,159	7,246
2025	**8,748**	**8,308**	**7,706**	**6,888**	**6,510**	**7,632**
2010	8,901	8,430	7,828	7,056	6,686	7,780
2011	8,326	7,854	7,245	6,412	6,039	7,175
2012	9,015	8,638	8,045	7,195	6,805	7,940

Table 10: Comparing wind power, weather and growth effects on the NSW's by % decrease in average hourly generator energy

NSW	a	b	c	d	e
% decrease	**0.0**	**6.1**	**13.0**	**22.3**	**26.4**
2014	**0.0**	**7.1**	**14.0**	**23.2**	**27.2**
2010	0.0	7.1	13.6	22.3	26.3
2011	0.0	7.8	15.1	24.6	28.5
2012	0.0	6.3	13.4	22.7	26.8
2025	**0.0**	**5.0**	**11.9**	**21.3**	**25.6**
2010	0.0	5.3	12.1	20.7	24.9
2011	0.0	5.7	13.0	23.0	27.5
2012	0.0	4.2	10.8	20.2	24.5

(Percentage decrease in energy from Scenario A)

3.2.3 Comparing the three effects in QLD

Figure 6 and Table 11 shows the effect of wind power, weather and demand growth on 'non-wind' generator energy in QLD. Table 12 shows the percentage decrease in generator energy from Scenario A. The increase in wind power from Scenario A to E shows a steady decrease in this generator energy for all weather and growth Scenarios that are years 2010-2012 and 2014-2025 respectively. The wind power induced generator energy decreases at a rate in QLD that is about half that of the NEM. This reflects the smaller deployment of wind generation in QLD across the wind penetration scenarios compared to the other States as a proportion of State energy demand and aggregate State generation capacity. QLD's emissions and energy follow a similar pattern and rates of decrease. The overall decrease in QLD's energy is 8.0% compared to 8.2% for emissions (Bell et al. 2015a, sec. 3.2.3).

Figure 6: Comparing wind power, weather and growth effects on the QLD's average hourly generator energy

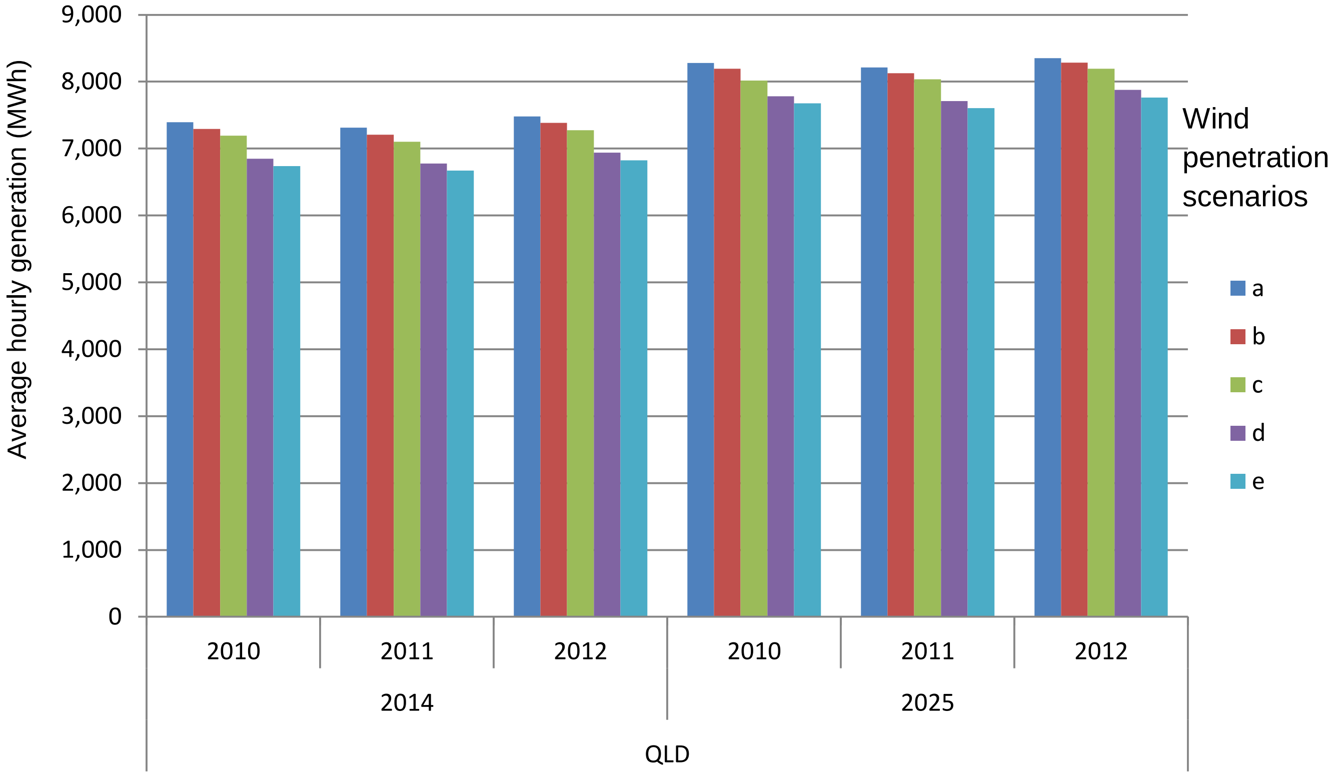

Table 11: Comparing wind power, weather and growth effects on the QLD's average hourly generator energy

QLD	a	b	c	d	e	Average
Average	**7,838**	**7,748**	**7,635**	**7,323**	**7,213**	**7,551**
2014	**7,395**	**7,295**	**7,189**	**6,856**	**6,744**	**7,096**
2010	7,392	7,292	7,193	6,850	6,737	7,093
2011	7,312	7,207	7,100	6,777	6,672	7,013
2012	7,481	7,385	7,274	6,940	6,823	7,181
2025	**8,280**	**8,201**	**8,080**	**7,791**	**7,681**	**8,007**
2010	8,277	8,194	8,014	7,784	7,675	7,989
2011	8,213	8,125	8,033	7,712	7,606	7,938
2012	8,351	8,284	8,194	7,876	7,762	8,094

Table 12: Comparing wind power, weather and growth effects on the QLD's % average hourly generator energy

QLD	a	b	c	d	e
% decrease	**0.0**	**1.2**	**2.6**	**6.6**	**8.0**
2014	**0.0**	**1.4**	**2.8**	**7.3**	**8.8**
2010	0.0	1.4	2.7	7.3	8.9
2011	0.0	1.4	2.9	7.3	8.7
2012	0.0	1.3	2.8	7.2	8.8
2025	**0.0**	**1.0**	**2.4**	**5.9**	**7.2**
2010	0.0	1.0	3.2	6.0	7.3
2011	0.0	1.1	2.2	6.1	7.4
2012	0.0	0.8	1.9	5.7	7.0

(Percentage decrease in energy from Scenario A)

3.2.4 Comparing the three effects in SA

Figure 7 and Table 13 shows the effect of wind power, weather and demand growth on generator energy in SA. Table 14 shows the percentage decrease in generator energy from Scenario A. The increase in wind power from Scenario A to E shows a steady decrease in this generator energy for all weather and growth Scenarios that are years 2010-2012 and 2014-2025 respectively. The decrease rate of generator energy induced by wind power in SA is about 10% higher than the NEM. Most of SA's reduction in generator energy comes in Scenario B. This coincides with SA's largest wind power deployment in Scenario B as shown in Table 4. The power from the smaller wind power deployments in Scenarios C, D and E is more likely to be exported reducing emission elsewhere in the NEM rather than within SA. SA's emissions and energy follow a similar pattern. However, the emissions reduction rate is slightly higher than the energy reduction rate at 27.0% and 25.5%, respectively (Bell et al. 2015a, sec. 3.2.4).

Figure 7: Comparing wind power, weather and growth effects on the SA's average hourly generator energy

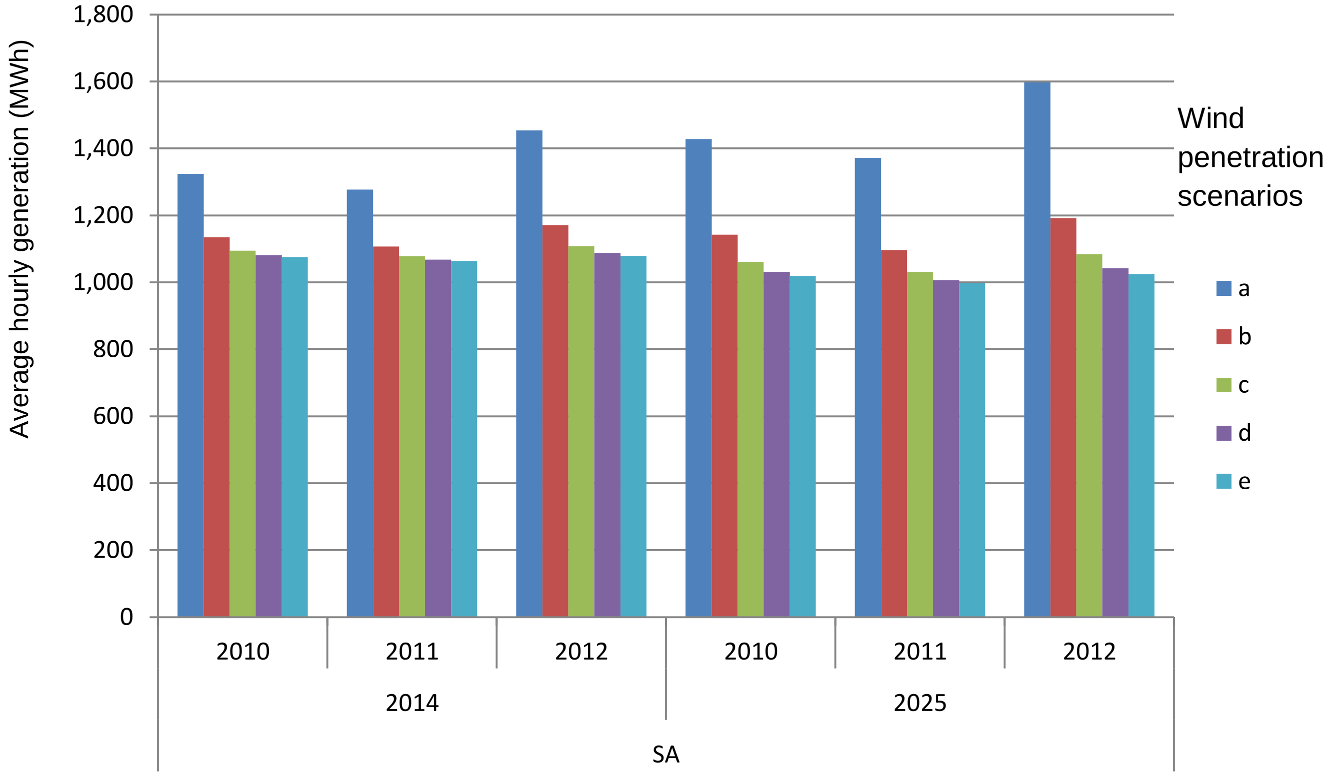

Table 13: Comparing wind power, weather and growth effects on the SA's average hourly generator energy

SA	a	b	c	d	e	Average
Average	**1,409**	**1,141**	**1,076**	**1,053**	**1,043**	**1,144**
2014	**1,351**	**1,138**	**1,094**	**1,079**	**1,073**	**1,147**
2010	1,324	1,135	1,095	1,081	1,076	1,142
2011	1,277	1,107	1,078	1,068	1,064	1,119
2012	1,454	1,171	1,108	1,088	1,080	1,180
2025	**1,466**	**1,144**	**1,059**	**1,026**	**1,014**	**1,142**
2010	1,428	1,142	1,061	1,031	1,019	1,136
2011	1,372	1,097	1,031	1,006	997	1,101
2012	1,597	1,192	1,084	1,042	1,025	1,188

Table 14: Comparing wind power, weather and growth effects on the SA's % average hourly generator energy

SA	a	b	c	d	e
% decrease	**0.0**	**18.7**	**23.2**	**24.9**	**25.5**
2014	**0.0**	**15.7**	**18.9**	**20.0**	**20.4**
2010	0.0	14.3	17.3	18.3	18.7
2011	0.0	13.3	15.5	16.3	16.6
2012	0.0	19.5	23.8	25.2	25.8
2025	**0.0**	**21.8**	**27.6**	**29.8**	**30.6**
2010	0.0	20.0	25.7	27.8	28.6
2011	0.0	20.1	24.8	26.7	27.3
2012	0.0	25.4	32.1	34.8	35.9

(Percentage decrease in energy from Scenario A)

3.2.5 Comparing the three effects in TAS

Figure 8 and Table 15 shows the effect of wind power, weather and demand growth on generator energy in TAS. Table 16 shows the percentage decrease in generator energy from Scenario A. The increase in wind power from Scenario A to E shows a large decrease in 'non-wind' generator energy in Scenario B and much smaller decreases in subsequent Scenarios for all weather years 2010-2012 and demand growth scenario years and 2014 and 2025. The wind power induced generator energy decrease rate in TAS is almost four times that of the NEM. Most of TAS's reduction in generator energy comes in Scenario B. This coincides with TAS's second largest wind power deployment in Scenario B shown in Table 4. There is no wind power deployment in Scenario C in TAS but neighbouring VIC has a major deployment in Scenario C. Cheap imported wind power from VIC would potentially displace fossil fuel and hydro generation in TAS.

Note that the potential displacement of hydro generation in TAS reflects the ANEM modelling assumptions. (1) Supply offers of hydro plant are based upon long run marginal costs, considering whether the particular plant can take on the role of baseload, intermediate or peak load. (2) Wind generation is dispatched according to much lower short run marginal costs.

Figure 8 shows a large increase in generator energy from 2014 to 2025 in Scenario A to meet the growth in electricity demand. Table 16's comparatively large disparity in percentage decrease in generator energy between 2014 and 2025 reflect the larger 'non-wind' generator energy in Scenario A in 2025. The rate of reductions in TAS's emissions and energy differ considerably This reflects the partial displacement of hydro generation in TAS by wind generation, which shows up in 'non-wind' generator energy reductions but has no impact on carbon emissions to the extent that zero emissions wind energy displaces zero emissions hydro energy in TAS. From scenario A to B, the overall percentage decrease in energy is 32.6% compared to the percentage decrease in emissions of 17.2% (Bell et al. 2015a, sec. 3.2.1). From scenario A to E, the overall percentage decrease in energy is 59.4% compared to the percentage decrease in emissions of 22.0%.

Figure 8: Comparing wind power, weather and growth effects on the TAS's average hourly generator energy

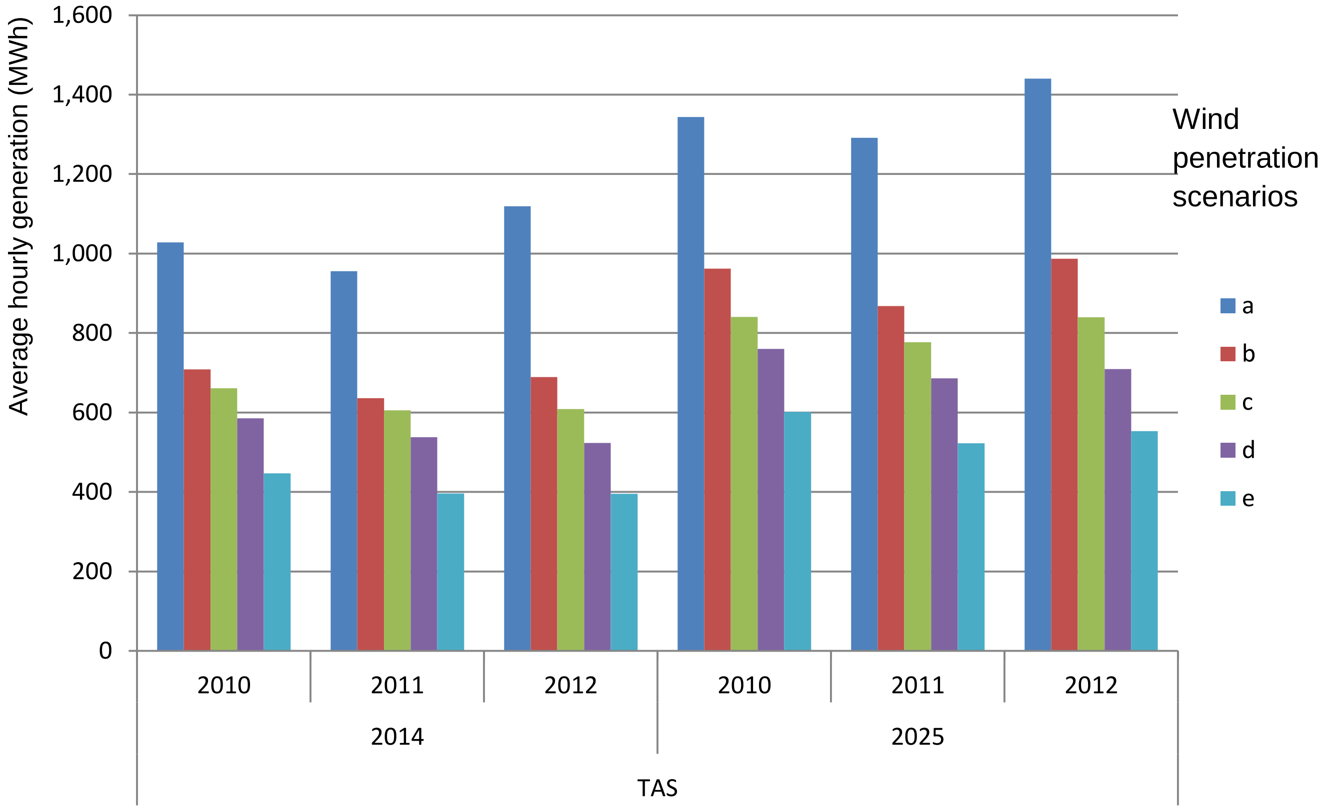

Table 15: Comparing wind power, weather and growth effects on the TAS's average hourly generator energy (MWh)

TAS	a	b	c	d	e	Average
Average	**1,196**	**809**	**722**	**634**	**486**	**769**
2014	**1,034**	**678**	**625**	**549**	**412**	**660**
2010	1,028	708	661	585	446	686
2011	955	636	606	538	396	626
2012	1,119	689	608	524	395	667
2025	**1,359**	**939**	**819**	**718**	**559**	**879**
2010	1,344	962	840	760	601	902
2011	1,292	868	777	686	522	829
2012	1,440	987	839	709	553	906

Table 16: Comparing wind power, weather and growth effects on the TAS's % change in average hourly generator energy

TAS	a	b	c	d	e
% decrease	**0.0**	**32.6**	**39.5**	**46.8**	**59.4**
2014	**0.0**	**34.3**	**39.3**	**46.7**	**59.9**
2010	0.0	31.1	35.7	43.1	56.6
2011	0.0	33.4	36.6	43.7	58.6
2012	0.0	38.4	45.6	53.2	64.7
2025	**0.0**	**30.9**	**39.7**	**47.0**	**58.8**
2010	0.0	28.4	37.5	43.4	55.3
2011	0.0	32.8	39.8	46.9	59.6
2012	0.0	31.5	41.7	50.7	61.6

(Percentage decrease in energy from Scenario A)

3.2.6 Comparing the three effects in VIC

Figure 9 and Table 17 shows the effect of wind power, weather and demand growth on generator energy in VIC. Table 18 shows the percentage decrease in generator energy from Scenario A. The wind power induced generator energy decrease rate in VIC is the smallest in the NEM of about only 3 percent. This is a matter for attention given VIC is the largest emitter in the NEM. Section 4 discusses this further.

The increase in wind power shows a steady decrease in generator energy for all weather and growth scenarios that are years 2010-2012 and 2014-2025 respectively. Table 4 shows VIC has no wind power deployment in Scenario E. However, the adjoining States of both TAS and SA have smaller demand bases and large deployments of wind power in Scenario E. The surplus wind power could be exported from TAS and SA to VIC.

VIC's emissions and energy follow a similar pattern but the overall percentage decrease in energy is 3.6% compared to the percentage decrease in emissions of 2.8% (Bell et al. 2015a, sec. 3.2.1). This indicates that wind power is primarily displacing higher cost gas and hydro generation rather than the cheaper but more carbon emission intensive brown coal generation, which is consistent with the merit order effect.

Figure 9: Comparing wind power, weather and growth effects on the VIC's average hourly generator energy

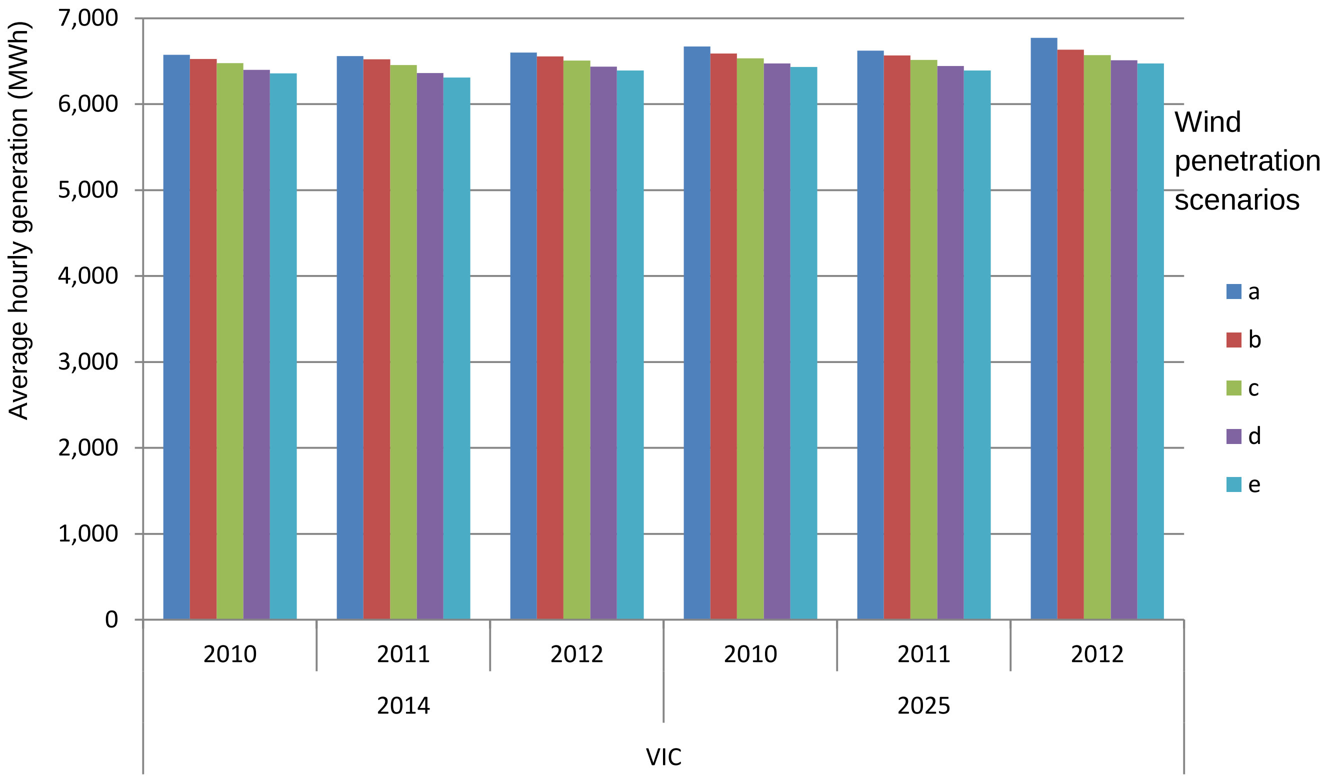

Table 17: Comparing wind power, weather and growth effects on the VIC's average hourly generator energy (MWh)

VIC	a	b	c	d	e	Average
Average	**6,633**	**6,565**	**6,510**	**6,437**	**6,392**	**6,507**
2014	**6,578**	**6,534**	**6,480**	**6,398**	**6,353**	**6,469**
2010	6,574	6,527	6,478	6,399	6,358	6,467
2011	6,560	6,520	6,456	6,362	6,309	6,441
2012	6,601	6,554	6,506	6,435	6,392	6,497
2025	**6,687**	**6,596**	**6,540**	**6,475**	**6,432**	**6,546**
2010	6,670	6,589	6,534	6,472	6,431	6,539
2011	6,622	6,565	6,514	6,445	6,392	6,508
2012	6,770	6,633	6,571	6,509	6,472	6,591

Table 18: Comparing wind power, weather and growth effects on the VIC's % decrease in average hourly generator energy

VIC	a	b	c	d	e
% decrease	**0.0**	**1.0**	**1.8**	**2.9**	**3.6**
2014	**0.0**	**0.7**	**1.5**	**2.7**	**3.4**
2010	0.0	0.7	1.5	2.7	3.3
2011	0.0	0.6	1.6	3.0	3.8
2012	0.0	0.7	1.4	2.5	3.2
2025	**0.0**	**1.4**	**2.2**	**3.2**	**3.8**
2010	0.0	1.2	2.0	3.0	3.6
2011	0.0	0.9	1.6	2.7	3.5
2012	0.0	2.0	2.9	3.9	4.4

(Percentage decrease in energy from Scenario A)

4 Discussion

We have conducted a sensitivity analysis of the effect of increasing the number of wind turbine generators (WTG) on the average hourly generator energy in the Australian National Electricity Market from Scenario A that is no WTG or 0% to Scenario E that is sufficient WTG to meet the 2020 Large Renewable Energy Target. The sensitivity analysis also considered the effect of weather and electricity demand growth on average wholesale spot prices. We used simulations from the Australian National Electricity Market (ANEM) Model (Wild et al. 2015) to perform the sensitivity analysis. This reports builds on insights gained in the other project reports on carbon dioxide emissions, transmission congestion and wholesale spot prices (Bell et al. 2015a, 2015b, 2015c). These reports also use the ANEM model and the five wind power penetration Scenarios A to E.

4.1 Comparing energy and emissions

Table 19 compares the percentage decrease in carbon dioxide emissions and energy generated from Scenario A to Scenario E that is with increasing penetration of wind power. Table 19 averages across the weather years 2010 to 2012 and the growth projection years 2014 and 2025 shown in Table 20 in the Appendix.

Table 19: Comparing percentage decrease in emissions and energy generated

	% Emissions decrease*				% Energy decrease				% Emissions - % Energy			
	b	c	d	e	b	c	d	e	b	c	d	e
NSW	6.2	13.0	22.6	26.8	6.1	13.0	22.3	26.4	0.1	0.0	0.3	0.4
QLD	1.3	2.5	6.8	8.2	1.2	2.6	6.6	8.0	0.1	-0.1	0.2	0.2
SA	19.2	24.3	26.3	27.0	18.7	23.2	24.9	25.5	0.5	1.1	1.4	1.5
TAS	17.2	20.0	21.5	22.0	32.6	39.5	46.8	59.4	-15.4	-19.5	-25.3	-37.4
VIC	0.7	1.2	2.2	2.8	1.0	1.8	2.9	3.6	-0.3	-0.6	-0.7	-0.8
NEM	3.4	6.4	11.1	13.1	5.2	8.7	13.7	16.3	-1.8	-2.3	-2.6	-3.2

(* Source: Bell et al. 2015a)

The States NSW, QLD and SA experience a larger decrease in percentage emissions than in percentage decrease in energy. The converse is true in TAS and VIC. In the NEM overall, there is a larger percentage decrease in energy than in emissions. In part, this outcome reflects the displacement of hydro generation by cheaper wind generation as well as the difference in the relative costs of brown and black coal.

As discussed, VIC's large high emissions intensive brown coal fleet explains both the small percentage change in energy decrease and the even smaller change in emission. The more expensive but lower emissions intensive gas generators as well as zero emission hydro generators in VIC reduce generation rather than the cheaper but high emissions intensive brown coal fleet. This outcome is consistent with the merit order effect that posits the displacement of the more expensive gas, diesel and hydro generation with the cheaper wind generation.

TAS has the largest percentage decrease in both emissions and in energy where the percentage decrease in energy is far larger than decrease in emissions. A number of factors help explains this situation. TAS has large penetration of wind power compared to its demand. TAS's only fossil fuel generation consists of relatively more expensive NGCC and OCGT plant that is very susceptible to displacement by much cheaper wind generation. Wind power displaces the power from the NGCC and OCGT but this produces a relatively smaller reduction in emissions because of the lower carbon emission intensity gas generation relative to coal. Finally, wind generation in TAS also partially displaces hydro generation in TAS. While this displaced hydro generation shows up in generator energy reductions, it has no impact on emission reductions because zero emissions wind energy is displacing zero emissions hydro energy.

As discussed, the potential displacement of hydro generation in TAS reflects assumptions in the ANEM model. (1) Supply offers for hydro plant are based on long run marginal costs, considering whether the particular plant can take on the role of baseload, intermediate or peak load. (2) Wind generation is dispatched according to much lower short run marginal costs.

4.2 Transitioning from fossil fuels to renewable energy

The ANEM model (Wild et al. 2015) assumes that the fossil fuel generators continue operating at their minimum operating level but in reality these generators shutdown when the economic conditions are unfavourable. The shutdown of these fossil fuel generators is desirable and essential to address climate change. The majority of the fossil fuel fleet is near or past their working life needing major refurbishment. The management of these fossil fuel generators are in the best position to decide when to shut down their generators. For instance the recent decision to close the Northern Power Station and Torrens Island A eliminates all coal generation in SA and a significant portion of gas thermal capacity. This represents success for wind power in SA. The remaining gas thermal generator is Torrens Island B.

However, fossil fuel managers will keep running their generators as long as possible if they can extract more profits by refurbishing their generators. Extending the LRET to 100% will help fossil fuel managers schedule the shut down their generators rather than refurbish. Additionally, the reintroduction of the Carbon Pollution Reduction Scheme would change the relative marginal cost between coal, gas and other types of generation. This change would favour the closure of the more emissions intensive plant first and favour shutting down over refurbishment. We discuss extending the LRET and reintroducing the CPRS in the emissions report (Bell et al. 2015a). The closure of the fossil fuel generators and coalmines raises a number of issues, such as redeploying staff to other industries, cleaning up the coalmines, disposing of the power plants and declining fossil fuel shares values.

Introducing a 100% LRET would aid the redeployment of staff from the fossil fuel industry to the renewable sector by providing investment certainty and fossil fuel staff with more confidence to transition to renewable energy. There is also the requirement to clean up the old coalmines and dismantle the old fossil fuel generators. The coalmines have many toxicity issues to address and the old generators full of asbestos. This raises the issues of liability of the existing shareholders and operators to pay for the dismantling of the generators and cleaning up coalmines.

Cleaning up of the coalmines and dismantling the fossil fuel generators will reduce shareholder value but these liabilities required considering at the establishment of the company. The book value of the generators is zero after depreciation over many years if the company owned the generator since construction and commissioning. The book value of the generator may be non-zero in more recent purchases, such as, AGL’s acquisition of Macquarie Generation (MacGen). However, the management lacked due diligence acquiring MacGen without considering the requirement to address climate change. The shareholders are required to hold management responsible for taking such high-risk investments. The majority of fossil fuel shareholders are foreign. Australians needs to make sure the shareholders pay to clean up the mess from which they have profited rather than rely on the Australian taxpayer.

5 Conclusion

We find the average hourly generator energy for all States in the NEM decrease when wind power increases from Scenario A that is ‘0% or no wind power’ to Scenario E that meets Australia’s Large Renewable Energy Target (LRET) of 2020. The LRET and wind power are successful in reducing both carbon dioxide mission and fossil fuel generation.

VIC is the largest emitter in the NEM and its emissions and generator energy are least sensitive to wind power but Table 19 shows as a proportion, emissions decrease less than energy. Our emissions report (Bell et al. 2015a) discusses how to address this situation via the reintroduction of the Carbon Pollution Reduction Scheme rebranded as “Pollution Penalties”. In contrast, TAS is both the smallest emitter and energy generator in the NEM but Table 19 shows as a proportion, emissions decrease less than energy. TAS’s large wind power deployment displacing both lower emission intensity gas and zero emission intensity hydro generation explains this.

Wind power has already been successful in helping ferment the planned closure of fossil fuel generators in SA. There is a requirement to introduce a much higher 100% renewable energy to smooth the transition from fossil fuel to renewable energy. Our emissions report also discusses the 100% LRET. The higher target will help managers of fossil fuel companies to favour shutting down their generators rather than refurbishing. The higher target will also help fossil fuel staff more confidently transition to the renewable energy sector.

There is a requirement to ensure companies that own the coalmines and fossil fuel generators are reserving funds to clean-up the coalmines and the old generators to avoid Australian taxpayers funding the clean-up.

6 Acknowledgements

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7 Appendix

Table 20 compares the percentage decrease in energy generated and carbon dioxide emissions for the five wind power scenarios A to E, the weather scenario 2010, 2011 and 2012 and the demand growth scenario from 2014 to 2015. This report discusses different portions of Table 20.

Table 20: Percentage decrease in energy generated and emissions

	Energy Generated				Carbon dioxide emissions*			
	b	c	d	e	b	c	d	e
NSW	**6.1**	**13.0**	**22.3**	**26.4**	**6.2**	**13.0**	**22.6**	**26.8**
2014	**7.1**	**14.0**	**23.2**	**27.2**	**7.2**	**14.3**	**23.8**	**27.9**
2010	7.1	13.6	22.3	26.3	7.2	13.8	22.8	26.9
2011	7.8	15.1	24.6	28.5	8.1	15.6	25.4	29.5
2012	6.3	13.4	22.7	26.8	6.4	13.6	23.2	27.3
2025	**5.0**	**11.9**	**21.3**	**25.6**	**5.2**	**11.7**	**21.4**	**25.8**
2010	5.3	12.1	20.7	24.9	5.2	11.6	20.8	25.0
2011	5.7	13.0	23.0	27.5	5.8	13.2	23.5	28.1
2012	4.2	10.8	20.2	24.5	4.7	10.4	20.0	24.2
QLD	**1.2**	**2.6**	**6.6**	**8.0**	**1.3**	**2.5**	**6.8**	**8.2**
2014	**1.4**	**2.8**	**7.3**	**8.8**	**1.4**	**3.0**	**7.7**	**9.2**
2010	1.4	2.7	7.3	8.9	1.4	2.9	7.7	9.3
2011	1.4	2.9	7.3	8.7	1.5	3.1	7.7	9.2
2012	1.3	2.8	7.2	8.8	1.3	2.9	7.6	9.2
2025	**1.0**	**2.4**	**5.9**	**7.2**	**1.2**	**2.0**	**5.9**	**7.2**
2010	1.0	3.2	6.0	7.3	1.0	2.1	6.0	7.4
2011	1.1	2.2	6.1	7.4	1.1	2.3	6.3	7.6
2012	0.8	1.9	5.7	7.0	1.4	1.6	5.4	6.5
SA	**18.7**	**23.2**	**24.9**	**25.5**	**19.2**	**24.3**	**26.3**	**27.0**
2014	**15.7**	**18.9**	**20.0**	**20.4**	**16.9**	**20.7**	**22.1**	**22.6**
2010	14.3	17.3	18.3	18.7	15.4	19.0	20.3	20.8
2011	13.3	15.5	16.3	16.6	15.2	18.0	19.0	19.4
2012	19.5	23.8	25.2	25.8	20.0	25.2	26.8	27.5
2025	**21.8**	**27.6**	**29.8**	**30.6**	**21.6**	**27.8**	**30.4**	**31.4**
2010	20.0	25.7	27.8	28.6	19.7	25.9	28.5	29.4
2011	20.1	24.8	26.7	27.3	20.1	25.7	27.9	28.7
2012	25.4	32.1	34.8	35.9	24.9	31.8	34.9	36.0
TAS	**32.6**	**39.5**	**46.8**	**59.4**	**17.2**	**20.0**	**21.5**	**22.0**
2014	**34.3**	**39.3**	**46.7**	**59.9**	**12.4**	**14.1**	**15.0**	**15.2**
2010	31.1	35.7	43.1	56.6	11.5	13.3	14.3	14.6
2011	33.4	36.6	43.7	58.6	9.5	10.5	10.9	11.1
2012	38.4	45.6	53.2	64.7	16.1	18.5	19.7	20.0
2025	**30.9**	**39.7**	**47.0**	**58.8**	**22.1**	**25.9**	**28.1**	**28.7**
2010	28.4	37.5	43.4	55.3	20.6	24.7	27.0	27.7
2011	32.8	39.8	46.9	59.6	21.9	25.0	26.4	26.8
2012	31.5	41.7	50.7	61.6	23.7	28.0	30.9	31.6

	Energy Generated				Carbon dioxide emissions*			
	b	c	d	e	b	c	d	e
VIC	**1.0**	**1.8**	**2.9**	**3.6**	**0.7**	**1.2**	**2.2**	**2.8**
2014	**0.7**	**1.5**	**2.7**	**3.4**	**0.5**	**1.2**	**2.4**	**3.0**
2010	0.7	1.5	2.7	3.3	0.6	1.2	2.3	2.9
2011	0.6	1.6	3.0	3.8	0.5	1.4	2.8	3.5
2012	0.7	1.4	2.5	3.2	0.4	1.0	2.0	2.6
2025	**1.4**	**2.2**	**3.2**	**3.8**	**0.9**	**1.2**	**2.0**	**2.5**
2010	1.2	2.0	3.0	3.6	0.6	1.1	2.0	2.6
2011	0.9	1.6	2.7	3.5	0.5	1.1	2.1	2.8
2012	2.0	2.9	3.9	4.4	1.5	1.2	2.0	2.2
NEM	**5.2**	**8.7**	**13.7**	**16.3**	**3.4**	**6.4**	**11.1**	**13.1**
2014	**5.3**	**8.6**	**13.7**	**16.3**	**3.6**	**6.7**	**11.5**	**13.5**
2010	5.0	8.2	13.2	15.7	3.5	6.5	11.1	13.1
2011	5.2	8.5	13.7	16.2	3.7	6.9	11.8	13.8
2012	5.5	9.1	14.3	16.8	3.5	6.7	11.5	13.6
2025	**5.1**	**8.8**	**13.7**	**16.4**	**3.3**	**6.0**	**10.7**	**12.7**
2010	4.9	8.8	13.2	15.8	3.1	5.9	10.4	12.5
2011	5.1	8.6	13.8	16.5	3.2	6.3	11.1	13.3
2012	5.3	9.0	14.1	16.8	3.6	5.8	10.4	12.2

(* Source: Bell et al. 2015a)

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