Simulations of the Effects of Greenhouse Gas Mitigation Policies for the Australian Electricity Sector

Final Report

Philip Adams

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EXECUTIVE SUMMARY

INTRODUCTION

This report contains projections of the economy-wide effects of greenhouse gas (GHG) mitigation policies for the Australian electricity sector. The projections are derived from the Victoria University Regional Model (VURM), a multi-sector dynamic economic model of Australia's six states and two territories, which is linked to Jacobs' detailed bottom-up model of electricity supply. The purpose of the projections is to compare the economy wide impacts of different approaches to mandatory carbon pricing.

Results for three scenarios are reported.

1. The *reference-case* is the control simulation against which the other two simulations are compared. The reference case includes an all-of-economy carbon price starting in 2020 and is consistent with action limiting global temperature increases to 2 degrees Celsius above pre-industrial levels. The reference-case is referred to in the CCA's consultation paper on electricity sector policy options as *Cap-and-trade (lump sum)*, because there is lump sum recycling of all permit revenue.
2. The first policy simulation is referred to in the CCA's consultation paper as *Cap-and-trade (tax cuts)*. It differs from the reference-case, due to a change in how revenue

from the cap-and-trade scheme from electricity generators is recycled; specifically, through cuts to personal and company income taxes.

3. The second policy simulation (*Emissions intensity*), deviates from the reference simulation due the implementation of an emissions intensity (EI) scheme in the electricity generation sector. An EI scheme involves free allocation of emissions permits to electricity generators, which lower electricity prices but also the amount of permit revenue that can be recycled.

In all scenarios, carbon pricing revenue from sectors other than electricity is returned lump sum to households

THE REFERENCE CASE

Other than the carbon price, the reference case represents a business-as-usual trajectory of the economy. The following are some key features.

- Growth in real national GDP in the first half of the period is slightly higher than in the second half, in line with Treasury projections, which point to a slowing in the rate of growth of the working-age population and hence of employment and real GDP. Average annual growth over the full projection period is 2.8 per cent.
- The fastest growing states in terms of real GSP are projected to be Queensland and WA. The slowest growing states are Tasmania and SA, though the gap between the slowest and fastest growing regions is less than in recent times.
- Through most of the period real Gross National Income (GNI) grows in line with real GDP, but in some of the earlier years there are departures in growth trajectories due to large changes in the terms of trade and the introduction of the carbon price.
- Australia's terms of trade are assumed to return to their historically-normal level by 2017 and to remain roughly at that level thereafter.
- The fastest growing industry is projected to be Non-hydro renewable generation (implied by inputs from the Jacobs model), while coal generation quickly falls and ceases after 2031. At the bottom of the industry growth rankings are coal-related sectors, and the large metal producers that are assumed to have no growth in production over the longer-term in line with current industry expectations of 'business-as-usual' activity in those sectors. Nearly all of the remaining industries have close to average growth prospects.

- The total level of emissions is projected to fall at an average annual rate of 1.9 per cent between 2014 and 2050. By 2050, economy-wide emissions total 278 Mt, which is 49.1 per cent lower than in 2014.

MODELLING ASSUMPTIONS FOR THE POLICY SIMULATIONS

In all scenarios Australia has a fixed mandated level of economy-wide emissions. Australia can import or sell permits freely based on the difference between its mandated and actual emissions in any year. This ensures comparability between the scenarios as they achieve the same overall level of emissions.

Some of the key macroeconomic assumptions in the policy simulations are noted below.

Labour markets

In each policy simulation, the real *after-tax* wage rate is assumed to be sticky in the short-run and flexible in the long-run. Thus, relative to the reference-case, favourable actions generate short-run gains in aggregate employment, and long-run gains in the national real wage rate. Note, that if the personal income tax rate changes (as in the first policy simulation), then this will have a direct effect on employment in the short-run. With the *after-tax* wage sticky, a cut in tax rate will cause employees to reduce their *pre-tax* wage demands, thus reducing wage pressures on employers.

Government consumption and fiscal balances

In the policy simulations, real public consumption is simply held fixed at its reference-case level.

Demography

The national population is held fixed at reference-case levels, but some deviation in the labour force is allowed in response to a change in personal income tax rates. In the first policy simulation it is assumed that a cut in income tax lifts participation rates.

INPUTS TO THE POLICY SIMULATIONS

Cap-and-trade (Tax cuts)

The tax cuts affect personal and corporate tax rates. For the personal rate, the calculated reduction relative to reference-case values in 2020 is 4.3 per cent. This falls to 1.6 per cent in 2050. For the corporate rate, the reductions are 4.3 per cent in 2020, falling to 1.2 per cent by 2050.

Emissions intensity

The EI subsidy effectively subsidises electricity generation. As a result, relative to reference case levels, electricity prices fall and there is a net reduction in carbon-tax revenue recycled to households.

The cut in electricity price initially is around 20 per cent. This reduces to less than five per cent by 2050. The subsidy is estimated to be $12.9 billion in 2020. Thereafter, it dips and rises back to around $7.4 billion in 2050.

POLICY PROJECTIONS

The table below summarises results from the two policy simulations, expressed as deviations away from levels in the reference-case simulation. Results are shown for the start of the period and the end of the period.

Summary Table: Key variables in the policy simulations (deviations away from reference case values)

Variable	Tax cuts		EI	
	2020	2050	2020	2050
National employment (%)	0.58	0.18	0.50	0.00
National capital (%)	0.11	0.37	0.01	0.18
Real GDP (%)	0.50	0.37	0.31	0.23
Real GNI (national welfare) (%)	0.43	0.36	0.18	0.18
Real private consumption (%)	0.25	0.58	-0.54	0.06
Real Gross State Product (%)				
NSW	0.44	0.51	-0.01	0.30
VIC	0.63	0.42	0.61	0.06
QLD	0.35	0.23	0.56	0.97
SA	0.69	0.39	0.02	-1.01
WA	0.49	0.25	0.39	0.46
TAS	0.79	0.57	0.45	-1.78
NT	0.39	-0.37	-0.02	-0.12
ACT	0.43	0.25	0.05	-1.26
Domestic GHG emissions (kt)	2,333	2,061	11,679	2,047

Cap-and-trade (Tax cuts)

It is assumed that employees are concerned about their after-tax real wage rate. Thus when income taxes are cut, they allow a fall (relative to reference case) in before-tax real wages. This precipitates a reduction in the real cost of labour, which is employment enhancing. In the short run, as shown in the Summary table, the cut in income tax increases employment relative to its reference-case level by 0.58 per cent.

Over time, the employment deviation declines, but remains positive. It declines because the initial favourable impact on employment encourages employees to demand higher wages, reversing the initial cut in real labour cost. In 2050, the employment deviation is 0.18 per cent. In the long-run employment is above reference-case because the tax cut leads to an increase in labour-force participation.

Capital is the other main factor of production. The tax cuts cause an increase in the after-tax rate of return, which encourages investment. The gradual increase in the capital stock reduces the labour-to-capital ratio, increasing real wages and reducing the level of employment. By 2050 the capital-stock deviation is 0.37 per cent, while the employment deviation is 0.18 per cent.

The percentage change in real GDP is driven from the input side by what happens to employment and capital. Relative to reference-case levels, employment of both factors rises, leading to increased real GDP. In the final year it is up 0.37 per cent.

Real GDP leads to increased real national income (GNI) and to a higher level of real private consumption. In 2050, real private consumption is up 0.58 per cent relative to its reference-case level, while real GNI is up 0.36 per cent.

As shown in the summary table, the increase in real GDP is spread fairly evenly across the economy, except for the NT. The differences across regions are explained in most cases by differences in regional industrial compositions (see the main report for more details).

Finally, as shown in the summary tables, the tax cuts mildly stimulate GHG emissions. Reflecting the general increase in activity, aggregate emissions rise relative to reference-case levels by 2.3 Mt (2020) and 2.1 Mt (2050).

Emissions Intensity

Early on the EI subsidy has a positive impact on employment, because it lowers the real cost of labour. As shown in the summary table, in 2020 relative to reference case values employment is up 0.50 per cent (the real cost of labour is down 0.47 per cent).

The subsidy reverses some of the effects of the carbon price on the electricity sector. It cuts the price of electricity and therefore lowers costs of production throughout the economy (relative to reference case values). With the price of labour initially tied to the price of consumption (the real wage rate is sticky), lower costs mean increased profit. Increased profit with little change in the wage rate, allows the real cost of labour to fall.

Over time, VURM allows the real wage rate to adjust upwards in response to the initial increase in employment. By 2050 employment has returned to its reference-case value.

With the real cost of labour rising after the first few years, the real cost of capital falls and producers increase investment. By 2050, with employment returned to its reference case level, capital is up 0.18 per cent relative to its reference case value. Increased capital and employment leads to increased real GDP (see the Summary table).

Differences between real GDP and real GNI arise for two main reasons: changes in net foreign income and changes to Australia's terms of trade. In the first few years, Australia's permit purchases are higher than the reference-case, which reduces net foreign income relative to reference case values. Thus relative to reference-case values in 2020, real GNI is up by 0.18 per cent, while real GDP has increased by 0.31 per cent. Thereafter, the gap between the two indicators narrows as the need to purchase emissions from overseas falls away. Throughout the period, the influence of the terms of trade is negligible.

The story for real private consumption in the first few years is interesting. In 2020 the EI subsidy removes over $10 billion from income available for consumption. The benefit to consumers of reduced electricity prices only partly compensates, leaving real consumption down by around 0.5 per cent. In later years, the size of the subsidy as a share of total consumption falls away, allowing real consumption spending to recover relative to reference case levels.

Finally, at the state level, two general themes emerge, one relating to the first few years and the other to the longer-run. In the early years, there are two opposing forces at play. One is positive for industries and regions – a cut in cost of electricity relative to the reference case. The other is negative - the reduction in real private household spending. Nonetheless, as shown in the Summary table, the impact of the EI subsidy in these years is generally positive, with gains for most regions in line with the increase in real GDP.

Over the longer-term, however, the dispersion of regional outcomes increases. In 2050 the gap between the region that does least well (Tasmania) and the region that does best (Queensland) is nearly three percentage points. The regions that lose GDP share in the long run (like Tasmania) are over represented by industries that benefit least from the cut in electricity cost – generally non-traded sectors with relatively small electricity-input costs.

The subsidy to electricity production stimulates electricity consumption and GHG emissions, especially in the early years of the EI scheme. Aggregate emissions are 11.7 Mt higher than reference-case levels in 2020, reducing to 2.0 Mt by 2050.

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1 INTRODUCTION

The key distinguishing characteristic of Computable General Equilibrium (CGE) modelling in Australia is its orientation to providing *detailed* inputs to the policy-formation process. This characteristic is ably demonstrated in this paper via an analysis of the impacts of Greenhouse Gas (GHG) mitigation policies on the Australian electricity sector, which has been commissioned by the Climate Change Authority (CCA).

The analysis relies on applications of the Victoria University Regional Model (VURM), which is the rebranded version of the Monash Multi-Regional Forecasting model (MMRF). The change of name reflects the Centre of Policy Studies' (CoPS') move from Monash University to Victoria University in early 2014. VURM is a dynamic economic model of Australia's six states and two territories. It models each region as an economy in its own right, e.g., the model contains region-specific prices, consumers, industries, etc. Technical documentation of the model equations and database can be downloaded from http://www.copsmodels.com/elecpapr/g-254.htm.

The rest of this paper is organized as follows. A brief general description of VURM is given in Section 2. For the simulations reported in this paper, we use information on the composition of electricity supply, electricity prices and costs from modelling undertaken by the Jacobs Group (further details are available in Jacobs' modelling report for the CCA). In Section 3 we describe the linking process, whereby Jacobs' projections are incorporated into the VURM modelling.

VURM produces sequences of annual solutions connected by dynamic relationships, e.g., physical capital accumulation. Policy analysis with VURM involves the comparison of two alternative sequences of solutions, one generated without the policy change and the other with the policy change in place. The first sequence serves as a control path from which deviations are measured to assess the effects of the policy shock.

For the modelling reported in this paper, the first sequence is called the *reference-case.* Aspects of simulation design and projections for the reference-case simulation are explained in Section 4. The reference-case is referred to in the CCA's consultation paper on electricity policy options as *Cap-and-trade (lump sum).* It incorporates a cap-and-trade emissions trading scheme with lump sum recycling of all permit revenue.

Section 5 deals with inputs and projections for the first of two policy simulations. This simulation is referred to in the CCA's consultation paper on electricity sector policy options as *Cap-and-trade (tax cuts)*. It differs from the reference-case, due to a change in how revenue from the cap-and-trade scheme from electricity generators is recycled; specifically, through cuts to personal and company income taxes. In the final section, Section 6, our focus is on the second policy simulation, *Emissions intensity.* This simulation deviates from the reference simulation due the implementation of an emissions intensity scheme, rather than a cap-and-trade scheme, in the electricity generation sector. The results reported in Sections 5 and 6 are expressed as deviations between the values of variables in the policy simulation and their values in the reference-case.

2 OVERVIEW OF THE VURM MODELLING FRAMEWORK

Based on the model's full database for 2009-10, in each region 79 industries produce 83 commodities.[1] Capital is industry- and region-specific. In each region, there is a single household and a regional government. There is also a Federal government. Finally, there are foreigners, whose behaviour is summarised by demand curves for international exports and supply curves for international imports.

The model includes a number of satellite modules providing more detail on government finance accounts, household income accounts, population, and energy and greenhouse gas emissions. Each of the 'satellite' modules is linked into other parts of the model, so that projections from the model core can feed through into relevant parts of a module and vice versa, changes in a module can feed back into the model core. The model also includes extensions to the core model theory dealing with links between demography and government consumption, the supply and interstate mobility of labour, and export supplies.

The model has a particular focus on greenhouse study and thus includes:

- A full set of energy and greenhouse-gas accounts that covers each emitting agent, fuel and region recognized in the model;
- quantity-specific carbon taxes or prices;
- equations for inter-fuel substitution in transport and stationary energy; and
- a representation of Australia's National Electricity Market (NEM).

2.1 ENERGY AND EMISSIONS ACCOUNTING

VURM includes accounting for all domestic emissions, except those arising from land clearing and land-use change. It does not include emissions from the combustion of Australian exports by the importing economy, but does include any fugitive or combustion emissions arising in Australia from the extraction or production of those exports.

[1] For the simulations reported in this paper, the full set of (79 industries, 83 commodities) has been aggregated to 70 industries uniquely producing 70 commodities.

VURM tracks emissions of greenhouse gases according to: emitting agent (79 industries and the household sector); emitting region (8 regions); and emitting activity (5 activities). Most of the emitting activities involve the burning of fuels (coal, natural gas and a single refined petroleum product). A residual category, named *Activity*, covers non-combustion emissions such as emissions from mines, as well as agricultural emissions not arising from burning of the fuel. *Activity* emissions are assumed to be proportional to the level of activity in the relevant industries (animal-related agriculture, coal, oil and gas mining, cement manufacture, etc.).

2.2 CARBON TAXES AND PRICES

VURM treats an emissions price/tax as a specific tax on emissions of GHG. On emissions from fuel combustion, the tax is imposed as a sales tax on the use of fuel. On *Activity* emissions, it is imposed as a tax on the production of the relevant industries.

Because sales taxes in VURM are generally assumed to be *ad valorem* (based on a percentage of sales value) and carbon taxes are generally levied on the quantity of GHG emitted, equations are required to translate a carbon tax into an *ad valorem* tax-equivalent. On one side of this relation, carbon dioxide emissions (from henceforth denoted CO_2-e) tax revenue is determined by:

- the specific tax rate expressed in $A per tonne of CO_2-e;
- the quantity of emissions measured in tonnes of CO_2-e; and
- a price index used to preserve nominal homogeneity within the model.

On the other side, the *ad valorem* tax revenue is determined by:

- the percentage *ad valorem* rate;
- the basic price of the underlying taxed flow to conform to the accounting in VURM; and
- the quantity of the underlying product flow that is subject to the carbon tax.

To translate from specific to *ad valorem* the two sides of the relation are set equal to each other.

2.3 INTER-FUEL SUBSTITUTION

VURM allows for various forms of inter-fuel substitution in electricity and non-electricity sectors.

Electricity-generating industries are differentiated according to the type of fuel used. There is also an end-use supplier (*Electricity supply*) in each region and a single dummy industry (*NEM*) covering the six regions that form Australia's National Electricity Market (New South Wales, Victoria, Queensland, South Australia, the Australian Capital Territory and Tasmania). Electricity flows to the local end-use supplier either directly in the case of Western Australia and the Northern Territory or *via* the *NEM* in the remaining regions. Further details of the operation of *NEM* are given below.

Purchasers of electricity from the generation industries (the NEM in the case of those regions in the NEM or the *Electricity supply* industry in each non-NEM region) can substitute between the different generation technologies in response to changes in generation prices, with the elasticity of substitution between the technologies typically set at around 5.

For other energy-intensive commodities used by industries, VURM allows for a weak form of input substitution. If the price of cement (say) rises by 10 per cent relative to the average price of other inputs to construction, the construction industry will use 1 per cent less cement and a little more labour, capital and other materials. In most cases, as in the cement example, a substitution elasticity of 0.1 is imposed. For important energy goods (petroleum, electricity and gas), the substitution elasticity in industrial use is set at 0.25. This price-induced input substitution is especially important in the scenarios modelled here, as electricity prices are substantially lower in the Emissions Intensity scenario than the other two scenarios.

2.4 NATIONAL ELECTRICITY MARKET

The NEM is a wholesale market covering nearly all of the supply of electricity to retailers and large end-users in NEM regions. VURM represents the NEM as follows.

Final demand for electricity in each NEM region is determined within the CGE-core of the model, in the same manner as demand for all other goods and services. All end users of electricity in NEM regions purchase their supplies from their own-region *Electricity supply* industry. Each of the *Electricity supply* industries in the NEM regions sources its electricity from a dummy industry called *NEM*, which does not have a regional dimension. In effect, the *NEM* is a single industry that sells a single product (electricity) to the *Electricity supply* industry in each NEM region. *NEM* sources its electricity from generation industries in each NEM region. Its demand for electricity is price-sensitive. For example, if the price of hydro generation from Tasmania rises relative to the price of gas generation from New South Wales, then *NEM* demand will shift towards New South Wales gas generation and away from Tasmanian hydro generation.

The explicit modelling of the NEM enables substitution between generation types in different NEM regions. It also allows for interregional trade in electricity, without having to trace explicitly the bilateral flows. Note that Western Australia and the Northern Territory are not part of the NEM and electricity supply and generation in these regions is determined on a region-of-location basis.[2]

[2] Note that transmission costs are handled as margins associated with the delivery of electricity to *NEM* or to the *Electricity supply* industries of WA and the NT. Distribution costs in NEM-regions are handled as margins on the sale of electricity from *NEM* to the relevant *Electricity supply* industries.

3 INCORPORATING RESULTS FROM THE JACOBS MODEL

3.1 PREAMBLE

VURM's modelling of electricity generation and supply, the NEM and electricity prices is quite sophisticated in a CGE context. Despite this, the model is inadequate as a tool for addressing the question at hand. Thus, the CGE model is linked to a more sophisticated bottom-up model of electricity supply, run and maintained by the Jacobs Group.[3]

There are a number of reasons to prefer linking to a detailed electricity model such as Jacobs' over the use of VURM's standard treatment of electricity.

- *Technological detail*. VURM recognizes six generation technologies. The Jacobs model recognizes many hundreds, some of which are not fully proved and/or are not in operation. For example, VURM recognizes one form of coal generation whereas the Jacobs model recognizes many forms, e.g., cleaner gasification technologies and generation in combination with carbon capture and storage. Having all known technologies available for production now or in the future, allows for greater realism in simulating the technological changes available in electricity generation in response to emissions reduction policies. The Jacobs model also captures details of the interrelationships between generation types. A good example of this is the reliance by hydro-generation on base-load power in off-peak periods to pump water utilized during peak periods back to the reservoir.
- *Changes in investment and capacity*. VURM treats investment in generation like all other forms of investment. Capital supply is assumed to be a smooth increasing function of expected rates of return which are set equal to current rates of return. Changes in generation capacity, however, are generally lumpy, not smooth, and investment decisions are forward-looking, given long asset lives. The Jacobs model

[3] The idea that examining environmental issues could be tackled effectively by linking a CGE model with a detailed bottom-up energy model has a long history with Australian modelers. A short history and description of such efforts is given in Adams and Parmenter (2013, Chapter 3). Full reference: Philip D. Adams and Brian R. Parmenter, "Computable General Equilibrium Modelling of Environmental issues in Australia: Economic Impacts of an Emissions Trading Scheme" chapter 3 in P.B. Dixon and D. Jorgenson (eds) *Handbook of CGE Modelling*, Vol. 1A, 2013, Elsevier B.V.

allows for lumpy investments and for realistic lead times between investment and capacity change. It also allows for forward-looking expectations, which aligns more with real-world experience than does VURM's standard (static) assumption. The demand for electricity is exogenous in the Jacobs model but when demand is endogenised by running the Jacobs model linked to VURM, investment in the electricity sector is essentially driven by model-consistent expectations.

- *Policy detail*. Currently, in Australia there are around 75 policies at the state, territory and Commonwealth levels affecting electricity generation and supply. These include: market-based instruments to encourage increased use of renewable generation; regulations affecting the prices paid by final residential customers; and regional policies that offer subsidies to attract certain generator types. Some of these policies interact with each other. Interactions and policy details are handled well in the Jacobs model, but are generally outside the scope of stand-alone modelling in VURM.
- *Sector detail*. In VURM, electricity production is undertaken by symbolic industries – *Electricity-coal Victoria*, *Electricity-gas NSW* etc. In the Jacobs model, actual generation units are recognized, e.g., unit *x* in power station *y* located in region *z*. Thus, results from the detailed electricity model can be reported at a more granular level, and in a way which industry experts fully understand. This adds to credibility in result reporting.

3.2 THE JACOBS MODEL

Formally, the Jacobs model is a mixed-integer linear programming model of Australia's electricity system. The objective function is the total cost (including fixed and variable costs) of the system. The model solves for optimal investment and generation to minimize total cost subject to constraints associated with minimum reserve requirements, policies, etc. More details are provided in the Jacobs' modelling report.

Inputs to the Jacob model cover:

- general system data for electricity demand by region and the reserve capacity requirements for each region;

- data for the capacity of each inter-regional interconnector and for transmission losses;
- data on fixed and variable costs of production for each generation plant (existing and new), and on capacities and plant-commissioning timeframes; and
- data on greenhouse-gas emissions for each generation option.

Outputs are categorized as *decision* variables and *calculated* variables. The main decision variables are investment (or changes in capacity) for the various generation options, and production (or dispatch) from each available generation type. The key calculated variables are total costs of each plant, total system cost, wholesale and retail electricity prices, greenhouse emissions and total greenhouse-emission abatement.

Jacobs' modelling of capacity changes takes account of establishment of new units and retirement of existing units. Its modelling of wholesale electricity prices is based on the long run marginal cost of generation. Retail prices comprise the wholesale price (multiplied by the marginal-loss factor in transmission) *plus* network fees *plus* gross retail margins, market fees and the cost of administering various government schemes, e.g., to encourage the purchase of renewable generation.

3.3 LINKING

The linking of the two models proceeds in an iterative way as follows. For the reference-case or for any of the policy simulations, an initial VURM simulation is conducted, with the electricity system unconstrained. From this simulation come annual projections for electricity demand by industry and state (denoted Pj).

These projections are supplied to the Jacobs model. Jacobs' modellers take the annual demand projections, generate within-year load profiles, and update their estimates for the variable costs of generation for each option. The electricity model is then run (with appropriate constraints relating to greenhouse gas emissions if necessary) to provide annual projections by State[4] for:

[4] The Jacobs simulations cover all of the electricity sold and bought through the NEM plus electricity for the South West Interconnected System (SWIS) in Western Australia. It therefore excludes electricity bought and sold outside of these two main grids.

1. sent-out generation (GWh) by generation type, aggregated to VURM's level of detail;
2. fuel usage by generation type (Pj), aggregated appropriately;
3. emissions by generation type (tonnes of GHG), aggregated appropriately;
4. investment ($m) and capacity (GW) by generation type, aggregated appropriately;
5. unit revenue by generation type ($ per GWh) aggregated appropriately[5];
6. operating costs (fixed and variable) by generation type ($ per GWh) aggregated appropriately; and
7. retail electricity prices by final customer category (Industrial, SME and Residential) ($ per GWh).

Items 1-7 are then input to VURM, enabled by closure changes that in effect turn off VURM's treatment of electricity supply and investment in the NEM states and WA. Details of the closure changes are given in Table 1. The first column shows the Jacobs model variable being transferred. The second column shows the VURM variable targeted. Most of these variables are naturally endogenous but must be made exogenous. The final column gives the VURM variable – typically a naturally exogenous variable – that is endogenised to allow the targeted variable to be exogenised.

The changes in generation mix imposed on VURM are initially cost-neutral, and so have no effect on the average price of the *Electricity supply* industry. Jacobs' estimates of changes in unit revenue by generator type and region are introduced into VURM *via* changes in a miscellaneous *Other cost* category. *Other cost* is a non-produced factor of production with a return that accrues to the producer. If the Jacobs' modelling indicates an increase in unit revenue that exceeds a weighted average of cost increases for material inputs, capital and labour, then in the VURM modelling the surplus accrues to *Other cost* (essentially, the surplus accrues as a "pure profit"). Jacobs' estimates of changes in retail prices for each customer type in each region are introduced into VURM *via* changes to *phantom taxes.* A phantom tax is a wedge between the price received by the producer and the price paid by the user. Unlike actual taxes imposed by

[5] Unit revenue is revenue per unit of output. In VURM it is analogous to the price received by the electricity generating industries. Hence, in VURM, it is equivalent to a "wholesale price". In the Jacobs' model, however, unit revenue is not strictly the same as the "wholesale price", and is not defined over generator type.

governments, revenue from a phantom tax accrues to the producer of the product. There are three customer types – Industrial, SME and Residential. As noted in Table 1, representative household sector in VURM pays the Residential price. Most mining and manufacturing industries in VURM pay the Industrial price. All other industries pay the SME price.

Table 1: Transfer of information from the Jacobs model to VURM

Jacobs' variable	VURM Target	VURM Instrument
1. Sent-out generation by type and region	Sent-out generation by type and region.	Cost-neutral shifts in input technologies of the Electricity-supply industry in each state.
2. Fuel usage by generation type and region.	Fuel usage by generation type and region	Cost-neutral shifts in input technologies of the fossil-fuel generation industries.
3. Emissions by generation type and region	Emissions per unit of fuel used by fossil-fuel generation industries	Naturally exogenous.
4. Investment and Capacity by generation type and region	Capital stock in use by generation type and region.	Shifts in the required rate of return by generation type and region, which allows capital supply to be exogenous and set equal to achieve the targeted changes in capacity (investment)
5. Unit revenue by generation type and region.	Average basic price of the output of generator industries in each region.	Equi-proportionate shifts in the price of "other costs" of each generator in a region to mimic changes in unit pure profit.
6. Operating costs by generation type and region	Basic prices of inputs to generator industries in each region	Input "twists" (or cost-neutral technological changes to input structures) of each generator in each region to accommodate changes in cost structures.
7. Retail electricity prices by final customer type by region	Prices paid by users of electricity supply in each region. Prices are distinguished by using agent. Households pay the "Residential" price. Most mining and manufacturing industries pay the "Industrial" price. All other industries pay the "SME" price.	Shifts in "phantom" taxes or subsidies that drive a wedge between the prices received by the Electricity supply industry and the relevant customer types in each region. Revenue from the "phantom" tax is returned to the producer (the Electricity supply industry) rather than to the Government.

Imposing these *Jacobs'* values in VURM and re-running completes the first iteration. Revised values for electricity demand are passed to the Jacobs model which then recalculates values for variables 1 to 7. Iterations continue until the retail prices of electricity in each region stabilize between successive iterations.

4 REFERENCE CASE

4.1 PREAMBLE

Using VURM we simulate three future scenarios for the Australian economy. The first is a scenario based on business-as-usual trends in demography, technology and Australia's trading conditions with the rest of the world. This is the reference-case simulation.

The reference-case scenario includes the effects of current government policies, but not possible future policy initiatives other than one in which Australia enters into a program of global GHG mitigation. The global scheme imposes a carbon price on all Australian emissions through a cap-and-trade scheme, consistent with action limiting global temperature increases to 2 degrees Celsius above pre-industrial levels. The policy begins in 2020, after being announced in 2018. Permit revenue from all emissions sources, including electricity generators, is recycled as a lump-sum payment to the representative household sector. No assistance is provided to emissions-intensive trade-exposed industries... This scenario is referred to in the CCA's consultation paper on electricity sector policy options as *Cap-and-trade (lump sum).*

Inputs to the reference-case are examined in Section 4.2. Projections are reported in Section 4.3.

4.2 INPUTS

The reference-case incorporates a large amount of information from specialist forecasting agencies, information on electricity supply from the Jacobs modelling, and inputs associated with the imposition of the carbon price. VURM traces out the implications of these inputs at a fine level of industrial and regional detail.

Information imposed in the reference-case includes the following.

1. *Changes in population and labour force*. These numbers come from the latest version (2015) of the Federal Treasury's Intergenerational Report (IGR).
2. *Changes in real GDP and underlying productivity*. For the years up to and including 2017, real GDP is an exogenous variable and set to growth rates consistent with 2015 Federal budget projections. To accommodate this information, we allow the rate of all-factor technological progress (also known as total factor productivity) to adjust endogenously.

From 2018 onwards, real GDP is endogenous and driven, in the main, by exogenous assumptions for growth in the labour force (see point 1) and growth in all-factor productivity. For all industries we assume all-factor technological progress at an annual rate of 1.5 per cent. Productivity growth at this rate is necessary to achieve real GDP growth within the historical trend range of 2.5 to 3.5 per cent, given other assumptions made for the reference-case.

3. *Changes in world trading conditions*. In VURM the behaviour of the Rest of World (RoW) is modelled *via* changes in the positions of export demand and import supply schedules. The export demand schedules are downward sloping, while the import supply schedules are flat at world prices.[6]

   Foreign currency prices for imports other than oil are assumed to be unchanged through the projection period. We assume a foreign-price of imported oil based on the CCA's analysis of the International Energy Agency (IEA)'s 2014 *World Energy Outlook.*

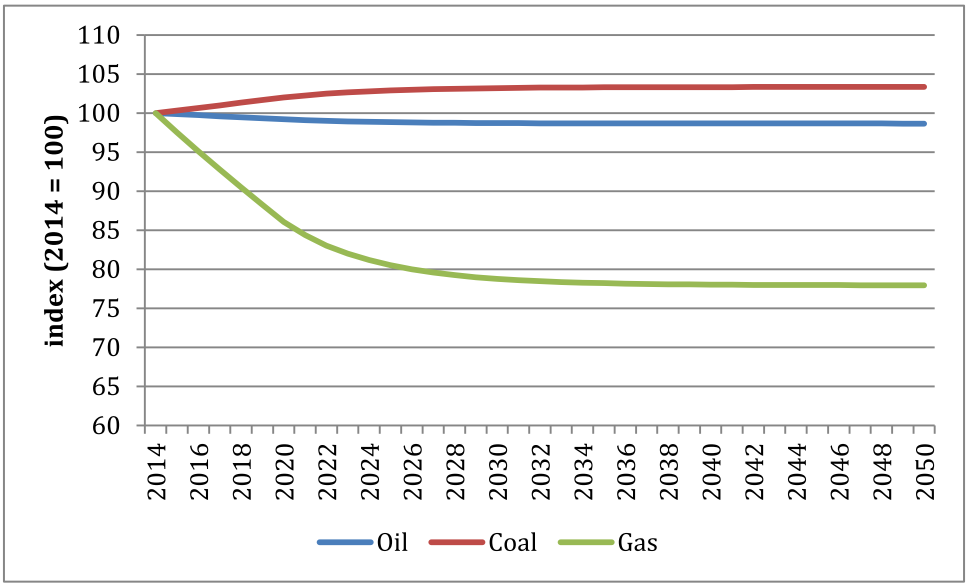
   On the export side, foreign demand schedules for energy products (oil, coal and LNG) move to accommodate growth in world prices as shown in Figure 1a. These are consistent with CCA's analysis of the IEA's 2014 *World Energy* Outlook through to 2020. For the years after 2020, growth rates were moderated from 2020 levels to zero, so that for the years after 2030 changes in prices are negligible.

   For non-energy commodities, export demand schedules shift to accommodate *initial* changes in the overall Terms of Trade (ToT) that are imposed exogenously. For the initial setting, it is assumed that the ToT returns to a historically normal level by 2020, and remains at that level thereafter. The final outcome is a little different, reflecting the impacts of the carbon price on Australian supply of exported non-energy products (see our discussion below on reference-case projections).

4. *Regional GSP*. Up to and including 2017, growth rates are set to values based mainly on published state government forecasts. Growth rates for 2018 onwards are determined endogenously.

[6] Values for the foreign elasticities of demand are set within the range of -3.5 to -5.0.

Figure 1a: World prices (USD) for Coal, Oil and Gas in Reference case (index levels, 2014 = 100)



5. *National-level assumptions for changes in industry production technologies and household preferences.* Changes are imposed that mimic the effects of autonomous energy efficiency improvements. Specifically, we assume that all industries reduce their use of electricity and gas per unit of output at the rate of 0.5 per cent per annum, and that the share of energy products in the budget of the representative household falls by 0.5 per cent per annum.
6. *Forecasts for land-use change and for forestry sequestration.* Estimates taken from modelling undertaken by CoPS for a ClimateWorks study: *Pathways to Deep Decarbonisation in 2050: How Australia can prosper in a low carbon world*. http://climateworks.com.au/sites/default/files/documents/publications/climateworks_pdd2050_technicalreport_20140923.pdf .
7. *Capital constraints and expansions in certain mining and manufacturing industries.* For the ClimateWorks modelling, a number of assumptions were made about future capacity changes in certain manufacturing industries based on information supplied by industry experts. These are carried over into the CCA modelling. Specifically, we assume no new net investment for industries producing aluminium, iron and steel, and refined petroleum products. Plant closures are modelled for the motor vehicles and parts industry in 2015, 2016 and 2017 based on industry announcements, and

large capacity increases are assumed for LNG produced in Queensland in 2015, 2016 and 2017.

8. *Carbon price.* Figure 1b shows projections for the carbon price in US and AUS dollars. Estimates for the price of CO_2 in US$ per tonne were provided by CCA based on its analysis of carbon prices consistent with limiting temperature increases to 2 degrees Celsius from the Intergovernmental Panel on Climate Change's Fifth Assessment Report.[7]

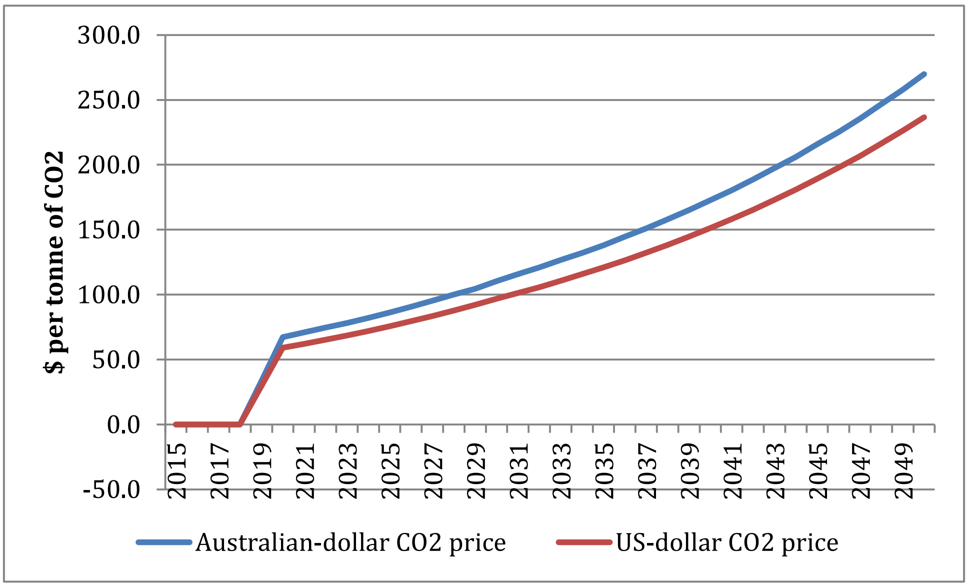
   The CCA provided international prices in US dollars, which were converted to Australian dollar series within VURM. In VURM, the nominal exchange rate is an endogenous variable, moving to achieve required changes in the real exchange rate (or international competitiveness). The nominal exchange rate remains fairly steady through the projection period, as implied by the numbers in Figure 1b.

   Note in Figure 1b that the carbon price (AUS dollars) in 2019 is $33 and in 2020 it is $68. Formally the cap-and-trade scheme starts in 2020, after being announced in 2018. However, for the purpose of modelling the scheme in VURM we choose to start the scheme in 2019 with a price roughly half the price in 2020. This is for two reasons: (a) to provide for announcement effects in 2019 that mimic early investment and abatement responses to the reality of a carbon price in 2020; and (b) to smooth the initial step-up in price and hence ease the initial computational burden on VURM.[8]

[7] The US dollar carbon price series was derived by the CCA based on the median carbon price associated with an atmospheric concentration of between 430 and 480 ppm carbon dioxide equivalent observed in a meta-analysis of global carbon prices for the Intergovernmental Panel on Climate Change. The median values from this analysis were inflated to 2014 US dollars, and growth rates were calculated to interpolate for years between 2020, 2030 and 2050.

[8] Introducing the carbon price in one year could cause issues with the modelling. For example, it could cause gross investment in some industries to pass through zero, which is not an allowable solution. The solution adopted here was to smooth the introduction of the carbon price over two years.

Figure 1b: Price of GHG emissions in the Reference case ($ per tonne of CO2)



9. *Initial changes in generation supply, prices, etc., from the Jacobs' model.* Jacobs' modelling starts from 2018. Thus in the VURM simulation, information from the Jacobs' model is incorporated from 2018 onwards. As explained in Section 3, data from Jacobs is both an input to the VURM simulation and, at the end of the iterative procedure, an output of the VURM simulation. Final VURM/Jacobs projections for electricity supply and price are discussed below in Section 4.3.

4.3 PROJECTIONS

We start with projections for the national macro-economy. This is followed by projections for national industry production, for GHG emissions by source, and for aspects of electricity supply (dual with Jacobs projections). The projection period starts in 2014, which is the year of record for the VURM database, and ends in 2050. The policy simulations reported in later sections deviate from the reference-case only after 2018, so results for those simulations are reported for the period 2018 to 2050.

4.3.1 MACROECONOMIC VARIABLES

Figure 2 shows the reference-case path for growth in real GDP and for growth in the labour force (from the IGR). As noted in Section 4.2, real GDP growth to 2017 is tied to federal government projections. Thereafter, real GDP is endogenous.

The main drivers of GDP growth from 2018 onwards are assumptions for growth in the labour force and all-factor productivity. Growth in the labour force with the rate of unemployment more-or-less fixed implies growth in employment (persons). Growth in employment adjusted for changes in all-factor productivity implies growth in *effective* employment (growth in persons employed, adjusted for changes in worker productivity). Over the longer-term, growth in effective employment tends to match growth in effective capital, thus establishing growth in real GDP from the input side.

As illustrated in Figure 2, real GDP grows at an average annual rate of 2.9 per cent between 2014 and 2030, slowing to an average rate of 2.7 per cent between 2031 and 2050. Average annual growth over the full projection period (2.8 per cent) is in line with the historical norm for Australia.

Note that the slight unevenness of the growth path after 2020 reflects the impacts of the carbon price and year-to-year changes in electricity prices, generation mix and generation investment coming from the linked-Jacobs projections.

Figure 2: Real GDP and Labour force in the Reference case (growth rates (%), 2014 to 2050)

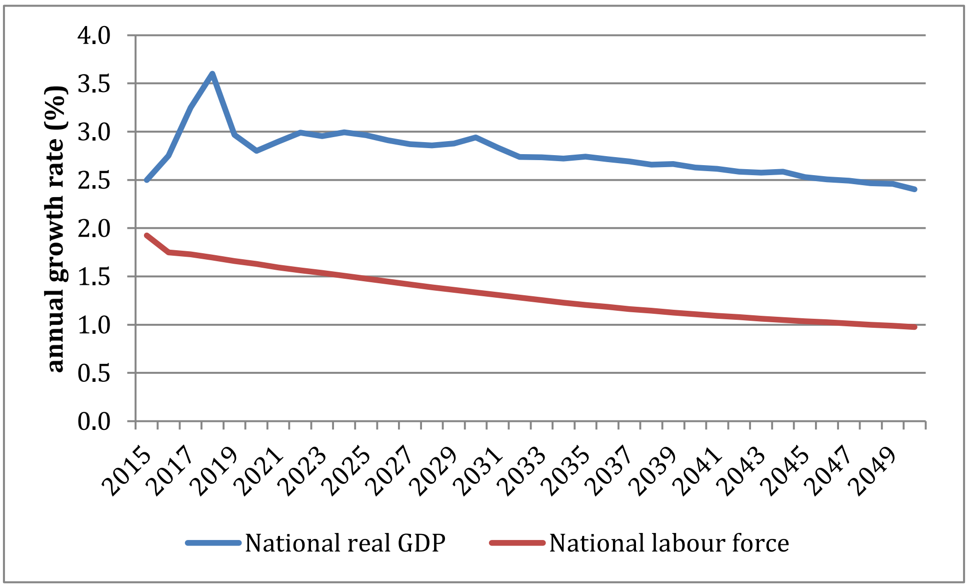


Figure 3 shows the growth trajectories for real Gross State Product (GSP) for each state and Territory. Initially, growth in real GSP in Queensland exceeds GSP growth elsewhere, reflecting the start-up of several large LNG plants in that state. Growth in real GSP in Tasmania is generally below that of other states, reflecting subdued prospects for many of that state's manufacturing and agricultural sectors. On average across the period, the export-oriented states – Queensland and Western Australia – are projected to be the fastest growing state economies, followed by New South Wales and Victoria. South Australia and Tasmania are the slowest growing, though the gap between the slowest and fastest growing states and territories is a little less than in recent times.

Figure 3: Real GSP in the Reference case (growth rates (%), 2014 to 2050)

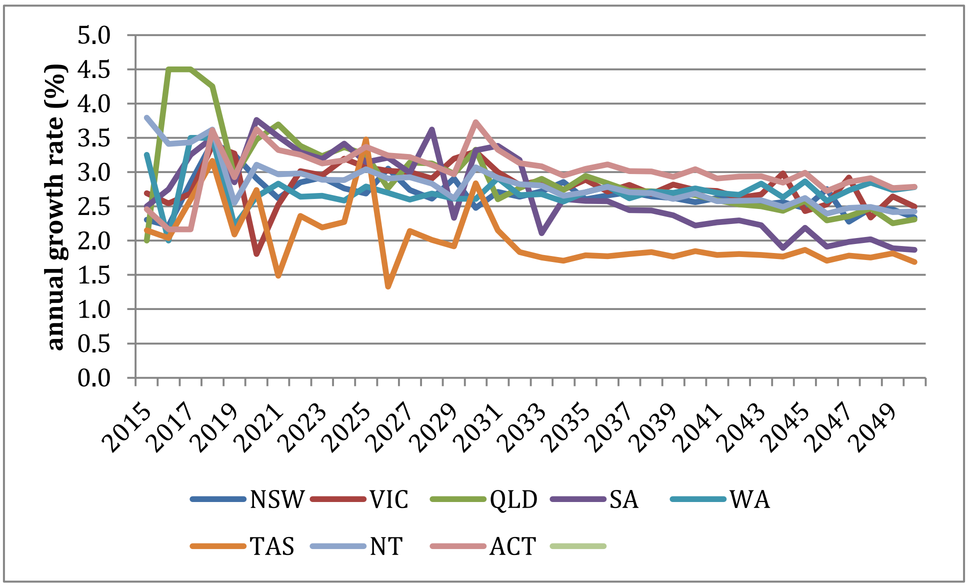
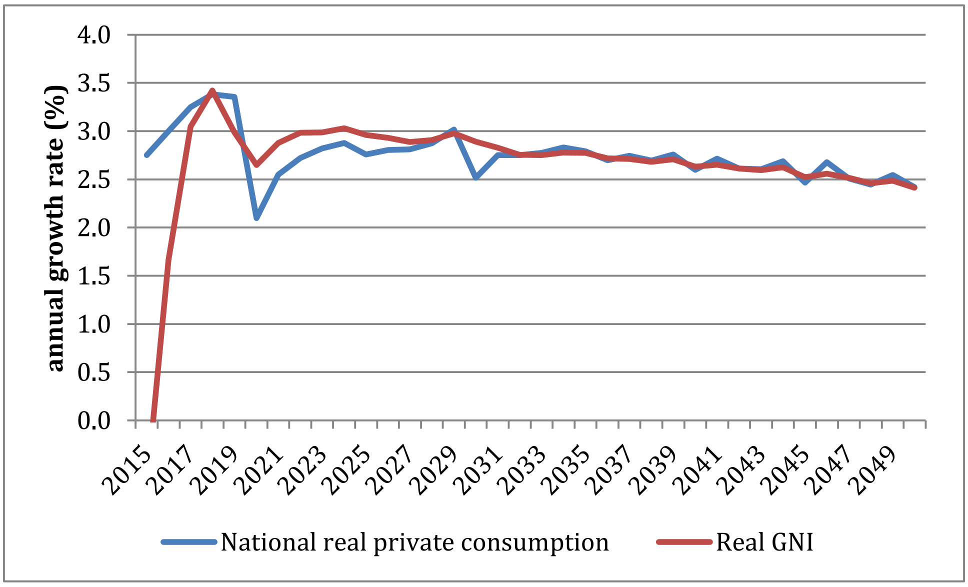


Figure 4 shows growth rates for real private consumption and for real Gross National Income (GNI). Real GNI equals the nominal value of GDP plus net foreign income from overseas (typically a negative number for Australia) deflated by the price of Gross National Expenditure (GNE). The price of GNE is the average of prices for private consumption, public consumption and investment.

In the reference-case, with no changes in income tax rates, nominal consumption moves in line with Household Disposable Income (HDI).[9] A good proxy for HDI is nominal GNI. It follows, that any differences in real rates of growth for private consumption and GNI will reflect changes in the ratio of the price of consumption to the price of GNE. Increases (decreases) in the price of private consumption relative to the price of GNE mean lower (higher) growth in real private consumption relative to real GNI, all else equal.

Figure 4: Real Private Consumption and Real GNI in the Reference case (growth rates (%), 2014 to 2050)



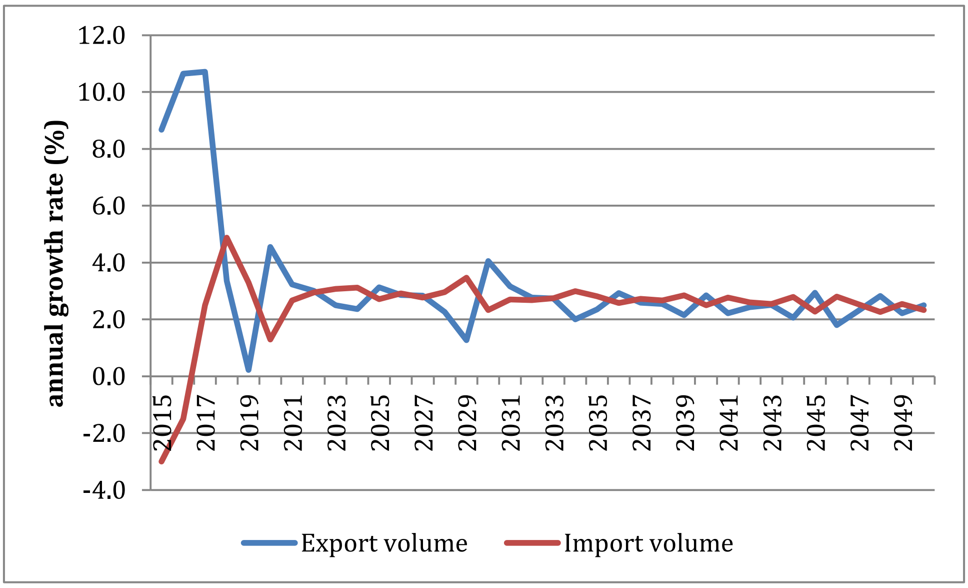
As shown in Figure 4, after 2030 real private consumption and real GNI grow in line with real GDP. At the start of the period, there is a relatively large increase in real consumption relative to real GNI, reflecting a fall in the price of consumption relative to the price of GNE brought about by strong growth in real wages. Compared to the price of consumption, the price of GNE is affected more by changes in wages growth, because

[9] In VURM, the consumption function links private consumption to HDI via the Marginal Propensity to Consume (MPC). In the reference case, the MPC is constant. Thus the percentage growth rate of consumption equals the percentage growth rate of HDI.

the public-consumption component of GNE is highly labour-intensive. The dips in both series in 2020 and 2021 are due to the introduction of the carbon price, which reduces the real purchasing power of households.

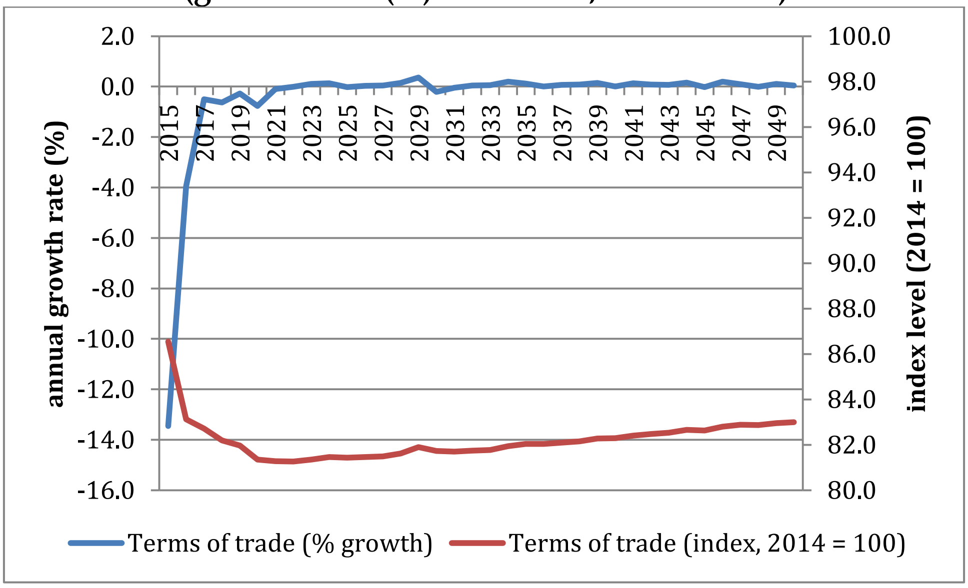
Over the fifteen years leading up to 2014, the volumes of international exports and imports grew rapidly relative to real GDP. This reflects several factors – declining transport costs, improvements in communications, reductions in protection in Australia and overseas, technological changes favoring the use of import-intensive goods such as computers and communication equipment, and rapid growth in Chinese demand and supply of traded manufacturing products. All these factors are extrapolated into the early years of the reference-case, but their influence is assumed to weaken over time (see Figure 5). On average, from 2018 onwards trade volumes grow in a relatively tight band of between 2 and 4 per cent per annum, which is in line with growth in real GDP. This implies little long-term improvement in the current imbalance between export and import volumes.

Figure 5: Export and Import volumes in the Reference case (growth rates (%), 2014 to 2050)



Australia's terms of trade are assumed to return to their historically-normal level by 2017 and to remain roughly at that level thereafter. Figure 6 shows reference-case values for the terms of trade in terms of annual growth rates (%), and annual levels. The levels values are for an index where the base year of 2014 is assigned the value 100. In 2011, the terms of trade were at their most recent peak, with an index value of around 170. In 2015 the index is projected to be 87, falling to just under 82 in 2017. For the years after 2017 the index remains at levels between 81 and 84. There is a little unevenness in the growth pattern due to the effects of the carbon price and the ups and downs in the Jacobs numbers. However, these factors are relatively minor, and have little or no effect on the general stabilization story.

Figure 6: Terms of Trade in the Reference case (growth rates (%) and levels, 2014 to 2050)



4.3.2 NATIONAL INDUSTRY PRODUCTION

Table 2 shows reference-case projections for average annual growth in output at the national level. The industries are listed in order of their modelled growth, from highest to lowest.

Electricity generation –Electricity generation – Other renewable (industry 39) has strong growth prospects. A small amount of nuclear generation (industry 40) appears in the Jacobs modelling in the 2040s, which leads to an undefined (denoted *nd)* growth rate because this industry presently does not exist.[10] Non-hydro renewable generation is projected to grow at an average annual rate of 5.1 per cent. Its prospects are implied by inputs from the Jacobs model and are greatly enhanced by government policy action, particularly the GHG price, which is incorporated into the reference-case simulation after 2019. Generation from gas (industry 37, rank 14) is projected to grow at a relatively strong average annual rate of 3.2 per cent, supported by the GHG price. The same policies restrict the average annual growth rate of emission-intensive coal generation (industry 36, rank 70) to -15.6 per cent. The Jacobs inputs have the production of hydro generation changing little over the projection period (industry 38, rank 66), due to constraints associated with water availability.

Projected growth in overall *Electricity supply* (industry 41, rank 64) is relatively slow at 1.0 per cent per annum. In line with recent history, the reference-case includes an autonomous annual 0.5 per cent rate of electricity-saving technological change in all forms of end-use demand. This, coupled with a contraction in production of the main electricity-using industry – *Aluminum* (industry 30, rank 68) – explains the relatively slow growth projected for *Electricity supply*. Both the main metals producers, *Aluminium* and *Iron and steel* (industry 29, rank 63) lie towards the bottom of the growth rankings. In the modelling we impose capacity constraints on these industries that are in line with current industry expectations of no growth in production over the longer-term.

Projections of strong growth of softwood plantations on land previously used in marginal broad-acre agriculture underlie strong growth in forestry production (industry 7, rank 3). Forestry exports grow slightly faster than forestry production, while growth in production of the main downstream user of forest products, *Wood products* (industry 21, rank 15), is a little below that of its primary supplier.

Gas mining and LNG is the fourth ranked industry, with a projected average annual growth rate of 3.7 per cent. Prospects for this industry are favourable because of

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[10] The CCA inclusion of nuclear generation in the Jacobs modelling does not reflect a preference for this technology. The inclusion of nuclear generation is discussed further in Jacobs' modelling reports for the CCA.

expected strong growth in exports of LNG and in domestic demand, as electricity generators and other users of coal substitute away from coal towards gas and renewable sources of energy in response to a progressively increasing price of GHG. Prospects for the LNG-component are also enhanced by the expansion in Queensland in the first few years of the reference simulation. In contrast, growth in the *Coal mining* (industry 9, rank 69) is low because the carbon price reduces demand for coal in Australia.

Table 2: Projections for National Industry Output in the Reference-case (average annual growth (%) between 2014 and 2050, ranked)

Rank		Industry	% growth	Rank		Industry	% growth
1	40	Electricity generation - Nuclear	Nd	36	46	Construction services	2.7
2	39	Electric generation - Other renew.	5.1	37	57	Communication services	2.7
3	7	Forestry	5.1	38	47	Wholesale trade	2.7
4	11	Gas mining and LNG	3.7	39	49	Accommodation, hotel services	2.6
5	70	Uranium mining	3.7	40	53	Rail - passenger services	2.6
6	13	Non-ferrous ore mining	3.6	41	23	Printing	2.6
7	69	Other services	3.6	42	55	Water transport services	2.6
8	26	Plastic and rubber products	3.4	43	5	Other agriculture	2.6
9	8	Agricultural services	3.3	44	50	Road - freight services	2.6
10	14	Non-metallic mineral mining	3.3	45	51	Road - passenger services	2.5
11	67	Arts and recreational services	3.3	46	4	Crops	2.5
12	58	Banking services	3.3	47	17	Dairy products	2.5
13	19	Beverages	3.2	48	27	Non-Metallic mineral products	2.5
14	37	Electricity generation - gas	3.2	49	48	Retail trade	2.5
15	21	Wood products	3.1	50	33	Motor vehicles and parts	2.4
16	60	Dwelling ownership services	3.1	51	3	Other animals	2.3
17	64	Education services	3.1	52	28	Cement	2.3
18	66	Residential care services	3.0	53	16	Meat products	2.3
19	22	Paper and pulp	3.0	54	52	Rail - freight services	2.3
20	44	Residential construction	3.0	55	20	Textiles, clothing and footwear	2.2
21	56	Air transport services	3.0	56	2	Dairy cattle	2.2
22	12	Iron ore mining	3.0	57	45	Non-residential construction	2.0
23	25	Basic chemicals	2.9	58	43	Water and drainage supply	1.9
24	18	Other food products	2.9	59	54	Pipeline services	1.8
25	65	Health services	2.9	60	1	Sheep and cattle	1.7
26	59	Finance services	2.9	61	15	Mining services	1.6
27	61	Business services	2.9	62	42	Gas supply	1.1
28	35	Other manufacturing	2.8	63	29	Iron and steel	1.0
29	6	Fishing and hunting	2.8	64	41	Electricity supply	1.0
30	62	Public administration	2.8	65	24	Refined petroleum products	0.5
31	34	Other equipment	2.8	66	38	Electricity generation - Hydro	0.2
32	63	Defence	2.8	67	10	Oil mining	0.0
33	31	Other non-ferrous metals	2.7	68	30	Aluminium	-0.1
34	68	Repairs	2.7	69	9	Coal mining	-1.0
35	32	Metal products	2.7	70	36	Electricity generation - coal	-15.6

Production of *Oil* (industry 10, rank 67) is assumed to stagnate, reflecting estimates of supply availability from current reserves which are imposed on the model. Similar prospects are projected for *Refined petroleum products* (industry 24, rank 65). Based on announcements and plans in place, we assume that capacity in this sector will not change over the projection period, with Australia's petroleum needs increasingly being met from imports.

Prospects for the non-energy mining industries are governed by the model's projections for Australian exports (see Figure 5 for an Australia-wide perspective).

Forecasts for the agricultural sector are, in the main, determined by the prospects of downstream food and beverage industries. These have below-average growth prospects, reflecting fairly weak growth in exports and expected increases in import penetration on local markets.

Most manufacturing industries have weak growth prospects, due mainly to increases in import competition and weak growth in exports. This reflects a long-standing trend away from manufacturing in the Australian economy. The effects of increasing import competition are seen most clearly in the prospects for *Motor vehicles and parts* (industry 33, rank 50) and *Textiles, clothing and footwear* (industry 20, rank 55). Growth prospects for the former are also dampened by plant closures in the first two years of the reference-case, based on announced closures.

Nearly all of the remaining industries have close to average growth prospects. The prospects for building-related industries (industries 28, 43, 44, 45 and 46) reflect the model's projection for growth in real national investment. Over the period, real investment grows at rates that are slightly below that of real GDP.

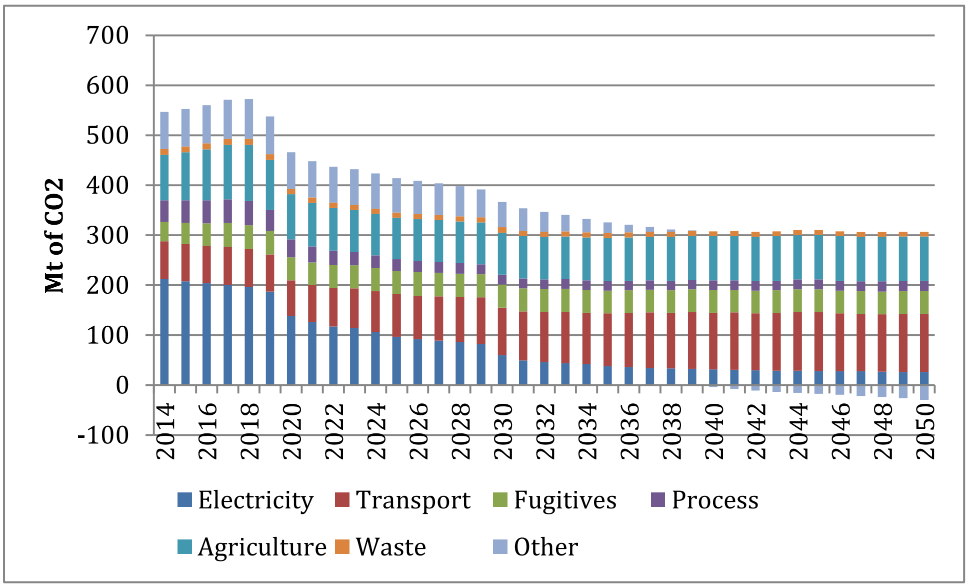
Public administration (industry 62, rank 30) and *Defence* (industry 63, rank 32) are strongly oriented towards public consumption, which is fixed to reference-case levels. *Dwelling services* (industry 60, rank 16) is projected to grow slightly faster than aggregate private consumption, reflecting its expenditure elasticity of 1.2.

4.3.3 GHG EMISSIONS BY SOURCE

Figure 7 is a stacked chart for the level of GHG emissions (Mt CO_2-e) by major source category at the national level. It covers all emissions except for emissions from land clearing, in line with Kyoto-accounting principles.

The total level of emissions is projected to fall at an average annual rate of 1.9 per cent between 2014 and 2050. By 2050, emissions total 278 Mt CO_2-e, which is 49.1 per cent lower than in 2014.

Figure 7: Emissions by Major Source in the Reference case (Mt of CO_2-e)



The largest source of emissions is electricity generation. In 2014, electricity contributed around 39 per cent to total emissions. The Jacobs modeling indicates that electricity generation emissions will decline rapidly. Over the projection period, emissions from generation fall at an average annual rate of around 6 per cent, with much of the overall contraction occurring before 2030. In 2030, electricity's share in total emissions is 16.3 per cent. In 2050 the share has fallen to 9.4 per cent.

The second largest source of emissions is agriculture, with a 2014-share of 16.6 per cent. In the Kyoto-accounting framework, most of Australia's agricultural emissions come from methane emitted by animals. Reference-case growth prospects for these livestock industries are positive, but below that of real GDP. Thus we would expect moderate growth in emissions. However, in the VURM modelling the carbon-price induces technological change that reduces emissions per unit of agricultural output.

Transport contributes 13.9 per cent to total emissions in 2014, and has projected emissions growth of 1.2 per cent per annum. Around 60 per cent of transport emissions are due to private motor vehicle transport, demand for which is projected to grow at an average annual rate of 2.3 per cent. Much of the remaining transport emissions come from *Road freight transport* and *Road passenger transport*, which grow at average annual rates of between 2.5 per cent and 2.6 per cent (Table 2). Emissions grow by less than private vehicle and road freight activity however, because it is assumed that the share of electrical vehicles in the total small-vehicle fleet will expand significantly, while vehicle energy efficiency will also improve.

Of the remaining sources, growth in fugitive emissions is highest because of strong growth in gas mining. Industrial-process emissions are projected to fall, reflecting the uptake of more GHG-efficient technologies as a result of the carbon price.

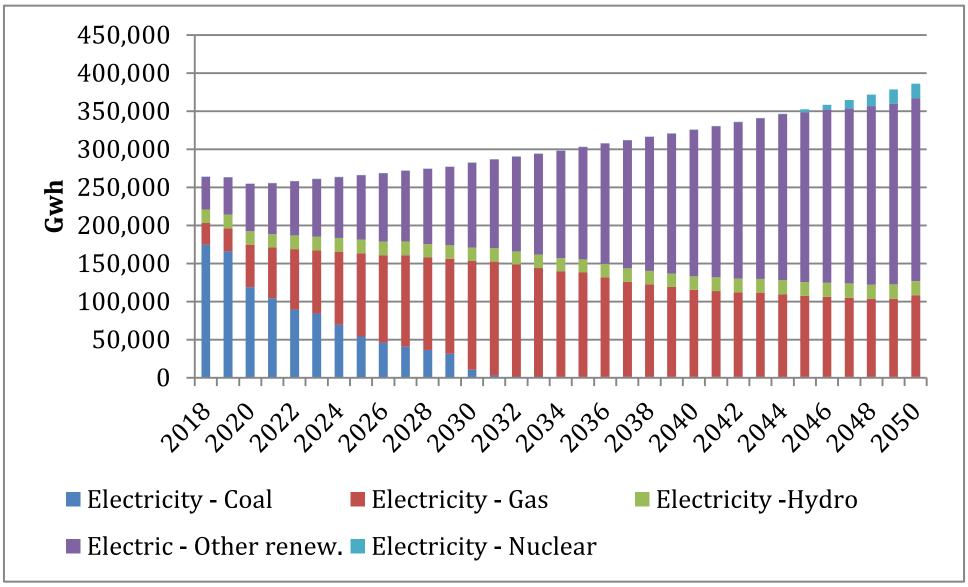
4.3.4 ASPECTS OF ELECTRICITY SUPPLY AND PRICE

Figure 8 summarises the Jacobs projections for electricity supply by technology, which are part of the final VURM reference-case. The figure is a stacked column chart, showing for the national economy levels of generation by VURM generator type (GWh).[11] The chart spans the years 2018 to 2050, which is the period for which Jacobs' projections are available.

Overall electricity demand between 2018 and 2050 grows at an average annual rate of 1.2 per cent. This is seen in Figure 8 as GWh-generation-sent-out rises from 263,866 GWh in 2018 to 385,939 GWh in 2050. Coal generation, dominant in the first year, quickly falls and ceases after 2031. It is replaced by gas and non-hydro renewable generation. The share of hydro generation changes little. At the end of the period, some nuclear generation capacity enters the system.

[11] Remember that Jacobs provides information for the NEM and SWIS systems. Projections for other systems in WA and the NT incorporated into the national data shown in Figure 8 come independently from the VURM model.

Figure 8: Electricity generation in the Reference case (GWh of generation sent out)



Wholesale and retail electricity prices increase in response to the introduction of a carbon price from 2020, as discussed in Jacobs' public modelling report for the CCA.

5 POLICY SIMULATION: CAP-AND-TRADE (TAX CUTS)

5.1 *PREAMBLE*

The second modelling scenario deviates from the reference-case due to a change in how permit revenue is recycled. While revenue from emitting sectors other than electricity is still recycled through lump-sum payments, revenue from the electricity generators is used to cut income tax (personal and company).

Emissions sources outside electricity generation continue to face an exogenous carbon price, with revenue from that carbon price recycled to the representative household as a lump-sum payment. This ensures that changes from reference-case values are driven by policy differences affecting the electricity generation sector only.

The results reported in this section are expressed as deviations between the values of variables in the policy simulation and their values in the reference-case. These deviations arise primarily from the switch away from lump-sum payments to tax cuts for households. These initial differences set in motion a range of second-round effects, including minor differences in electricity generation supply and demand (reconciled within the Jacobs' model) and effects arising from macroeconomic mechanisms at play in the deviation simulations.

In Section 5.2, we calculate the size of the tax cuts imposed in this simulation, and explain the main macroeconomic mechanisms that operate in deviating from the reference-case. Results are given in Section 5.3.

5.2 *SIMULATION DESIGN*

5.2.1 *SIZE OF THE TAX CUTS*

Table 3 provides data that explain the size of the cuts in personal income tax rates underlying this simulation. The table has five columns of numbers.

- Column (1) shows reference-case values ($m) for the value of the carbon tax paid by the electricity generators. These are calculated as the product of electricity emissions and the carbon price. In the reference-case, the value of these permits is given as a lump-sum to the representative household.
- Column (2) shows values for the rate of personal income tax in the reference simulation. The rate of personal tax is calculated as a simple ratio of the tax paid to

an underlying tax base. In this case the base is the income accruing to households from wages and dividends.

- Column (3) shows values for the rate of corporate tax. This is calculated as a simple average of the tax paid to the total cost of capital, including depreciation allowances. Note, that in the reference case the personal and corporate tax rates are held constant.
- Columns (4) and (5) show revised tax rates after the carbon tax revenue from electricity generation has been used to cut the tax rates.

Table 3: Allocation of Carbon Tax Revenue from Electricity Generation: Tax Cuts versus Reference-case Lump Sum

Year	Reference-case value of permits from electricity generation ($m)	Reference-case personal tax rate	Reference-case corporate tax rate	Policy-personal tax rate	Policy-corporate tax rate
	(1)	(2)	(3)	(4)	(5)
2020	9226.3	0.1783	0.1202	0.1706	0.1150
2021	8897.5	0.1783	0.1202	0.1711	0.1154
2022	8676.1	0.1783	0.1202	0.1714	0.1157
2023	8869.5	0.1783	0.1202	0.1714	0.1157
2024	8626.4	0.1783	0.1202	0.1717	0.1160
2025	8292.6	0.1783	0.1202	0.1721	0.1163
2026	8234.7	0.1783	0.1202	0.1723	0.1165
2027	8378.3	0.1783	0.1202	0.1724	0.1166
2028	8483.9	0.1783	0.1202	0.1724	0.1167
2029	8493.2	0.1783	0.1202	0.1726	0.1168
2030	6504.2	0.1783	0.1202	0.1740	0.1176
2031	5601.6	0.1783	0.1202	0.1746	0.1180
2032	5513.6	0.1783	0.1202	0.1748	0.1181
2033	5430.4	0.1783	0.1202	0.1749	0.1182
2034	5395.1	0.1783	0.1202	0.1750	0.1183
2035	5144.9	0.1783	0.1202	0.1752	0.1184
2036	5080.7	0.1783	0.1202	0.1753	0.1185
2037	5079.1	0.1783	0.1202	0.1754	0.1185
2038	5177.8	0.1783	0.1202	0.1754	0.1186
2039	5274.1	0.1783	0.1202	0.1754	0.1186
2040	5357.8	0.1783	0.1202	0.1755	0.1186
2041	5456.3	0.1783	0.1202	0.1755	0.1187
2042	5528.0	0.1783	0.1202	0.1755	0.1187
2043	5633.8	0.1783	0.1202	0.1755	0.1187
2044	5821.0	0.1783	0.1202	0.1755	0.1187
2045	6019.3	0.1783	0.1202	0.1755	0.1188
2046	6177.0	0.1783	0.1202	0.1755	0.1188
2047	6373.6	0.1783	0.1202	0.1755	0.1188
2048	6542.8	0.1783	0.1202	0.1755	0.1188
2049	6761.0	0.1783	0.1202	0.1754	0.1188
2050	7106.1	0.1783	0.1202	0.1754	0.1188

The tax cuts (column 1) are allocated to personal tax and corporate tax in proportion to the 2018-value of each tax: roughly 65 per cent is allocated to cuts in personal tax and 35 per cent to cuts in company tax. Thus, for example, in 2020 the personal tax rate is reduced from 0.1783 in the reference-case to 0.1706. This is a reduction of 4.3 per cent. For corporates, the tax rate falls from 0.1202 to 0.1150, a fall of 4.3 per cent.[12]

Note that in percentage terms the size of the tax cuts diminish over time. In 2050, relative to reference-case values the rate of personal tax has been cut by 1.6 per cent, while the rate of corporate tax has been cut by 1.2 per cent. This reflects the fact that in each case the tax base is growing (at annual rates of around 2 to 3 per cent), while the overall value of the tax cut (column 1) has fallen since 2020.

5.2.2 ASSUMPTIONS FOR THE OPERATION OF THE CAP-AND-TRADE SCHEME AND FOR THE MACRO-ECONOMY

The design of the cap-and-trade scheme in the tax cuts simulation is identical to the design in the reference-case, with the exception of the recycling of revenue from electricity generation. The US-dollar carbon price is identical (see Figure 1b), and while the Australian dollar price can deviate from its reference-case level with deviations in the nominal exchange rate, the model projects virtually no change. Coverage of the scheme is the same in both cases and there is no explicit assistance for emissions-intensive trade-exposed industries, although these industries will benefit from tax cuts.

Australia can import or sell permits freely based on the difference between its mandated and actual emissions in any year. It is assumed that the level of emissions in this scenario is Australia's mandated level. However, in the other scenarios if total emissions fall below the mandated level, then Australia can sell the residual at the going world price. On the other hand, if Australia's emissions rise above the mandated level, then Australia is required to purchase emission permits at the going world price.

[12] The company tax rate show in an effective rate on the total capital base. It differs from the statutory company tax rate due to differences between the taxable and the actual capital base, for example due to depreciation or other deductions.

The following assumptions are made for key aspects of the macro economy in the policy simulation.

Labour markets

In the reference simulation, the national real wage rate is endogenous and moves to reconcile growth in employment demand with exogenously imposed growth in labour supply.

In a policy simulation, the real *after-tax* wage rate is assumed to be sticky in the short-run and flexible in the long-run. Thus, relative to the reference-case, favourable actions generate short-run gains in aggregate employment, and long-run gains in the national real wage rate. This labour market assumption is consistent with conventional macro-economic modelling, in which the national unemployment rate and the size of the labour force (the unemployment-rate denominator) are either fixed or partly dependent on the real *after-tax* wage level.

Note, that if the personal income tax rate changes, then this will have a direct effect on employment in the short-run. With the *after-tax* wage sticky, a cut in tax rate will cause employees to reduce their *pre-tax* wage demands, thus reducing wage pressures on employers. Reduced wage pressure leads to higher employment. A cut in tax rate will also lead to increased employment in the long-run if, as a result of the tax cut, the national participation rate were to rise leading to an increase in labour force.

At the regional level, labour is assumed to be mobile between state economies. Labour is assumed to move between regions so as to maintain inter-state unemployment-rate differentials at their reference-case levels. Accordingly, regions that are relatively favorably affected by a change in the economy will experience increases in their labour forces as well as in employment, at the expense of regions that are less favorably affected.

Private consumption and investment

In the policy simulation, private consumption expenditure is determined *via* a relationship that links nominal consumption to nominal household disposable income (HDI). The major part of HDI is GNI, but it also includes the lump-sum return of emissions permit income, with an allowance for payments of personal income tax.

In the policy simulation, the coefficient of proportionality (called the average propensity to consume (APC)) is an endogenous variable that moves to ensure that the balance on current account in the balance of payments remains at its reference-case level. Thus any change in aggregate investment brought about by the policy change (effectively the income tax cut) is accommodated by a change in domestic saving, leaving Australia's call on foreign savings unchanged.

This treatment of domestic and foreign savings is sufficient, but more extreme than is necessary, to ensure that the long-run deviation in real private consumption from its reference-case level is a valid measure of the impacts of the policy change on the welfare of the representative household. A less extreme treatment would be to impose a foreign-debt constraint directly and allow the year-to-year pattern of aggregate consumption and the current account to reflect year-to-year changes in disposable income.

Investment in the electricity sector is determined based on inputs from the Jacobs modelling (see Section 3). Investment in most other industries is allowed to deviate from its reference-case value in line with deviations in expected rates of return. In the policy scenarios, VURM allows for short-run divergences in rates of return from their reference-case levels. These cause divergences in investment and hence capital stocks that gradually erode the initial divergences in rates of return. Provided there are no further shocks, rates of return revert to their reference-case levels in the long run. The exceptions to this rule are the industries with capacity constraints in the reference-case – oil mining, petroleum products, iron and steel and aluminium. Net investment in these industries remains fixed as in the reference-case.

Government consumption and fiscal balances

VURM contains no theory to explain changes in real public consumption. In the policy simulations, real public consumption is simply held fixed at its reference-case level.

The fiscal balances of each jurisdiction (federal, state and territory) as a share of nominal GDP are fixed at their values in the reference-case. Budget-balance constraints are accommodated by endogenous movements in lump-sum payments to the representative household.

Production technologies and household tastes

VURM contains many variables to allow for shifts in technology and household preferences. In the policy scenarios, most of these variables are exogenous and have the same values as in the reference-case projection. The exceptions are technology variables that are made endogenous to allow for changes in the fuel intensity of electricity generation, based on data from the Jacob electricity modeling (see Section 3.3).

Demography

The national population is held fixed at reference-case levels, but some deviation in the labour force is allowed in response to a change in personal income tax rates. In the policy simulation it is assumed that changes in income tax rates affect participation rates. Specifically, a cut in income tax rate encourages an increase in participation relative to reference-case levels, and hence an increase in labour supply. Since our labour market specification assumes in the long-run a given unemployment rate, any increase in labour force, must lead to an increase in the number of persons unemployed and employed.

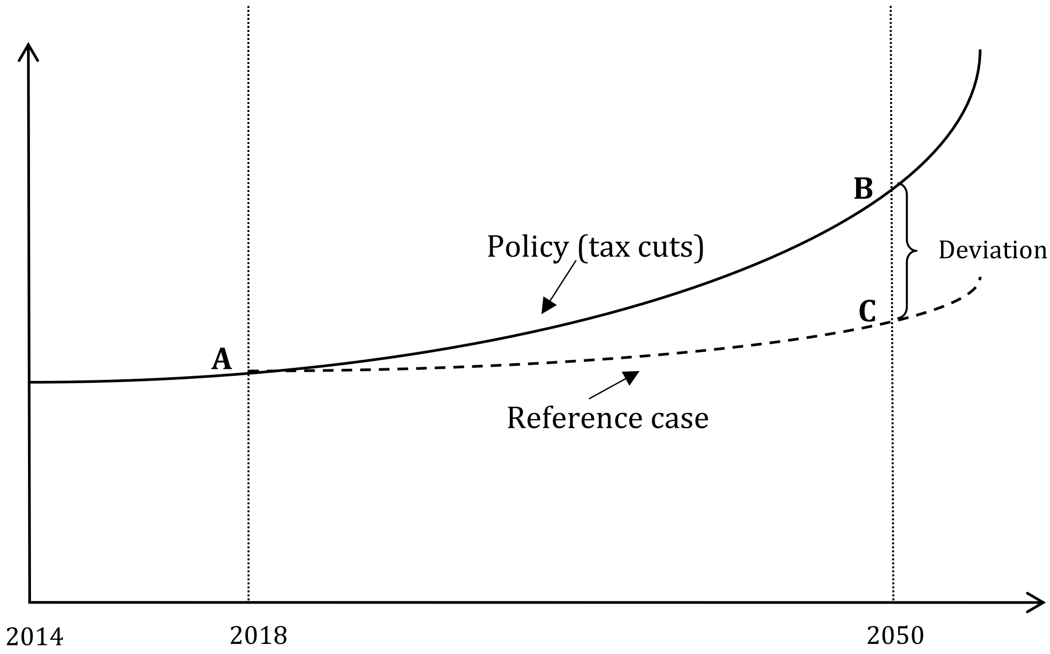
5.3 RESULTS

Figure 9 illustrates the interpretation of VURM results for the effects of a policy shock, such as an income tax cut, on a particular variable, say, real GDP. The reference-case is to be thought of as a projection through time for the variable without the tax cuts. The reference-case is depicted as the path between points A and B. The model is also used to produce an alternative projection in which endogenous variables shift away from reference-case values to accommodate the exogenous shocks associated with the alternative recycling policy for the cap-and-trade scheme. A typical alternative projection for the variable considered is shown as the path between points A and C.

Figure 9 has been drawn with the variable trajectories smooth and with the deviations away from the reference-case path also growing smoothly. In this case, it is apparent that there are a number of options for reporting the effects of the tax cuts, all of which will tell a similar story.

One option is to compare average annual growth in the reference-case with average annual growth in the policy simulation. Alternatively, deviations can be reported by comparing the value of variables in a specific year in the policy simulation, with values in the reference-case. Deviations could be expressed as percentage changes from reference-case values in the final year of the simulation period, or as absolute ($m or Mt, etc.) changes from reference-case values. In the case of smooth trajectories, intermediate-year comparisons will not be seriously misleading, relative to a final-period comparison.

Figure 9: Interpretation of VURM results



More fundamental than this cosmetic point, is the question of how to report results in cases in which (unlike Figure 9) the reference-case path, the alternative policy path or the deviation between the two paths, does not develop smoothly. This will often be the case when incorporating results from the Jacobs modelling. One option is to report a time-profile of the deviations of reference-case values from the alternative-policy values. Another is to use an aggregate measure, which includes all the year-specific deviations. The present value of the deviations is an obvious choice.

In the discussion the follows in this section and in Section 6, we offer fairly general explanations of results. Specific numerical detail in whatever form required can be provided upon request.

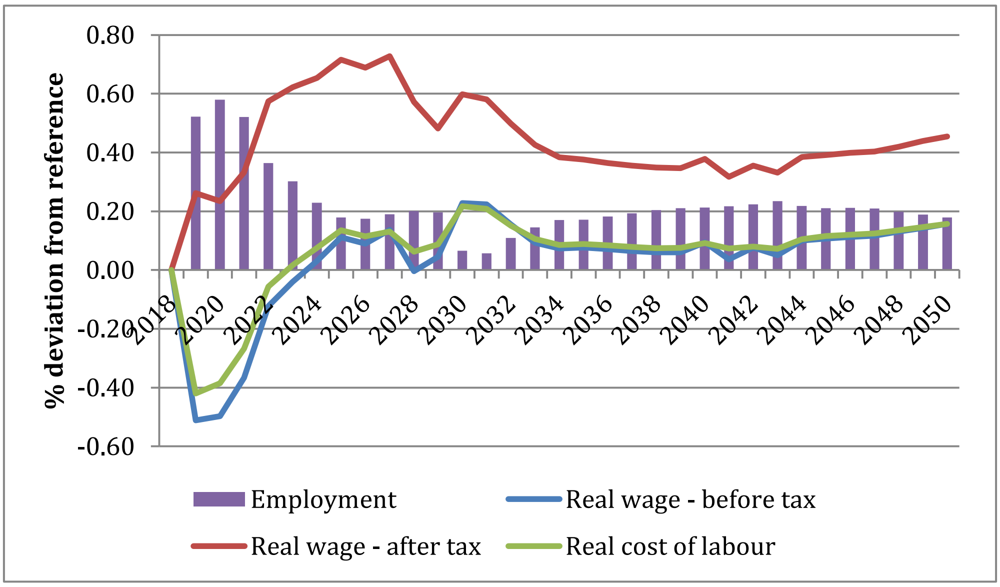
The rest of this section contains a discussion of deviations from reference-case values in the tax-cuts simulations. A series of figures provide time-profiles of the deviations for key variables. In the discussion, italicized headings outline the main features of the results.

5.3.1 MACROECONOMIC VARIABLES

In the short run, the cut in income tax increases employment relative to its reference-case level. Over time, the employment deviation declines, but remains positive as the national real wage rate rises.

The explanation of national macroeconomic effects begins with the impacts on the national labour market. Figure 10 shows percentage deviations in national employment (shown as columns), the national real wage rate (before-tax), the national real wage (after-tax), and the national real cost of labour. The real wage rate (before and after-tax) is defined as the ratio of the nominal wage rate (before and after-tax) to the price of consumption. The real cost of labour is defined as the ratio of the nominal wage rate to the national price of output. The real wage is distinguished from the real cost of labour because the former relates to the income of households, while the latter drives employer decisions regarding labour demand.

Figure 10: Real Wages and Employment with Tax cuts
(% deviations from reference-case values)



According to the labour-market specification in VURM (Section 5.2.2), the real after-tax wage rate is initially sticky (i.e., initially the nominal after-tax wage rate moves with the price of consumption), but over time adjusts with a lag upwards (downwards) in response to a rise (fall) in employment. The tax cuts force a wedge between the before-tax and after-tax real wage rates, as shown in Figure 10. In 2020 the gap between the before-tax wage and the after-tax wage is around 0.7 percentage points. The gap narrows over time in line with the reduction in size of the income tax cuts (see Table 3).

In this simulation, the real cost of labour follows the real before-tax wage rate. In 2020, relative to reference case levels, the real cost of labour has been cut by 0.4 per cent, while the real before-tax wage is down 0.5 per cent. In 2020, therefore, the tax cut has reduced the real cost of labour, inducing employers to expand employment. In 2020, relative to reference case levels, employment is up 0.6 per cent. This employment stimulus causes the after-tax real wage to eventually rise in 2020 by just over 0.2 per cent relative to its reference-case level.

If there were no further shocks, then over time the real after-tax wage rate would progressively increase relative to reference-case levels, increasing the real cost of labour and forcing the employment deviation back to zero. In this simulation, however, the cut to taxes leads to a permanent increase in employment through its positive impact on the labour supply.[13] Hence as shown in Figure 10, employment and real wage rates (before and after tax) all stabilize at levels above their reference-case values. In 2050, the employment deviation is nearly 0.2 per cent.

Note that the deviations in employment and the real wage rate are not smooth over time, especially in the early years, reflecting in the main year-to-year changes in electricity investments driven by the Jacobs' modelling.

Also note that even though the increase in national employment is small, this does not mean that employment at the individual industry or regional level remains close to reference-case values. In some industries and regions, there may be more significant permanent employment responses, compounding or defusing existing (reference-case) pressures for structural change.

The tax cuts expand capital and over time reduces the economy's labour-to-capital ratio.

Figure 11 shows information similar to that shown in Figure 10, but for the other main factor of production, capital. Percentage deviations in the national capital stock are shown as columns. Also plotted are deviations in the national rate of return on capital (ROR) before-tax, the ROR after-tax, and the national real cost of capital. Rates of return (before and after-tax) are defined as the ratio of the nominal cost of capital (before and after-tax) to the price of investment net of depreciation. The real cost of capital is defined as the ratio of the nominal cost of capital to the national price of output. The ROR drives decisions about capital supply (investment), while the real cost of capital drives industry decisions about capital required.

In the first two years, the tax cuts cause the real cost of labour to fall relative to reference case levels (Figure 10). This allows the real cost of capital to rise (Figure

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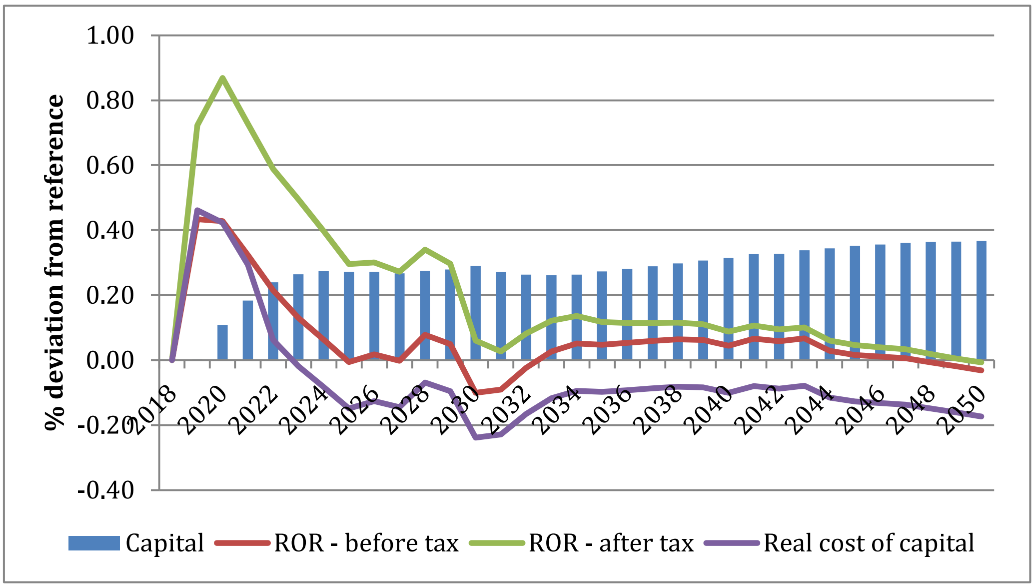
[13] Recall from the discussion under the heading of *labour market* in Section 5.2.2 that a cut in tax rate will also lead to increased employment in the long-run if, as a result of the tax cut, the national participation rate were to rise leading to an increase in labour force. In the VURM modelling, the economy will always gravitate towards an unchanging long-run rate of unemployment. Thus a larger labour force in the long run means a larger number of people employed and unemployed.

11).[14] Because capital has risen in price relative to labour, employers replace capital with labour, thereby increasing the economy's labour-to-capital ratio. In 2020, relative to reference case levels, employment is up 0.58 per cent and capital is up 0.11 per cent.

Figure 11: Real Rates of Return and Capital with tax cuts (% deviations from reference-case values)



Capital responds slowly to the tax cuts because of investment-gestation lags. Thus, as shown in Figure 11, in 2020 the increase in capital is relatively small. In that year, relative to reference-case levels, both the real cost of capital and the before-tax ROR are up nearly 0.45 per cent. Because of the tax-cut, the after-tax ROR has risen by 0.72 per cent.

The increase in the after-tax return encourages investment, and capital starts to expand. At the same time, the initial increase in real cost of capital is reversed as the real cost of labour rebounds, and the economy-wide labour-to-capital ratio falls. By 2050 the capital-stock deviation is almost 0.4 per cent while the employment deviation is around

[14] To a good approximation, at the national level the price of production (or the price of GDP at factor cost) is a geometric average of the prices of capital and labour. Thus an increase in the real cost of labour (the ratio of the price of labour to the price of production) implies a decrease in the real cost of capital (the ratio of the price of capital to the price of production).

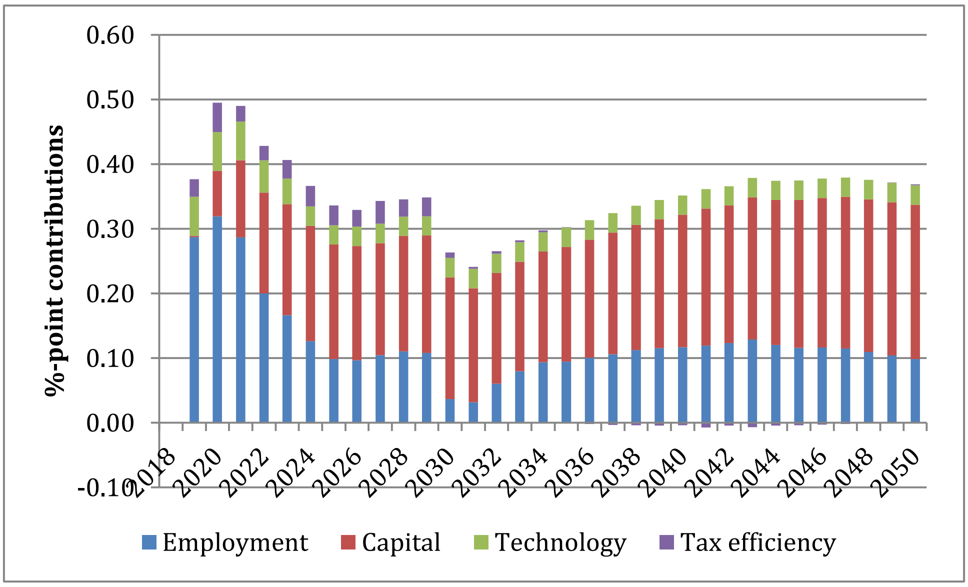
0.2 per cent. Thus, relative to reference-case levels, the employment of both factors is up and the ratio of labour to capital has fallen by 0.2 (= 0.4 – 0.2) per cent.

Increased capital and increased employment generates increased real GDP.

The percentage change in real GDP is a share-weighted average of the percentage changes in quantities of factor inputs (labour, capital and land), with allowance for technological and efficiency changes. Figure 12 shows, in stacked annual columns, the contribution of each component other than land to the overall percentage deviation in real GDP. In this simulations, although land can be re-allocated between uses, its availability overall is fixed.

Real GDP increases relative to its reference-case level in all years of the simulation. In the final year it is up 0.37 per cent.

Figure 12: Contributions to Changes in real GDP with Tax cuts (contributions to percentage deviation in real GDP)

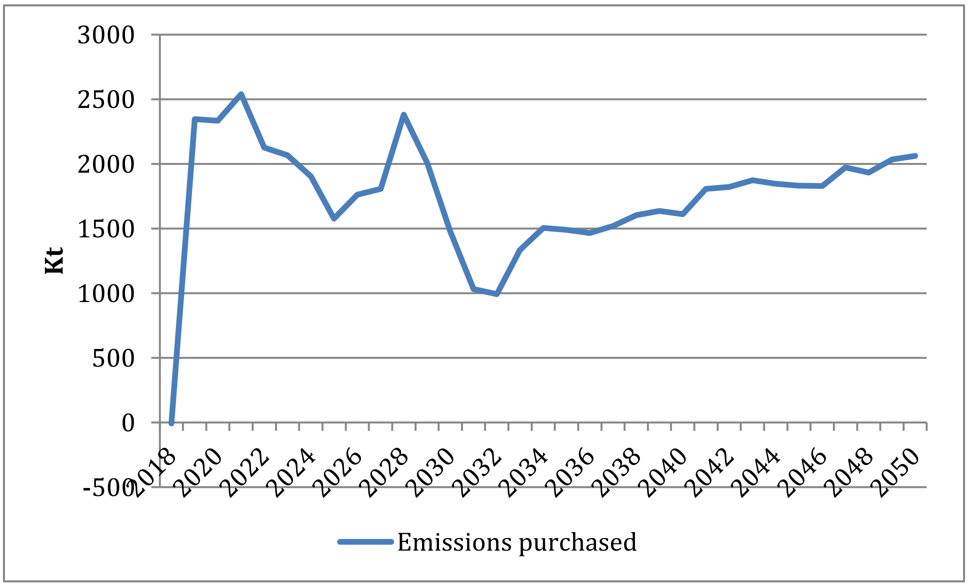


As Figure 12 shows, in the final year of the simulation increased employment contributes 0.10 percentage point to the real GDP deviation and increased capital contributes 0.24 percentage points. This leaves 0.03 percentage points to be explained by other factors. These other factors are changes in technological progress, and changes in real indirect tax bases (called here "tax efficiency" effects).[15]

The tax cuts have little impact on total emissions, and hence on Australia's need to buy or sell emission permits.

Figure 13 plots changes (Kt of CO_2-e) away from reference case levels in Australia's total GHG emissions. The tax cuts have relatively little impacts on overall GHG emissions relative to the reference case. In 2050 emissions in the policy simulation are 2.1 Mt above their reference-case level, driven mainly by an increase in size of the economy. Thus in that year 2.1 Mt of permits must be purchased from overseas. This is worth $550 million, at a price of $270 per tonne.

Figure 13: Total emissions with Tax cuts (Kt changes away from reference case values)

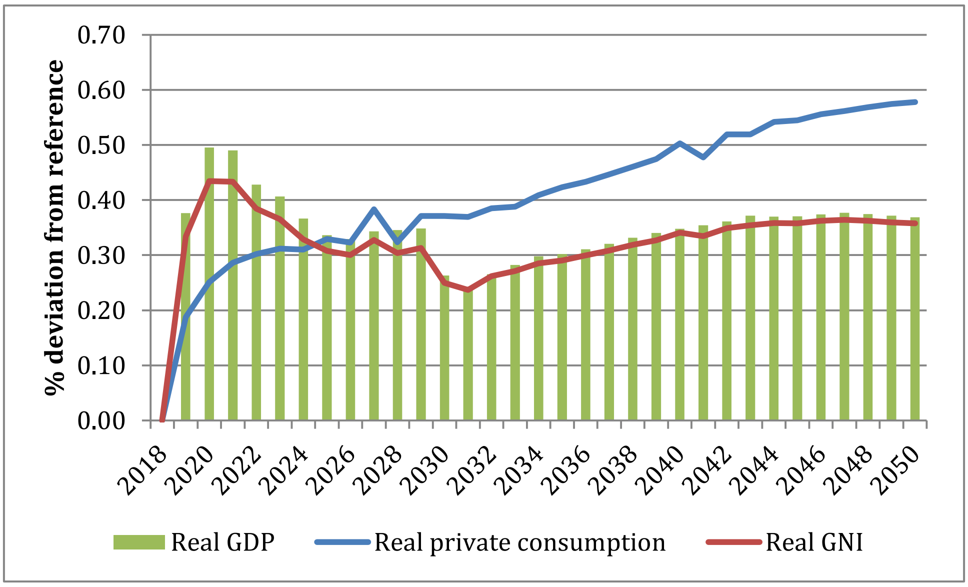


[15] GDP is the sum of the cost of primary factors plus indirect taxes. *Real* GDP changes with changes in the quantity of factor inputs adjusted for changes in factor productivity (or changes in technological productivity), and changes in the underlying quantities of indirect-taxed flows (or changes in real indirect tax bases).

The tax-cuts are welfare enhancing, as indicated by the positive impacts on real GNI and real private consumption.

Figure 14 shows percentage deviations from reference-case values for real private consumption, real GNI and real GDP (columns). In 2050, real private consumption is up 0.58 per cent relative to its reference-case level, while real GNI is up 0.36 per cent.

Figure 14: Real Private Consumption, Real GNI and Real GDP with Tax cuts (% deviations from reference-case values)



The percentage deviations in real GNI are generally in line with those for real GDP, although in the early years the increases in the former are generally less than the increases in the latter. To understand why, it is necessary to understand the relationship between the two measures. GDP is a measure of production. GNI is a measure of income. In nominal terms they differ by the amount of net foreign income entering Australia. In this simulation, net foreign income falls slightly due to the purchase of emission permits (Figure 13). This is one reason why the tax cuts increase real GDP relative to real GNI in the early years.

The other reason is that the tax cuts lower the economy's terms of trade (see Figure 16 below). Real GDP is nominal GDP, deflated by the price of GDP. Real GNI is nominal GNI, deflated by the price of GNE.[16] An improvement (deterioration) in the terms of trade will increase (decrease) the price of GDP, which includes the price of exports but not the price of imports, relative to the price of GNE, which includes the price of imports but not the price of exports. With a lower terms of trade, the price of GDP falls slightly relative to the price of GNE, and thus depresses real GNI relative to real GDP.

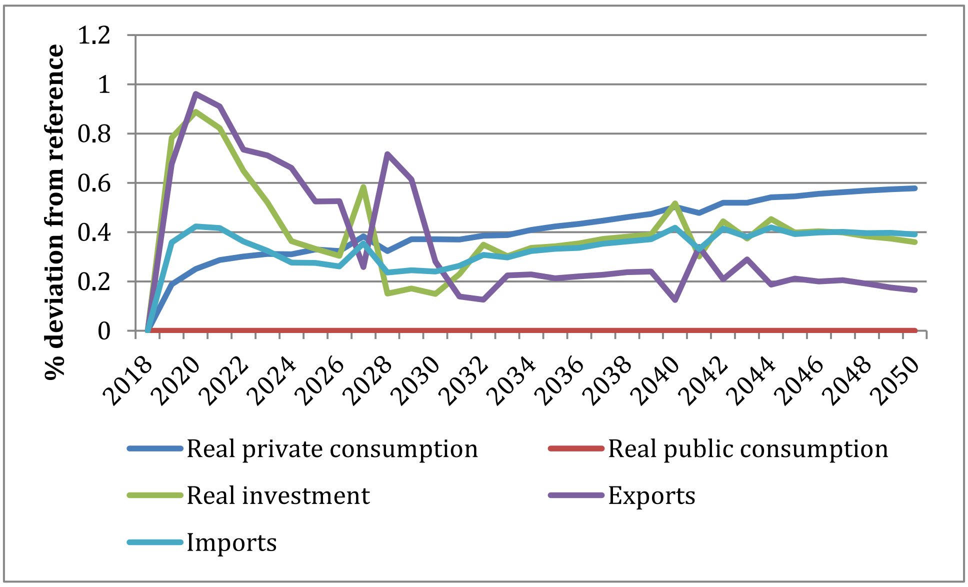
A final point to note from Figure 14 is that after 2024 real private consumption progressively rises relative to real GNI. The steadily increasing gap is due, in part, to increases in the Average Propensity to Consume (APC). At the end of the period, the APC is 0.12 per cent above its reference case level. As discussed in Section 5.2.2, the APC responds endogenously to ensure that the economy's balance on current account is unaffected by the tax cuts. All else unchanged, a higher APC means a lower private savings rate. The private savings rate can fall, because the government savings rate rises due to the assumption of unchanged government consumption.

During the first ten years, real gross national expenditure falls relative to real GDP resulting in an improvement in the net volume of trade. Thereafter, the situation is reversed.

Figure 15 shows percentage deviations from reference-case values for real private consumption (C), real public consumption (G), real investment (I), real exports (X) and real imports (M). Deviations in C have already been discussed. Deviations in G are set to zero (see Subsection 5.2.2). Deviations in I reflect the increases in gross investment necessary to accommodate the increases in capital shown in Figure 11.

[16] As noted earlier, Gross National Expenditure (GNE) is the sum of private consumption, public consumption and investment. Thus the price of GNE is a weighted average of the prices of the three items of final domestic demand. The price of GDP is a weighted average of the price of GNE and of the price of exports relative to the price of imports (i.e., the terms of trade).

Figure 15: Expenditure-side Components of Real GDP with Tax cuts (% deviations from reference-case values)



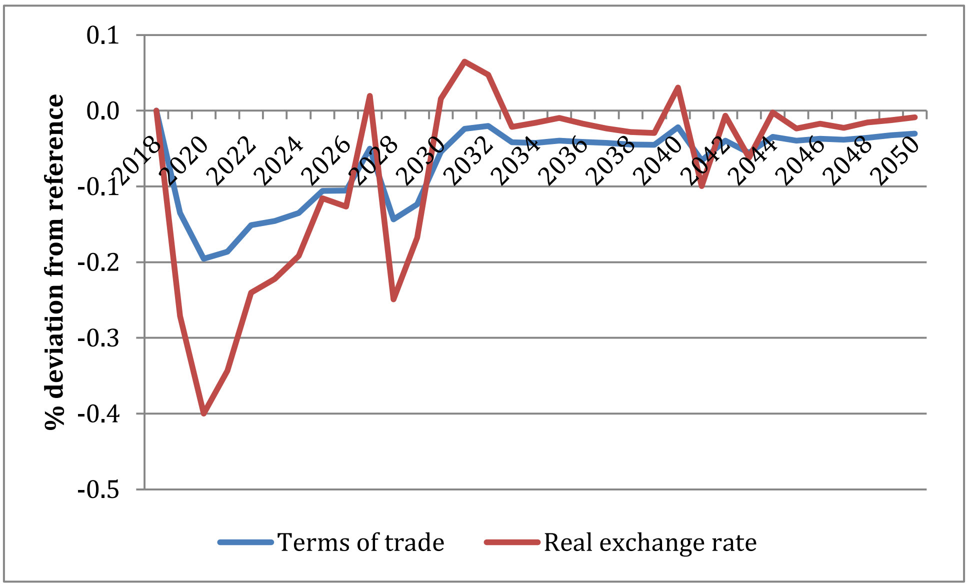
On balance, through to around 2030 real GNE (C+I+G) rises by a little less than real GDP (Y), implying an improvement in the net volume of trade (X-M). After 2030, the reverse is true with real GNE rising relative to real GDP, resulting in deterioration in the net volume of trade. In 2050, the volume of exports is 0.16 per cent above its reference-case level, and the volume of imports is up 0.39 per cent.

Increased Australian exports lowers their price on world markets, resulting in a slight contraction to the terms-of-trade.

Figure 16 shows percentage changes relative to reference-case values in the economy's terms of trade and real exchange rate.

The terms of trade is the ratio of the average foreign-currency export price to the average foreign-currency import price. An improvement in the terms of trade, all else unchanged, increases the real purchasing power of income relative to real GDP. In these simulations the foreign-currency price of imports is exogenous and fixed to reference-case levels. The positions of export demand schedules are fixed, but because they are downward sloping any change in Australian supply conditions will affect prices and hence the terms of trade.

Figure 16: The Terms of Trade and Real Exchange Rate with Tax cuts (% deviations from reference-case values)



To achieve the necessary improvement in net volume of trade during the first part of the period, real devaluation of the exchange rate is required. In 2020, the real exchange rate has dropped 0.4 per cent relative to its reference case level. Real devaluation improves the competitiveness of export industries on foreign markets and the competitiveness of import-competing industries on local markets. With real devaluation comes deterioration in the terms of trade. A weaker currency shifts Australian producers down world demand curves. Volumes are up, but prices are down.

After 2030, changes in the terms of trade and real exchange rate are much smaller than in the first ten years of the simulation. Over the longer term, the economy's net volume of trade deteriorates (see Figure 15), but much of this is brought about by increases in imports arising from generally higher demand associated with a larger economy.

5.3.2 NATIONAL INDUSTRY PRODUCTION

Production in all industries increases relative to reference-case levels throughout most of the period.

Table 4 gives percentage deviations in production from reference-case levels for industries nationally in 2020, 2030 and 2050.[17] The projections paint a fairly bland overall picture of increases relative to reference-case levels, which are broadly in line with the projected change in real GDP.

Table 4: National Industry Output with Tax cuts
(% deviations from reference-case values, 2020, 2030 and 2050)

	Industry	2020	2030	2050		Industry	2020	2030	2050
1	Sheep and cattle	0.6	0.2	0.3	36	Electricity generation - coal	0.0	0.0	0.0
2	Dairy cattle	0.6	0.2	0.3	37	Electricity generation - gas	0.8	5.2	0.2
3	Other animals	0.4	0.3	0.3	38	Electricity generation - Hydro	0.0	0.0	0.0
4	Crops	0.5	0.2	0.2	39	Electric gen. - Other renew.	0.2	-2.6	0.2
5	Other agriculture	0.4	0.3	0.3	40	Electric. generation - Nuclear	0.2	0.1	0.1
6	Fishing and hunting	0.8	0.2	0.2	41	Electricity supply	0.4	0.1	0.2
7	Forestry	0.7	0.1	0.1	42	Gas supply	0.3	0.3	0.2
8	Agricultural services	0.7	0.2	0.2	43	Water and drainage supply	0.4	0.2	0.3
9	Coal mining	0.4	0.4	0.3	44	Residential construction	0.8	0.5	0.7
10	Oil mining	0.2	0.1	0.1	45	Non-residential construction	0.8	0.0	0.2
11	Gas mining and LNG	0.9	0.2	0.2	46	Construction services	0.7	0.2	0.4
12	Iron ore mining	0.2	0.5	0.4	47	Wholesale trade	0.6	0.3	0.4
13	Non-ferrous ore mining	0.4	0.6	0.4	48	Retail trade	0.4	0.3	0.4
14	Non-metallic mineral mining	0.8	0.3	0.3	49	Accommodation, hotel services	0.6	0.4	0.5
15	Mining services	0.5	0.4	0.4	50	Road - freight services	0.6	0.2	0.3
16	Meat products	0.6	0.2	0.3	51	Road - passenger services	0.5	0.2	0.2
17	Dairy products	0.5	0.2	0.3	52	Rail - freight services	0.4	0.4	0.4
18	Other food products	0.7	0.2	0.3	53	Rail - passenger services	0.6	0.2	0.2
19	Beverages	0.6	0.4	0.3	54	Pipeline services	0.4	0.4	0.3
20	Textiles, clothing and footwear	0.8	0.3	0.3	55	Water transport services	0.6	0.2	0.2
21	Wood products	0.9	0.2	0.3	56	Air transport services	0.7	0.2	0.2
22	Paper and pulp	0.7	0.3	0.3	57	Communication services	0.4	0.2	0.3
23	Printing	0.5	0.2	0.3	58	Banking services	0.5	0.4	0.5
24	Refined petroleum products	0.3	0.1	0.1	59	Finance services	0.5	0.3	0.4
25	Basic chemicals	0.8	0.3	0.3	60	Dwelling ownership services	0.2	0.5	0.7
26	Plastic and rubber products	0.8	0.2	0.3	61	Business services	0.7	0.2	0.3
27	Non-Metallic mineral products	0.8	0.2	0.4	62	Public administration	0.1	0.0	0.1
28	Cement	0.7	0.2	0.4	63	Defence	0.0	0.0	0.0
29	Iron and steel	0.8	0.1	0.1	64	Education services	0.6	0.0	0.1
30	Aluminium	0.3	0.1	0.1	65	Health services	0.2	0.1	0.2
31	Other non-ferrous metals	0.6	0.4	0.2	66	Residential care services	0.2	0.1	0.2
32	Metal products	0.9	0.2	0.3	67	Arts and recreational services	0.4	0.3	0.5
33	Motor vehicles and parts	0.8	0.3	0.3	68	Repairs	0.5	0.2	0.3
34	Other equipment	0.9	0.2	0.2	69	Other services	0.5	0.4	0.6
35	Other manufacturing	0.9	0.2	0.3	70	Uranium mining	0.4	0.6	0.3

[17] The table reports numbers for production, rather than real value added (the measure preferred by the Australian Bureau of **Statistics).** In the modelling, at the regional level, for each industry real value added and production move together. However, at the national level, percentage changes can differ because value added weights for adding across regions can differ from production weights.

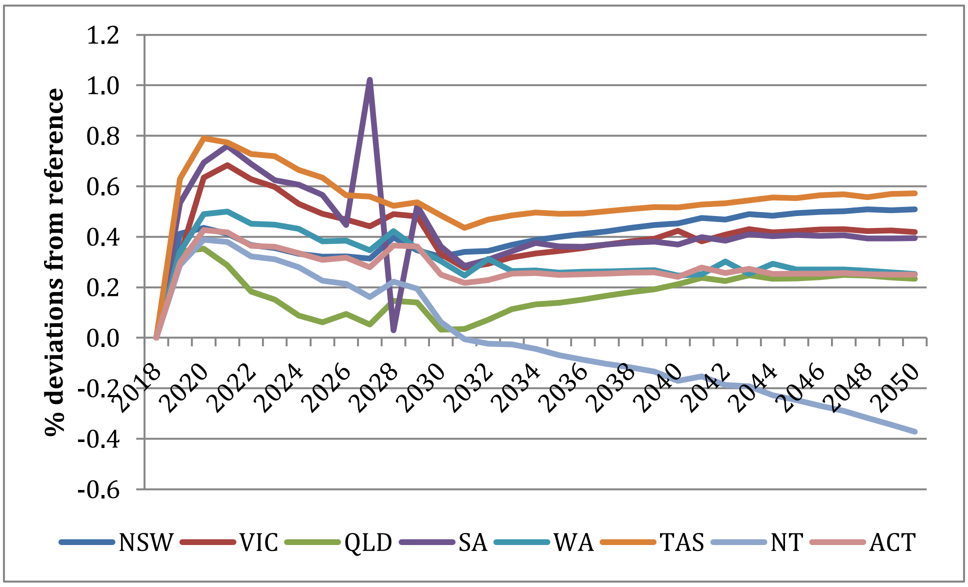
The only exceptions are the electricity generation industries directly affected by Jacobs' projections. According to VURM, the tax cuts will lead to an expansion in the economy, and hence an increase in the need for electricity. This is seen in Table 4 by the projections for production of the *Electricity supply* industry (industry 41). In 2020, national production of Electricity supply has increased 0.4 per cent relative to its reference-case level. In 2030 and 2050 the increases are 0.1 per cent and 0.2 per cent. The additional use of electricity is mainly met from increased gas generation.

5.3.3 REAL GROSS STATE PRODUCT

Real GSP rises relative to reference-case levels in all states/territories, except NT.

Figure 17 shows projected percentage deviations from reference-case levels for real GSP. To a large extent, the pattern of impacts on real GSP reflects the national industry effects of the tax cuts (see Table 4). Just as some industries experience output gains relative to reference-case levels greater than other industries, so some regions experience output gains greater than others. Differences between regions are explained in most cases by differences in regional industrial compositions.

Figure 17 Real GSP with Tax cuts
(% deviations from reference-case values)



As a result of the tax cuts, the Northern Territory loses share in national GDP. The NT has a fairly narrow and less resilient economy, with a small manufacturing base, a mining sector based around LNG, uranium and bauxite production, and a services sector relatively dependent on government rather than private consumption. The tax cuts stimulate private consumption and, by assumption, have no effect on public consumption (see Figure 15). This bias is enough to cause real GSP in the NT to fall relative to the average.

At the other end of the scale is Tasmania, which is favoured most by the tax cuts. Like the NT, Tasmania has a relatively small and narrow manufacturing base, and is over-represented in service sectors. Unlike the NT, however, the main source of demand for service industries is private and foreign consumption (the latter being primarily due to foreign tourism). The shift towards private consumption and away from public consumption, coupled with minor real devaluation of the currency (see Figure 16), is enough to elevate Tasmania's GDP share.

The remaining regions are projected to experience gains in real GSP broadly in line with the national average over the longer term. In the short-term, Queensland's GSP share falls before recovering. The short-term fall results from a reduction in LNG exports (relative to reference-case levels), due to increased domestic gas demand for electricity across the eastern states. The relatively sharp rise and subsequent fall in South Australia's GSP between 2027 and 2029 is because the detailed electricity modelling brings forward by one year a large amount of renewable-generation investment in SA in the reference-case.

6 POLICY SIMULATION: EMISSIONS INTENSITY

6.1 PREAMBLE

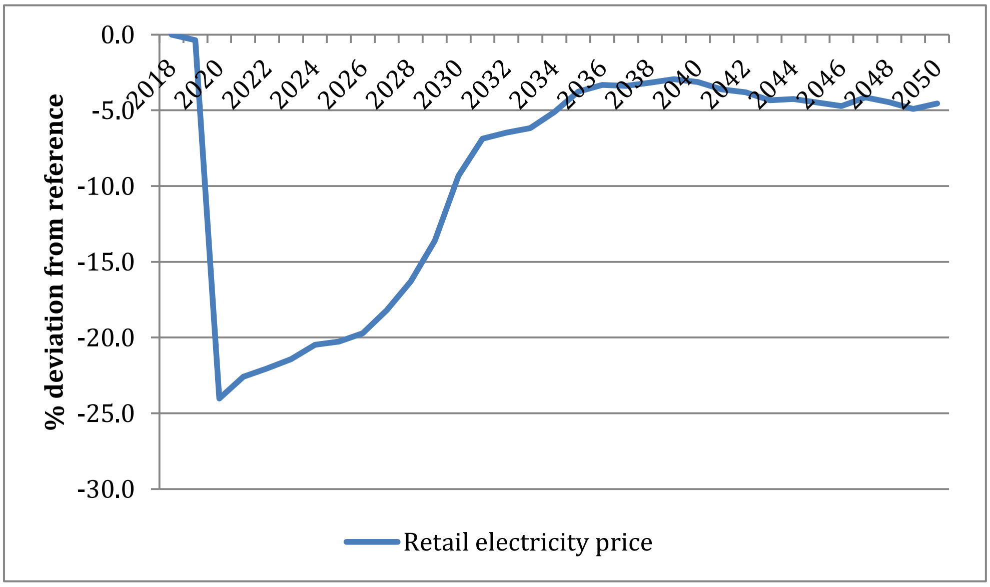
In this second of two policy scenarios, an Emissions Intensity (EI) scheme is implemented, in which all emitters face an exogenous carbon price, but electricity generators receive free allocations of emissions permits. These allocations are the product of a pre-determined emissions intensity target and each generator's output. In this scenario, all permit revenue is recycled through lump-sum payments (as in the reference-case). However, the amount of recycled revenue is lower than in the reference-case, due to the free allocation of permits to generators.

6.2 SIMULATION DESIGN

6.2.1 KEY INPUTS

In this scenario, one of the key drivers of deviations away from reference-case values is the Jacobs-model determination for the price of electricity. Figure 18 shows the final deviations (from reference-case values) in the NEM retail electricity price, based on a 'blended' series for retail prices using a weighted average of changes in retail prices for all customer-types and regions from the Jacobs' model. Retail prices trends in Western Australia are broadly similar.

Figure 18: NEM Retail Electricity Price with the EI scheme (% deviations from reference-case values)



By 2024, the NEM weighted average retail electricity price is around 20 per cent lower than in the reference-case. These deviations narrow over time; in 2050, the average NEM retail price is down around 5 per cent.

The other key driver of change away from the reference-case scenario is the value of the EI subsidy, shown in Table 5. The subsidy represents a reduction in generator cost relative to reference-case levels. This is the driver of the price reductions shown in Figure 18. It also represents a loss of income to the representative household, relative to reference-case values, although some of the value returns to households indirectly through lower electricity prices.

Table 5: Value of the EI Subsidy ($m values (2014 prices))

Year	Subsidy value ($m)	Year	Subsidy value ($m)
2018	0	2035	2,954
2019	0	2036	3,133
2020	12,873	2037	3,329
2021	12,523	2038	3,525
2022	12,138	2039	3,735
2023	11,635	2040	3,967
2024	11,066	2041	4,213
2025	10,385	2042	4,473
2026	9,596	2043	4,758
2027	8,694	2044	5,042
2028	7,631	2045	5,383
2029	6,370	2046	5,720
2030	5,066	2047	6,076
2031	3,507	2048	6,469
2032	2,481	2049	6,912
2033	2,630	2050	7,373
2034	2,781		

6.2.2 OTHER ASSUMPTIONS

Assumptions for the cap-and-trade scheme with the EI subsidy in place, and for general macroeconomic behaviour relating to deviations from the reference-case due to the subsidy, are the same as for the Tax cuts policy simulation (see Section 5.2.2). There is no explicit assistance for emissions-intensive trade-exposed industry, but the lower electricity prices under this scenario do have the effect of assisting these (and other) industries.

6.3 RESULTS

6.3.1 MACROECONOMIC VARIABLES

The EI subsidy lowers the general cost of production. In the short-run this lifts employment relative to reference-case values, but the initial increase is quickly eliminated through real wage adjustment.

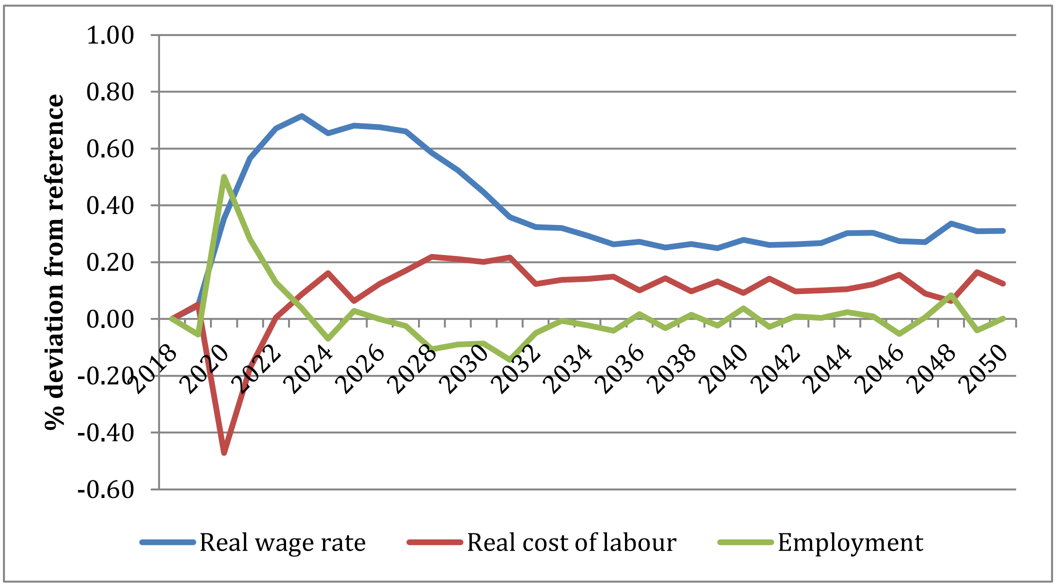
As for the first policy simulation in Section 5.3, the explanation of national macroeconomic effects begins with the impacts on the national labour market. Figure 19 shows percentage deviations in national employment (columns), the national real wage rate, and the national real cost of labour. We do not show separately before-tax and after-tax real wage rates, since with no change in income tax rates deviations in the two are identical.

As shown in Figure 19, in 2020 the EI subsidy has a positive impact on employment, because it lowers the real cost labour. In that year, relative to reference-case levels, employment is up 0.50 per cent, while the real cost of labour is down 0.47 per cent.

The real cost of labour falls when the EI subsidy is introduced because the subsidy reverses (to some extent) the effects of the carbon price on the electricity sector. Thus the subsidy cuts the price of electricity (Figure 18), and therefore lowers costs of production throughout the economy (relative to reference case values). With the price of labour initially tied to the price of consumption (the real wage rate is sticky), lower costs mean increased profit. Increased profit with little change in the wage rate, means that the real cost of labour falls.[18]

[18] This is a rather subtle, but important mechanism at play in this simulation. Recall that the real cost of labour is the price of labour relative to the general price of production. For the economy as a whole, the general price of production is a weighted average of the prices of primary factors – labour, capital and land. If we ignore land, then the general price of production is a weighted average of the economy-wide wage rate and the economy-wide cost of capital (or unit profit). If profits are up, but wages are unchanged, then the real cost of capital rises and the real cost of labour falls.

Figure 19: Real Wages and Employment with the EI scheme (% deviations from reference-case values)

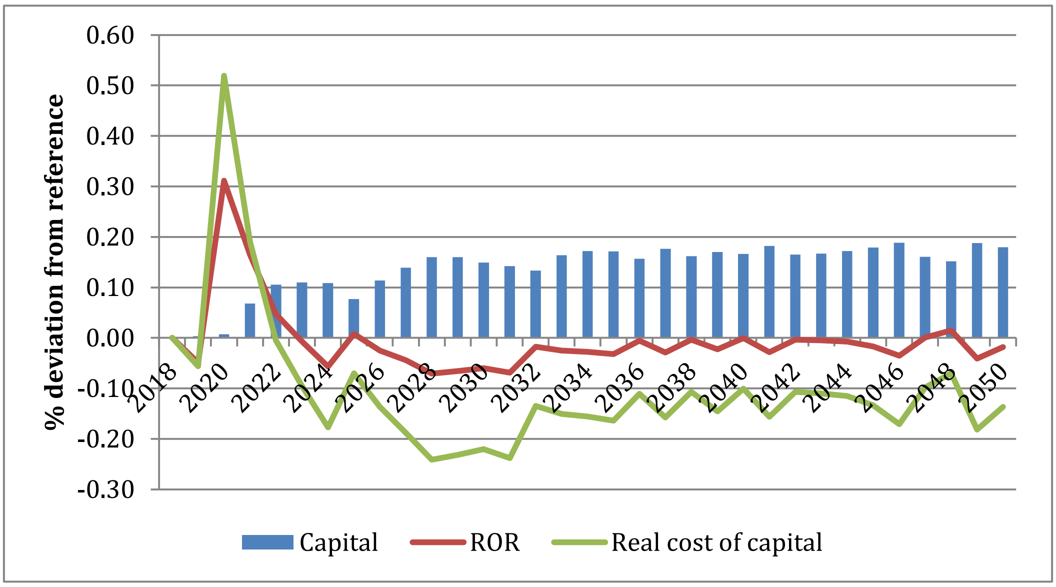


Over time, VURM allows the real wage rate to adjust upwards in response to the initial increase in employment. The deviations with respect to reference-case levels then stabilise at around 0.3 per cent and employment broadly returns to its reference-case value. Some small year-to-year movements occur, primarily reflecting changes in investment timing in the electricity sector arising within the Jacobs model. In 2050, relative to reference-case levels, the real wage rate is up 0.32 per cent and the real cost of labour is up 0.16 per cent.

The EI subsidy leads to increased capital in the long-run, and thereby lowers the economy-wide labour/capital ratio.

Figure 20 shows percentage deviations in the national capital stock (columns), the national rate of return on capital (ROR) and the real cost of capital. In 2050, the capital stock deviation is almost 0.2 per cent, implying a decrease in the ratio of labour-to-capital of around 0.2 per cent.

Figure 20: Capital, Rate of Return and the real cost of Capital with the EI subsidy (% deviations from reference-case values)

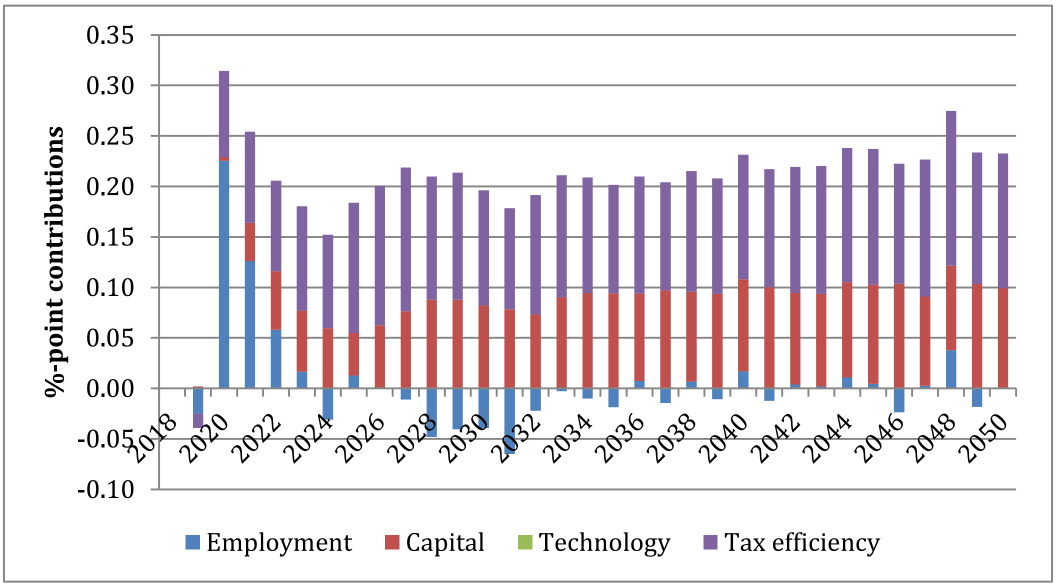


The EI subsidy expands capital because of changes in relative factor prices. As the real cost of labour rises (see Figure 19), the real cost of capital falls (Figure 20). Because capital becomes slightly cheaper, producers replace labour with capital. With employment returning to its reference case path, so capital must rise above its reference case path.

Increased capital and employment leads to increased real GDP. Another positive for real GDP is the effective reduction in the carbon-tax base from whole-of-economy in the reference case, to non-electricity sectors in the policy simulation.

The percentage change in real GDP is a share-weighted average of the percentage changes in quantities of factor inputs (labour, capital and land), with allowance for technological and efficiency changes. Figure 21 shows, in stacked columns, the contribution of each component other than land to the overall percentage deviation in real GDP on an annual basis. Real GDP increases relative to its reference-case level in all years of the simulation. In the final year it is up 0.23 per cent.

Figure 21: Contributions to changes in real GDP with the EI subsidy (contributions to percentage deviation in real GDP)



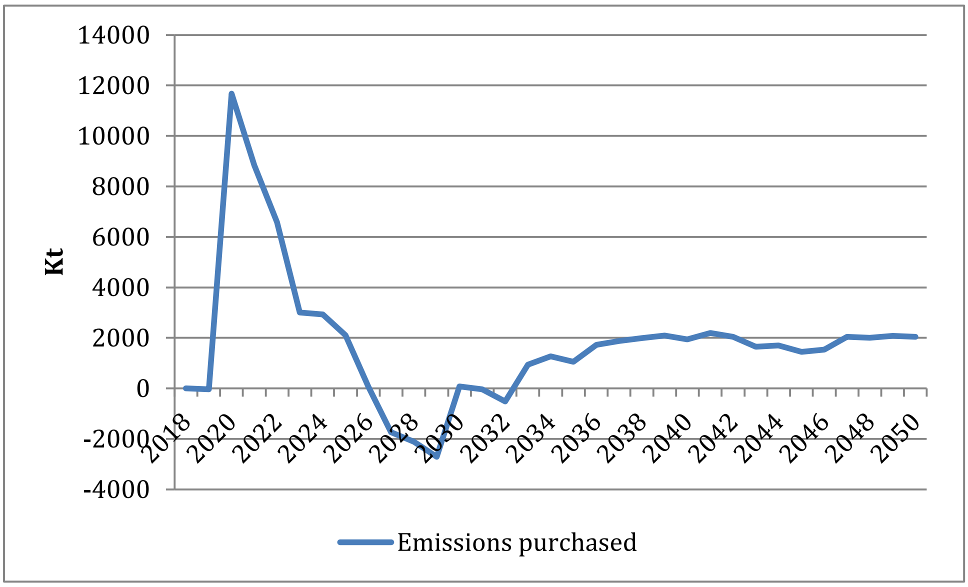
As Figure 21 shows, in the final year of the simulation employment contributes a negligible amount to the real GDP deviation. Increased capital contributes 0.10 percentage points. The remainder of the derivation (0.13 percentage points) is explained by *tax efficiency* effects.

To understand the tax-efficiency contribution, recall that the EI is a subsidy that effectively offsets the revenue raising effects of the carbon tax in electricity generation. Relative to the reference case, with the EI subsidy in place the base of the carbon tax has been effectively reduced from whole-of-economy to basically the non-electricity economy. Thus in the EI subsidy-simulation the real indirect tax base has been reduced, resulting in the relatively large *tax efficiency* effects relative to the reference-case shown in Figure 21.

The EI causes little change in overall emission levels relative to reference case values

Figure 22 plots changes in total GHG emissions in the EI subsidy simulation relative to the reference-case. In 2050 emissions in the policy simulation are around 2.0 Mt above their reference-case level.

Figure 22: Total emissions with the EI subsidy
(kt CO_2-e changes away from reference case values)



At the start of the period, however, the economy's purchases of permits is much larger. In 2020, around 11.7 Mt more permits must be purchased than in the reference-case. This is equivalent to around 2 per cent of Australia's current emissions and valued at around $700 million at a price of around $70 per tonne. The increase in emissions in 2020 reflects general activity effects and Jacobs' projections of higher emissions from electricity generation.

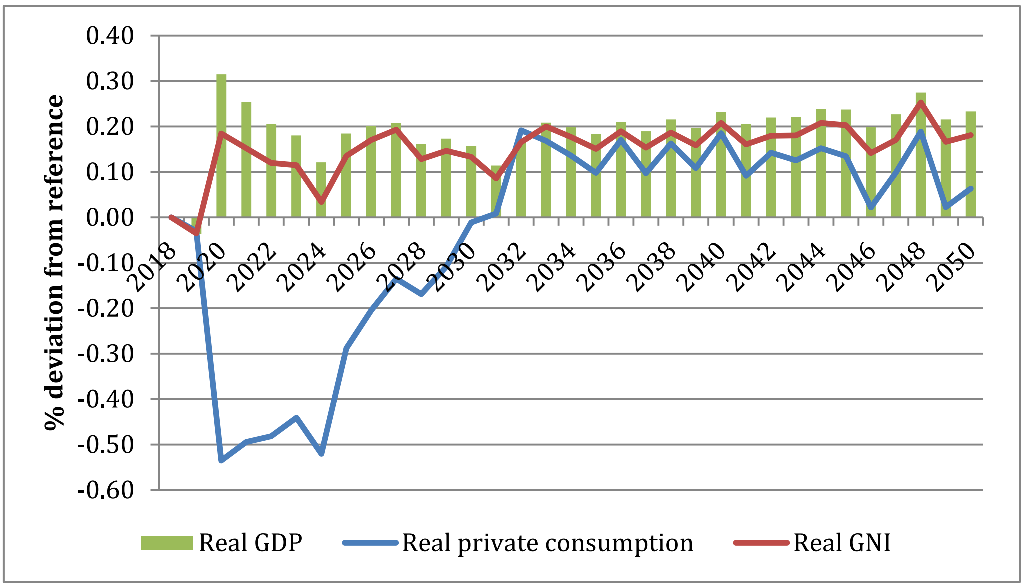
The EI-subsidy generally increases national welfare (real GNI) in line with real GDP

Figure 23 shows percentage deviations from reference-case values for real private consumption, real GNI and real GDP (columns).

The percentage deviations in real GNI generally follow those for real GDP. As explained in Section 5.3.1, differences between real GDP and real GNI arise for two main reasons: changes in net foreign income and changes to Australia's terms of trade. In the first few years, Australia's permit purchases are comparatively significant (see Figure 22). In these years net foreign income is reduced relative to reference case values, and this shows up in Figure 23 as a reduction in real GNI relative to real GDP during the early part of the projection period.

Australia's terms of trade is slightly depressed due to the EI subsidy. This too dampens real GNI relative to real GDP. The level of permit purchases and the terms of trade both stabilize over time, making the effect of the EI subsidy on GDP and GNI quite similar.

Figure 23: Real Private Consumption, Real GNI and Real GDP with the EI subsidy (% deviations from reference case values)



The story for real private consumption is not so clean cut. For the years to 2030, the EI subsidy causes real private consumption to fall relative to reference case values. The fall is particularly significant early on. The reason is clear from the data in Table 5. In the early years the subsidy is valued at over $10 billion each year. This is around 1.2 per cent of the total value of private consumption spending. In the early years the subsidy reduces electricity prices relative to the reference case by around 20 per cent (Figure 18). Electricity represents around 2 per cent of the household budget, so the 20 per cent reduction in price leads to a fall in the price of consumption of around 0.4 per cent.[19] Income available for consumption is up by 0.2 per cent (the real GNI line in Figure 23). Thus to a reasonable approximation, in the early years the introduction of the EI

[19] In these simulations the CPI is the numeraire, so in the simulation results the reduction in electricity price causes all prices to rise by 0.4 per cent relative to the CPI.

subsidy causes real consumer spending to be lower relative to reference case values by (1.2 - 0.4 - 0.2) = 0.6 per cent. The actual fall in real consumption shown in Figure 23 for the first few years is around 0.5 per cent.

In later years, the size of the subsidy as a share of total consumption falls away (see Table 5). This allows real consumption spending to recover relative to reference case levels. Over this period little change in the Average Propensity to Consume is required to keep the balance on current account at its reference-case level.[20]

Real gross GNE falls relative to real GDP in the first half of the period, leading to improvements in the net volume of trade. In the second half of the period, the changes in GDP and GNE are smaller and little change is required in the net volume of trade.

Figure 24 shows percentage deviations from reference-case values for real private consumption (C), real public consumption (G), real investment (I), real exports (X) and real imports (M). Deviations in C have already been discussed. Deviations in G are set to zero (see Subsection 5.2.2). Deviations in I reflect the increases in gross investment necessary to accommodate the increases in capital shown in Figure 20.

On balance, during the first ten years real GNE (C+I+G) falls relative to real GDP, implying an improvement in the net volume of trade (X-M)[21]. Thereafter the situation is less clear. The absolute magnitude of the deviations from the reference-case is smaller, and the gap between real GNE and real GDP fluctuates.

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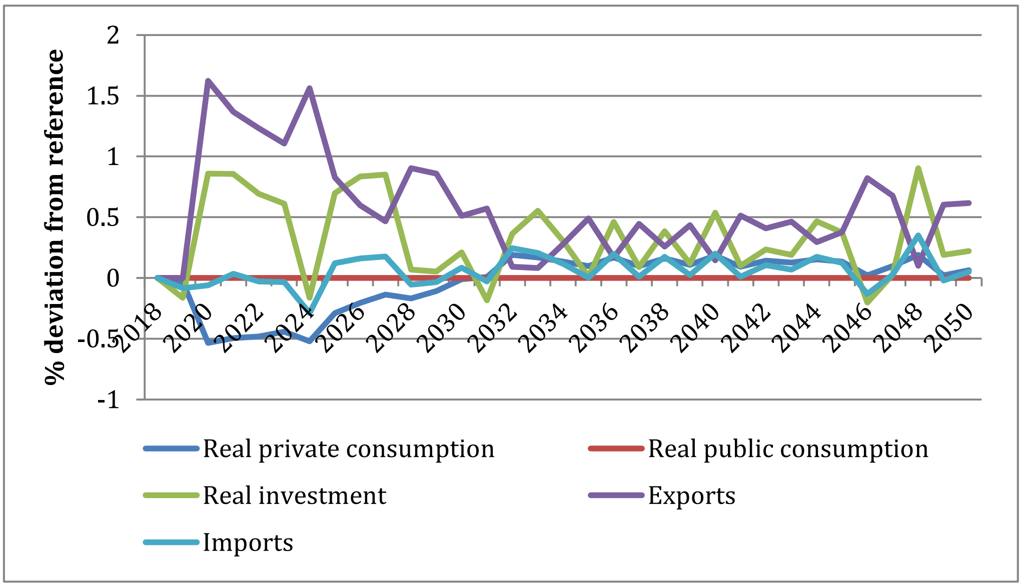
[20] Recall that as part of the simulation design, the APC moves to keep the current-account balance at its reference case value. This does not mean that the national savings rate is constant, since the government savings rate rises with the expansion in the economy (it is assumed that there is no change in government consumption).

[21] Mild deterioration in the net volume of trade requires the *percentage* increase in exports to be noticeably less than the percentage increase in imports, because through the reference-case the *level* of exports is noticeably less than the *level* of imports.

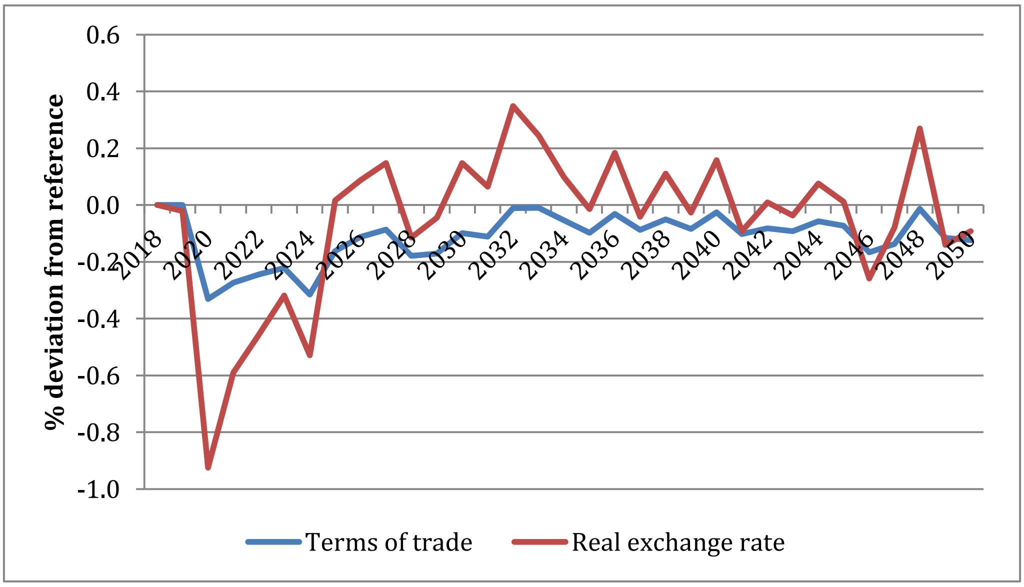
Figure 24: Expenditure-side Components of Real GDP with the EI subsidy (% deviations from reference case values)



Lower electricity prices stimulate higher exports, which expands global supply of these goods and so slightly depresses the terms of trade.

Figure 25 shows percentage changes relative to reference-case values in the economy's terms of trade and real exchange rate.

Figure 25: The Terms of Trade and Real Exchange Rate with the EI subsidy (% deviations from reference case values)



As noted in the discussion of Figure 24, during the first ten years there is an improvement in the net volume of trade. This requires real devaluation of the exchange rate. Real devaluation improves the competitiveness of export industries on foreign markets and the competitiveness of import-competing industries on local markets. With real devaluation comes deterioration in the terms of trade. A weaker currency shifts Australian producers down world demand curves. Volumes are up, but prices are down.

After 2028 the deviations in real exchange rate and terms of trade are generally smaller than in the first ten years, reflecting smaller changes in the net volume of trade. Over the longer term a very small deterioration in the terms of trade is accompanied to an exchange rate which, on average, remains largely unchanged from its reference case level.

6.3.2 NATIONAL INDUSTRY PRODUCTION

Production in nearly all industries in nearly all years increases relative to reference case levels. The cut in electricity prices is particularly advantageous to industries relatively intensive in their use of electricity and with significant trade exposure.

Table 6 gives percentage deviations from reference-case production levels for industries at the national level, in 2020, 2030 and 2050. The outcomes for 2030 and 2050 are more subdued than those for 2020. In later years, most industries experience increased output, with changes relative to reference-case levels of up to 1 per cent. The main exceptions are the electricity generation industries (industries 36 to 40), reflecting the Jacobs modelling, and several mining and manufacturing sectors that are trade exposed and relatively intensive in their use of electricity, and which grow by more than 1 per cent. In the latter group are *Coal mining* (industry 9, production up 2.2 per cent in 2050)[22], *Gas mining and LNG* (industry 11, 1.3 per cent), and *Other non-ferrous metals* (industry 31, 1.7 per cent).

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[22] The expansion in coal production is due entirely to an expansion in coal exports. Coal mining is relatively intensive in its use of electricity – especially for underground mining. It is also highly trade exposed. This combination means that when the cost of electricity is cut, the subsequent reduction in unit cost translates into a relatively large increase in output.

Table 6: National Industry Output with the EI subsidy
(% deviations from reference case values, 2020, 2030 and 2050)

	Industry	2020	2030	2050		Industry	2020	2030	2050
1	Sheep and cattle	0.5	0.0	0.1	36	Electricity generation - coal	0.0	0.0	0.0
2	Dairy cattle	0.5	0.0	0.0	37	Electricity generation - gas	5.5	3.2	-1.3
3	Other animals	0.2	0.1	0.1	38	Electricity generation - Hydro	0.0	0.0	0.0
4	Crops	0.4	-0.2	-0.1	39	Electric. Gen. - Other renew.	-3.5	-0.3	-1.6
5	Other agriculture	0.1	0.0	0.0	40	Electric. generation - Nuclear	-0.8	-0.4	1.4
6	Fishing and hunting	0.6	-0.1	0.0	41	Electricity supply	4.3	1.7	0.9
7	Forestry	0.6	-0.1	0.0	42	Gas supply	0.4	0.6	0.0
8	Agricultural services	0.6	-0.1	0.1	43	Water and drainage supply	0.0	0.1	0.1
9	Coal mining	1.2	2.3	2.2	44	Residential construction	-1.8	0.4	0.0
10	Oil mining	0.1	0.0	0.0	45	Non-residential construction	1.8	0.1	0.3
11	Gas mining and LNG	1.6	0.9	1.3	46	Construction services	0.2	0.1	0.1
12	Iron ore mining	0.1	0.5	0.5	47	Wholesale trade	0.4	0.2	0.2
13	Non-ferrous ore mining	0.4	1.9	1.6	48	Retail trade	0.1	0.1	0.1
14	Non-metallic mineral mining	1.0	0.5	0.4	49	Accommodation, hotel services	-0.2	0.0	0.0
15	Mining services	0.8	1.1	1.0	50	Road - freight services	0.5	0.2	0.2
16	Meat products	0.5	0.1	0.1	51	Road - passenger services	0.3	0.0	0.0
17	Dairy products	0.5	0.0	0.1	52	Rail - freight services	0.5	0.9	0.7
18	Other food products	0.6	0.0	0.1	53	Rail - passenger services	0.6	-0.1	0.1
19	Beverages	0.3	-0.1	0.0	54	Pipeline services	0.5	0.8	-0.3
20	Textiles, clothing and footwear	0.6	-0.2	0.1	55	Water transport services	0.9	0.5	0.5
21	Wood products	0.9	0.3	0.2	56	Air transport services	0.6	0.0	0.1
22	Paper and pulp	0.6	0.2	0.1	57	Communication services	0.0	0.0	0.1
23	Printing	0.3	0.0	0.1	58	Banking services	-0.1	-0.1	0.1
24	Refined petroleum products	0.1	0.0	0.0	59	Finance services	-0.1	-0.1	0.0
25	Basic chemicals	0.7	0.1	0.1	60	Dwelling ownership services	0.0	-0.4	0.1
26	Plastic and rubber products	0.9	0.2	0.2	61	Business services	0.4	0.0	0.1
27	Non-Metallic mineral products	0.5	0.2	0.2	62	Public administration	0.0	0.0	0.0
28	Cement	0.4	0.3	0.2	63	Defence	0.0	0.0	0.0
29	Iron and steel	1.6	0.2	0.2	64	Education services	0.5	-0.4	-0.1
30	Aluminium	3.4	1.3	0.8	65	Health services	-0.3	-0.1	0.0
31	Other non-ferrous metals	1.2	3.0	1.7	66	Residential care services	-0.3	-0.1	-0.1
32	Metal products	1.1	0.2	0.3	67	Arts and recreational services	-0.4	-0.1	0.0
33	Motor vehicles and parts	1.1	0.8	0.9	68	Repairs	0.3	0.1	0.1
34	Other equipment	2.3	0.8	0.7	69	Other services	-0.8	-0.1	-0.1
35	Other manufacturing	3.0	1.6	1.0	70	Uranium mining	0.1	0.0	-0.8

In 2020, industry prospects are affected by two main forces. The first is the cut in electricity price relative to the reference case. The second is the contraction (relative to reference-case levels) in real private consumption (see Figure 24). The former yields relative large positive outcomes for the industries listed above, as well as for *Iron and Steel* (industry 29, production up 1.6 per cent in 2020), *Aluminium* (industry 30, 3.4 per cent), *Other equipment* (industry 34, 2.3 per cent) and *Other manufacturing* (industry 35, 3.0 per cent). The second is negative for consumption-focused industries with little exposure to international trade. Good examples are *Residential construction* (industry

44, production down 1.8 per cent in 2020), and a range of community and public services (industries 65 through to 69).

The industry that gains most in 2020 is *Electricity supply* (industry 41), with increased production of 4.3 per cent relative to reference case values. With the retail price of electricity initially down by around 20 per cent (Figure 18), this suggest an *ex-ante* price elasticity of electricity of a bit over 0.2 (= 4.3 / 20). The increase in overall electricity use through the period drives the Jacobs projections for electricity generation sectors (industries 36 to 40).

6.3.3 REAL GROSS STATE PRODUCT

Over the long-run some regions gain share in real GDP, other regions lose share.

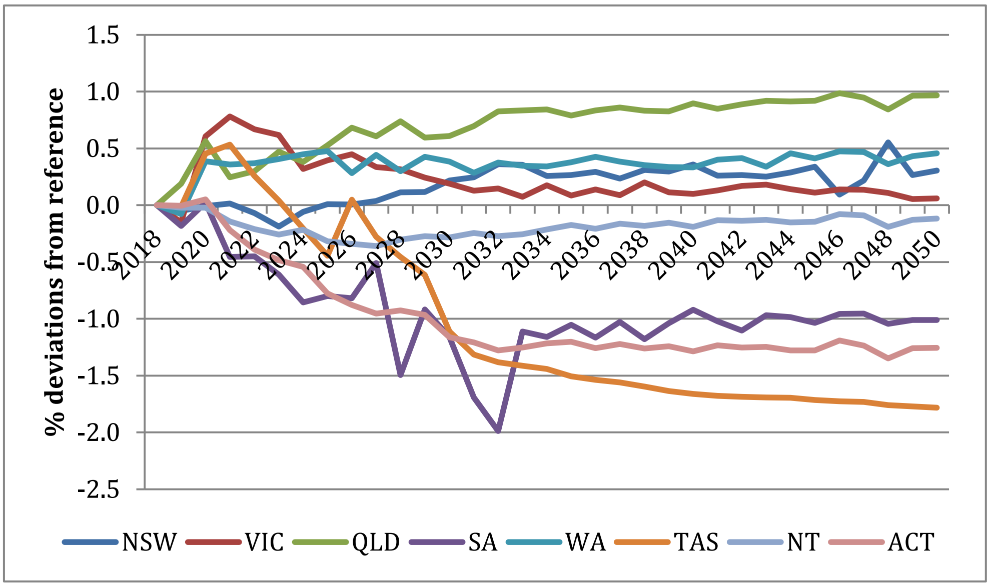
Figure 26 shows projected percentage deviations from reference-case levels for real GSP by state and territory. To a large extent, the pattern of impacts on real GSP reflects the national industry effects of the EI subsidy (see Table 6).

Two general themes emerge from Figure 26, one relating to the first few years and the other to the longer-run. In the early years, there are two opposing forces at play. One is positive for industries and regions – a cut in cost of electricity (relative to reference case levels). The other is negative - the reduction in real private household spending (relative to reference case levels). Nonetheless, the impact of the EI subsidy in these years is generally positive, with gains for most regions in line with the increase in real GDP.

Over the longer-term, however, the dispersion of regional outcomes increases. In 2050 the gap between the region that does least well (Tasmania) and the region that does best (Queensland) is nearly three percentage points. The dominant factor in the long-term is the cut in electricity price; the negative consumption effects diminish, and in effect disappear.

The regions that gain GDP share in the long-run are over-represented by industries that benefit most from the cut in electricity price – trade-exposed sectors with relative high electricity-input costs. The regions that lose GDP share are over represented by industries that benefit least – generally non-traded sectors with relatively small electricity-input costs.

Figure 26: Real GSP with the EI subsidy
(% deviations from reference case values)



Queensland's economy expands the most relative to reference-case levels because of relatively strong increases in production of metals, coal and LNG; these industries are over-represented in that state's economy. Tasmania's economy contracts the most relative to reference-case levels, because it has virtually none of the strongly-expanding sectors. Note that a region with a relatively large share of expanding national sectors, will generally have consumption demand higher than regions with a relatively small share of expanding national sectors; this is due to local multiplier effects. This accentuates the gap initially due to differences in industrial composition.

Other regions that lose GDP share in the long-run are the Australian Capital Territory and South Australia. Like Tasmania, both these states are under-represented in metals, coal and LNG. Negative local multiplier effects tend to be slightly smaller in these regions compared to Tasmania, because of lower state-wide consumption shares.

The other states and territories gain GSP roughly in line with the gain overall in real GDP. Somewhat surprisingly, included in this middle group is Western Australia. Western Australia has an industrial composition similar to Queensland, with relatively high shares of metals and LNG, but it has virtually no coal. The expansion of coal exports relative to the reference case is a key factor explaining Queensland's elevated position.