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The sensitivity of the NSW economic and fiscal outlook to global coal demand and the broader energy transition for the 2021 NSW Intergenerational Report

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[1] The views in this paper are those of the authors and do not necessarily reflect those of NSW Treasury.
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NSW GOVERNMENT

Acknowledgement

NSW Treasury acknowledges the Traditional Owners of the land on which we live and work, the oldest continuing cultures in human history.

We pay respect to Elders past and present, and the emerging leaders of tomorrow.

We celebrate the continuing connection of Aboriginal and Torres Strait Islander peoples to Country, language and culture and acknowledge the important contributions Aboriginal and Torres Strait Islander peoples make to our communities and economies.

We reflect on the continuing impact of policies of the past, and recognise our responsibility to work with and for Aboriginal and Torres Strait Islander peoples, families and communities, towards better economic, social and cultural outcomes.

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Coal mining is a major industry in New South Wales and a significant revenue source for the NSW Government. Most coal produced in New South Wales is exported and therefore the future of the industry is largely dependent on global demand. In 2020, New South Wales' three top thermal coal export markets – Japan, South Korea and China – all announced their intention to achieve net zero emissions by the middle of the century. Consequently, global demand and thus coal production is now projected to be significantly weaker than the long-term estimates presented in the 2016 NSW Intergenerational Report (IGR).

The factors underpinning weakening global demand for coal – technological development and policy settings aimed at reducing greenhouse gas (GHG) emissions – will also impact domestic energy generation. All five of New South Wales' coal generators which, together, supply 84 per cent of the State's utility-scale electricity, are expected to retire over the coming two decades. Research by the CSIRO indicates that solar and wind generation, combined with storage technologies, will be the cheapest way to replace these generators. Alongside this, while 99 per cent of light vehicles on New South Wales roads currently have internal combustion engines, the number of electric vehicles is set to grow considerably over coming decades.

It is fairly self-evident that declining global coal demand, relative to projections made in previous IGRs, will impact NSW's economic and fiscal outlook. The domestic energy transition, however, also presents both risks and opportunities. This paper presents an approach to assessing the potential magnitude and scale of the economic and fiscal impacts of this transition for the 2021 NSW Intergenerational Report. It constitutes an indicative assessment of some transitional climate risks, and accompanies a separate paper *An indicative economic and fiscal impact assessment of four key areas of climate risk for the 2021 NSW Intergenerational Report*, by the same authors, which focuses on a selection of physical risks of climate change.

This paper draws on output from Computable General Equilibrium (CGE) modelling as well as NSW Treasury's Long Term Fiscal Pressures Model (LTFPM) to test the sensitivity of New South Wales' fiscal and economic outlook to global coal demand.

Global coal demand scenario

The modelling will initially focus on three scenarios:

- a central projection, or reference case
- a higher global coal demand scenario
- a lower global coal demand scenario.

The reference case is calibrated to reflect the NSW IGR's broader assumptions regarding long term economic growth, including population, participation and productivity. It is also the same as the reference case used in *An indicative economic and fiscal impact assessment of four key areas of climate risk for the 2021 NSW Intergenerational Report*. All three scenarios also incorporate central projections of the technological composition of electricity generation and wholesale electricity prices from the NSW *Electricity Infrastructure Roadmap* and estimates of electric vehicles uptake from the Australian Energy Market Operator (AEMO).

The scenarios differ in projected global coal demand, and therefore NSW coal production. Specifically:

- Under the reference case, coal production remains at current levels until 2031 before declining to 44 per cent of current levels by 2061
- Under the higher global coal demand scenario, coal production increases by 20 per cent by 2027, before declining to 52 per cent of current levels by 2061
- Under the lower global coal demand scenario, coal production declines to zero by 2042 and remains there until 2061.

The sensitivity of the NSW fiscal and economic outlook to global coal demand

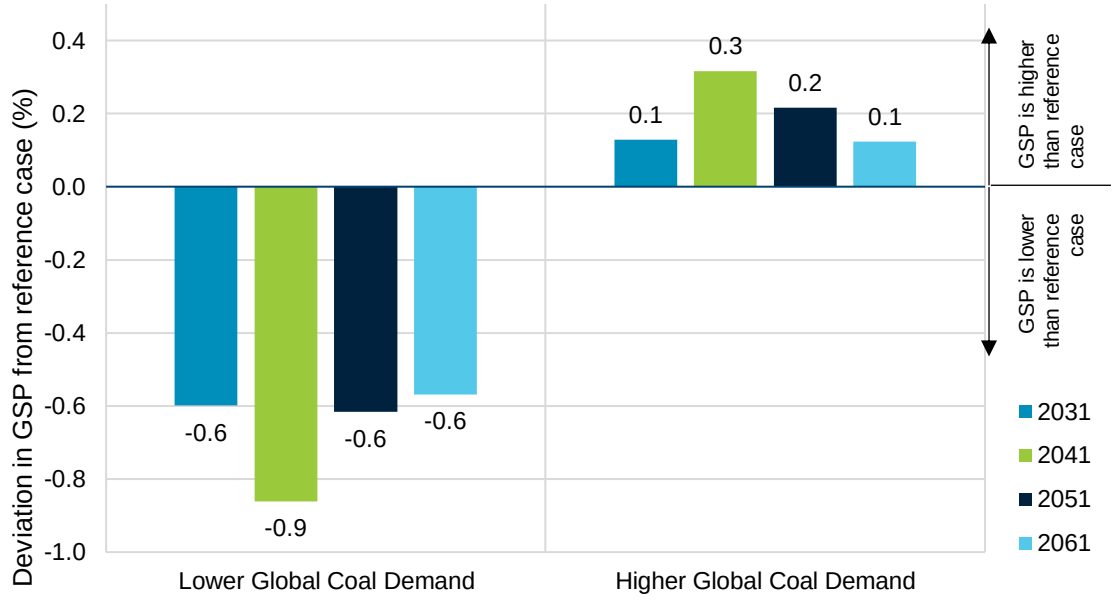
In comparison to the reference case, the **higher global coal demand** scenario projections show:

- Gross State Product (GSP) to be 0.3 per cent higher in 2041, and 0.1 per cent higher in 2061
- the fiscal gap to be 0.04 percentage points smaller, indicating an improved budget position.

In comparison to the reference case, the **lower global coal demand scenario** projections show:

- GSP would be 0.9 per cent lower in 2041, and 0.6 percent lower in 2061
- the fiscal gap to be 0.12 percentage points larger

Chart E1: Sensitivity of NSW Gross State Product to global coal demand



Source: NSW Treasury and VURM

The broader transition in energy generation

The modelling is then extended to consider the potential impact of the broader transition in energy generation. Two additional scenarios are introduced:

- Higher Global Coal Demand + Slow and Disorderly Transition Scenario
    - this scenario assumes that both the global *and domestic* transition to renewable energy is slower and more disorderly than under the reference case. Specifically, it extends the core assumptions underlying the higher global coal demand scenario – that the transition to renewable energy generation is slower than anticipated – to the domestic setting. This is put into effect with two additional assumptions: firstly, the transition toward renewable energy generation in NSW is assumed to be slower and more disorderly than the reference case, leading to higher and more volatile electricity prices. Secondly, the uptake of electric vehicles is assumed to be lower than under the reference case.
- Lower Global Coal Demand + Higher Electric Vehicles Uptake Scenario
    - this scenario extends the assumptions underlying the lower global coal demand scenario by incorporating faster uptake of electric vehicles into the scenario. The transition to renewable electricity generation is assumed to share the same characteristics as under the reference case, given this transition path reflects the recently legislated *Electricity Infrastructure Roadmap.*

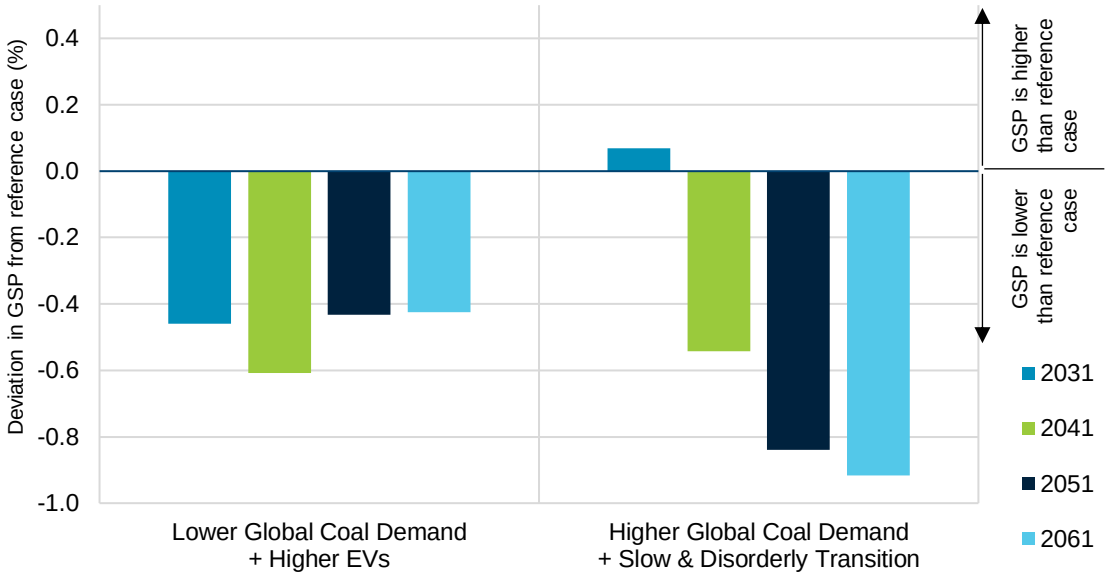
The sensitivity of the NSW economic and fiscal outlook to the broader energy transition.

In comparison to the reference case, the **lower global coal demand + higher EVs scenario** projections by 2061 show:

- GSP to be 0.4 per cent, or $6.4 billion (real 2019-20), lower
- the fiscal gap to be 0.10 percentage points larger.

Higher electric vehicle uptake in this scenario improves economic growth compared to the original lower global coal demand scenario. Electric vehicles utilise cheaper and domestically produced electricity, rather than more expensive imported petrol, providing economic benefits.

Chart E2: The sensitivity of Gross State Product to the broader energy transition



Source: VURM and NSW Treasury

In comparison to the reference case, the **higher global coal demand + slow and disorderly transition scenario** projections by 2061 show:

- GSP to be 0.9 per cent, or $13.7 billion (real 2019-20 dollars), lower
- the fiscal gap to be 0.08 percentage points larger.

This scenario has the slowest economic growth of all scenarios included in this paper. Higher and more volatile electricity prices dampen economic activity across the economy, while lower electric vehicle uptake acts as a further drag on growth. These are sufficient to more than outweigh the economic and fiscal benefits of higher global coal demand.

The results reported here are preliminary and will be refined in line with newer data and updates to the LTFPM prior to the publication of the 2021 IGR.

Discussion

Declining global demand for coal will reduce New South Wales' economic growth over the projection period and will have impacts both on employment and the fiscal outlook. There are also significant economic and fiscal risks in the broader transition in energy generation. Specifically, a slow and disorderly transition in domestic energy generation would be sufficient to more than offset any benefits from higher global coal demand. Further opportunities for industry development are beyond the scope of modelling in this paper but are considered in the report *NSW: A Clean Energy Superpower.*[2]

[2] KPMG and NSW Office of the Chief Scientist and Engineer, 'NSW: A Clean Energy Superpower Industry Opportunities Enabled by Cheap, Clean and Reliable Electricity'.

1. Introduction

Coal mining is a major industry in New South Wales and has a significant impact on the economy and NSW Budget. The industry is highly export oriented and also constitutes a significant revenue source for the NSW Government. Over the coming decades, however, global demand for coal is expected to weaken considerably. This is being driven by a combination of policy measures at a global scale aimed at reducing greenhouse gas (GHG) emissions, and technological development which is lowering the cost of renewable generation. This will impact the New South Wales economy and budget, and because it is driven by global factors, is largely outside the control of the New South Wales Government.

Beyond coal exports, energy more broadly plays a critical role in the NSW economy. It is a key input for every industry and an essential expenditure item for households. Since the industrial revolution, most energy used in Australia, and globally, has been generated through the combustion of fossil fuels, including coal and oil. Over the coming decades, the factors which are driving changes in global coal demand will also impact the way energy is generated in Australia and this is also expected to have a significant impact on the New South Wales economy and budget.

New South Wales Treasury is required to produce the NSW Intergenerational Report (IGR) every five years under the *Fiscal Responsibility Act 2012*. It includes projections of the economic and fiscal outlook over the next 40 years, with a specific legislative requirement to estimate the 'fiscal gap', defined as the change in the primary balance of the general government sector as a share of GSP. Internationally, the scope of IGR equivalent reports has been expanding beyond their initial focus of ageing risks, to include analysis of other long-term structural economic and fiscal risks, such as housing and productivity.

The 2021 IGR will be the first NSW IGR to include explicit modelling of the potential impacts of climate change and will incorporate modelling of both physical and transitional risks. Physical risks relate to the impacts of changes in the climate itself, while transitional risks refer to those in the economic transition toward lower GHG emissions.

This paper will set out an approach to modelling a selection of key transitional risks for New South Wales, while a separate paper *An indicative assessment of four key areas of climate risk for the 2021 NSW Intergenerational Report*[3] sets out the approach to modelling a selection of physical risks. The paper will utilise Computerised General Equilibrium (CGE) modelling to assess a range of scenarios encompassing changes in global coal demand, as well as the broader transition in energy generation domestically. Outputs from the CGE modelling will then be used in Treasury's Long-Term Fiscal Pressures Model (LTFPM) to test the sensitivity of the fiscal outlook to changes in the pace of the transition.

The modelling focuses initially on three scenarios:

- a central projection, or reference case
- a high global coal demand scenario
- a low global coal demand scenario.

[3] NSW Treasury, 'An Indicative Assessment of Four Key Areas of Climate Risk for the 2021 NSW Intergenerational Report'.

In order to contextualise the projected impacts in these scenarios, the modelling is then extended to consider the broader transition in energy generation. The additional scenarios are:

- a high global coal demand + slow and disorderly transition scenario
- a low global coal demand + high electric vehicle uptake scenario.

The findings of this paper will be used in the IGR alongside the findings of the modelling on physical climate risks[4] to demonstrate the sensitivity of the NSW economic and fiscal outlook to some of the key risks associated with climate change. This will improve the quality of fiscal and economic estimates in the IGR by ensuring robust and transparent analysis of the key risks facing New South Wales over the coming decades.

[4] NSW Treasury.

2. Context

Coal mining is a significant industry in NSW and is highly dependent on global demand

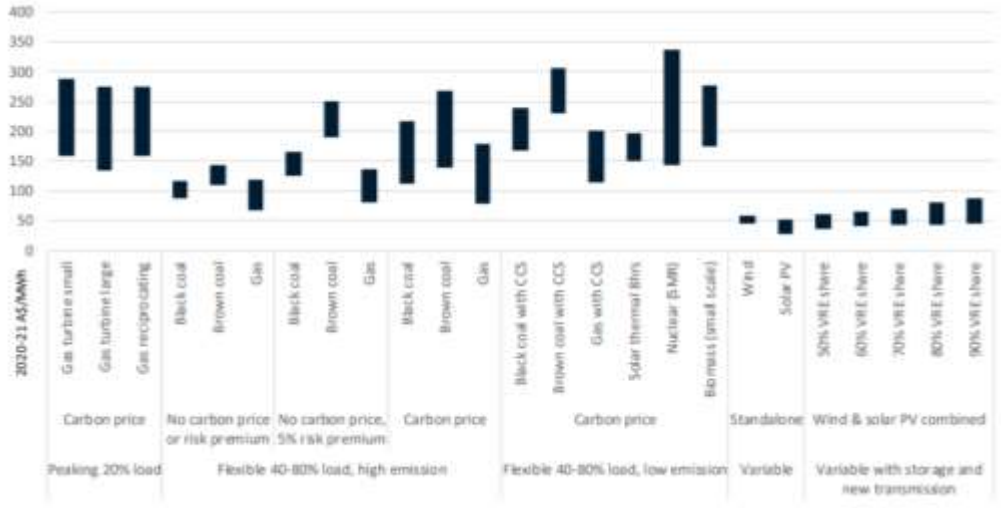
The NSW coal industry is heavily export oriented. 86 per cent of NSW coal is exported and this constitutes New South Wales' largest export commodity.[5] Most of New South Wales' coal production is thermal coal – the type used to generate utility-scale electricity. Hence the key driver of NSW coal production is global demand – only a very small proportion is used domestically. This means that it is global demand, not domestic policy settings, that will be the primary driver of future coal production in New South Wales.

Coal mining also has a significant impact on New South Wales' fiscal outlook and the economy more generally. Coal royalties revenue is also a significant revenue source for NSW, contributing $1.5 billion to the NSW Government budget in 2019-20.[6]

Global demand is expected to weaken considerably since the 2016 IGR

In 2020 New South Wales' top three thermal coal export destinations – Japan, South Korea and China – all announced their commitment to net zero emissions by the middle of the century.[7] More recently, the European Union and the Biden Administration in the United States have outlined policies which would impose carbon tariffs on imports from countries with higher greenhouse gas (GHG) emissions.[8] This, plus the lasting effects of the COVID-19 pandemic, has led to forecasts of global demand being revised down considerably, including, for example the *2020 World Energy Outlook*, published by the International Energy Agency.[9]

Chart 1 CSIRO projected levelised cost of electricity generation by technology for 2030



Source: CSIRO Gencost 2020-21

[5] Mining, Exploration and Geoscience (MEG), Department of Regional NSW, 'NSW Mining Industry Overview FY2018-2019'.
[6] Source: NSW Treasury
[7] 2050 for Japan and South Korea, 2060 for China.
[8] Holzman, 'Biden Could Seek Carbon Taxes with Same Strategy Trump Used for Steel, Aluminum'.
[9] International Energy Agency, 'World Energy Outlook 2020'.

A broader transition in energy generation is also underway

In the coming decades, the way we generate energy looks set to undergo the most significant change since the industrial revolution. In the year to November 2020, 84 per cent of utility-scale electricity generated in New South Wales was sourced from five coal generators,[10] all of which are expected to reach the end of their useful lives over the coming two decades.[11] Research from the CSIRO indicates that wind and solar power, combined with storage, will be the cheapest way to replace these generators (see Chart 1).[12]

The generation of energy in the transport sector is also set to change. 99 per cent of light passenger vehicles on New South Wales roads are internal combustion engine vehicles (ICEVs), fuelled by either petrol of diesel.[13] This fuel is generally imported from other States (mostly Western Australia) and from overseas[14] and distributed by some 2,000 petrol stations around the State.[15] It is also subject to fuel excise, levied by the Commonwealth, which acts as a de facto road user charge.

Over the coming decades this economic system is set to be disrupted. Technological innovations are driving down the price of electric vehicles and improving their functionality, for example through increasing range and reducing charging times. Supply constraints may also play a role: an increasing number of countries, including two of the largest right hand drive markets, Japan and the UK, announced their intention to phase out sales of ICEVs by the 2030s.[16] General Motors has also recently announced it will cease production of ICEVs by 2035.[17] Given Australia imports all of its light vehicles, global factors outside the control of Australian governments are likely to be a key driver of the transition to electric vehicles.

The New South Wales Government has announced a range of policy initiatives aimed at better managing this change

The New South Wales Government, along with other Australian governments, has already started to respond to these developments with a range of policy commitments. The New South Wales Government announced in the NSW 2020-21 Budget that royalties revenue from coal would be placed into the New Generations Fund (NGF), a sovereign wealth fund, to ensure future generations are able to benefit from the sale of today's non-renewable resources.

Along with all other state and territory governments, NSW has committed to Net Zero emissions by 2050.[18] Combined, GHG emissions from coal mining, electricity generation, and private motor vehicles constitute more than half of all New South Wales GHG emissions, meaning transition in these three sectors will constitute a key component of this commitment.

In late 2020, the New South Wales Government also announced, and then legislated, the *Electricity Infrastructure Roadmap* (through the *Electricity Infrastructure Act 2020*), which sets out measures to

[10] Australian Energy Market Operator, 'NEM Data Dashboard'.
[11] Australian Energy Market Operator, '2020 Integrated System Plan'.
[12] Graham et al., 'GenCost 2020-21: Consultation Draft. CSIRO Publications Repository: CSIRO'.
[13] Roads and Maritime Services, 'Motive Power by Vehicle Type - Registered Vehicles as at 30 September 2020'.
[14] Department of Industry, Science, Energy and Resources, 'Australian Petroleum Statistics, Commonwealth of Australia 2021'.
[15] Knight Frank, 'NSW Service Stations Insight'.
[16] Davis, 'Japan Plans Phase-Out of New Gasoline Cars by Mid-2030s'.
[17] Welch, 'GM Plans to Sell Only Zero-Emission Models by 2035'.
[18] Osborne, 'Net-Zero Emissions by 2050 Target Adopted'.

facilitate the State's coal generators replacement with renewable energy and storage. In August, the New South Wales Government released the findings of the *NSW Review of Federal Financial Relations*, which recommended the introduction of a new road user charge to replace declining fuel excise revenues. The Victorian and South Australian Governments also announced the introduction of a distance-based charge for electric vehicles.

A range of international institutions have recommended jurisdictions undertake more systematic assessment of risks associated with climate change

Risks associated with climate change can be generally classified into two key types: physical climate risks, which relate to the impacts of changes in the climate on the economy; and transitional risks which relate to the process of reducing GHG emissions and include both costs and benefits. A range of international institutions, including credit ratings agencies Moody's and S&P, and central banks (including the Reserve Bank of Australia) through the Network for Greening the Financial System (NGFS), have recommended that governments more explicitly consider and account for both the physical and transitional risks of climate change in fiscal planning.[19]

Previous IGRs have considered the impact of changes in energy generation. The 2011 IGR included analysis of the fiscal impacts on New South Wales of the Commonwealth's carbon price. The 2016 report (and previous reports) included projections of coal production based on data from the International Energy Agency, which at the time anticipated continued growth in coal production through the projection period. Since these reports, Commonwealth policy settings have changed (the carbon price has been repealed) and consensus forecasts of global coal demand have been revised down considerably. The 2021 IGR has the opportunity to extend its modelling to consider the wider economic impacts of the energy transition, as well as direct impacts on the fiscal outlook.

This paper will assess the sensitivity of the New South Wales economic and fiscal outlook to changes in the pace of transition away from fossil-fuel based energy generation

The modelling presented in this paper is aimed at providing a greater understanding of the economic and fiscal impacts associated with changes in global coal demand, as well as the broader transition in energy generation. This will be incorporated into the 2021 NSW IGR alongside a separate paper focused on selected physical risks of climate change.[20] Together, these papers will better inform New South Wales long-term fiscal planning by considering how sensitive economic and fiscal outcomes are to differences in the pace of the global transition toward lower GHG emissions, and to differences in the climate scenario. This will provide additional confidence and transparency in New South Wales long term fiscal planning processes, and thus contribute to the objectives of the *Fiscal Responsibility Act 2012*.

The modelling is aimed at understanding the sensitivity of the economic and fiscal outlook to differences in global coal demand, and the broader transition in energy generation. It does not

[19] Moody's Investors Service, 'Issuer In-Depth 29 January 2020: State of New South Wales (Australia) Droughts and Bushfires Materially Increase Budget Pressures and Pose Long-Term Challenges'; Kernan et al., 'How Does S&P Global Ratings Incorporate Environmental, Social, And Governance Risks Into Its Ratings Analysis'; Network for Greening the Financial System, 'NGFS Publishes a First Set of Climate Scenarios for Forward Looking Climate Risks Assessment alongside a User Guide, and an Inquiry into the Potential Impact of Climate Change on Monetary Policy'.

[20] NSW Treasury, 'An Indicative Assessment of Four Key Areas of Climate Risk for the NSW Intergenerational Report 2021'.

constitute an assessment of New South Wales Net Zero Emissions commitment, nor does it account for potential new industry opportunities, for example the deployment and export of hydrogen energy.

3. Previous approaches to modelling the energy transition

Modelling for the NSW Intergenerational Report

The 2016 NSW Intergenerational Report included projections relating to two revenue items of relevance to subsectors modelled in this paper. Coal volumes were projected to grow at a long-term rate of 1.2 per cent per annum over the projection period (to 2056), a finding that was then used to estimate royalties revenue. Projections also accounted for Commonwealth grants through National Partnerships, one of which relates to transport expenditure including roads. However, there is no formal link between Commonwealth road-related revenues, which are primarily derived from fuel excise, and road-related expenditures. This approach did not include an assessment of wider economic impacts or sensitivity analysis of changes in these assumptions.

Modelling transitional risks of climate change

A number of reports have sought to estimate the economic impact of transitioning to a lower emissions economy including, most notably, modelling conducted for the Garnaut Review in 2008, the Network for Greening the Financial System (an assemblage of central banks including the Reserve Bank of Australia) and for Deloitte in 2020.[21] These reports assessed both the physical and transitional risks of climate change together, and assumed that lower GHG emissions would be accompanied by reduced physical risks. This assumption holds at a global level but may not hold within a single country or subnational jurisdiction. For example, New South Wales GHG emissions account for less than 0.4 per cent of global GHG emissions,[22] which are not material in isolation. Separating the analysis of physical and transitional risks that face an individual jurisdiction can facilitate a better understanding of the dynamics of both kinds of climate risks.

A second feature adopted by Garnaut, the NGFS and Deloitte has been the assumption that a carbon price mechanism would drive the transition to a lower emissions economy. While entirely appropriate for these analyses – the Garnaut Review recommended the introduction of a carbon price – such an approach is not appropriate for the New South Wales IGR. There is no carbon price in New South Wales, or Australia more generally, and the IGR is conducted on the basis of no policy change.[23] Furthermore, the transition in the subsectors covered in this paper is driven by changes in global demand for NSW coal, and the falling cost of low emissions generation technologies domestically. It does not rely on an explicit, or even implicit, carbon price.

Sector-specific modelling

Other modelling of the energy transition has focused on specific subsectors of the economy. For example, the Australian Energy Market Operator modelled different transition scenarios in the National Energy Market, focused on the energy sector specifically, through the Integrated System Plan. This also included projections on electric vehicle uptake, which were estimated in partnership

[21] Garnaut, *The Garnaut Climate Change Review*; Deloitte Access Economics, 'Building Resilience in Our States and Territories'; Network for Greening the Financial System, 'NGFS Publishes a First Set of Climate Scenarios for Forward Looking Climate Risks Assessment alongside a User Guide, and an Inquiry into the Potential Impact of Climate Change on Monetary Policy'.

[22] Global Carbon Project, 'Global Carbon Project (GCP)'; NSW Department of Planning, Industry and Environment, 'Net Zero Plan. Stage 1: 2020-2030'.

[23] In contrast, there was a carbon price in place at the Commonwealth level at the time the 2011 IGR was published, hence the impact of this was included in projections contained in that report.

with the CSIRO. A range of forecasts have also been made regarding the future of global coal demand, including most recently by the International Energy Agency.[24] Sector-specific modelling can provide valuable information about how specific parts of the economy are likely to develop, by including more detailed information in its assumptions and approach than is generally possible with modelling focused on the wider economy. However, this modelling generally does not provide an indication of how these sector-specific developments will impact the wider economy.

[24] International Energy Agency, 'World Energy Outlook 2020'.

4. Modelling approach

Overview

Modelling in this section is aimed initially at providing an indication of the scale and direction of economic and fiscal impacts associated with changes in global demand for NSW coal. The modelling is then broadened beyond the coal industry to consider the economic and fiscal impact of different transition scenarios across the broader energy sector, specifically in electricity generation and the uptake of electric vehicles. The scenarios in this assessment do not represent all possible outcomes. Rather, they are intended to illustrate the relative impact of changes in global coal demand, and then contextualise these impacts with reference to transition across the broader energy sector. Combined, the subsectors included in this modelling account for over half of total NSW GHG emissions,[25] meaning the results of this modelling constitute a partial assessment of some of the key transitional risks associated with climate change. A separate paper, *An indicative assessment of four key areas of climate risk for the 2021 NSW Intergenerational Report*,[26] provides an indication of the economic and fiscal impacts of four key physical climate risks.

The approach taken in this paper is similar to that utilised to assess physical climate risks.[27] The modelling initially considers three scenarios:

- a central projection, or reference case
- a higher global coal demand scenario
- a lower global coal demand scenario.

A series of 'shocks' are applied to a Computable General Equilibrium (CGE) model – the Victoria University Regional Model (VURM) – reflecting different levels of global coal demand. The model then provides information on how the different scenarios would impact the overall economy. This is then combined with analysis utilising Treasury's Long-Term Fiscal Pressures Model (LTFPM) to estimate the sensitivity of the fiscal outlook across the three scenarios.

Following this, the modelling is extended beyond coal mining to include transition across the broader energy sector. Firstly, the higher global coal demand scenario is extended to also encompass a slow and disorderly transition in electricity generation and electric vehicles uptake. The lower global coal demand scenario is in turn augmented with higher uptake of electric vehicles. These additional scenarios are intended to provide more holistic analysis of how the global transition to renewable energy generation technologies could impact the NSW economy and budget.

Scenarios

Scenarios are used in this assessment to test a range of potential transition pathways in the global and domestic transition toward lower emissions. A reference case is first estimated with three key characteristics. Firstly it is calibrated to match projections and assumptions on the "Three Ps" of economic growth (productivity, participation and population), which have been estimated in separate

[25] Adams et al., 'MMRF: Monash Multi-Regional Forecasting Model: A Dynamic Multi-Regional Model of the Australian Economy'; NSW Department of Planning, Industry and Environment, 'Net Zero Plan. Stage 1: 2020-2030'.
[26] NSW Treasury, 'An Indicative Assessment of Four Key Areas of Climate Risk for the NSW Intergenerational Report 2021'.
[27] NSW Treasury.

research papers.[28] Secondly, the reference case is identical to the reference case used in the assessment of physical climate risks and therefore assumes an 'intermediate warming' scenario (Representative Concentration Pathway 4.5).[29] Thirdly, the reference case incorporates the central projections for each of the subsectors considered in this paper (electricity generation, coal production and electric vehicles uptake). This means that the central estimate of transition in each of these subsectors is assumed to be consistent with the long run productivity growth rate assumption recommended in the NSW Treasury paper *Projecting Long Run Productivity Growth Rates for the 2021 Intergenerational Report,*[30] which is 1.3 per cent per annum.

There is overlap between this paper and the topics covered in other technical research papers in this series: specifically, there are factors associated with the energy transition that impact economic growth, primarily through impacts on productivity. However as noted in the NSW Treasury productivity research paper,[31] productivity growth depends on a range of factors, including the pace and scope of economic reforms, technological development, the industry structure of the economy, demographics, the distribution of income and wealth and geopolitical concerns. It is feasible that detailed research into each of these would yield conclusions regarding their impact (positive or negative) on productivity growth. Indeed, the productivity technical paper endeavours to weigh these factors and concludes that on balance risks tend toward on the downside. Ultimately, however, the NSW Treasury productivity technical paper decides against using a 'building block' approach, and instead assumes productivity growth to eventually return to a long-run historical average, which yields 1.3 per cent annual productivity growth.[32]

This approach to projecting productivity growth is relevant for setting the key assumptions underlying scenarios in this paper. Common practice in previous research has been to assume a baseline 'business as usual' scenario, then impose shocks to derive a new energy transition scenario, which generally utilises a carbon price and generally finds lower economic, and implicitly, productivity growth. This approach is not, however, consistent with the method used to project underlying productivity growth outlined in the productivity technical paper. Given the preferred method is based on an historical average, rather than taking a 'building block' approach that looks at the component drivers of productivity, it is not methodologically possible to make modifications to a specific component, such as changing global demand for NSW coal. The purpose of this research paper is not to project long run economic growth. Rather, it is to set out an approach that can be used to assess the sensitivity of the economic and fiscal outlook to a range of risks relating to the global energy transition. The approach developed in this paper therefore operates within the baseline 'Three Ps' assumptions adopted elsewhere in Treasury research, incorporating each of these into the reference case.

Accordingly, the estimates presented in this paper should be interpreted as the sensitivity of the economic and fiscal outlook to differences in global coal demand and the broader energy transition. They are generally applicable to alternative estimates of long run economic growth. For example, an alternative estimate as to the productivity outlook for the reference case may not assume that

[28] NSW Treasury, 'Preliminary Participation Rate Projections for the 2021 Intergenerational Report'; NSW Treasury, 'Projecting Long Run Productivity Growth Rates for the 2021 Intergenerational Report'.
[29] NSW Treasury, 'An Indicative Assessment of Four Key Areas of Climate Risk for the NSW Intergenerational Report 2021'.
[30] NSW Treasury, 'Projecting Long Run Productivity Growth Rates for the 2021 Intergenerational Report'.
[31] NSW Treasury.
[32] This is lower than the 1.5 per cent assumed in the 2016 IGR reflecting weaker productivity growth in recent years.

productivity growth continues on its 30 year historical trend, but may instead use a lower assumption based on the potential impacts of lower global coal demand than was projected in previous IGRs.

Having generated a reference case consistent with the “Three Ps” assumptions, an intermediate warming scenario and the central projections for each of the three subsectors considered in this paper, the VURM CGE model is used to consider four alternative scenarios, as described in the previous section.

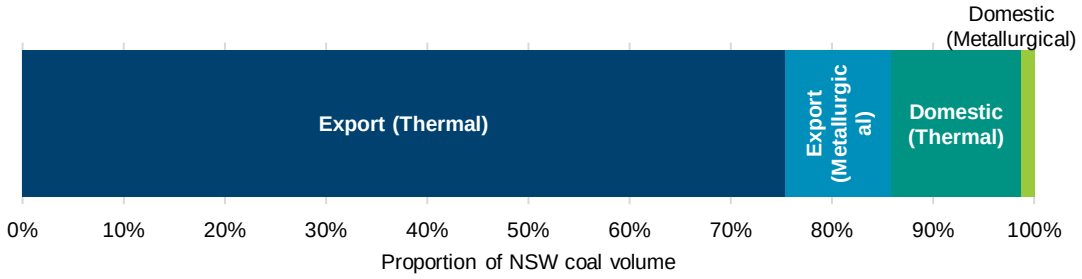
Unlike some previous assessments, differences across the scenarios do not rely on an explicit or shadow carbon price. Information on the nature of the transition in each subsector is imposed directly into the model. The VURM CGE model then estimates how these different transition paths would impact the economy overall and provides information in the form of a deviation from the reference case. The specific assumptions underlying each scenario are outlined in the following sections.

5. The sensitivity of the economic and fiscal outlook to global coal demand

Coal Production in New South Wales

Coal mining is a major industry in New South Wales, with 39 mines operating throughout the State employing around 22,000 people.[33] In 2019-20, New South Wales produced 200 Mt of coal. Most of this - 88 per cent - was thermal grade. 86 per cent of coal mined in New South Wales was exported (see Chart 2). The NSW Government raised $1.5 billion in royalties revenue levied on coal production in 2019-20, accounting for 1.9 per cent of total NSW Government revenues.[34] Meanwhile, fugitive methane emissions from coal mining account for around 9 per cent of the State's total GHG emissions.[35]

Chart 2 New South Wales Coal Production by type and destination (2019-20)



Source: NSW Treasury; Department of Regional NSW

Transition in the coal sector

The heavy reliance of the NSW coal industry on exports of thermal coal means that future production will be largely determined by global demand. Recently the top three markets for NSW thermal coal – Japan, South Korea and China – have all announced their commitment to net zero emissions within the forecast period of the IGR (2050 for Japan and South Korea; 2060 for China).[36] Furthermore, the costs of renewable generation and storage are forecast to fall considerably over the coming decades. This does not necessarily mean that no coal will be used in the future – new coal generators continue to be built[37] and *net* zero policies allow for offsets. Nonetheless, future coal production is now expected to be considerably weaker than was forecast for the 2016 IGR.

Projecting future coal production

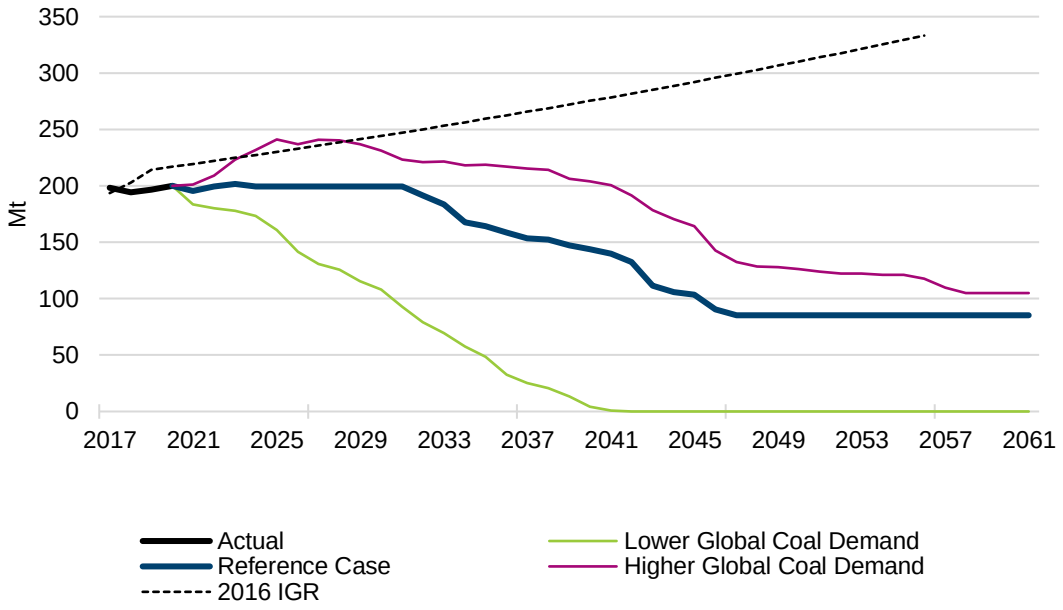
The Department of Regional NSW produces projections of coal production over the coming decades for the NSW Government. These projections underpin the New South Wales Government's *Strategic Statement on Coal Exploration and Mining in NSW*, released in 2020.[38] Forecasts are based on

[33] Mining, Exploration and Geoscience (MEG), Department of Regional NSW, 'NSW Mining Industry Overview FY2018-2019'.
[34] Source: NSW Treasury
[35] Australian Government Department of Industry, Science, Energy and Resources, 'State and Territory Greenhouse Gas Inventories 2018'.
[36] It is noted that coal shipments to China are already being disrupted as part of ongoing trade tensions.
[37] Thurbon et al., 'Forget about the Trade Spat – Coal Is Passé in Much of China, and That's a Bigger Problem for Australia'.
[38] Department of Regional NSW, 'Strategic Statement on Coal Exploration and Mining in NSW'.

analysis of current and potential future mines, and include a central projection, as well as 'maximum' and 'minimum' projections. The scenarios differ in their assumptions as to whether or not new mining proposals will ultimately proceed. Approvals are based on a range of factors, with all scenarios possible under current policy settings. The overall economic and fiscal impact of differences between these forecasts will be assessed as part of this paper.

Chart 3 presents the projections for coal production volumes. As outlined in the *Strategic Statement*, coal production is projected to remain relatively stable over the medium term (i.e. until the mid-2030s), before declining to less than half of today's current production volumes. Under the higher global coal demand scenario, coal production increases to near 250 Mt through the 2020s, before declining over the later years of the forecast. Under the lower global coal demand scenario, NSW coal production declines more quickly, with no coal production beyond 2042.

Chart 3 NSW Treasury and Department of Regional NSW projected coal volumes (total tonnage)

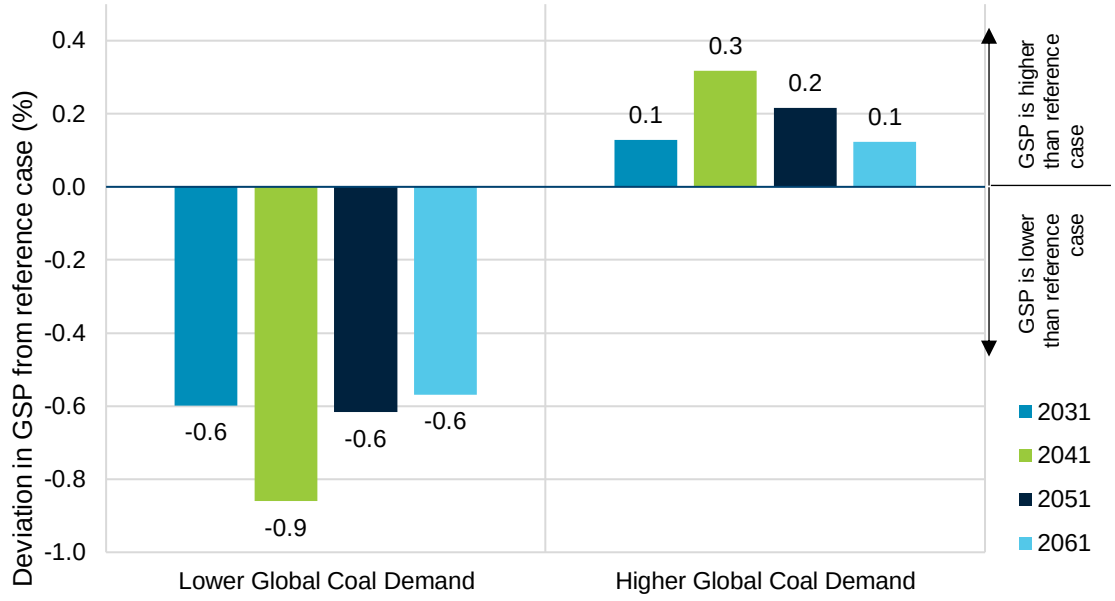


Source: NSW Treasury; Department of Regional NSW.

Economic impacts

The key economic impacts of the differences in global coal demand produced by the CGE modelling are set out in Chart 4. Compared with the reference case, the higher global coal demand scenario lifts GSP by up to 0.3 per cent by 2041, although this scenario trends closer to the reference case over time, and GSP is projected to be only 0.1 per cent higher than the reference case by 2061. The lower global coal demand scenario, in which coal production in NSW ceases after 2042, results in GSP being 0.9 per cent lower than the reference case in 2041 and remaining 0.6 per cent lower in 2061.

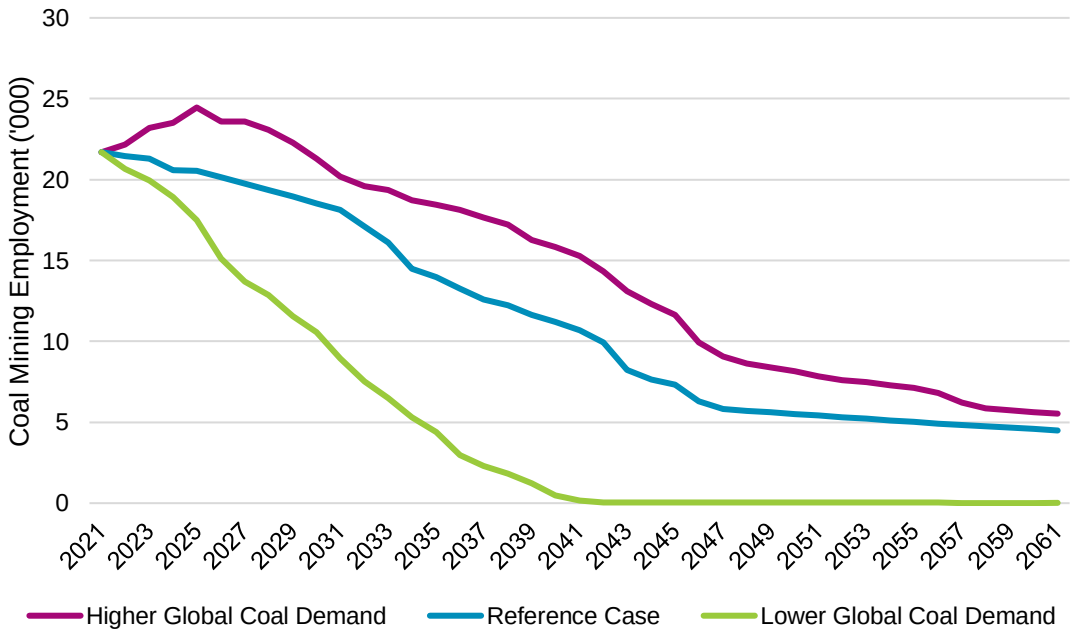
Chart 4 Sensitivity of NSW Gross State Product to global coal demand



Source: NSW Treasury and VURM

Declining global coal demand will also impact employment in the coal mining sector, which currently employs around 22,000 people. Depending on the level of global demand, this is projected to decline by between 75 and 100 per cent by 2061, with a central estimate of 80 per cent decline, or 18,000 fewer jobs (see Chart 5).

Chart 5 NSW employment in coal mining



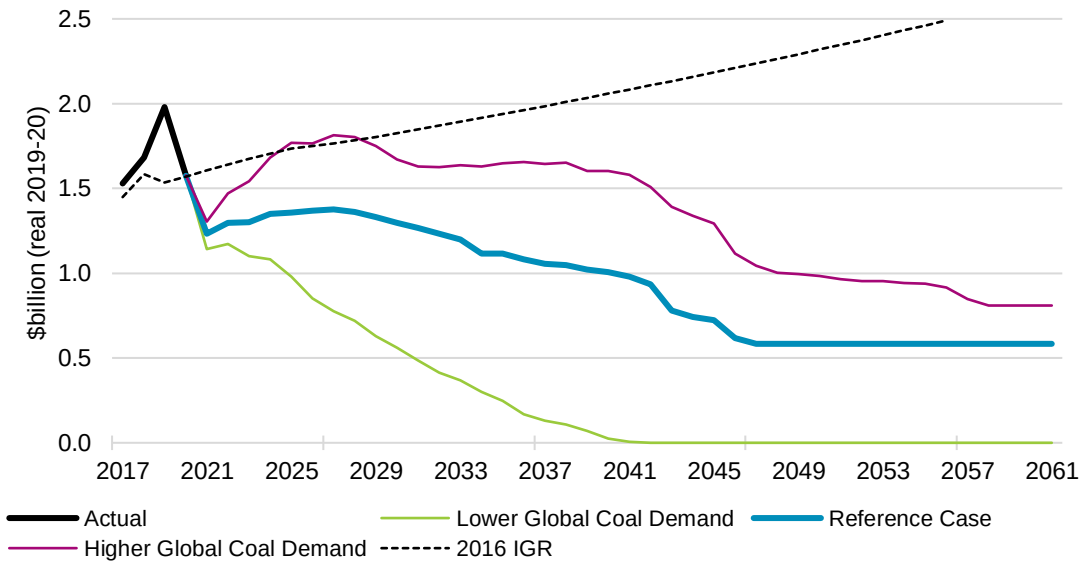
Source: NSW Treasury and VURM

Fiscal impacts

Chart 6 shows projected coal royalties revenue under each of the three scenarios. Under the reference case, annual royalties revenue from coal is projected to decline to $580 million (real 2019-20 dollars) by 2061, or around a third of current levels. Under the lower global coal demand scenario, coal royalties revenue declines to zero by 2042. Under the higher global coal demand scenario, coal royalties revenue is projected to be $810 million (real 2019-20 dollars) by 2061 as global demand remains stronger than that projected under the reference case.

Under all scenarios, royalties revenue is substantially below that projected in the 2016 IGR, reflecting significant shifts in expectations of global demand in recent years. The 2016 IGR projected $73 billion (real 2019-20 dollars) in cumulative coal royalties revenue between 2020-21 and 2055-56.[39] This has been revised down to $35 billion under the reference case, $51 billion under the higher global coal demand scenario and $11 billion under the lower global coal demand scenario (all real 2019-20 dollars).

Chart 6 Coal Royalties Revenue Projections (Real 2019-20 Dollars)



Source: NSW Treasury

The fiscal outlook is sensitive to both royalties revenue as well as economic growth. Specifically, under the higher global coal demand scenario, the fiscal gap is projected to be 0.04 percentage points smaller than under the reference case, indicating an improved budget position. Under the lower global coal demand scenario, the fiscal gap is projected to be 0.12 percentage points larger than under the reference case.

Note that the results presented here are preliminary and will be updated in line with overall economic forecasts and a range of other modelling for the 2021 IGR, to be published later in 2021.

[39] This was the final year of the 2016 IGR projection.

6. The broader transition in energy generation

While the impact of declining global demand for NSW coal will be significant, this needs to be considered in the context of the challenges and opportunities that come with the broader transition towards renewable energy. This section extends the modelling above by considering two additional scenarios.

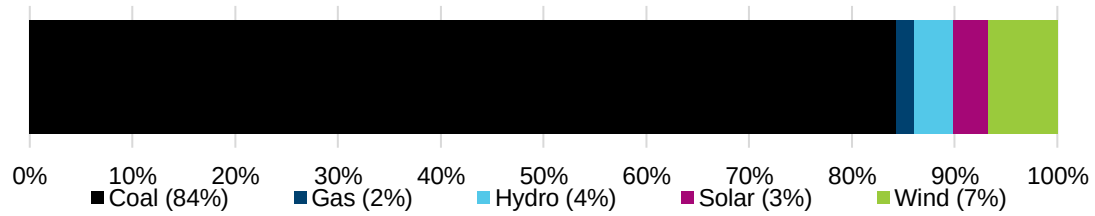
- Higher Global Coal Demand + Slow and Disorderly Transition Scenario: this scenario assumes that both the global *and domestic* transition to renewable energy is slower and more disorderly than under the reference case. Specifically, it extends the core assumptions underlying the higher global coal demand scenario – that the transition to renewable energy generation is slower than anticipated – to the domestic setting. This is put into effect with two additional assumptions: firstly, the NSW transition away from aging coal plants is not effectively planned and accordingly replacement energy generation is not in place in timely manner, leading to higher and more volatile electricity prices. Secondly the uptake of electric vehicles is assumed to be lower than under the reference case.
- Lower Global Coal Demand + Higher Electric Vehicles Uptake Scenario: this scenario extends the assumptions underlying the lower global coal demand scenario by incorporating faster uptake of electric vehicles into the scenario. The transition to renewable electricity generation is assumed to share the same characteristics as under the reference case, given this transition path reflects the recently legislated *Electricity Infrastructure Roadmap.*

The next section discusses the modelling inputs for each of these two additional subsectors in more detail.

Electricity Generation in NSW

84 per cent of utility scale electricity generated in NSW in 2020 was derived from NSW's five coal generation plants (see Chart 7).[40] Although the sector accounts for only around one per cent of GSP, and represents around 0.5 per cent of employment,[41] it forms a critical input for nearly every other part of the economy, and an essential expense for households. GHG emissions from electricity generation were 51 Mt CO_2-e in 2017, or 39 per cent of NSW's total emissions – the largest single source of GHG emissions.[42]

Chart 7 Electricity Generation in NSW by Source 2020



Source: AEMO Data Dashboard. Utility-scale generation only (excludes rooftop solar).

[40] Australian Energy Market Operator, 'NEM Data Dashboard'. Note this excludes generation from rooftop solar and other distributed energy resources.
[41] Australian Bureau of Statistics, '5220.0'; Australian Bureau of Statistics, '6291.0'.
[42] NSW Department of Planning, Industry and Environment, 'Net Zero Plan. Stage 1: 2020-2030'.

Transition in Electricity Generation

The electricity sector is expected to undergo significant change in the coming decades as each of the State's coal generators are progressively retired. Given the substantial role each plant plays in the State's energy system, there are risks associated with their retirement: when coal generators have been decommissioned in other states, these have often been accompanied by significant spikes in electricity prices across the National Energy Market (NEM), including in New South Wales. To address this risk, the NSW Government has recently announced and legislated the *Electricity Infrastructure Roadmap*, which seeks to ensure replacement electricity generation infrastructure is in place in time for the expected plant closures. This is to be achieved through the NSW Government sharing some of the investment risk for new generation and storage infrastructure with the private sector.

Projecting the Future of Electricity Generation

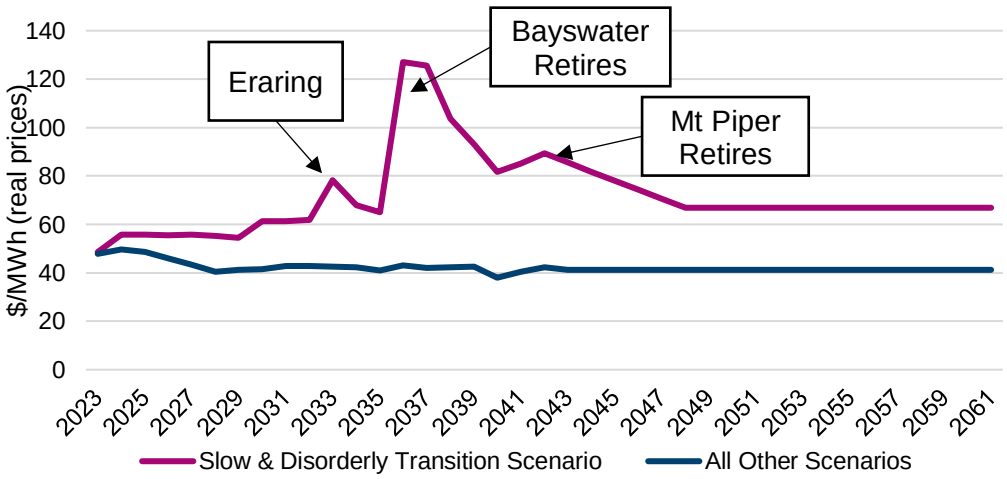
Modelling of electricity generation in this paper considers two key inputs:

- the amount of electricity generated by each technology type
- the wholesale price of electricity

These are assumed to be in line with modelling conducted by Aurora Energy Research as part of the development of the *Roadmap.*[43] This modelling extended only to 2042 and must therefore extended to 2061 for the purposes of this modelling project. Given the Aurora modelling indicated prices would be broadly stable in real terms to 2042, it is assumed this trend continues to 2061 (see Chart 8).

Under the slow and disorderly transition scenario, however, new forms of generation are not in place by the time coal generators are decommissioned, leading to significant price spikes (see Chart 8). These subside over time, but prices are assumed to remain higher than under the other scenarios, reflecting relatively slower technological development under this scenario. Specifically, after 2042, prices are assumed to return to the average experienced between 2031 and 2035 prior to the closure of the Bayswater coal generator (which leads to a large spike in prices).

Chart 8 Projected Wholesale Electricity Price in NSW



Source: NSW Treasury

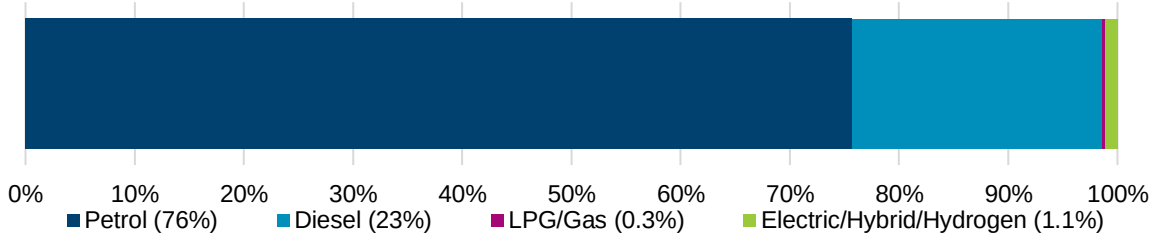
[43] NSW Department of Planning, Industry and Environment, *NSW Electricity Infrastructure Roadmap*.

Long term projections of electricity prices are inherently uncertain, and comprehensive modelling for the period after 2042 was not available for this analysis. The pricing assumptions adopted for this modelling are designed to be broadly consistent with the overall scenario drivers, but do not represent all possible trajectories.

Electric Vehicles in New South Wales

The overwhelming majority of motor vehicles in New South Wales are powered by internal combustion engines: 99 per cent of light vehicles currently registered in NSW are Internal Combustion Engine Vehicles (ICEVs), fuelled by either petrol, diesel or LPG (see Chart 9). The fundamental characteristics of most motor vehicle engines have remained unchanged in over a century, and an array of physical and economic infrastructure is based on this basic model: Australia imports around a third of its automotive fuel, with most domestic production occurring in Western Australia.[44] This is then distributed to consumers through a network of around 2,000 petrol stations located throughout New South Wales.[45]

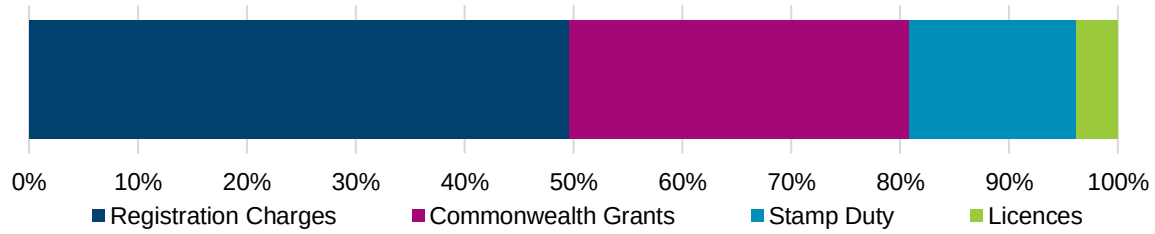
Chart 9 NSW Vehicle Registrations by Fuel Type (September 2020)



Source: NSW Treasury

The Commonwealth Government levies excise on petrol, which operates as a de facto road user charge. The Commonwealth raised $17.6 billion in excise on diesel and petrol in 2019-20,[46] which represented over 80 per cent of total Commonwealth road related revenues.[47] The Commonwealth in turn contributes to road construction and maintenance in New South Wales, with Commonwealth grants accounting for 31 per cent of the State's road-related revenues (see Chart 10).

Chart 10 New South Wales Road Related Revenues



Source: Bureau of Infrastructure and Transport Research Economics; NSW Treasury. Excludes GST and tolls.

[44] Department of Industry, Science, Energy and Resources, 'Australian Petroleum Statistics, Commonwealth of Australia 2021'.
[45] Knight Frank, 'NSW Service Stations Insight'.
[46] Commonwealth of Australia, 'Budget 2021-21', 10–24.
[47] Bureau of Infrastructure, Transport and Regional Economics, 'Australian Infrastructure Statistics Yearbook 2018'.

Transition to electric vehicles

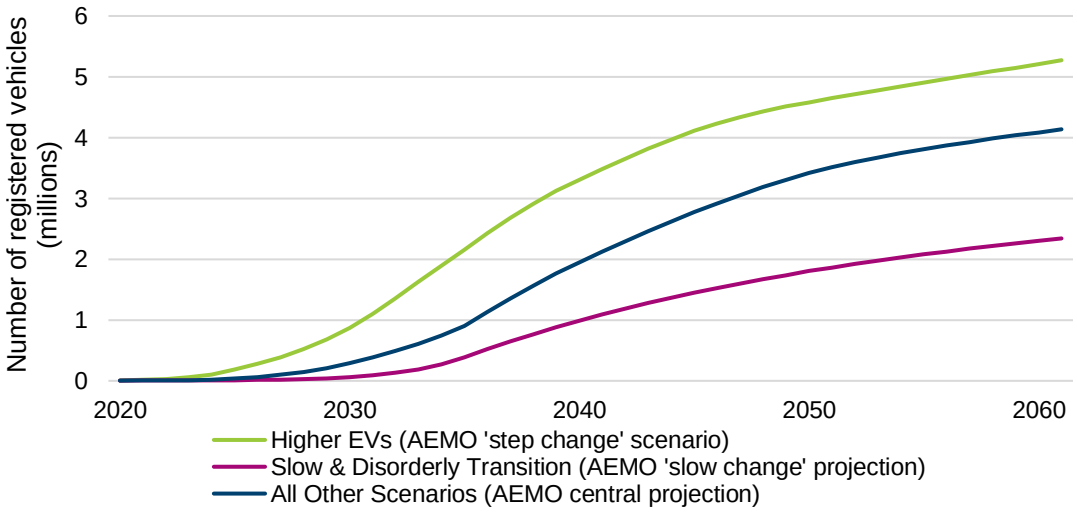
The uptake of electric vehicles is accelerating, with global sales increasing 40 per cent in 2019.[48] As part of their commitments to achieve net zero emissions by 2050, some countries have recently announced they will prohibit sales of petrol-fuelled vehicles in the coming decades, including the UK in 2030 and Japan in 2035,[49] two of the largest markets for right hand drive vehicles. The pace of transition in New South Wales will ultimately depend on whether and when prices become competitive with conventional vehicles, other technological advances such as improved range and faster charging, the availability of charging facilities, and potentially on the global supply of vehicles.

Any transition to electric vehicles will have a range of implications for the economy and governments. As noted in the NSW Review of Federal Financial Relations, fuel excise would no longer operate as a broad de facto road user charge and associated funding source, a consideration which has already resulted in the introduction of electric vehicle charges in Victoria and South Australia. Vehicle range and charging facilities are both more challenging and more critical in regional New South Wales due to the combination of lower population density and the number of longer journeys driven. Given uncertainty in how all these issues are ultimately resolved, modelling different uptake scenarios of electric vehicles will ensure the IGR is accounting for a range of economic, fiscal and policy development risks.

Projecting electric vehicle uptake

Projections of electric vehicle uptake to 2050 are sourced from the AEMO Integrated System Plan and extended for an additional ten years with reference to growth in the overall vehicle fleet and linear extension of trends regarding vehicle preference. Chart 11 outlines which AEMO scenario has been used for each scenario in this paper, along with the specific projections.

Chart 11 Projected number of light electric vehicles registered in NSW



Source: Australian Energy Market Operator; NSW Treasury.

[48] International Energy Agency, 'Global EV Outlook 2020'.
[49] Reuters, 'Japan May Ban Sale of New Gasoline-Powered Vehicles in Mid-2030s'.

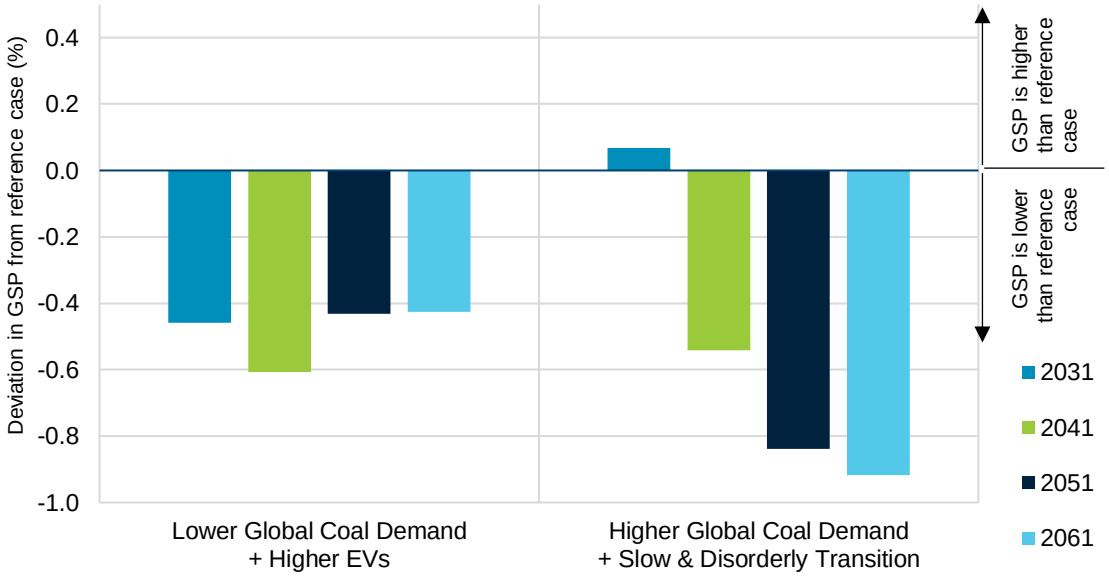
7. Economic and fiscal impacts of the broader energy transition

Impacts on Economic Output

The projected economic impacts of the broader energy transition scenarios produced by the CGE modelling are set out in Chart 12. Under the lower global coal demand + higher EVs scenario, economic growth is lower throughout the projection period than under the reference case and remains 0.4 per cent lower in 2061.

Under this scenario, higher uptake of electric vehicles significantly moderates the negative economic impacts of lower global coal demand. This is because electric vehicles are powered by domestically produced and relatively inexpensive electricity, rather than imported petrol. Under this scenario, the economy is projected to be 0.6 per cent below the reference case in 2041 (compared with 0.9 per cent without higher electric vehicles uptake). By 2061, the NSW economy is projected to be 0.4 per cent smaller than under the reference case, compared with 0.6 per cent smaller in the scenario with only lower coal demand.

Chart 12 The sensitivity of Gross State Product to the broader energy transition



Source: VURM and NSW Treasury

Under the slow and disorderly transition scenario, higher and more volatile electricity prices, combined with lower uptake of electric vehicles have a significant negative impact on economic growth, and result in growth being lower than under the reference case, despite higher global coal demand supporting higher coal production. These effects also build over time, as higher and more volatile electricity prices work their way through the economy. This scenario has the slowest economic growth of all scenarios by 2061, with GSP being 0.9 per cent below the reference case.

Fiscal Impacts

While the broader energy transition scenarios do not impact the fiscal position through direct impacts on specific revenue collections, they have an indirect impact through their effect on overall economic growth. Under the higher global coal demand scenario + slow and disorderly transition scenario, the fiscal gap is projected to be 0.08 per cent larger than under the reference case by 2061. As with the broader economic impacts, the effect of higher and more volatile electricity prices, and lower uptake of electric vehicles fully offset higher revenue from coal royalties. Under the lower global coal demand + higher EVs scenario, the fiscal gap is projected to be 0.10 per cent larger than under the reference case by 2061, with higher uptake of electric vehicles moderating, but not fully offsetting lower coal royalties revenue.

8. Discussion

Declining global coal demand will impact the economy and NSW budget

The NSW coal mining industry is primarily oriented around the export of thermal coal, which is used to generate electricity overseas. This means the future of the industry will be largely determined by global demand for this type of electricity generation, which in turn will be impacted by the cost of alternative electricity generation technologies as well as global policy settings. Since the 2016 New South Wales IGR there has been a significant shift in the outlook for the coal mining industry. Australia's top three thermal coal export markets have committed to achieving net zero emissions by the middle of the century, and the cost of renewable energy generation has fallen below the cost of new coal generation. There remains some uncertainty around the pace of the decline in global demand however, and this paper explores the potential for these differences to impact New South Wales' economic and fiscal outlook.

Declining global demand for NSW coal will impact employment in coal mining. Under the reference case, employment in coal mining is projected to decline by an average of 600 jobs per year for the next two decades, with many of these being relatively highly skilled positions. The NSW Budget will also be significantly impacted, with cumulative coal royalties revenue between 2021 and 2056[50] projected to be $38 billion (real 2019-20 dollars) lower under the reference case than that projected in the 2016 IGR.

Transition in energy generation more broadly presents both risks and opportunities

The modelling presented in this paper extends beyond just the coal mining sector to more comprehensively test the implications of the underlying assumptions regarding the broader energy transition. Global demand for NSW coal is largely outside the control of the NSW and Commonwealth Governments, but the broader energy transition will present a range of both risks and opportunities. Firstly, there would be significant economic costs under a slow and disorderly transition toward renewable energy. The modelling presented here indicates that the impact of higher and more volatile electricity prices could more than offset any economic benefits from higher coal production. Under this scenario, growth is projected to be the slowest of all scenarios, despite higher global coal demand. The fiscal outlook under this scenario is also roughly the same as under the lower global coal demand + higher electric vehicle uptake scenario, again despite significantly higher global demand for coal and associated royalties.

The modelling also projects economic benefits from higher uptake of electric vehicles. The benefits arise from electricity being produced within New South Wales to power electric vehicles, rather than importing energy from other states or from overseas, as is currently the case for motor vehicle fuel. Electricity is also cheaper than petrol per unit of energy.

[50] This was the final year of the 2016 IGR projection

Some factors are outside the scope of the modelling

This modelling has not accounted for the economic impact of potential future policy measures, such as changes in the tax treatment of electric vehicles. There are also opportunities in newer industries that have not been included in the modelling, for example the potential for New South Wales to increase exports of newer energy technologies such as hydrogen. The potential for the development of new industries are explored further in *NSW: A Clean Energy Superpower*, conducted by KPMG for the NSW Government.[51]

[51] NSW Department of Planning, Industry and Environment, *NSW Electricity Infrastructure Roadmap*.

9. Conclusion

The modelling presented in this paper is aimed at improving the quality of economic and fiscal projections in the 2021 NSW IGR through considering the potential impact of changes in global coal demand, and the broader transition in energy generation. This modelling constitutes an assessment of some of the key transitional risks of climate change and is accompanied by a separate paper focused on a selection of physical climate risks.[52] Together these papers provide an indication of the direction and scale of physical and transitional climate risks.

A key motivation for the modelling presented in this paper has been to understand how the future trajectory of coal production in New South Wales is likely to impact the NSW economy and budget. The NSW Government derives revenue directly from coal production hence the NSW IGR has always included projections of coal production. The scope of the paper is broader than this, however, to ensure that the impact of declining global coal demand is put in context of other risks associated with the broader transition in energy generation.

Broadening the scope beyond coal allows for a more robust and nuanced economic assessment of the future impacts of the energy transition. Overall, the results indicate that there are both risks and opportunities associated with the development of new, low emissions energy generation technologies. While it is clear the NSW Budget is sensitive to differences in global demand for coal, the modelling in this paper finds that a slow and disorderly transition to renewable energy could pose an even more significant risk to the fiscal outlook. Furthermore, the State's economy could benefit from higher electric vehicles uptake as they are powered by relatively cheap renewable electricity generated within the State, rather than imported and more expensive petrol.

The scenarios considered in this paper represent only some of the many potential futures for NSW and should not be considered comprehensive. The potential for new innovations or policy changes have not been modelled. The analysis in this paper will, however, assist in understanding the scale, drivers and consequences of the energy transition, and will therefore inform more robust economic and fiscal projections in the NSW IGR.

[52] NSW Treasury, 'An Indicative Assessment of Four Key Areas of Climate Risk for the NSW Intergenerational Report 2021'.

Technical Appendix

The Victoria University Regional Model (VURM) is used to produce a number of scenarios for the New South Wales and Rest of Australia (RoA) economies based on the inputs outlined in section 5. The first is a reference case. The remaining scenarios depart from the reference case in response to different assumptions relating to key energy variables in the NSW economy.

In this section, we briefly describe VURM, and then explain some of the key behavioural assumptions underlying the deviation scenarios. The section concludes with a short explanation of how the shocks are applied.

VURM

In the version of VURM used for the study, there are 83 industry sectors in two regions, New South Wales and the RoA. The latter region is an aggregation of the other five Australian states and the two territories.

Investment is allocated across industries to maximise rates of returns to investors (households, firms). Capital creators assemble, in a cost-minimizing manner, units of industry-specific capital for each industry. Each state has a single representative household and a state government. There is also a federal government. Finally, there are those overseas, whose behaviour is summarised by export demand curves for the products of each state and by supply curves for international imports to each state.

As is standard in CGE models, VURM determines the supply and demand for each regionally produced commodity as the outcome of optimising behaviour of economic agents. Regional industries choose labour, capital and land to maximize their profits while operating in a competitive market. In each region a representative household purchases a particular bundle of goods in accordance with the household's preferences, relative prices and its amount of disposable income.

Interregional trade, interregional migration and capital movements link each regional economy. Governments operate within a fiscal federal framework.

VURM provides results for economic variables on a year-on-year basis. The results for a particular year are used to update the database for the commencement of the next year. In particular, the model contains a series of equations that connect capital stocks to past-year capital stocks and net investment. Similarly, debt is linked to past and present borrowing/saving and regional population is related to natural growth and international and interstate migration. For a detailed description of the theoretical structure of the VURM model, see Adams, et al (2011).[53]

[53] Adams et al., 'MMRF: Monash Multi-Regional Forecasting Model: A Dynamic Multi-Regional Model of the Australian Economy'.

Key assumptions underlying the alternative scenarios

Labour markets

At the national level, lagged adjustment of the real-wage rate to changes in energy-related variables is assumed. These changes can cause employment to deviate from its reference value initially, but thereafter, real wage adjustment steadily eliminates the short-run employment consequences. This labour-market assumption reflects the idea that ultimately national employment is determined by demographic factors, which are unaffected by energy-related volumes and prices.

At the regional level, labour is assumed to be mobile between state economies. Labour is assumed to move between regions to maintain inter-state unemployment-rate differentials at their reference-case levels. Accordingly, regions that are relatively favourably affected by changes away from base in the energy sector will experience increases in their labour forces as well as in employment, at the expense of regions that are relatively less favourably affected.

Private consumption and investment

Private consumption expenditure is determined via a consumption function that links nominal consumption to household disposable income (HDI). In the alternative simulations, 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 different energy-related assumptions is accommodated by a change in domestic saving, leaving Australia's call on foreign savings unchanged.

Investment in all but a few industries is allowed to deviate from its reference-case value in line with deviations in expected rates of return on the industries' capital stocks. In the alternative 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.

Government consumption and fiscal balances

VURM contains no theory to explain changes in real public consumption. The primary fiscal modelling is conducted using NSW Treasury's Long-Term Fiscal Pressures model, which utilises the output from VURM as an input. In the VURM simulation, public consumption is simply indexed to nominal GDP. The fiscal balances of each jurisdiction (federal, state and territory) as a share of nominal GDP are allowed to vary relative to reference case values in line with projected changes in expenditure and income items.

Production technologies and household tastes

VURM contains many variables to allow for shifts in technology and household preferences. In the alternative scenarios, most of these variables are exogenous and have the same

values as in the reference case projection. The exceptions are technology variables, used to introduce shocks to the model.

Shocks

The deviation scenarios shift away from the Base case in response to three sets of shocks relating to:

1. Coal Production
2. Electricity generation, and
3. Electric vehicle uptake.

Coal production (and price)

Coal production is a naturally model-determined (endogenous) variable. To impose changes (away from reference case) in coal production, we reverse the natural setting of the model, by making production exogenous and a previously naturally user-determined (exogenous) variable endogenous. The latter is all-factor (labour, capital and land) technological progress in the coal industry. Thus, exogenous changes in coal production are imposed via model-determined shifts in the productivity of factors (labour, capital and land) used in coal production.

Fixing production *via* a supply-side shift causes the price of coal to move away from reference case values. These price movements will typically be quite large and require control. This is handled by making price exogenous *via* endogenous shifts in demand. The variable (previously exogenous) made endogenous is world demand for Australian coal. Thus, the model determines changes in world coal demand that are necessary to achieve a given path for coal price in an environment where coal production is also exogenous.

Electricity generation

Changes away from the reference case are imposed on sent-out generation shares by type (coal generation, gas generation, hydro generation and other renewable generation) and on wholesale electricity prices. These are imposed separately for New South Wales and the RoA.

Changes in generation mix are imposed *via* endogenous changes in retail demand. For example, in the slow transition case, coal generation is required to increase relative to reference case levels. This is achieved by model-determined shifts in retail demand towards coal generation and away from other forms of generation. The shares imposed are initially cost-neutral and so have no effect on the wholesale and retail prices of electricity. External estimates of changes in the average retail price of electricity in each region are introduced *via* model-determined changes in a miscellaneous other cost category in the model's retail electricity industries.

Electric vehicles uptake

In its current state of development, VURM does not explicitly recognise electric vehicles separately from internal-combustion vehicles. To model changes in the rate of electric vehicles uptake, we simply enforce changes in the mix of energy used by users of passenger and light-commercial vehicles. These users are the road-transport industries (excluding heavy-vehicle freight) and the household sector.

The changes in fuel mix are constrained to be energy-neutral in the sense that 1 Pj of electricity replaces 1 Pj of petroleum product. However, they are not necessarily cost-neutral because 1 Pj of electricity for vehicle power is less expensive that 1 Pj of petroleum.

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