Energy Efficiency Forecasts 2021 – Final Report

Prepared for:	**Australian Energy Markets Operator**
Date:	**22 July 2021**

Revision History					
Rev No.	Description	Prepared by	Reviewed by	Authorised by	Date
00	Draft Report (WIP)	PH			14/5/2021
01	Exposure Draft Final Report	PH,BJ	PH,BJ	PH	26/5/2021
02	Final Report	PH,BJ	PH,BJ	PH	13/7/2021
03	Final Report rev.	PH	PH	PH	22/7/2021

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Executive Summary

2021 energy efficiency forecasts show modest increases in projected savings for the residential sector, compared to those produced in 2020, but significantly lower savings for the Business Mass Market (BMM) sector.

In the residential sector, major national policy settings have been largely static over the last decade, but there have been some increases in state energy efficiency targets and budget measures. In addition, we forecast market-led or autonomous energy efficiency improvement (AEEI) this year for the first time. We expect rising gas savings over time, relative to electricity savings, reflecting fuel switching towards electricity from both market influences (eg, more use of heat pumps for space conditioning) and policy influences.

In the BMM sector (which comprises both commercial and industrial energy users, excluding large industrial loads), efficiency forecasts are lower than in past years, primarily as we find that the rate of efficiency improvement appears to have slowed over the last decade, at least in BMM Commercial. While this trend requires further analysis to fully explain, it is expected to reflect a combination of market influences – such as longer trading/operating hours and more persons per floor – although these effects will have been counteracted to some degree by some clear efficiency improvements, notably LED lighting. On the policy side, there were no new energy performance standards for non-residential buildings during the past decade (after BCA2010, which took effect by at least 2012), and there is a literature regarding the 'performance gap', or non-realisation of expected Code savings. In addition, there have been ongoing delays in the implementation of new standards and labelling initiatives under the GEMS program, and some measures (eg, for standards for fluorescent lighting and ballasts) have been overtaken by market changes. Further, we note in this report a reduction in savings from the Commercial Building Disclosure program, and a levelling off in the take-up and savings rates for NABERS Energy for Offices. State energy savings targets have generally increased at a modest rate over the last decade, but NSW targets have been constant in recent years – albeit that they are now projected to increase to 2030, and the scheme itself has been extended to 2050.

In the small and medium sized industrial sector (BMM Industrial), efficiency trends cannot be established with confidence due to data limitations that are primarily related to confidentiality. In addition, AEMO's segmentation of BMM by enterprise energy demand (ie. 10 MW for at least 10% of the year) means that energy consumption and economic value of output data, which are organised on the ANZSIC frame, cannot easily be aligned. Overall, policy-induced electricity and gas savings are forecast to be modest in scale in BMM Industrial, and much lower than in BMM Commercial. This reflects the paucity of policy measures in the industrial sector, despite its high energy use, together with the fact that some of the policy savings will accrue to large industrial loads, not represented in these forecasts.

While the conceptual approach to forecasting this year represented an enhancement on past years, due to explicit modelling of total energy efficiency change and of autonomous energy efficiency improvement, the extent of data challenges was greater, and more limiting on the conclusions, than expected. In principle, it should be feasible to establish the total change in energy efficiency at the sectoral (or sub-sectoral) level with reasonable precision. However, diverging electricity consumption data series make this unexpectedly challenging. In addition, data on gas consumption is only available from one source – Australian Energy Statistics. Also, AEMO's market segmentation – while important for operational requirements – does not align with statistical data sources.

An overall conclusion from the 2021 analysis is that there appears to be a case for AEMO to regularly forecast market-led or autonomous energy efficiency improvement (AEEI), as policy impacts only explain part of the total efficiency change. Also, measuring total efficiency change, and then apportioning this into policy-induced and market-led segments, is an effective way of ensuring that neither savings element is over-estimated. That said, quantitative analysis of market-led efficiency change would require more detailed analysis of efficiency trends at the sub-sectoral and end-use levels, and practically this work would have to be done outside the annual forecasting cycle. While this report represents quantitative estimates and projections of AEEI, it is important to note that these are associated with much higher uncertainty than are our estimates and projections of policy-induced savings.

For the policy-induced component of efficiency change, independent evaluations of major efficiency measures, with a brief to quantify additionality to other policy measures and to AEEI, would assist in overcoming uncertainties. For the NCC, key questions such as the apparent non-realisation of modelled savings, or the 'performance gap', may require the collection of audit-based data.

For GEMS, and as discussed at the Energy Efficiency Workshop in March, a key element of a retrospective analysis would be to ensure that the current (and projected future) impact of individual GEMS measures is placed onto a single and internally-consistent conceptual basis – either adjusting for discrepancies between past RIS assumptions and the subsequent reality, or else abandoning those sources entirely and creating a new and consistent 'without policy' counterfactual scenario – including AEEI – against which to quantify incremental energy savings.

Most of the significant uncertainties noted in this report relate to data limitations. In some cases, these are program reporting issues that could at least potentially be addressed by program managers and/or reporting agencies (eg, ESC in Victoria, IPART in NSW). This could extend, for example, to unambiguous statements of annualised energy savings by fuel and sector from state energy savings schemes, in particular for schemes that use carbon metrics, as this entails an additional layer of interpolation between targets and energy savings impacts. We also note difficulties in aligning AEMO's observation of heating/ cooling and baseload load splits (based on meter data) with direct observation of household energy use patterns and the thermal energy requirements calculated by CSIRO that underpin NatHERS.

Further, we note above that VEU already – and no doubt ESS and REPS in future – and even other measures such as NCC or GEMS provisions – may move increasingly away from simple 'energy savings' impacts towards impacts that are more subtle and complex. These may include fuel switching (potentially in favour of, as well as away from, gas) and various kinds of demand management, with effects on annual energy consumption that may be ambiguous, if they are not carefully monitored and reported.

We recommend that AEMO:

1. Engages with the Dept of Industry, Science, Energy and Resources (with respect to *Australian Energy Statistics* and the *National Greenhouse and Energy Reporting* system), and with the Australian Energy Regulator (with respect to RIN data), to seek to reconcile energy consumption data, and potentially to align data sources and constructs.
2. Considers whether a change to its market segmentation would be feasible, to support greater alignment with data sources based on the ANZSIC frame.
3. Encourages or commissions additional research, outside the annual forecasting process, on *total* energy efficiency change, particularly in the BMM Commercial sector (but also Industrial, if data challenges can be overcome), seeking to clarify not only the total change (informed by recommendation 1 above) but also the separate contributions of market-led and policy-induced components.
4. Encourages more transparent program impact reporting, including explicit statements of annual energy savings impacts by fuel and market segment.
5. Encourages governments to commission independent evaluations of key policy measures, including the NCC energy performance requirements and GEMS, with a particular focus on the realisation of expected savings and on additionality to market-led efficiency change.

1. Introduction

1.1 Purpose

This Report presents 2021 annual forecasts of energy efficiency savings, or avoided consumption, by region, fuel and load type, for the residential and business mass market (commercial and industrial sectors), to FY2053. It also provides:

- a recap of the scope of policy measures included
- estimates of market-led or autonomous energy efficiency improvement (AEEI)
- a description of the methodology used for the forecasts
- a description of risks and uncertainties associated with the forecasts
- insights into key themes and trends affecting energy efficiency
- strategies used to improve future forecasts.

1.2 Background

This project has been undertaken for the Australian Energy Markets Operator (AEMO). AEMO is an independent organisation responsible for operating eastern, south-eastern and western energy markets and systems in accordance with the National Electricity Rules, Wholesale Electricity Market (WEM) Rules, National Gas Rules, Wholesale Electricity Market Rules and Gas Services Information Rules. Its functions include:

- market and system operator of the National Electricity Market
- market and system operator of the Wholesale Electricity Market in Western Australia
- market and system operator of the Victorian wholesale gas market
- operator of the short-term trading market (wholesale) for gas hubs in Sydney, Adelaide and Brisbane
- operator of the Wallumbilla gas supply hub (wholesale)
- market operator of retail gas markets in New South Wales, the Australian Capital Territory, Queensland, South Australia, Victoria, and Western Australia
- national transmission planning for electricity transmission networks.

The context for the current project is AEMO's (annual) preparation of electricity and gas Statements of Opportunity (SOO). The SOO documents represent key planning references for the electricity and gas sectors in Australia, setting out demand and energy consumption expectations under a range of plausible scenarios and by sector and region. This information assists market participants and other parties to plan investment, capacity, demand management and other strategies, with the aim of ensuring secure, reliable and affordable energy supplies.

1.3 Scope

The forecasts cover the NEM regions and the South-Western Interconnected System (SWIS) in WA, but exclude the Northern Territory.

1.4 Definitions/Glossary

Term	Definition
Energy efficiency	The amount of energy used per unit of useful work/output. In this project, we distinguish total efficiency market-led and policy-led efficiency. The energy efficiency savings quantified represent 'avoided consumption', or consumption that would have occurred if not for the improvement in energy efficiency. Note that for the historical period, and by definition, avoided energy consumption is already captured in metered consumption data.
Total energy efficiency	At the sectoral or sub-sectoral level, the overall change in energy consumption per unit of useful work/output. By definition, total efficiency change is equal to the sum of market-led and policy-led efficiency. See Chapter 3 for further specification at the sectoral/sub-sectoral level.
Market-led energy efficiency	The fraction of total change in energy efficiency over time that would have been (in the past) or is (in the future) expected to occur in the absence of any of the policy measures noted, including due to autonomous technology change, responses to energy and factor prices, and changing preferences.
Policy-led energy efficiency	The fraction of total change in energy efficiency over time that is attributable to specific policy measures. Note that policy-led or policy-induced savings are rarely the same as those reported in policy/program statistics, due to the need to account for non-additionality between specific policy measures, and also between policy measures as a whole and market-led efficiency change.
Additionality/ non-additionality	Energy savings are only attributed to a measure (or effect) to the extent that it can be established that they are *additional* to those that would have occurred in the absence of the measure or effect. The portion of claimed savings that cannot be established as additional are known as 'non-additional'.

Note that savings are presented by financial year.

2. Methodology and Process

2.1 Policy Review

The project commenced with a web-based review of current policy measures and Budget announcements in each jurisdiction, and then followed up with phone calls to representatives of key agencies. SPR and Watt Advocacy & Communications contacted representatives of the following organisations over the period 12 to 26 February 2021.

Table 1: Agencies Directly Contacted

Jurisdiction	Agency	Measure(s)
Federal	Australian Renewable Energy Agency	Energy efficiency projects
	Clean Energy Finance Corporation	Energy efficiency projects
	Clean Energy Regulator	Emissions Reduction Fund – energy efficiency methods
	Department of Prime Minister & Cabinet	National energy policy
	Department of Industry, Science, Energy and Resources	Residential and business mass market energy efficiency policies and programs
Australian Capital Territory	Environment, Planning and Sustainable Development Directorate	Energy Efficiency Improvement Scheme
New South Wales	Department of Planning, Industry and Environment	Energy Security Safeguard including the Energy Savings Scheme and the Peak Demand Reduction Scheme
South Australia	Department of Energy and Mining	Retailer Energy Productivity Scheme
	Essential Services Commission of South Australia	Retailer Energy Efficiency Scheme
Victoria	Department of Environment, Land, Water and Planning	Victorian Energy Upgrades Residential and business mass market energy efficiency measures
	Department of Treasury and Finance	Government energy efficiency upgrades Social housing energy efficiency upgrades
	Solar Victoria	Solar hot water rebates

The purpose of these calls was to seek to:

- verify the materiality of energy efficiency savings (particularly within measures that target multiple outcomes, such as ERF, CEFC, ARENA and others

- discover or verify any recent or intended near-future changes to measures
- discover relevant data sources for documenting program impacts.

We note that all agencies contacted were extremely helpful, and many were able to share data and/or reports on a confidential basis to assist in this research, as indeed many do annually. For larger agencies, up to three or four different meetings were held with different program managers. We acknowledge and express our gratitude for all these contributions.

2.1.1 Application of AEMO Criteria

The following criteria were identified by AEMO In assessing which efficiency policies and measures should be included within the forecasts. These derive from the National Energy Rules, v156, NER 5.22.3b):

- A commitment has been made in an international agreement to implement that policy
- That policy has been enacted in legislation
- There is a regulatory obligation in relation to that policy
- There is material funding allocated to that policy in a budget of the relevant participating jurisdiction, *or*
- The Ministerial Council of Energy (MCE) has advised AEMO to incorporate the policy.

AEMO noted that MCE (or Energy Ministers) have not advised them to incorporate any particular policies. Few international agreements specifically refer to domestic policy measures, and we are not aware of any such measures in the energy efficiency field. Legislation and regulation are straight-forward criteria to apply, at least once a measure is fully established. Therefore, only the 'material funding' criterion requires more interpretation.

AEMO does not have a formal definition of 'material' in this context. We have taken into account:

- the amount of funding (per year)
- the duration/certainty of funding
- the size of funding *relative* to the size of the jurisdiction and the sub-sector or end-use targeted.

For example, $100 million of energy efficiency funding is *relatively* more significant in Tasmania than in New South Wales, due to the smaller number of energy-using entities in the former. In the case of the ACT, where there are significant measures in place relative to the size of the jurisdiction, we note that this forms only a small part of the NSW NEM region, therefore the materiality of energy savings have been assessed relative to the NSW jurisdiction.

Also, for any given jurisdiction, we consider the size of the sector, sub-sector or end-use targeted (eg, $100m in energy efficiency funding for upgrading hot water systems in social housing, particularly in smaller jurisdictions, could lead to a *large* change in the total energy efficiency of hot water generation, albeit only within this sub-sector and end-use. However, in the latter case, there would be no presumption that more energy is saved in *total,* compared to a scenario in which the same funding allowed to reach the most cost-effective efficiency opportunities, regardless of sector or end-use.

2.1.2 Measures Table

Reflecting AEMO's criteria, as above; we applied web-based research and direct consultations in reviewing 60 strategies (groups of measures) and individual measures with the potential to impact residential, business and other large industrial load energy users (LILs). This phase was led by Watt Advocacy & Communications. Details for each measure are set out in Table 3 overleaf. Of these, 16 were modelled in this project, as summarised in Table 2.

Table 2: Measures for Inclusion in Forecasts

Jurisdiction	Name of Measure
Federal	Emissions Reduction Fund (Climate Solutions Package)
Federal	Greenhouse and Energy Minimum Standards (GEMS)/Equipment Energy Efficiency Program (E3)
Federal	Building energy performance requirements: National Construction Code 2019 (NCC), incl. NatHERS and BASIX
Federal	NABERS
Federal	Commercial Building Disclosure (CBD)
Federal	Clean Energy Finance Corporation (CEFC)
NSW	NSW Energy Savings Scheme (ESS) (as part of the NSW Energy Security Safeguard)
VIC	Victorian Energy Upgrades (VEU)
VIC	Energy Efficient Heating and Cooling (Victoria's Household Energy Savings Package)
VIC	Energy Efficient Social Housing (Victoria's Household Energy Savings Package)
VIC	Minimum EE standards for rented homes (Victoria's Household Energy Savings Package)
VIC	Solar Hot Water Rebate
VIC	Big Build: Public/Social Housing
VIC	Business Recovery Energy Efficiency Fund (BREEF)
VIC	Greener Government Buildings
SA	Retailer Energy Productivity Scheme (REPS) (formerly REES)

The primary reasons why certain measures were not included in the draft forecasts are:

- a lack of demonstrated/realised energy efficiency savings. Note that this can occur for different reasons including:
  - the primary focus of a measure is something other energy efficiency, even if there may be some efficiency impacts as a by-product
  - a measure may new with no demonstrated track record of savings as yet
  - information/advisory measures are not included (in the absence of independent evaluations demonstrating material impact)

Table 3: Policy Review Summary

Juris-diction	Name of Measure	Description	Criterion	Sectors	Include?	Rationale?
Federal	2030 Emissions Reduction Target	Australia has committed to reducing its greenhouse gas emissions by 26 to 28 per cent below 2005 levels by 2030.	International Agreement	Residential, Business mass market, Large Industrial Loads (LILs)	NO	Individual measures to meet Australia's 2030 Target have been assessed including the Emissions Reduction Fund, the Climate Solutions Package and the National Energy Productivity Plan
Federal	National Energy Productivity Plan (NEPP)	The National Energy Productivity Plan (NEPP) provides a framework and an initial economy-wide work plan designed to accelerate action to deliver a 40 per cent improvement in Australia's energy productivity by 2030. In better coordinating energy efficiency, energy market reform and climate policy, it brings together new and existing measures from across COAG's work program, as well as from the Commonwealth and industry.	Budget	Residential, Business mass market, LILs	NO	Individual measures under the NEPP have been assessed
Federal	Climate Solutions Package	The Climate Solutions Package provides an additional $3.5 billion investment to deliver on Australia's 2030 Paris Agreement commitments, building on existing climate change mitigation policies and programs. The Package includes: - the Climate Solutions Fund, a $2 billion investment to build on the Emissions Reduction Fund (ERF) and continue investment in low cost abatement - support for a range of new energy efficiency measures for homes, businesses and community organisations.	Budget	Residential, Business mass market, LILs	NO	Individual measures under the Climate Solutions Package have been assessed
Federal	Emissions Reduction Fund (Climate Solutions Package)	The Emissions Reduction Fund (ERF) incentivises Australian businesses to cut the amount of greenhouse gases they create and to undertake activities that store carbon. The ERF includes seven energy efficiency methods covering residential, business mass market and industrial sectors. These methods include fuel switching activities.	Legislation	Residential, Business mass market, LILs	YES	Material energy efficiency savings
Federal	Technology Investment Roadmap and first Low Emissions Technology Statement	The Technology Investment Roadmap is a strategy to accelerate development and commercialisation of low emissions technologies. Enabling technologies include infrastructure, like charging and refuelling stations, energy management systems, digital infrastructure, energy efficiency, and market design activities required to overcome the challenges and realise the opportunities for priority low emissions technologies. The Roadmap assumes that fuel switching to electricity or low emissions alternatives (e.g. hydrogen or biomass) will present opportunities to reduce emissions.	Budget	Business mass market, LILs	NO	The Technology Co-Investment Fund has been assessed as a measure under the Technology Investment Roadmap
Federal	Technology Co-Investment Fund (Technology Investment Roadmap)	The Technology Co-Investment Fund will address barriers to industry uptake of energy efficiency and create the enabling environment for low emissions technology investments by the private sector. It includes funding from the 2020 Budget for feasibility studies into energy efficiency opportunities for industry, administered by the Australian Renewable Energy Agency (ARENA).	Budget	Business mass market, LILs	NO	No current or proposed material measures

Juris-diction	Name of Measure	Description	Criterion	Sectors	Include?	Rationale?
Federal	Greenhouse and Energy Minimum Standards (GEMS)/Equipment Energy Efficiency Program (E3) (NEPP)	The Greenhouse and Energy Minimum Standards (GEMS) is a national framework for appliances and equipment energy efficiency in Australia. The Equipment Energy Efficiency (E3) Program is a cross jurisdictional program through which the Australian Government and state and territory governments and the New Zealand Government collaborate to deliver a single, integrated program on energy efficiency standards and energy labelling for equipment and appliances. The Minimum Energy Performance Standards (MEPS) under the E3 program seek to address problems relating to lack of information on the energy performance of appliances and equipment and incentives that may result in poor energy efficiency choices.	Legislation	Residential, Business mass market	YES	Material energy efficiency savings
Federal	Building energy performance requirements: National Construction Code 2019 (NCC)/Nationwide House Energy Rating Scheme (NatHERS) (NEPP)	The Australian Government is working with states and territories to implement minimum energy performance requirements for new buildings and major refurbishment. The National Construction Code (NCC) includes energy efficiency measures for all building classifications. The Nationwide House Energy Rating Scheme (NatHERS) is a star rating system (out of ten) that rates the energy efficiency of a home, based on its design. BASIX is the pathway for compliance with the NCC in New South Wales. Energy efficiency savings may be tempered by fuel switching from gas to electricity fuel for space heating.	Regulation	Residential, Business mass market	YES	Material energy efficiency savings
Federal	National Residential Scorecard trial (NEPP)	In 2018-19, COAG's Energy Council provided funding to pilot a national version of the Victorian Residential Efficiency Scorecard (Scorecard) tool in capital cities (Adelaide, Brisbane, Canberra, Hobart, Perth and Sydney). A customised version of the Scorecard was developed for tropical climate zones across northern Australia. It was adjusted to include key features that are important to tropical housing design, such as ventilation, shading, roof colour and ceiling fans. Further work is underway to extend NatHERS to existing homes, building upon the pilots and the Victorian Scorecard.	Budget	Residential	NO	No material energy efficiency savings
Federal	Energy Efficiency in Government Operations (EEGO) (NEPP)	Energy efficiency improvements in government office buildings are committed to by both building owners and government tenants through the use of Green Lease Schedules (GLS). This includes minimum energy performance standards.	Budget	Business mass market	NO	No material energy efficiency savings
Federal	NABERS (NEPP)	NABERS (National Australian Built Environment Rating System) provides simple, reliable, and comparable sustainability measurement across building sectors like hotels, shopping centres, apartments, offices and data centres. NABERS provides a rating from one to six stars for building efficiency across energy, water, waste and the indoor environment.	Legislation	Business mass market	YES	Material energy efficiency savings
Federal	Commercial Building Disclosure (CBD) (NEPP)	The Commercial Building Disclosure (CBD) program requires sellers and lessors of large commercial office spaces to provide energy efficiency information to prospective buyers and tenants. This creates a more informed commercial property market and encourages more energy efficient buildings and reduced emissions. NABERS is used in the CBD program.	Legislation	Business mass market	YES	Material energy efficiency savings
Federal	National Green Leasing Policy (NEPP)	The National Green Leasing Policy is the first nationally consistent approach by the Australian Government and state and territory governments, as tenants of buildings, to drive a reduction in the environmental impact of buildings through improved operational performance. It contains green leasing principles to guide governments.	Budget	Business mass market	NO	No material energy efficiency savings

Juris-diction	Name of Measure	Description	Criterion	Sectors	Include?	Rationale?
Federal	Business Energy Advice Program (BEAP) (Climate Solutions Package)	The $11.7 million Business Energy Advice Program (BEAP) delivers advice to help small businesses and their representatives get better energy deals and increase their energy efficiency.	Budget	Business mass market, LILs	NO	Scale of energy efficiency savings not expected to meet AEMO criteria
Federal	Trajectory for Low Energy Buildings (NEPP)	The Trajectory for Low Energy Buildings is a national plan that aims to achieve zero energy and carbon-ready commercial and residential buildings in Australia. This involves implementing cost effective increases to the energy efficiency provisions in the National Construction Code (NCC) for residential and commercial buildings from 2022.	Budget	Residential, Business mass market	NO	Individual measures are assessed separately
Federal	Energy Efficient Communities Program (Climate Solutions Package)	The Energy Efficient Communities Program will deliver $40 million in grants to help businesses and community groups lower their energy bills and reduce emissions. (Business and Communities Streams).	Budget	Business mass market, LILs	NO	Program underway: no evidence of material energy efficiency savings yet
Federal	Hotel Energy Uplift Program	The Hotel Energy Uplift Program will deliver $10.2 million in grants to help small and medium hotels reduce their energy use, improve energy productivity and deliver carbon abatement.	Budget	Business mass market	NO	Program underway: no evidence of material energy efficiency savings yet
Federal	Australian Renewable Energy Agency (ARENA) (Climate Solutions Package)	Energy efficiency does not fit within the current ARENA Act mandate. To date, ARENA has had a minor focus on energy efficiency, which has been an incidental outcome to renewable energy projects.	Legislation	Business mass market, LILs	NO	Scale of energy efficiency savings not expected to meet AEMO criteria
Federal	Clean Energy Finance Corporation (CEFC) (Climate Solutions Package)	The Clean Energy Finance Corporation invests in energy efficiency, electrification and fuel switching projects in the business mass market and industrial sectors.	Legislation	Residential, Business mass market, LILs	YES	Material energy efficiency savings
Federal	Energy Efficiency Opportunities (EEO) Program	The Energy Efficiency Opportunities (EEO) program was designed to improve the identification and evaluation of energy efficiency opportunities by large energy-using corporations and, as a result, encourage implementation of cost-effective energy efficiency opportunities. Companies were required to conduct rigorous assessments of their energy use and publicly report on assessment outcomes.	Legislation	Business mass market, LILs	NO	Historical measure: closed in 2014
Federal	Home Insulation Program	The Home Insulation Program provided funding for residential ceiling insulation.	Legislation	Residential	NO	Historical measure: closed in 2014
Federal	Community Energy Efficiency Program (CEEP)	The Community Energy Efficiency Program (CEEP) was a grant program that provided co-funding to local governing bodies and non-profit community organisations to implement projects that delivered a range of energy efficiency measures in council and community owned buildings, facilities and sites; particularly where this would benefit low socio-economic and other disadvantaged communities or support energy efficiency in regional and rural councils. The program closed on 30 June 2016. $96.3 million was paid in grant funding and 153 projects were completed.	Budget	Business mass market	NO	Historical measure: closed in 2016

Juris-diction	Name of Measure	Description	Criterion	Sectors	Include?	Rationale?
Federal	Energy Efficiency Information Grants (EEIG)	The Energy Efficiency Information Grants (EEIG) program assisted industry associations and non-profits to provide practical, tailored energy efficiency information to small and medium enterprises (SMEs) and community organisations, allowing them to make informed decisions about energy efficiency, and thereby reduce their operational costs. Across 2 funding rounds, 46 recipients received a total of $33.2 million. The program closed on 30 June 2015.	Budget	Business mass market	NO	Historical measure: closed in 2015
Federal	Local Government Energy Efficiency Program (LGEEP)	The Local Government Energy Efficiency Program (LGEEP) provided financial assistance to local governments for the installation of solar and heat pump hot water systems in community buildings and facilities, particularly where those authorities were situated in low socio-economic or otherwise disadvantaged areas. Grants were awarded to 214 local councils for a total of $6.7 million. The program closed on 30 June 2014.	Budget	Business mass market	NO	Historical measure: closed in 2014
Federal	Low Income Energy Efficiency Program (LIEEP)	The Low Income Energy Efficiency Program (LIEEP) was a grant program established to provide grants to government, business and community organisations to trial approaches to improve the energy efficiency of low income households and enable them to better manage their energy use. Across two funding rounds, 20 recipients were successful in securing grants worth a total of $55.3 million. The program closed on 30 June 2016.	Budget	Residential, Business mass market	NO	Historical measure: closed in 2016
Federal	Renewable Energy Bonus Scheme (REBS) - Solar Hot Water Rebate	Under the Renewable Energy Bonus Scheme (REBS), over 255,000 rebates totalling $323 million was provided to eligible home-owners, landlords or tenants replace electric storage hot water systems with solar or heat pump hot water systems. Eligible households could claim a rebate of $1,000 for a solar hot water system or $600 for a heat pump hot water system. The program closed in 2012.	Budget	Residential	NO	Historical measure: closed in 2012
NSW	NSW Energy Savings Scheme (ESS) (NSW Energy Security Safeguard)	The NSW Energy Savings Scheme (ESS) reduces energy consumption by creating financial incentives for organisations to invest in energy savings projects. Energy savings are achieved by installing, improving or replacing energy savings equipment. From 2021, the Scheme's targets will extend to 2030 and it will cover a wider range of activities that reduce demand on electricity and gas networks. In line with the NSW Government's aspirations to achieve net zero emissions by 2050, the Safeguard could also include switching from high-emission fuels such as onsite diesel to cleaner alternatives if the activity increases the efficiency of the overall energy consumption at the site, and does not increase greenhouse gas emissions.	Legislation	Residential, Business mass market, LILs	YES	Material energy efficiency savings
NSW	Peak Demand Reduction Scheme (NSW Energy Security Safeguard)	The NSW Peak Demand Reduction Scheme is a market-based certificate scheme to encourage peak demand reduction. The Scheme will increase the capacity to reduce demand at times when electricity spot prices are high or there is a supply–demand imbalance.	Budget	Residential, Business mass market, LILs	NO	Scale of energy efficiency savings not expected to meet AEMO criteria
NSW	BASIX assessment tool	BASIX (The Building Sustainability Index) is a NSW Government planning requirement that affects anyone submitting a Building Application for a new house, alteration, addition, villa, townhouse, unit, swimming pool or outdoor spa.	Legislation	Residential	NO	Assessed as part of national building energy efficiency regulations (NCC/NatHERS)
QLD	Affordable Energy Plan	From 1 January 2018, more than $300 million of initiatives were rolled out to make electricity more affordable for Queensland residential and business customers under the Affordable Energy Plan.	Budget	Residential, Business mass market	NO	Individual measures under the Affordable Energy Plan have been assessed
QLD	Business Energy Savers Program	The Queensland Business Energy Savers Program provided free energy audits and advice for agricultural customers and large business customers, and co-contributions to fund energy-efficiency upgrades. This program has closed.	Budget	Business mass market, LILs	NO	Historical measure

Juris-diction	Name of Measure	Description	Criterion	Sectors	Include?	Rationale?
	(Affordable Energy Plan)					
QLD	Energy Efficient Appliance Rebate (Affordable Energy Plan)	The $20 million Energy Efficient Appliance Rebate scheme offered rebates for eligible purchases from 1 January to 3 June 2018. Air conditioners, fridges and washing machines with a minimum 4 star energy efficiency rating were eligible for a rebate of up to $300. This program has closed.	Budget	Residential	NO	Historical measure
QLD	Energy Savvy Families (Affordable Energy Plan)	The Queensland Government provided digital meters to 4,000 eligible low-income families in regional Queensland to help them gain a greater understanding of when and how they use their electricity. This program has closed.	Budget	Residential	NO	Historical measure
VIC	Victorian Energy Upgrades (VEU) (Energy Efficiency and Productivity Strategy)	The Victorian Energy Upgrades (VEU) program helps businesses and households cut power bills and reduce greenhouse gas emissions. It does this by providing access to discounted energy-efficient products and services. Targets are legislated to 2025. 50 per cent of the 2025 target is expected to be achieved through fuel switching activities.	Budget	Residential, Business mass market, LILs	YES	Material energy efficiency savings
VIC	Energy Efficient Heating and Cooling (Victoria's Household Energy Savings Package)	The Victorian Government is investing $335.5 million over four years to provide efficient, lower cost heating and cooling for 250,000 low income and vulnerable households. The program will provide a base rebate of $1,000 towards the cost of installing high efficiency heating and cooling (average cost $1,700). Rebates and grants will be provided by Solar Victoria to help households install high-efficiency reverse cycle air conditioners, replacing inefficient heaters (including gas heaters). Some upgrades may also be eligible for a Victorian Energy Upgrade incentive.	Budget	Residential	YES	Material energy efficiency savings
VIC	Energy Efficient Social Housing (Victoria's Household Energy Savings Package)	The Victorian Government is investing $112 million to improve the energy efficiency of 35,000 social housing properties. The program will focus on improving the efficiency of appliances and thermal performance. The upgrades will include insulation and draught sealing and installing energy efficient appliances, such as heating and hot water systems, to save on bills and make homes more comfortable. This includes grants for community housing providers.	Budget	Residential	YES	Material energy efficiency savings
VIC	Improving EE standards for new homes (Victoria's Household Energy Savings Package)	The Victorian Government is investing $5.9 million to introduce a new 7-star energy efficiency standard for new homes, delivering more comfortable homes with lower running costs while reducing energy demand and emissions.	Budget	Residential	NO	Assessed as part of national building energy efficiency regulations (NCC/NatHERS)
VIC	Minimum EE standards for rented homes (Victoria's Household Energy Savings Package)	New minimum energy efficiency standards will be introduced for rental properties that will reduce costs and improve comfort for residents. This includes improving standards for heating, ceiling insulation and hot water systems. The new standards are expected to benefit Victorian renters living in around 350,000 older properties who currently struggle with high energy costs and homes that are hard to keep warm or cool.	Budget	Residential	YES	Material energy efficiency savings
VIC	Energy Savvy Upgrades (formerly the Affordable Retrofits program under Home Energy Assist Program) (Energy Efficiency and	The Energy Savvy Upgrades program will partner with community organisations to offer subsidised energy efficiency and renewable energy upgrades to a limited number of households struggling to pay energy bills for reasons like living on a low income, living with a chronic or ongoing medical condition or mobility issues, caring for family members or loss of employment.	Budget	Residential	NO	Scale of energy efficiency savings not expected to meet AEMO criteria

Juris-diction	Name of Measure	Description	Criterion	Sectors	Include?	Rationale?
	Productivity Strategy)					
VIC	Healthy Homes Program (under the Home Energy Assist Program) (Energy Efficiency and Productivity Strategy)	The Healthy Homes Program provides free home energy upgrades to up to 1,000 Victorians who live with complex healthcare needs and have low incomes, in Melbourne's western suburbs and the Goulburn Valley.	Budget	Residential	NO	Scale of energy efficiency savings not expected to meet AEMO criteria
VIC	Solar Hot Water Rebate	Solar Victoria provides a rebate of up to $1,000 on solar hot water systems. On average, households that install solar hot water systems can expect to save between $140 to $400 per year on their electricity bills. The Solar Homes output will provide 770,000 households over 10 years with either solar panel energy systems, solar hot water systems, or battery storage for homes with existing solar energy systems. Properties that are connected to reticulated natural gas, without solar PV greater than 2.5kW, can only install gas-booster solar hot water systems.	Budget	Residential	YES	Material energy efficiency savings
VIC	EnergySmart Public Housing Project	The Department of Health and Human Services has delivered energy efficiency upgrades to 1,500 public housing properties across the state.	Budget	Residential	NO	Historical measure
VIC	Big Build: Public/Social Housing	The $5.3 billion Big Housing Build will construct more than 12,000 new homes throughout metro and regional Victoria. The new homes will meet 7-star energy efficiency standards, making them more comfortable during summer and winter, and saving tenants on their power bills.	Budget	Residential	YES	Material energy efficiency savings
VIC	Business Recovery Energy Efficiency Fund (BREEF)	The $31 million Business Recovery Energy Efficiency Fund (BREEF) provides simultaneous grant funding to businesses for both capital works and energy demand management technologies. The program aims to: - increase energy productivity and reduce energy costs for Victoria's large energy users - accelerate the uptake of innovative energy efficiency and demand management technologies in the Victorian industrial and commercial sectors and participation in demand-side opportunities. Projects may include the installation of energy efficient equipment, replacing emissions-intensive equipment with low-emissions alternatives, including switching from natural gas to biogas or electric alternatives, and the purchase of communications and monitoring technology to reduce energy use at a site.	Budget	Business mass market, LILs	YES	Material energy efficiency savings
VIC	Hospital Energy Efficiency Upgrades	The Victorian Government provided $40 million to improve energy efficiency in public hospitals with solar power and high-efficiency LED lighting.	Budget	Business mass market	NO	Policy settings currently under development
VIC	Agricultural Technology/Energy Efficiency Strategy	The Victorian Government has committed $65 million in the 2020 Budget for a new strategy for Victoria's agricultural sector. This strategy will develop, fund and deliver better infrastructure across the supply chain, explore new technology and innovation and boost energy efficiency on farms.	Budget	Business mass market, LILs	NO	Strategy under development: no current or proposed measures
VIC	Boosting Business Productivity (Energy Efficiency and Productivity Strategy)	The $6.1 million Boosting Business Productivity program supports businesses to access expert advice and support needed to cut energy and materials costs, reduce greenhouse emissions, and improve energy productivity. The program includes grants for businesses, a sustainable finance service, and various training, events and information resources.	Budget	Business mass market	NO	Scale of energy efficiency savings not expected to meet AEMO criteria

Juris-diction	Name of Measure	Description	Criterion	Sectors	Include?	Rationale?
VIC	Greener Government Buildings	The Greener Government Buildings (GGB) program improves the energy efficiency of existing government buildings to reduce operating costs and greenhouse gas (GHG) emissions. Since its establishment in 2009, the GGB has facilitated over $200 million in energy efficiency and renewable energy projects across 35 projects. Combined, these projects are estimated to achieve annual savings of $27 million and abate over 132,000 tonnes of GHG per year. Energy is saved through a combination of: - lighting upgrades (e.g. LED) - heating, ventilation and cooling upgrades (HVAC) - solar panels - building automation and controls	Budget	Business mass market	YES	Material energy efficiency savings
VIC	Better Commercial Buildings (Energy Efficiency and Productivity Strategy)	Sustainability Victoria offered funding to boost the performance of commercial buildings of up to $30,000 per building through the Better Commercial Buildings program.	Budget	Business mass market	NO	Historical measure
ACT	Energy Efficiency Improvement Scheme (EEIS)	The ACT Government introduced the Energy Efficiency Improvement Scheme in 2013. It places a requirement on electricity retailers to achieve energy savings in households and small-to-medium businesses. A target has also been placed on them to ensure a proportion of the savings are delivered to low income households. Larger retailers must undertake approved energy saving initiatives while smaller retailers can either deliver initiatives or pay a contribution to fund those initiatives. The EEIS is not a certificate registry scheme. In this way it is similar to the South Australian Retailer Energy Efficiency Scheme (REES), and different from the Victorian Energy Upgrade (VEU) Scheme and NSW Energy Savings Scheme (ESS). Instead, retailers achieve abatement toward their obligation by engaging methods to deliver approved activities.	Budget	Residential, Business mass market	NO	No future targets set for 2021 - 2030
ACT	Commitment to phase out of gas by 2045 (2021 Budget)	The ACT Government will commence work to develop legislation to prevent future gas mains networks connections in greenfield residential developments and infill developments for implementation in 2021-22.	Budget	Residential, Business mass market, LILs	NO	Plan for implementation by 2024
ACT	Building Energy Efficiency Upgrade Fund	Community clubs undertaking energy efficiency upgrades will receive support from the ACT Government through the Building Energy Efficiency Upgrade Fund. This could include water and ventilation audits, partial grants for certain energy and water efficiency upgrades and no-interest loans for certain upgrades such as rooftop solar.	Budget	Business mass market	NO	Scale of energy efficiency savings not expected to meet AEMO criteria
ACT	Sustainable Household Scheme	Zero-interest loans of up to $15,000 will be available to eligible households through the Sustainable Household Scheme. The Scheme will finance a range of products that will reduce household emissions including rooftop solar panels, household battery storage, and efficient electric appliances.	Budget	Residential	NO	Scale of energy efficiency savings not expected to meet AEMO criteria
ACT	Minimum energy efficiency requirements for rental properties	Policy settings for this program are under currently development. Staged implementation is likely in 2022 - 2023.	Budget	Residential	NO	Policy settings currently under development

Juris-diction	Name of Measure	Description	Criterion	Sectors	Include?	Rationale?
SA	Retailer Energy Productivity Scheme (REPS) (formerly REES)	The Retailer Energy Productivity Scheme (REPS, formerly the Retailer Energy Efficiency Scheme) supports households and businesses to reduce their energy costs. This Scheme includes fuel switching activities using energy sources with improved productivity outcomes.	Regulation	Residential, Business mass market	YES	Material energy efficiency savings
SA	Energy Advisory Service	The Energy Advisory Service provides households and small to medium businesses with free, independent energy saving advice and referrals to other helpful services. Business that use less than 160MWh of electricity a year are eligible.	Budget	Residential, Business mass market	NO	Scale of energy efficiency savings not expected to meet AEMO criteria
SA	Energy Efficient Upgrades for Government Buildings	The South Australian Government provided $60 million over two years in the 2020 Budget to improve energy efficiency in government buildings.	Budget	Business mass market	NO	Policy settings currently under development
WA	Household Energy Efficiency Scheme	Energy Minister Bill Johnston announced the delivery of a range of measures to assist vulnerable households in reducing their energy costs through the four-year, $13 million Household Energy Efficiency Scheme. This scheme is planned to commence mid-2021 and include services such as household energy assessments, tailored education, LED lightbulb replacements and other low-cost energy efficient items.	Budget	Residential	NO	Policy settings currently under development
WA	Clean Energy Future Fund	The Clean Energy Future Fund was launched in April 2020 and supports the implementation of innovative clean energy projects in Western Australia which offer high public value through contributing: - significant, cost-effective reduction in greenhouse gas emissions below projected (or baseline) emissions as a direct result of the clean energy project - design, deployment, testing or demonstration of innovative clean energy projects likely to deliver community benefits or lead to broad adoption and significant reductions in greenhouse gas emissions. The Fund includes projects that will enhance energy efficiency and materially reduce emissions from the built environment or manufacturing.	Budget	Business mass market, LILs	NO	Funding rounds currently open
TAS	Tasmanian Energy Efficiency Loan Scheme (TEELS)	The Tasmanian Energy Efficiency Loan Scheme (TEELS) was a joint initiative delivered by the Tasmanian Government, Aurora Energy and Westpac Banking Corporation providing up to $10 million in the form of no-interest finance (up to $10,000) for the purchase of energy efficient products for households and small businesses.	Budget	Residential, Business mass market	NO	Scale of energy efficiency savings not expected to meet AEMO criteria

- where savings are likely to be wholly or largely non-additional to other measures that are included
- where budget funding is not considered material relative to the size of the jurisdiction(s) or sector(s) targeted
- where measures have been announced but relevant funding/legislation is not yet in place.

Table 3 also includes measures that may have contributed material energy savings in the past but which now are closed. These measures will be included in historical analysis but will not form part of the set of forecast measures.

2.2 AEMO Scenarios

The energy efficiency forecasts are undertaken by scenario. Key AEMO scenario assumptions and drivers are set out in Table 4.

Table 4: AEMO Scenario Parameters

Scenario	Slow Growth	Current Trajectory	Net Zero	Sustainable Growth	Export Superpower	Rapid Decarbonisation
Economic growth and population outlook	Low	Moderate	Moderate	Moderate	High	High
Energy efficiency improvement	Low	Moderate	Moderate	High	High	High
DSP	Low	Moderate	Moderate	High	High	High
Distributed PV	Moderate, but elevated in the short term	Moderate	Moderate	High	High	High
Battery storage installed capacity	Low	Moderate	Moderate	High	High	High
Battery storage aggregation / VPP deployment by 2050	Low	Moderate	Moderate	High	High	High

Scenario	Slow Growth	Current Trajectory	Net Zero	Sustainable Growth	Export Superpower	Rapid Decarbonisation
Battery Electric Vehicle (BEV) uptake	Low	Moderate	Moderate	High	High	High
BEV charging time switch to coordinated dynamic charging by 2030	Low	Moderate	Moderate	High	Moderate/ High	High
Electrification of other sectors	Low	Low/ Moderate	Moderate	Moderate/ High	Moderate/ High	High
Hydrogen uptake	Minimal	Minimal	Minimal	Minimal	Large NEM-connected export and domestic consumption	Minimal
Shared Socioeconomic Pathway (SSP)[1]	SSP3	SSP2	SSP2	SSP1	SSP1	SSP1
International Energy Agency (IEA) 2020 World Energy Outlook (WEO) scenario	Delayed Recovery Scenario (DRS)	Stated Policy Scenario (STEPS)	Stated Policy Scenario (STEPS)	Sustainable Development Scenario (SDS)	Net Zero Emissions by 2050 case (NZE2050)	Net Zero Emissions by 2050 case (NZE2050)
Representative Concentration Pathway (RCP) (mean temperature rise by 2100)	RCP7.0 (~4°C)	RCP4.5 (~2.6°C)	RCP4.5 (~2.6°C)	RCP2.6 (~1.8°C)	RCP1.9 (<1.5°C)	RCP1.9 (<1.5°C)
Decarbonisation target	No explicit decarbonisation target.	26-28% reduction by 2030.	26-28% reduction by 2030 Economy-wide net zero target by 2050.	Consistent with limiting temperature rise to 2 degrees. Economy-wide before 2050	Consistent with limiting temperature rise to 1.5 degrees. Economy-wide net zero	Consistent with limiting temperature rise to 1.5 degrees. Economy-wide net zero

[1] Further details on the IEA scenarios, SSPs and RCPs are provided on AEMO's website – see, for example, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios

Scenario	Slow Growth	Current Trajectory	Net Zero	Sustainable Growth	Export Superpower	Rapid Decarbonisation
					by early 2040s	by early 2040s
Generator and storage build costs	CSIRO GenCost Central	CSIRO GenCost Central	CSIRO GenCost Central	CSIRO GenCost High VRE	CSIRO GenCost High VRE	CSIRO GenCost High VRE
Generator retirements	In line with expected closure years, or earlier if economic to do so.	In line with expected closure years, or earlier if economic.	In line with expected closure years, or earlier if economic or driven by decarbonisation objectives beyond 2030.	In line with expected closure year, or earlier if economic or driven by decarbonisation objectives	In line with expected closure year, or earlier if economic or driven by decarbonisation objectives	In line with expected closure year, or earlier if economic or driven by decarbonisation objectives
Relative project finance costs	Lower than Current Trajectory, reflecting lower rates of return with lower economic growth	In line with current long-term financing costs appropriate for a private enterprise	In line with current long-term financing costs appropriate for a private enterprise	As per Current Trajectory	As per Current Trajectory	As per Current Trajectory

Source: AEMO

2.3 Methodology

2.3.1 Theoretical Framework

Our methodology draws on two key approaches. The first is known as 'factorisation' or 'decomposition', as pioneered by Dr Lee Schipper and the International Energy Agency.[2] This approach examines changes in (E)nergy use (or (E)missions over time as a function of at least three factors:

- (A)ctivity levels (such as output, growth by sector),
- (S)tructure (the mix of activities within a sector) and
- (I)ntensity (changes in the intensity of fuel use per unit of structure and/or activity).

This generates the 'EASI' identity:

[2] See, for example, International Atomic Energy Agency et al, *Energy Indicators for Sustainable Development: guidelines and methodologies*, 2005, Annex 3.

$$E = A \sum_j S_j * I_j \,.$$

In this decomposition:

E represents total energy use in a sector;

A represents overall sectoral activity (e.g. value added in manufacturing);

Sj represents sectoral structure or mix of activities within a sub-sector j (e.g. shares of output by manufacturing sub-sector j); and

Ij represents the energy intensity of each sub-sector or end-use j (e.g. energy use/real US dollar value added),

where the index j denotes sub-sectors or end uses within a sector.

Changes in (F)uel mix can be added, as needed, to create an 'EASIF' identity.

This approach enables an observed or expected change in energy consumption to be attributed to specific effects: an activity effect is a change in consumption driven by a change in activity levels while all other factors remaining constant. Similarly, a structural effect would be the change in energy consumption driven by a change in the structure of a sector (eg, more apartments and less detached houses), and an intensity effect is change in energy consumption driven by a change in energy intensity (or efficiency) with structure and activity remaining constant.

Factorisation is a form of 'bottom up' modelling, and its strength (as well as its weakness) is that it is data hungry. It is a key strength, in that data is (to varying degrees) available to quantify the extent of annual change in activity, structure and intensity (and fuel mix, if required) at sectoral or sub-sectoral (or even end-use) levels. When compared to econometric or other modelling approaches, however, there is more time and cost associated with compiling and analysing data under the factorisation approach.

The second key approach we bring to these forecasts is stock turnover modelling. Stock growth (eg, numbers of dwellings, floor area of buildings) is a key Activity metric in the factorisation methodology. Second, stock turnover (retirements, conversions, and net change) are key elements of Structural change in the framework. Third, by taking account of stock vintage, it is possible to associate dwellings or buildings with different average energy intensities, in particular in the presence of building code energy performance requirements that are specific to particular vintages. At the same time, future Intensity scenarios can be modelled as a function of projected stock growth (linked to demand drivers) and turnover by scenario.

2.3.2 Approach

Residential/Business mass market Sectors

Our general approach, then, is to model annual energy consumption by sector and fuel commencing with a frozen efficiency scenario from an appropriate historical base year. By deriving historical average energy intensities (by fuel, sector (or sub-sector where appropriate) and region/climate zone), and then modelling stock growth and turnover (for residential and commercial buildings),[3] the change in total energy efficiency in the historical period can be calculated.

We then model the expected contribution to this total energy efficiency change from market-led factors, with reference to literature (or, where necessary, working assumptions) on rates of autonomous energy efficiency improvement (AEEI). We model separately the contribution of the policy measures noted above (including those that operated in the historical period, but which have since ceased), drawing on program reporting, policy evaluations and other sources. Approaches taken to modelling individual policy measures varies, as a function of the policy and its mode of operation, and these are described in more detail below. Also, Appendix B summarises the key discounts applied by measure.

As a next step, the extent of overlap or non-additionality within the set of policy measures that impact on a sector, end-use, or region, is estimated, with the impacts of individual measures discounted as needed to avoid double-counting. The sum of discounted policy impacts and AEEI each year should at least broadly agree with the annual change in total energy efficiency, as calculated above – noting that we are not here modelling all possible factors affecting historical consumption and, for the projections period, the project is to estimate energy consumption savings, not total consumption.

Note that we take into account changing fuel mixes for each sector in the historical period. Also, we adjust for behind-the-meter consumption of distributed PV, as this consumption is not included in key statistics including Australian Energy Statistics (or other sources ultimately reflecting metered consumption) yet forms a rising share of actual consumption, notably in the residential sector, and to a lesser degree in other sectors.

For the projections period, we model sectoral stock growth and turnover with reference to key demand driver by scenario, as determined by AEMO and described in Chapter 2 above. Different approaches are taken for different sectors, as described in the sections below. We also project AEEI (which responds to AEMO scenarios) and the impacts of individual policies, in a manner broadly consistent with that used for the historical period. However, as none of AEMO scenarios assume frozen policy (as would be the case in a conventional 'business as usual' projection), we need to make explicit assumptions about key policy settings. Detailed assumptions, specific to individual sectors and policy measures, are set out below. These measures and setting are selected to align with AEMO scenario parameters and assumptions, as also discussed in Chapter 2.

Stock turnover modelling is feasible for the residential and commercial building sectors, as there is high confidence data available with respect to gross stock formation (ABS Building Activity data) and in addition, for residential buildings only, the Census provides a perspective on net stock growth, which also informs estimates of stock retirements. Data on net stock change in the non-residential

[3] This approach is not appropriate for the industrial sector, as discussed below.

building sector is limited to certain jurisdictions, and stock retirement rates must be estimated elsewhere.[4]

Industrial Sector

For the industrial sector, confidentiality constraints limit the availability of data for bottom-up modelling, at least across the sector as a whole (the above framework can be used for individual sub-sectors where enterprises agree to provide energy and output data). Also, the diverse nature of inputs, processes and outputs across the industrial sector limits to scope to model the sector meaningfully at an aggregated level.

Top-down analysis *can* be undertaken for overall change in energy intensity using sectoral or sub-sectoral value-added as a proxy for useful output, matched to energy consumption at the same sectoral/sub-sectoral levels. However, since many factors unrelated to energy efficiency are likely to impact on this metric (energy consumption per unit value added) – including at least changes in commodity prices, exchange rates, and factors costs – this is considered a poor indicator of efficiency change over time.[5] Therefore for this study, we primarily rely on bottom-up estimates of program impact in the industrial sector, noting that – at the current time, at least – there is very little policy targeting industrial energy efficiency in any case.

2.4 Residential Sector

2.4.1 Overview of Key Process Steps

The key steps in modelling residential energy savings associated with energy efficiency improvement for this project are as follows:

1. Construct a model that depicts historical observations and energy consumption changes - with regional, end use and fuel type detail (ie. reticulated gas and imported electricity). This gives a residential energy use baseline.

2. Build in a capability to reflect autonomous and policy driven measures that will affect energy efficiency outcomes.

3. Project 'baseline' estimates forward – based on a 'central' or BAU estimate (in alignment with AEMO scenarios).

4. Revise the 'baseline' projections in accordance with changes to key drivers of energy consumption – as depicted in alternative AEMO scenarios that capture changes in the economic activity levels, construction and energy efficiency policy settings.

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[4] Note that SPR is currently updating the 2012 Commercial Building Baseline Study, including capturing new data that may enable greater precision in estimating net stock growth for non-residential building for all regions of Australia.

[5] Indeed, the IEA developed the EASIF framework precisely to overcome the limitations of energy/unit GDP.

5. Identify and quantify current and announced suite of measures that are likely to materially affect energy efficiency at the jurisdictional level, and within the relevant electricity and gas networks.

6. Scale and add to this suite of energy efficiency measures to reflect the energy saving and transformational ambition of the AEMO future energy market scenarios.

7. Superimpose the relevant energy efficiency measures on projections of end user energy consumption (by region and networked energy source) to deliver annual estimates of the net energy savings (ie. GWh of electricity, TJ of reticulated natural gas) that are likely to be achieved.

The activities and inputs associated with these broad steps are discussed below.

2.4.2 Scope and Structure of Sector

As per the 2019 SPR analysis, gas and electricity consumption in the residential sector focuses on usage by three types of residential building, as defined under the National Construction Code (NCC) and captured in ABS Census data. These are:

- Detached dwellings (ie. houses, NCC Class 1ai buildings)
- Townhouses and semi-detached terrace houses (NCC Class 1aii buildings)
- Units and apartments (NCC Class 2 buildings).[6]

Census data for these structures has been cross-tabulated and aligned with forecasts provided by AEMO on the number of metered properties (by type) within the electricity (ie. NEM, SWIS) and gas networks being examined. However, the AEMO dwelling data (based on BIS Oxford forecasts) referenced 'houses' and 'attached dwellings' only – with the potential for some cross-over in the categorisation of townhouses, and the associated estimation of an average floor area for each category.

Distinguishing Class 1ai, Class 1aii and Class 2 structures allows for superior estimation of space conditioning energy requirements based on the average floor area of these types of structures, and their thermal performance properties.

Further, allocation of residential energy users to different climate zones at the State and Territory level allows for more reliable estimates of the energy requirement of households in particular locations to satisfy their heating and cooling needs. Household energy requirements differ markedly across climate zones – and this can also be true for typical energy requirements for households in

[6] We do not include houses, units and apartments that are attached to houses or shops and offices (potentially, Class 4 parts of buildings). The incidence of separate metering is unclear, as the extent to which these dwellings conform with 'typical' energy use patterns for space heating, cooling and hot water. The 2016 Census reports 4,744 flats attached to houses Australia-wide - under 0. 4% of the reported apartment total, and 28,548 houses or flats attached to shops and offices – again, about 0.4% of the number reported for stand-alone houses.

classified to the same NCC climate zone, but in a different State. Location information is also important to identifying the availability and use of reticulated gas as a household energy source, and the likely impact of measures that affect the incidence and efficiency of gas use.

Since 2003, new dwellings have been subject to energy efficiency requirements under the NCC,[7] and reasonable estimates can be made of the long-term thermal energy performance of these structures, assumed to be built in compliance with the Code requirements of the day. Various studies summarising information from household energy audits can be used to attribute an 'average' level of thermal energy performance to residential building constructed prior to 2003.

Total residential energy use (by State-based climate zone) can be separated into estimates of space heating and cooling, and baseload requirements. The latter will be the residual of total observed energy consumption and the load associated with space conditioning (ie. heating and cooling). The baseload estimate is an aggregate of household energy use for water heating, cooking, lighting and appliance usage.

Changes in space heating and cooling requirements reflect changes in the size, composition and thermal efficiency of the residential building stock (including new builds), driven by policy and background factors. Baseload energy requirements is also affected by growth in the number of dwellings but, with the exception of water heating, tends to be less sensitive to locational factors. Baseload energy efficiency improvements also reflect AEEI plus the impact of policy measures.

This analysis aggregates Census data on dwelling structures at the local government area (LGA) level to allocate residential energy usage to relevant climate zones within each State. The NCC defines eight distinct climate zones that can result in different heating and cooling needs at a regional level. CSIRO has modelled the energy required to maintain an ambient level of comfort (ie. top up heating and cooling) for households in these different locations throughout the year. Metering data from AEMO is used to determine the proportion of households within each State-specific climate zone that is serviced by the relevant energy transmission network (ie. the NEM, SWIS or reticulated gas).

Locational differences (and similarities) in residential energy use are depicted in Figure 1 below. This is taken from the Residential Energy Baseline Study commissioned by the federal Department of Industry, Science, Energy and Resources. It is the most detailed and authoritative study of household energy use in Australia that is publicly available. Its latest survey information was captured in 2014.

Unlike the 2019 modelling, this study will not seek to estimate the extent to which energy efficiency measures would attenuate energy demand under peak and extreme load conditions. Energy demand and efficiency impacts for the Northern Territory have also been omitted from this study.

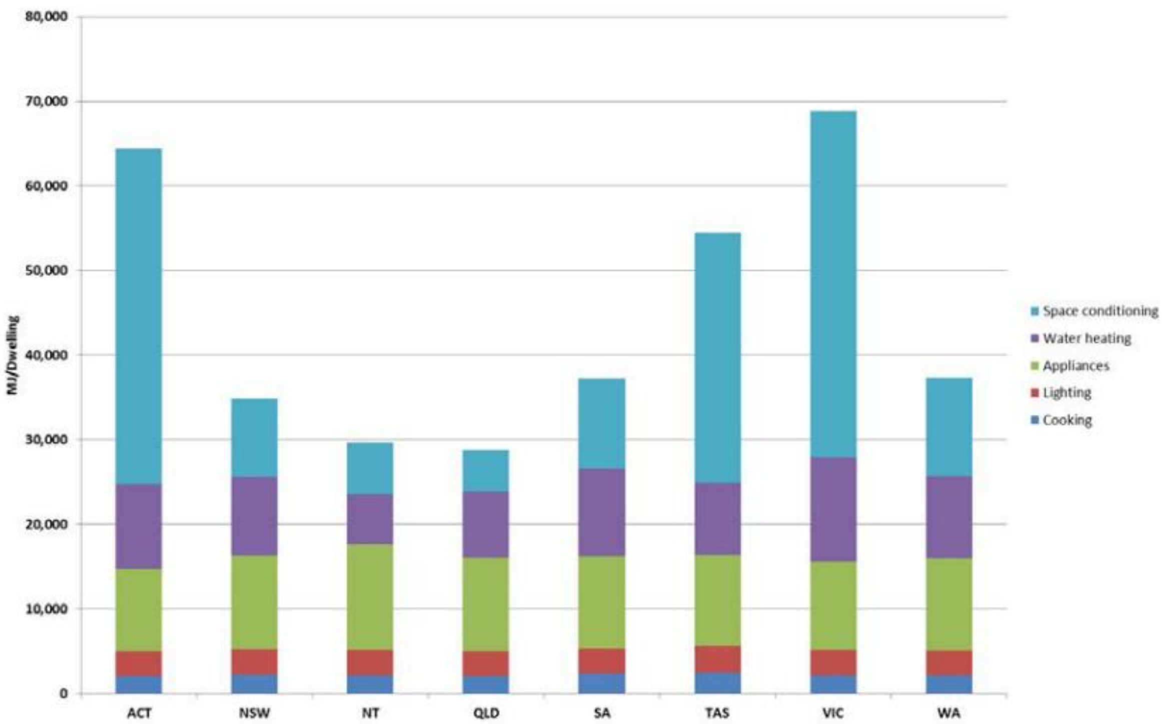
[7] Noting that there have been, and still are, significant variations by jurisdiction.

2.4.3 Historical Analysis

The base year for residential energy performance is FY2010. Future improvements in energy efficiency - and changes in the level and mix of energy requirements will be measured relative to this datum.

However, in order to track the impact of population growth and policy measures on residential energy consumption, changes in key measures and the housing stock will be tracked back to 2001. This enables the impact of past measures to be explicitly projected forward into future years and distinguished from the incremental effect of new measures. It also allows a longer time horizon for identifying trends (and variability) in background levels of efficiency gain, that is, autonomous energy efficiency improvement (AEEI).

Figure 1: Household energy consumption by end-use and jurisdiction, 2014



Source: Residential Energy Baseline Study: Australia (August, 2015), p.32

2.4.4 Projections

Residential energy consumption and associated savings projections will proceed from the last observation year (FY 2020 for electricity and calendar 2020 for gas). These projections are consistent with the scenarios provided by AEMO and include the impact of current and prospective energy efficiency measures –consistent with the savings 'ambition' reflected in the scenarios. In some cases, new State measures have been postulated as an input to the more ambitious energy efficiency scenarios. These should be seen as indicative 'placeholders' for possible future schemes. They do not reflect current public policy discussions, nor do they anticipate detailed future design or implementation outcomes. Their purpose is to represent possible new savings that could arise in scenarios featuring higher policy ambition.

Scenarios and energy efficiency policy settings agreed by AEMO are represented in Table 4 above. Broadly these settings equate to three levels of energy efficiency *policy settings* (ie., low, moderate and high). However, these settings combine with demand drivers to create a unique set of outcomes for each scenario.

These energy efficiency settings reflect and build on the survey of current and agreed energy efficiency measures at the Federal and State level. These are detailed in Table 3 above. Those that are most likely to be relevant drivers of residential energy efficiency – embodying action across all jurisdictions or at the State or Territory level - are highlighted in Table 5, alongside important past measures that have had a material impact on the observed and expected trajectory of residential energy consumption. Deeper consideration of these measures suggests that some are more likely to target and impact residential energy efficiency than others.

Table 5: Policy Measures Impacting on Residential Energy Efficiency

Target jurisdiction	Measure	Active duration	Focus	Comment
National	Emission Reduction Fund (ERF)	2014-2030	Multi-sectoral	Competitive, and 25 kt CO2e project threshold applies. Transaction costs of aggregation likely to be major impediment
National	Greenhouse and Energy Minimum Standards (GEMS) /Equipment Energy Efficiency Program (E3) (NEPP)	E3: 1992 – 2024 GEMS: 2013-2024	Appliance energy performance standards and labelling	Major contributor to business mass market and residential EE performance through impact on new/replacement appliance, water heater and lighting purchases. Key impact on baseload energy consumption.
National	National Construction Code (NCC) efficiency requirements / National House Energy Rating Scheme (NatHERS)	Introduced 2003, incremental changes tom minimum performance rqt	Residential buildings (and beyond)	State action varies on stringency and timing eg. Vic and SA mandated higher standard (4 & 5 Star from 2004), NSW implements BASIX alternative which has broader compliance focus.

Target jurisdiction	Measure	Active duration	Focus	Comment
Clean Energy Finance Corp (CEFC)	Investment support for EE, fuel switching & electrification projects	2013-2050	Multi-sectoral	Contract-based financing arrangements. Mainly focused on large projects. Scope of residential savings to be determined but likely low.
NSW	BASIX	2004, ongoing	Residential buildings	Broader compliance focus than NCC regs. Marginally smaller EE improvement indicated (than NCC) in some years, but now aligned with NCC.
NSW	Energy Savings Scheme (ESS)	2009-2050	Multi-sectoral	Evolved, streamlined and monitored scheme. Likely to be material & effective – although new lighting standards and increasing market saturation will be important to outyear savings estimates.
VICTORIA	Victorian Energy Upgrades (VEU)	2010-2025	Multi-sectoral	Significant market-based certificate scheme. Material potential impact for residential. Larger energy users (eg. commercial) likely to offer more commercially attractive projects. 'Interface with standards' issue also applies (see NSW ESS comments above).
VICTORIA	Energy Efficient Heating & Cooling (included in Victorian Household Energy Savings Package (VHESP))	2020-24	Residential appliances	$335.5m over 4 years focused on low income households targets substantial funds at a segment where potential for low cost EE improvement and 'gas to electric' switching is likely to be high. Retrofit focus
VICTORIA	Energy Efficient Social Housing (included in Victorian Household Energy Savings Package (VHESP))	2020-24	Residential appliances and building	$112m targeted at 35,000 properties. (avg ($3,200 per) Targets housing upgrades (retrofit) and appliance replacement/ upgrades.

Target jurisdiction	Measure	Active duration	Focus	Comment
VICTORIA	Big Build: Public housing (included in Victorian Household Energy Savings Package (VHESP))	2020-2024	New residential construction	Targets construction of 12,000 new homes with 7 Star energy performance (up from 6 Stars mandated under NCC currently).
SOUTH AUSTRALIA	Retailer Energy Productivity Scheme (REPS)* *(formerly REES)	REES: 2009-2020 REPS: 2021 - 2030	Residential & commercial appliances & building	EE upgrades delivering 2.5 PJ energy savings in 2021, ramping to 3.75 PJ in 2025. At least 0.5 PJ pa savings to be achieved in low-income households, and an equivalent amount from other households. Market driven system. See comments re NSW ESS. Energy credit earned for both demand reduction and load shifting, in addition to on-site supply augmentation.
WA	Household Energy Efficiency Scheme		Residential	Under development – no details available.
ACT	Energy Efficiency Improvement Scheme (EEIS)	2013 to 2020	Residential & Commercial	Operates as a large retailer obligation. Extension status and targets unclear.

Details of the modelling methodology, information sources, measures, treatments and key assumptions are provided in Table 6 below.

2.4.5 Materiality, additionality and double counting

Identifying the effectiveness of a policy measure can be challenging. Considerable effort is periodically invested in reviewing measures to ensure that they are achieving their intended purpose and doing so cost without excessive waste, distortion or cost. Even then, it is often difficult to determine the degree to which policies and measures under scrutiny have changed observed outcomes from what they otherwise would be.

In assessing established energy efficiency measures, there may be scope to rely on performance review processes to help assess the extent to which particular measures are driving savings through affecting attitudes, behaviours and purchase practices. Such reviews can also help determine how well the savings expected from a measure have been achieved.

Table 6: Model calibration and scenario testing methodology

Stage	Activity	Key elements	Information sources	Key outputs	Key observations/ assumptions
MODEL DEVELOPMENT					
1.	Assemble residential dwellings data by location	Dwelling classes x State x Local Govt Area (LGA)	Census 2001, 2006, 2011, 2016; AEMO connection data (NEM & SWIS)	Time series of housing total and year on year growth	Model stock turnover with reference to average age at demolition, using Poisson distribution. Assume 0.4% pa net turnover as per analysis of Ausgrid (NSW) customer base
2.	Allocate dwellings to (8) NCC climate zones	NCC climate zone boundaries (detailing included LGAs)	NCC State level climate maps & key LGA listings	7 climate zones depicted.	CZ 8 (Alpine) accounts for negligible dwelling share
3.	Apply estimate of average floor area ratio for dwelling types			Floor area represented in climate zone jurisdictions - and NEM and SWIS service areas	
4.	Estimate relative heating and cooling loads x NCC climate zone	Identify indicative heating & cooling loads for thermal comfort in major State-based climate locations; Allocate key NatHERS climate zones to NCC climate zones	NatHERS thermal load matrix for Star ratings 0-10 in 65 example sites in NatHERS climate zones	Climate zone and jurisdiction specific residential heating and cooling demands	Assume average household demand for thermal comfort conforms with load requirements applied in NatHERS
5.	Identify mains gas usage within State-	Estimate gas contribution to	Residential Baseline Study (2014) & ABS	Regional mains gas usage estimates - with	

Stage	Activity	Key elements	Information sources	Key outputs	Key observations/ assumptions
	based climate zones by end use	heating and appliance energy use (incl water heating)	Household Energy Consumption Survey (2012)	attribution to space conditioning and appliances (incl. water heating)	
6.	Estimate heating & cooling input energy requirement for gas and electricity	Adjust thermal load energy requirement (space heating cooling) for appliance co-efficient of performance to estimate input energy.	Residential Baseline Study, 2015.	Energy input requirement for household heating & cooling by network gas and electricity	Estimate energy input with reference to dominant technology coefficients of performance (CoP), gas & elect
7.	Explicitly account for rooftop PV	Factor in incidence of PV as a 'behind the meter' energy source, and allow for changes in metered and 'behind the meter' mix	Clean Energy Regulator PV capacity installation data	Estimate of behind the meter supply in household energy consumption	PV materially impacts metered household energy requirements
8.	Estimate baseload energy use	Estimate baseload energy use from total energy use observations (Baseload = Total - (Heating + Cooling)	AEMO electricity & gas consumption data	NEM & SWIS metered baseload energy consunption (elect, gas, x jurisdiction)	
9.	Estimate impact to date of EE measures	Estimate impact of key EE measures, include evidence on autonomous EE improvement. Adjust to align with observed historical EE	Literature analysis of AEEI, survey of EE measures, previous studies.	Insight to requirement for discounting of EE measures	AEEI scalable. C'wlth Treasury applies range 0.5 to 0.8% pa (incl impact of non-price measures) in CPRS analysis. Model assumes AEEI = 0.3%

Stage	Activity	Key elements	Information sources	Key outputs	Key observations/ assumptions
		performance. Only apply to new & replacement assets			pa, with acceleration under more ambitious EE scenarios
10.	Calibrate to NEM and SWIS observations	Apply representative household energy rqts to climate zone populations. Adjust to align with AEMO gas/ electricity series. Apply dwelling utilisation factor in each State (in the range 40-60%) to account for NatHERS assumption of 24/7 maintenance of comfort levels and associated energy demands	AEMO electricity & gas consumption data, meter numbers for NEM and SWIS customer bases. NatHERS State climate zone energy requirements (adjusted for technology co-efficients of performance)	Model of gas/ elect requirements of households by State/ CZ that aligns with AEMO time series observations. Resolve and align consumption outcomes 2001 to 2020.	
PROJECTIONS					
11.	Apply residential energy consumption drivers	regional population growth, projected growth in housing (based on persons per dwelling), trends in housing mix	ABS and State Planning population & housing forecasts; AEMO input. Resolve for major regions where possible	projected changes in number of dwellings Class 1a1m Class 1a2, Class 2 by NEM and SWIS customer region	
12.	Derive energy consumption baseline	Apply household energy use profile (Base, Heating,		Annual (FY & calendar) household energy consumption	

Stage	Activity	Key elements	Information sources	Key outputs	Key observations/ assumptions
		Cooling) x CZ to dwelling stock growth		outcomes from 2021 to 2053	
13.	Apply current & proposed EE policy measures	Reflect proposed measures at jurisdictional and end-use level	Detailed (national and State/Territory) - policy & measures survey commissioned by AEMO attribute impact to baseload (appliance) and heating/ cooling household energy requirements. Draw on stakeholder/ workshop feedback. GEMS input from Wilkenfeld & Assoc.	Estimated annual energy savings (MWh and GJ) attributable to confirmed EE measures, split by fuel type, jurisdiction and end use (base, heating, cooling). Explicit impacts for NEM and SWIS	Allocate at jurisdictional level; attenuate headline estimates for additionality considerations.
SCENARIOS & POLICY RESPONSES					
14.	Reflect AEMO outlook scenarios in baseline drivers	Adjust drivers for revisions to population or housing growth - as applicable	Draw relevant detail from AEMO scenarios (ie. Slow Growth, Current trajectory, Net Zero, Sustainable Growth, Export Superpower, Rapid decarbonisation)	Baseline revisions (as necessary) consistent with broader AEMO scenarios. Produce scenario consistent baseline household energy consumption mix for NEM and SWIS.	Population growth and associated housing demand are considered to be relatively insensitive to GDP, or energy mix factors. However, accelerated impetus toward electric for gas substitution can be expected to reduce expected gas savings due to lower use of

Stage	Activity	Key elements	Information sources	Key outputs	Key observations/ assumptions
					this energy source. Similarly, increased uptake of rooftop PV and batteries would see greater substitution of 'behind the meter' for delivered electricity.
15.	Develop and apply scenario consistent EE measures	Develop HIGH, MODERATE and LOW EE response packages.	Draw on AEMO scenarios and accompanying outputs (eg. projected electricity price impacts). Expand and/or enhance EE measures that are likely to support practical and cost-effective achievement of scenario policy objectives.	Annual EE energy saving estimates for baseload/ heating and cooling that are consistent with the aims embodied in the AEMO scenarios. Produce EE savings estimates at State level for electricity and gas. Electricity savings relate to total electricity requirement (ie. distributed + household PV)	

Regulatory initiatives at Commonwealth and State level are often supported by publicly available impact statements that seek to identify and quantify the stream of costs and benefits associated with a proposed measure. These can be a rich source of information on the ‘expected’ savings from energy efficiency initiatives such as mandatory standards.

Subsidy and awareness raising programs do not carry the same transparency requirements, but expectations for future energy savings may still be available. Table 6 above lists several programs with explicit greenhouse gas and/or energy savings targets (or obligations) - such as the NSW ESS or the new SA REPS. These targets represent a starting point for the consideration of impacts. However, it is possible that in some cases the energy savings from a measure will not be fully counted, for example due to ‘demonstration’ effects on third parties which add to the savings achieved. On the other hand, it is also possible that even when headline target objective is complied with, the true level of savings can be less than that initially observed. This can occur when early savings and changes in user technology choices and behaviour are not sustained.

Issues of additionality and double counting are also relevant. These factors can most readily come into play when measures overlap and are likely to affect the same set of energy services and users. Table 7 re-examines key EE measures listed in the context of overlapping jurisdictions and end-use objectives.

Table 7 suggests that in most cases (subject to the deeming rates applied to assess additionality and net savings delivered by the accelerated adoption of energy efficient technologies and practices), measures operate with a reasonable degree of complementarity, and duplication of savings claims is likely to be low. Key national measures such as NCC and GEMS have their principal impact on new builds and purchases (including replacement of ageing buildings, lighting and equipment), while programs focused on improvements and accelerated replacement of the existing stock effectively add to the pool of energy savings.

After considering the focus, funding and stage of development of these programs – in addition to issues of materiality and additionality – the following measures have been identified for explicit modelling in this analysis of potential residential energy savings:

1. Australia-wide: Greenhouse and Energy Minimum Standards (GEMS)
2. Australia-wide: National Construction Code building energy standards (NCC)
3. NSW households: Energy Savings Scheme (ESS)
4. Victorian households: Victorian Energy Upgrades (VEU)
5. Victorian Household Energy Savings Package (VHESP – with details provided in late April 2021)
6. South Australian households: Retailer Energy Productivity Scheme (REPS).

Key policy assumptions by scenario are set out in Table 8 below.

Table 7: Focus and Overlap of Residential Energy Efficiency Measures

Measure	Jurisdiction	Materiality	Technology focus	Vintage focus	Additionality
Emission Reduction Fund (ERF)	National (Aust)	Unlikely to be material in this sector	mixed (AB)	stock (S)	Potentially high
Greenhouse and Energy Minimum Standards (GEMS) /Equipment Energy Efficiency Program (E3) (NEPP)	National (Aust)	yes	appliances (A)	greenfields (G)	Major national driver for electrical efficiency, modelled
National Construction Code (NCC) efficiency requirements / National House Energy Rating Scheme (NatHERS)	National (Aust)	yes	building fabric (B)	greenfields (G)	Major national driver, modelled
Investment support for EE, fuel switching & electrification projects	National (Aust)	low	mixed (AB)	open (O)	Some additionality
BASIX	NSW (N)	yes	building fabric (B), appliances	greenfields (G)	Low – operates parallel to NCC, materially reflected in NCC modelling
Energy Savings Scheme (ESS)	NSW (N)	yes	mixed (AB)	stock (S)	High – and modelled
Victorian Energy Upgrades (VEU)	VIC (V)	yes	mixed (AB)	stock (S)	High – and modelled
Energy Efficient Heating & Cooling (VHESP)	VIC (V)	small relative to stock size	mixed (AB)	stock (S)	Potentially high – and modelled
Energy Efficient Social Housing (VHESP)	VIC (V)	small relative to stock size	mixed (B)	stock (S)	Potentially high – and modelled
Big Build: Public housing (VHESP)	VIC (V)	small relative to stock size	building fabric (B)	greenfields (G)	Potentially high – and modelled
Retailer Energy Productivity Scheme (REPS)	SA (S)	yes	mixed (AB)	stock (S)	High – and modelled
Energy Efficiency Improvement Scheme (EEIS)	ACT (A)	yes – for ACT, but small in the context of the NSW Region	mixed (AB)	stock (S)	Not assessed

Table 8: Key Policy Assumptions for Residential Measures by Scenario

Scenario:	Slow Growth	Current Trajectory	Net Zero	Sustainable Growth	Export Superpower	Rapid Decarbonisation
National Construction Code (NCC)	No change from current standards	6.5 stars in 2025, 7 in 2040, 7.5 in 2048	6.5 stars in 2025, 7 stars in 2039, 7.5 from 2047	6.5 stars in 2025, 7 in 2039, 7.5 from 2047	7 stars in 2022, 7.5 in 2027, 8 in 2030, 8.5 from 2035	7 stars in 2022, 7.5 stars in 2026, 8 stars in 2031, 9 stars from 2034.
Greenhouse and Energy Minimum Standards (GEMS)	No new/updated measures	No new/updated measures	Inclusion of measures assessed by GWA as "Possible"	Inclusion of measures assessed by GWA as "Possible" and "Suspended but could be reactivated"	Significant expansion of scope of program, covering all sectors and more products. 25% greater realisation of savings.	Significant expansion of scope of program, covering all sectors and more products. 25% greater realisation of savings.
State/territory energy savings schemes	For Vic, phase out after 2030. For NSW, remain at 2030 levels to 2053. For SA, phase out after 2025.	For Vic, phase out after 2030. For NSW, remain at 2030 levels to 2053. For SA, phase out after 2025.	For Vic, 2% growth in annual targets post 2030. For NSW, targets increase 0.25% per year from 2031. For SA, targets increase at 325 TJ per year. Other states set targets rising by 0.5% per year from 2022.	For Vic, 2% growth in annual targets post 2030. For NSW, targets increase 0.25% per year from 2031. For SA, targets increase at 325 TJ per year. Other states set targets rising by 0.5% per year from 2022.	For Vic, 4% growth in annual targets post 2030. For NSW, targets increase 0.5% per year from 2031. For SA, targets increase at 500 TJ per year. Other states set targets rising by 1% per year from 2022, then by 0.5% per year from 2031.	For Vic, 4% growth in annual targets post 2030 For NSW, targets increase 0.5% per year from 2031. For SA, targets increase at 500 TJ per year. Other states set targets rising by 1% per year from 2022, then by 0.5% per year from 2031.
Victorian Home Energy Savings Package	No new funding.	No new funding.	No new funding.	10% increase in funding/impact cf Current Trajectory	20% increase in funding/impact cf Current Trajectory	20% increase in funding/impact cf Current Trajectory

The Housing Insulation Program (HIP), which funded ceiling insulation for over 1.2 million homes across Australia over the course of 2009, has also been modelled as part of the calibration exercise. This scheme had a significant and ongoing impact on household energy performance for a material portion of the housing stock.

Finally, as discussed previously, AEMO has asked us to examine the implications of alternative future energy and policy trajectories that could involve upscaling of ‘business as usual’ energy efficiency efforts. To support these ‘high EE ambition’ scenarios, we have developed hypothetical energy efficiency programs that would operate in Western Australia, Queensland, and Tasmania in parallel with ramped up energy savings efforts in other Australian jurisdictions.

The savings generated by retrofit and replacement programs will be a function of time. That is, they will depend not only on the efficiency improvement that is achieved through replacement, but also how much earlier that replacement took place compared to a ‘business as usual’ approach. Retrofit programs essentially bring forward upgrades that could be expected to occur eventually – and can be credited with savings achieved in the interim period. These savings are distinct from those associated with measures that drive the adoption of technologies that are ‘above current code’ (eg. Victoria’s proposal to build 12,000 7-Star homes relative to the current 6 Star requirement), with the latter able to claim the full incremental (frozen efficiency) energy saving over the life of the asset, at least as long as the NCC standard remains at 6 star.

Our approach has been to model the energy efficiency savings for measures taking in account claimed or reported impacts, but also examining their degree of additionality to other measures and to market-led or autonomous energy efficiency improvement (AEEI), and the extent to which there is evidence of realisation or non-realisation of expected savings.

In many cases, the scale of individual impacts is small relative to the level of uncertainty and estimation error that is inherent in the data. Structural factors such as ‘market driven’ increases in energy efficiency, also commonly referred to as Autonomous Energy Efficiency Improvement (AEEI), aggregates and incorporates these influences. The availability and uptake of new technology and better energy management, driven by a host of factors, has also tended to increase residential energy efficiency over time, and separating these effects from policy ones is challenging.

Alongside the key policy drivers identified above, our residential modelling also includes AEEI as an energy efficiency driver. However, as highlighted previously, accounting for such market-led efficiency improvement generally means that policy-led efficiency impacts must be scaled back to avoid exceeding the total energy savings outcomes that are actually observed. Appendix B summarises discounts applied to savings measures.

2.5 Business Mass Market

2.5.1 Market Segmentation

AEMO defines the Business Mass Market (BMM) as all consumers other than residential and large industrial loads (LILs) – with LILs defined by AEMO as those organisations with electrical loads of 10 MW (or more) for at least 10% of the year. In practice, an operation classified as a LIL would typically consume more than 50 GWh of energy per year. BMM therefore captures 'smaller' non-residential energy users. It is further divided into BMM Commercial and BMM Industrial where relevant – for example, where policy measures apply to one segment but not the other. With reference to the Australian and New Zealand Standard Industrial Classification (ANZSIC) system, BMM Commercial represents non-residential users with a demand of at last 10 MW for 10% of the year (generally 50 – 60 GWh per year):

- Division A (Agriculture, fishing, forestry)
- Division D (28-29) (Water supply, sewerage and drainage services)
- Division E (Construction)
- Commercial and services (ANZSIC divisions F, G, H, J, K, L, M, N, O, P, Q, R and S)
- Division I (Transport, postal and warehousing)
    - - limited to stationary (non-transport) end-uses (50 – 53).

Specifically with respect to gas consumption, the business mass market sector includes:

1. small commercial (TV) customers, that use less than 10 TJ per customer per year

   - noting TV customers may also be residential customers, requiring a split to be estimated between the two customer types; and
2. medium commercial (TD) customers, that use at least 10 TJ but less than 500 TJ per year.

Note that other parts of Division D, notably including electricity generation, are excluded from the scope of the forecasts.

AEMO has provided estimates of the share of LIL electricity consumption by ANZSIC Division but was unable to separate gas consumption on a similar basis.

BMM Industrial is defined to include SMEs from:

- Division B (Mining)
- Division C (Manufacturing).

2.5.2 BMM Commercial Methodology

Energy Use

The majority of stationary electricity and gas consumption in the BMM sector in Australia occurs in Commercial and services.[8] In FY2019, these sectors are estimated to have consumed 243 PJ of electricity and 58 PJ of gas. By contrast, electricity consumption in Division A (Agriculture, forestry and fishing) is modest at 7.8 PJ for electricity and 1.3 PJ for gas: diesel is the main energy source for these sectors. Similarly, Division D (28-29) (Water supply, sewerage and drainage services) electricity consumption was modest (13.1 PJ) and gas consumption was only 1.3 PJ. Water pumping by water authorities is a major component of this sector's electricity consumption. Division E (Construction) is estimated to use less than 1 PJ of electricity and less than 3 PJ of gas in FY2019.[9]

Transport, postal and warehousing (Div. I) is a more material user of electricity (22.5 PJ in FY2019) and gas (21.5 PJ). However, only sub-divisions 50-53 ('other transport, services and storage') is likely to be (largely) stationary in nature, and these sub-sectors accounted for 10.8 PJ of electricity in FY2019 and 17.9 PJ of gas. This sector includes warehouses, including those in the cold chain that are highly energy-intensive. It appears that a significant source of gas consumption in this sector is the compression of gas in transmission pipelines.[10]

Finally, we note that the significant energy efficiency measures in the BMM sector (see below) relate to building-related energy end-use, where energy consumption is very largely contained within 'commercial and services', together with at least a portion of Division I's electricity consumption (eg, warehouses). Therefore, we model the policy-induced energy savings in the business mass market sector as those arising from Commercial and services and Division I.

Total Energy Efficiency Change

Total energy efficiency change in the BMM (commercial) sector is estimated top-down by expressing energy consumption by fuel per sqm of non-residential floor space over time. Fuel consumption, as above, is sourced primarily from AES, cross-referenced with AEMO consumption data. Floor area data is sourced from inhouse models as used for the ASBEC and COAG Energy Council 'trajectory' studies for non-residential buildings. SPR is currently undertaking a major update to the 2012 Commercial Building Baseline Study, but that new stock data from this source is not likely to be available until early in calendar 2022. Stock growth and turnover is related to AEMO-supplied values for gross state product by scenario.

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[8] DISER notes that this includes elements based on growth in energy consumption reported in NGERS, and growth in industry gross value added and expenditure, as reported in Australian National Accounts: State Accounts (ABS cat. no. 5220.0); that is, it is modelled rather than measured. See DISER, *Guide to the Australian Energy Statistics*, September 2020, p. 17.

[9] This includes a component of estimation based on growth in industry gross value added over time – refer to DISER, *Guide to the Australian Energy Statistics*, September 2020, p. 16.

[10] Ibid, p. 16.

Market-led Efficiency Change

The rate of market-led energy efficiency improvement is not well documented, and we draw on values from other studies, will primarily be represented by assumptions with respect to the rate of AEEI, after reviewing recent and relevant literature. Where assumptions have to be made, these will be stated clearly. In addition, any such assumptions are bounded by the total efficiency change, as described above. In this sense, what is at stake is only the apportionment of this total change between market and policy effects.

Another area where discounts may be applied are certain GEMS measures. Some GEMS measures have remained in place, without revision, for many years. In such cases, it is increasingly likely over time that savings estimated in good faith prior to the commencement of those measures – and even if they assume some AEEI – may be overtaken by technology and market change. For example, savings associated with MEPS or labelling for fluorescent lamps would today need to be discounted, due to the pervasive incidence of LED lighting and falling sales of fluorescent lamps, which would not have been anticipated in the relevant RIS.

Policy-induced Efficiency Change

Drawing on the Policy Review Summary Table 3, the policy measures assessed are:

- Energy performance measures in the National Construction Code
- Commercial products under the GEMS program
- Disclosure (NABERS and Commercial Building Disclosure)
- Emissions Reduction Fund (ERF)
- Clean Energy Finance Corporation (CEFC)
- State savings targets (ESS, VEU, REPS)
- VIC Budget Measures
    - Business Recovery Energy Efficiency Fund
    - Greener Government Buildings

ERF and CEFC both have a relatively minor focus on energy efficiency but savings were assessed as additional, if small, in this context. Similarly, new (2021) Victorian budget measures are included due to their significant funding (one of AEMO's selection criteria).

Non-Additionality (Double-Counting) and Discounts

We will model measures in the historical period using a two-pass approach, with the first based directly on program statistics, and the second representing the extent of discounting applied due to non-additionality either to other policy measures or to AEEI. This approach will provide greater transparency with respect to these two elements. For state energy efficiency schemes, deemed savings will be annualised in the first step.

Where more than one measure targets the same sector, fuel and end-use, there is a risk of non-additionality between these measures. That is, adding together the claimed savings of each measure would overstate the total savings. In this situation, it is extremely difficult to determine the exact attribution. In theory, market research might be undertaken, with energy users asked about their motivation. However, many consumers would be unaware of many measures that apply to their energy consumption. In practice, then, we employ a hierarchy – not unlike the policy measures criteria noted in the National Energy Rules, v156, NER 5.22.3b) (see Section 2.1.1) – under which:

- mandatory measures rank higher than (or crowd out) voluntary measures
- voluntary measures are ranked by their degree of leverage (eg, a 50% subsidy would be assumed to (largely) crowd out a 10% subsidy)
- unleveraged and voluntary measures – such voluntary disclosure, benchmarking or information/behaviour change measures – are assumed to rank last (meaning attributable savings may be displaced by higher rank measures in the case of overlap).

As noted, under the two-pass modelling approach, the extent of non-additionality will be assessed for each measures and, where necessary, a discount factor will be applied to savings, following the hierarchy above. Recall that in the historical period, the sum of AEEI and discounted policy-induced efficiency change cannot exceed the total observed change. This means that any error in the allocation of discounts to measures, as above, is limited to the allocation of savings between effects and measures and will not lead to double-counting or over-estimation of realised savings.

Non-realisation of estimated savings

Separate from additionality/non-additionality questions, the savings impact of some measures is estimated from program mechanics, or estimates from regulation impact assessment, drawing on the expected mode of operation of the measure. However, for various reasons, the realised savings may be less (on average) than expected.[11] Examples of this may include energy performance requirements under the National Construction Code – where the most recent RIS assumed 25% non-realisation of savings as a base case.[12] While this assumption is not (yet) substantiated by compliance audits – as we have not been able to determine that any state or territory undertakes compliance audits for non-residential buildings – it is based on plausible elements such as:

- a lack of commissioning requirements for building systems in the NCC

[11] Savings in individual cases may vary above and below the average expected while the program still realises the expected savings *on average*; this section instead refers to situations where the average realisation of savings may fall below that expected on a systemic basis.

[12] The Centre for International Economics, Decision Regulation Impact Statement: energy efficiency of commercial buildings, November 2018, Appendix D '*Are modelled energy savings realised?*'

- the risk that energy simulation models may systematically under-estimate actual building energy consumption (and/or modelling errors)
- non-compliance with Code requirements due to an expectation of non-enforcement, combined with financial incentives for construction firms to increase profits by reducing building specifications.

While the actual extent of such non-realisation of expected savings cannot be clear, so long as no compliance audits are undertaken, we consider it prudent – noting the substantial literature and also industry concern on this matter[13] – to follow the RIS practice and apply a 25% discount to expected Code savings for the time being.

2.5.3 Projections by Scenario

As discussed previously, savings projections to FY2053 vary based on two independent factors for each scenario:

- demand drivers as determined by AEMO
- policy assumptions/settings consistent with the scenario narratives.

Demand Drivers

Demand drivers are set out in Table 4 and supported by detailed data, provided by AEMO, including:

- gross domestic product
- gross state product
- gross value added by ANZSIC Division
- population.

These include historical data from FY2001 and projections to FY2051. As noted above, stock turnover projections will be modelled as proportionate to rates of change in either gross state product or gross value added, for relevant Divisions, subject to fit with historical data.

Market-led Efficiency

Future AEEI will be assumed to reflect historical values for at least the Slow Growth, Current Trajectory and Net Zero scenarios, which target representative concentration pathways (RCP, showing estimated mean temperature rise by 2100) of between ~4^{o} and ~2.6^{o}. Faster rates of AEEI will be tested for Sustainable Growth (RCP ~1.8^{o}) and, in particular, Export Superpower and Rapid Decarbonisation (RCP ~ 1.5^{o}).

[13] See, for example, pitt&sherry, *National Energy Efficient Buildings Project Report*, December 2014; or P. Shergold & B. Weir, *Building Confidence: improving the effective of compliance and enforcement systems for the building and construction industry across Australia*, February 2018.

Policy-led Efficiency

Table 9 provides information on the detailed policy assumptions to be applied by measure and scenario for the BMM sector. It is important to stress that while these policy assumptions are guided, where possible, by existing and forward-looking analyses – such Code trajectory studies, for example – they represent SPR's assessment of plausible potential policy settings that correspond to scenario narratives. We do not imply or assume any government endorsement of these settings. The intent is to illustrate plausible future efficiency outcomes consistent with the differing levels of policy ambition (as well as demand drivers) that are implicit in the scenario narratives. As noted in Table 4, the six scenarios map to only four (at most) degrees of energy efficiency policy differentiation. This reflects SPR judgements about the number of discrete (and significant) energy efficiency policy models that might plausibly be adopted by future governments under each scenario.

Table 9: Detailed Policy Assumptions by Measure and Scenario – Business Mass Market Sector

Policy Type/ Jurisdiction	Slow Growth	Current Trajectory	Net Zero	Sustainable Growth	Export Superpower	Rapid Decarbonisation
National Construction Code - frequency	NCC2025 delayed until FY2031 (4 review cycles from NCC2019), with the next iteration in 2043.	NCC2025 delayed until FY2031 (4 review cycles from NCC2019), with the next iteration in 2043.	NCC2025 delayed until FY2028 (3 review cycles from NCC2019), with the next iterations every 9 years thereafter.	NCC2025 agreed in May 2025 (with application from May 2026) and revised every 6 years (2 review cycles) thereafter.	NCC2025 agreed in May 2025 (with application from May 2026) and revised every 3 years (1 review cycle) thereafter.	NCC2025 agreed in May 2025 (with application from May 2026) and revised every 3 years (1 review cycle) thereafter.
National Construction Code - stringency	Iterations represent half of the COAG '2025' Trajectory changes (15.5% and 3.3%), delayed in time.	Iterations based on the COAG '2025' Trajectory changes (31% and 6.5%), delayed in time.	Iterations based on the COAG '2025' Trajectory changes (31% and 6.5%), delayed in time.	Iterations based on the COAG '2025' Trajectory changes (31%, 6.5%, 5%).	Iterations based on expected 'maximum NPV' stringency (follows COAG 2025 scenario, then 5% each iteration thereafter (equivalent to ~1.7% per year)	Iterations based on expected 'maximum NPV' stringency (follows COAG 2025 scenario, then 5% each iteration thereafter (equivalent to ~1.7% per year)
National Construction Code - enforcement	None	None	None	Non-realisation of savings reduced to 15% through mandatory commissioning and some enforcement effort.	Non-realisation of savings reduced to 0% over 10 years through mandatory commissioning, training/ education and enforcement effort.	Non-realisation of savings reduced to 0% over 10 years through mandatory commissioning, training/ education and enforcement effort.

Policy Type/ Jurisdiction	Slow Growth	Current Trajectory	Net Zero	Sustainable Growth	Export Superpower	Rapid Decarbonisation
GEMS	No new/updated measures	No new/updated measures	Inclusion of measures assessed by GWA as “Possible”	Inclusion of measures assessed by GWA as “Possible” and “Suspended but could be reactivated”	Significant expansion of scope of program, covering all sectors and more products. 25% greater realisation of savings.	Significant expansion of scope of program, covering all sectors and more products. 25% greater realisation of savings.
Disclosure (inc. NABERS and CBD)	No new/updated measures	No expansion of CBD/mandatory disclosure; slow growth in NABERS coverage of sectors	No expansion of CBD/mandatory disclosure; slow growth in NABERS coverage of sectors	Modest expansion of CBD/mandatory disclosure to cover sectors with NABERS tools	Universal mandatory disclosure with program material (to support behaviour change and random compliance audits	Universal mandatory disclosure with program material (to support behaviour change and random compliance audits
State/Territory Savings Schemes	Remain at currently projected levels/durations and jurisdictions, with no continuation after current cessation dates	Targets continue to increase at modest pace in existing jurisdictions	Targets continue to increase at modest pace in existing jurisdictions	Targets continue to increase, but at a more rapid pace; modest targets adopted by other states/territories. Some encouragement for electrification	Targets continue to increase, but at the most rapid pace cost effective, assuming a shadow (or actual) carbon price. Schemes in place for all jurisdictions.	Targets continue to increase, but at the most rapid pace cost effective, assuming a shadow (or actual) carbon price. Schemes in place for all jurisdictions. Electrification strongly encouraged
Budget measures/other regulation	No significant funding and no additional savings	Continuation of existing measures at current (real) funding levels; no new measures	Continuation of existing measures at current (real) funding levels; no new measures	Assume modest new measures in all jurisdictions, equivalent to an additional 20% of savings attributable to energy savings schemes in this scenario	Extensive programs in all jurisdictions and sectors[14], leading to additional savings equivalent to 100% of those attributable to energy savings schemes in this scenario	Extensive programs in all jurisdictions and sectors, leading to additional savings equivalent to 100% of those attributable to energy savings schemes in this scenario

[14] Indicative examples would include deep retrofits of existing buildings to the maximum degree cost-effective, extensive market transformation initiatives encouraging best practices and technologies; 'climate justice' public investments to assist with structural adjustment/new processes for industry, significant training/ professional development in energy performance.

Discounts/avoiding double-counting

The approaches to managing these risks in the projections period follows from those noted above for the historical period. Total energy efficiency change represents the sum of AEEI (as above) and policy-induced efficiency as modelled above for each scenario. Discount factors for non-additionality and non-realisation of savings will remain the same as in the historical period, except where these factors are specifically targeted by policy measures, such as improved Code compliance. Also, double-counting/non-additionality risks are higher in the scenarios that feature higher policy ambition, therefore it may be necessary to increase discounts for non-additionality in some cases. This effect would reduce additional savings from these higher ambition scenarios to a degree, but not completely, as measures are assumed to expand in scope/coverage as well as stringency or ambition.

Fuel Switching

This study does not seek to model *all* fuel switching that may occur in the business mass market sector (nor in other sectors), but rather does seek to identify where fuel switching is expected as a result of energy efficiency policies and measures. Candidates for investigation will include:

- NCC (minor switching from electricity to gas was modelled for NCC2019)
- Emissions Reduction Fund (methods include fuel switching)
- Clean Energy Finance Corporation investments
- Energy Savings Scheme (NSW), Victorian Energy Upgrades (VIC) and Retailer Energy Productivity Scheme (SA).

2.6 Business Mass Market (Industrial)

2.6.1 Overview

The scope of industrial forecasts is limited to small and medium-sized enterprises in Divisions B and C. Large Industrial Loads (LILs) are excluded. As noted in Section 2.3.2, LILs energy efficiency could only be modelled using the 'EASIF' approach one sector at a time, and then only with access to confidential output and energy consumption data. For this project, AEMO has estimated the split of electricity consumption between the BMM and LILs by ANZSIC Division but could not make a similar split for gas.

Total Energy Efficiency Change

As discussed in Section 2.3.2 above, it not feasible to determine total efficiency change in the BMM Industrial sector – that is, within the scope of this study and using the data sources available to it.[15]

[15] Detailed studies have been done in Australia and overseas of industrial energy efficiency, but at a sub-sectoral level and with the participation of companies, in order to access physical output measures such as

AEMO has estimated the portion of energy consumption by industrial BMM by Division. However, we have no ready measure of the output from these energy users.

Market-led Efficiency Change

As with the BMM commercial sector, literature quantifying the rate of market-led, or autonomous, energy efficiency improvement in the BMM industrial sector in Australia is limited. While dated, data from the former Energy Efficiency Opportunities (EEO) program remains relevant, noting that this program was skewed towards larger enterprises, consuming at least 0.5 PJ of energy per year).

Policy-induced Efficiency Change

Our policy review summary (see Table 3) confirms that there are relatively few significant policy measures currently operating in Australia that are likely to impact on industrial SME efficiency. These measures include aspects of:

- the GEMS program (eg, chillers, motors)
- state energy savings schemes (NSW, VIC)
- the Emissions Reduction Fund
- CEFC investments
- VIC Business Recovery Energy Efficiency Fund.

For all policy measures, we estimate the split between the SME and LIL portions of savings measures, either using guidance from program managers, where available, or in line with energy consumption shares.

Discounts/avoiding double-counting

While there are fewer energy efficiency measures in the industrial SME, we consider where measures may target the same sub-sectors, fuels and end-uses, and apply discount factors, using the same approach documented for the residential and business mass market sectors.

Fuel Switching

Some energy efficiency measures have indirect, or even direct, fuel switching impacts, including state savings scheme (notably Victorian Energy Upgrades), but also the ERF and CEFC. We expect fuel switching to occur increasingly in new buildings, but our focus on this question is limited to areas where fuel switching occurs in association with energy efficiency measures, and not purely market-based fuel switching effects.

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tonnes of product by type/specification. In Australia, past documentation and also methodologies from the Energy Efficiency Opportunities program remain relevant.

2.6.2 Projections Methodology

While we have noted that there is limited potential for top-down/bottom-up integrated modelling in this sector, estimating gross energy intensity, as discussed above, will provide analysis of the direction and magnitude of recent change in energy intensity, which may provide some short-term guidance into the future. However, as in previous years, the expected scale of energy savings in this sector is estimated largely bottom-up from relevant program statistics.

Noting that there are relatively few measures in this sector, projections for higher ambition scenarios require that the expected impact of new policy options are modelled. These are summarised considered in Table 10 below. As an example, and recognising the bespoke nature of many industry processes, mandatory efficiency assessments and reporting could be envisaged. As with CBD or other disclosure-based schemes, such a measure would not need to require (mandate) any prescriptive outcomes in order to generate efficiency impacts. That is, the business case for energy efficiency investments may already be attractive, but may not be examined, particularly at senior management levels, and therefore not acted upon. What could be mandated is the *process* of review and disclosure. As in other sectors, we recall that modelling such measures is not done with any expectation that such measures will be used, but rather to illustrate potential outcomes associated with scenario narratives.

Discounts/avoiding double-counting

As in other sectors, managing risks of double-counting and non-additionality in the industrial SME sector requires an examination of the extent to which measures target the same sub-sectors, fuels and end-uses. Where this does (or may) occur, discounts are applied to represent the degree of non-additionality between measures, using the same policy hierarchy noted for other sectors.

We note, however, that a particular challenge arises with state energy savings schemes, and potentially also with CEFC and ERF, in that they offer (or can offer) process- (or project-) based assessment methodologies that are not technology or end-use specific, and therefore they may present non-additionality risks that vary and are hard to assess in advance. In the case of ERF, its enabling legislation requires that non-additional savings are excluded.

Table 10: Industrial SME Policy Settings by Scenario

Policy Type/ Jurisdiction	Slow Growth	Current Trajectory	Net Zero	Sustainable Growth	Export Superpower	Rapid Decarbonisation
GEMS	No new/updated measures	No new/updated measures	Inclusion of measures assessed by GWA as "Possible" for this sector	Inclusion of measures assessed by GWA as "Possible" and "Suspended but could be	Significant expansion of scope of program, covering all sectors and more products, and	Significant expansion of scope of program, covering all sectors and more products, and

Policy Type/ Jurisdiction	Slow Growth	Current Trajectory	Net Zero	Sustainable Growth	Export Superpower	Rapid Decarbonisation
				reactivated" for this sector	delivering 25% greater realisation of saving than under Sustainable Growth.	delivering 25% greater realisation of saving than under Sustainable Growth.
State/Territory Savings Schemes	Remain at currently projected levels/durations and jurisdictions – including current coverage of industrial SMEs – with no continuation after current cessation dates	Targets continue to increase at modest pace in existing jurisdictions, with same proportion of savings attributable to industrial SMEs	Targets continue to increase at modest pace in existing jurisdictions, with same proportion of savings attributable to industrial SMEs	Targets continue to increase, but at a more rapid pace; modest targets adopted by other states/territories. Some encouragement for electrification, and all schemes include some access for industrial SMEs (where not already the case)	Targets continue to increase, but at the most rapid pace cost effective, assuming a shadow (or actual) carbon price. Schemes in place for all jurisdictions. All schemes provide access for industrial SMEs.	Targets continue to increase, but at the most rapid pace cost effective, assuming a shadow (or actual) carbon price. Schemes in place for all jurisdictions. Electrification strongly encouraged, and all schemes provide access for industrial SMEs.
Mandatory efficiency assessments and reporting	No significant funding and no additional savings	Continuation of existing measures at current (real) funding levels; no new measures	Continuation of existing measures at current (real) funding levels; no new measures	Assume modest new measures in all jurisdictions, equivalent to an additional 20% of savings attributable to energy savings schemes in this scenario	Extensive programs in all jurisdictions and sectors[16], leading to additional savings equivalent to 100% of those attributable to energy savings schemes in this scenario	Extensive programs in all jurisdictions and sectors, leading to additional savings equivalent to 100% of those attributable to energy savings schemes in this scenario

Fuel Switching

As in the BMM Commercial segment, some industrial energy efficiency measures have indirect, or even direct, fuel switching impacts, including:

- NSW Energy Savings Scheme, VIC Victorian Energy Upgrades
- ERF

[16] Indicative examples would include deep retrofits of existing buildings to the maximum degree cost-effective, extensive market transformation initiatives encouraging best practices and technologies; 'climate justice' public investments to assist with structural adjustment/new processes for industry, significant training/professional development in energy performance.

- CEFC.

However, in the industrial SME sector, even more than in the other sectors considered above, the business case for fuel switching is likely to be more delinked from the business case for energy efficiency. This flows from the higher (average) energy intensity of industrial, versus residential or business mass market, customers, as well as unique energy service requirements. Factors such as the relative costs of delivered energy services will likely be weighted in favour of the relative cost of energy supply, with the efficiency of energy use playing an important but often secondary role. That said, niche applications do exist, such as the replacement of low temperature steam boilers with heat pumps, for example, implying both an efficiency and a fuel switching impact. Other electrical technologies that make use of microwave or other energy carriers may similarly lead to fuel switching as well as efficiency outcomes.

For the projections, we take into account where programs have forward-looking targets (such as the Victorian Energy Upgrades program or ESS, for example) and, beyond these, align assumptions with scenario-specific narratives regarding the extent of fuel switching (most apparent in the Rapid Decarbonisation scenario).

3. 2021 Energy Efficiency Forecasts

3.1 Residential

As noted in Chapter 2, residential energy efficiency savings estimates are based on the aggregation of savings estimates derived from the following key drivers:

- Greenhouse and Energy Minimum Standards (GEMS) – affecting all jurisdictions
- National Construction Code building energy standards (NCC) – affecting all jurisdictions
- NSW Energy Savings Scheme (ESS) – affecting NSW households
- Victorian Energy Upgrades (VEU) – affecting Victorian households
- Victorian Household Energy Savings Package (VHESP), and
- Retailer Energy Productivity Scheme (REPS) – affecting South Australian households.

For ambitious energy efficiency scenarios all existing measures are assumed to ramp up, and jurisdictions without existing State-based measures are assumed to adopt programs similar to those operating in other States and territories.

In addition, a background trend of market driven energy efficiency improvement (AEEI) is also applied. For the (high ambition) Export Superpower and Rapid Decarbonisation scenarios, AEEI presents as a compounding improvement in annual household energy consumption of 0.3% year up to 2024 but increases by 10% (to ~0.33% pa) for the period to 2034, and then remains at around 5% above pre-2024 levels (~0.31% pa) for the remainder of the outlook period. For these high ambition scenarios, accelerated AEEI is assumed to result in a 24% improvement in residential energy efficiency (relative to 2010 efficiency levels) by 2050. This compares to a 13% improvement in efficiency by 2050 under the other scenarios.

3.1.1 National Construction Code energy performance requirements - methodology

Residential energy savings forecasts for the NCC are based on modelling electricity and gas requirements for dwelling heating and cooling loads according to their size and age. Dwellings built since 2003 have been subject to NCC minimum energy efficiency standards, and therefore (if built and operated as expected) have predictable average annual energy requirements in order to maintain thermal comfort. The 2014 Residential Baseline Study (RBS) provides valuable information on the mix of heating, cooling and 'baseload' appliances used by households in different States and this information, combined with information on the coefficient of performance of space conditioning appliances and typically residential floor areas across different locations, allows household gas and electricity consumption to be estimated. We applied the observed RBS 2014 household electricity and gas mix to generate residential energy and savings forecasts.

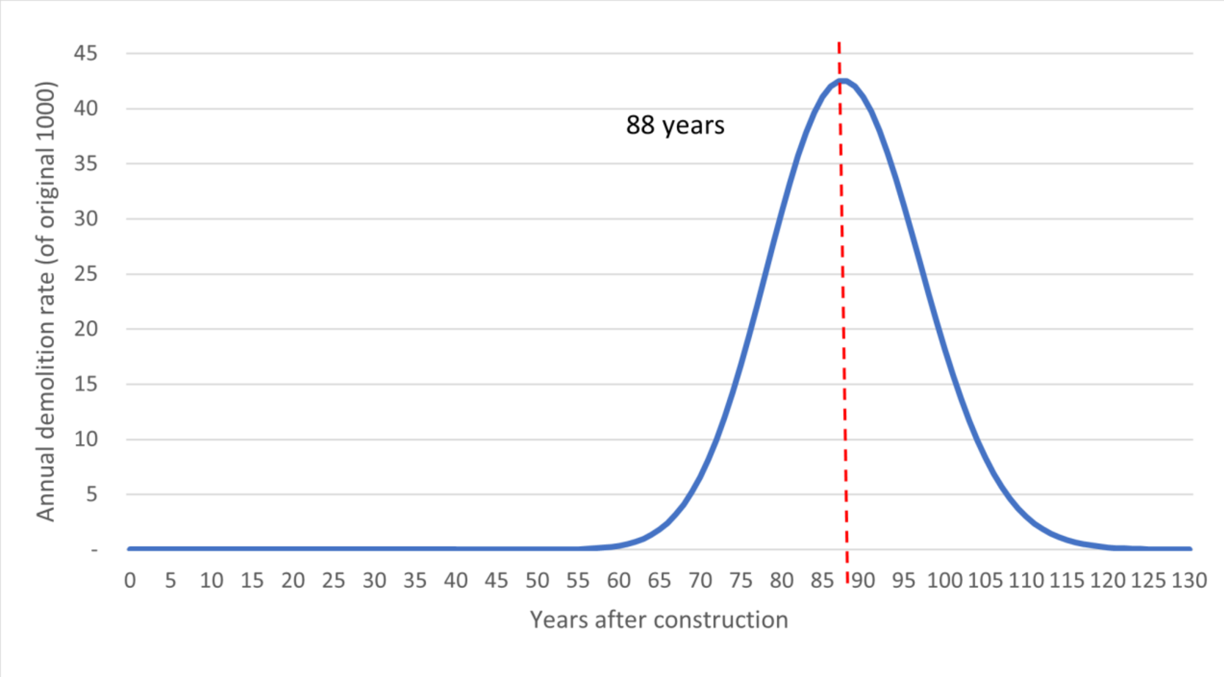
Changes to the NCC energy efficiency requirements impact new and replacement housing and will impact the energy requirement of those buildings over their service lifetime. The average efficiency of the house stock as a whole can be expected to increase as old houses are replaced by new ones, and as new homes are built to service population growth.

Based on previous analysis of housing in the Sydney basin, the Hunter Valley and NSW Central Coast we have assumed an average life to demolition (or major renovation) of around 88 years.[17] We also assume that this average lifespan leads to a pattern of demolition and replacement that can be represented by a Poisson decay function. This is illustrated in Figure 2. For a housing stock that is long established (eg. experienced 150 years or more of steady growth with new dwellings adding to the stock each year), the observed demolition rate of old homes (as a proportion of the total population) tends to stabilise. In our modelling of the SWIS and NEM catchments we have assumed an observed stock turnover rate of 0.4% per annum.[18]

Information on State and regional housing stock characteristics was obtained from Census and AEMO data. Census data allows the number and mix of dwellings to be tracked back to 2001, and trends in this mix occurring within each State climate zone – in combination with information on the average size of houses, townhouses and apartments, provides a basis for projecting the future housing mix - and its corresponding heating and cooling requirements. Annual projections developed in this way were scaled to align with the dwelling totals provided by AEMO as part of their scenarios.

[17] This is a weighted average and captures the typically shorter life of a house in a city location compared to that of a dwelling in a small town or rural area.
18 This estimate is consistent with observations from the National Housing Supply Council (2009), State of Supply Report which estimate dwelling demolitions across Australia during 2008 at around 45,000 within a total dwelling stock of about 8,860,000 homes. This puts the demolition rate at that time at around 0.5% pa. See Table 3.1 (p.35) of that report.

Figure 2: Assumed demolition profile: Poisson decay (house stock: 1000, avg life: 88 years)



Long term impacts of the Commonwealth's Housing Insulation Program (HIP) have also been modelled. This was rolled out across Australia during 2009 and resulted in a significant heating and cooling efficiency upgrade for over 1.2 million homes. The estimated uptake of HIP by climate zone, and the average level of thermal efficiency improvement achieved within each is shown in Table 11.

Table 11: Commonwealth Housing Insulation Program (2009) roll-out

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
No. homes insulated	489,259	279,941	339,186	41,115	67,965	15,304	2,728	5,761
% of total (based on Class 1ai & 1aii est)	10.9%	7.3%	11.3%	3.2%	4.1%	3.7%	2.3%	2.4%
Pre-HIP Star rating	1.0	1.3	0.8	1.6	1.4	1.1	1.6	1.7
Post-HIP Star rating	3.3	3.2	3.1	3.9	4.1	2.9	3.7	3.7
% in Climate zone 1			12%		3%		79%	
….. Climate zone 2	7%		77%					
….. Climate zone 3			5%		1%		21%	
….. Climate zone 4	12%	5%		4%	7%			
….. Climate zone 5	47%		6%	78%	86%			

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
….. Climate zone 6	30%	81%		18%	4%			
….. Climate zone 7	4%	14%				100%		100%

Source: Energy Efficient Strategies (2011), Report to ICANZ: THE VALUE OF RETRO-FITTING CEILING INSULATION T O RESIDENTIAL BUILDINGS, p.34, 44

3.1.2 Residential model calibration

Estimates for household energy consumption are matched to a historical data series for distributed electricity consumption in order to calibrate the model. Network energy consumption is directly metered and verifiable. It is therefore likely to be amongst the most reliable estimates available to us for calibration purposes. The model estimates both household electricity and gas consumption and depicts the growth in household investment in photovoltaic electricity generation (PV) from around 2010. The use of PV to supplement distributed electricity purchases is modelled at a State level.

Electricity consumption estimates generated by the model (using 'central' usage parameters) generally match AEMO data well. For instance, it is common practice to discount the energy requirement for space conditioning estimated by NatHERS by around 50%. This is because the NatHERS calculation assumes household comfort levels are maintained every day, all year. The NatHERS estimates also assume that the building is occupied in a standardised manner. Thirdly, NatHERS estimates refer to an energy requirement (MJ per annum) per square metre of living space, and can capture garages, storage areas and spare bedrooms in the estimate of enclosed floor space reported by the ABS. Generally, only minor adjustment of the 'dwelling utilisation' parameter was necessary to bring model predicted electricity consumption into alignment with the AEMO dataset.

Notably, the AEMO data provided spans the period July 2016 to March 2020 and this covers a period of drought and extreme climate events that would perturb 'normal' energy consumption requirements. This is also a factor in considering what constitutes a 'reasonable' match between modelled and actual when the objective is to project future energy consumption – and saving – outcomes.

AEMO also provided data on the amount of electricity consumed from the grid and an estimate of the additional amount of residential electricity consumption that was sourced off-grid. That is, from rooftop photo voltaic arrays. The estimate of the total (or "underlying") household electricity consumption of households in each jurisdiction. This was applied to calculate an estimate of electricity use per residential connection, allocated to baseload, heating load and cooling load. AEMO's estimates of electricity consumption per connection for 2020-21 are shown in Table 12. Total electricity use per connection outcomes were also an important factor in the model calibration exercise.

Table 12: AEMO guidance on per connection residential electricity usage (grid+PV), 2020-21

Region	Year	Base load	Heat load	Cool load	Total electricity
	MWh per connection				
NSW (incl ACT)	2021	5.23	0.66	0.42	6.31
QLD	2021	5.28	0.24	0.85	6.36
SA	2021	3.90	0.81	0.42	5.13
VIC	2021	3.86	0.87	0.17	4.90
TAS	2021	5.50	2.30	0.00	7.80
SWIS	2021	5.53	0.27	0.35	6.16

An overview of calibration outcomes follows.

South West Interconnected System (SWIS): WA

AEMO provided a 10-year electricity data series for WA. Our model was able to match details on electricity consumption from the grid quite closely for this period. In response to feedback from an earlier stakeholder workshop, our initial estimates for the annual impact of GEMS were discounted by a compounding 2.5% per year from 2010 as input to the modelling and calibration exercise. By FY2053, the originally estimated impact for GEMS (beyond what could be expected from market driven technical change and innovation) is effectively discounted by about 67%.

Further, the model reflects negligible household PV supply, and the dominance of distributed supply prior to 2010. AEMO advise that by FY2020, the share of PV sourced electricity supply has risen to around 25%. Our modelling reflects a linear increase from 2010 to this level.

The model, which uses ABS data to separately estimate energy consumption for houses, townhouses and apartments in State climate zones, was also adjusted to reflect the substantially incomplete coverage of the South West Interconnected System (SWIS) for homes in climate zone 6 (CZ6). Comparing ABS Census data with the AEMO count of metered connections suggested that the SWIS supplies electricity to about 70% of homes in this area. It omits homes in centres such as Broome and Karratha, and other smaller towns and settlements. The climate zone coverage in the model was adjusted accordingly.

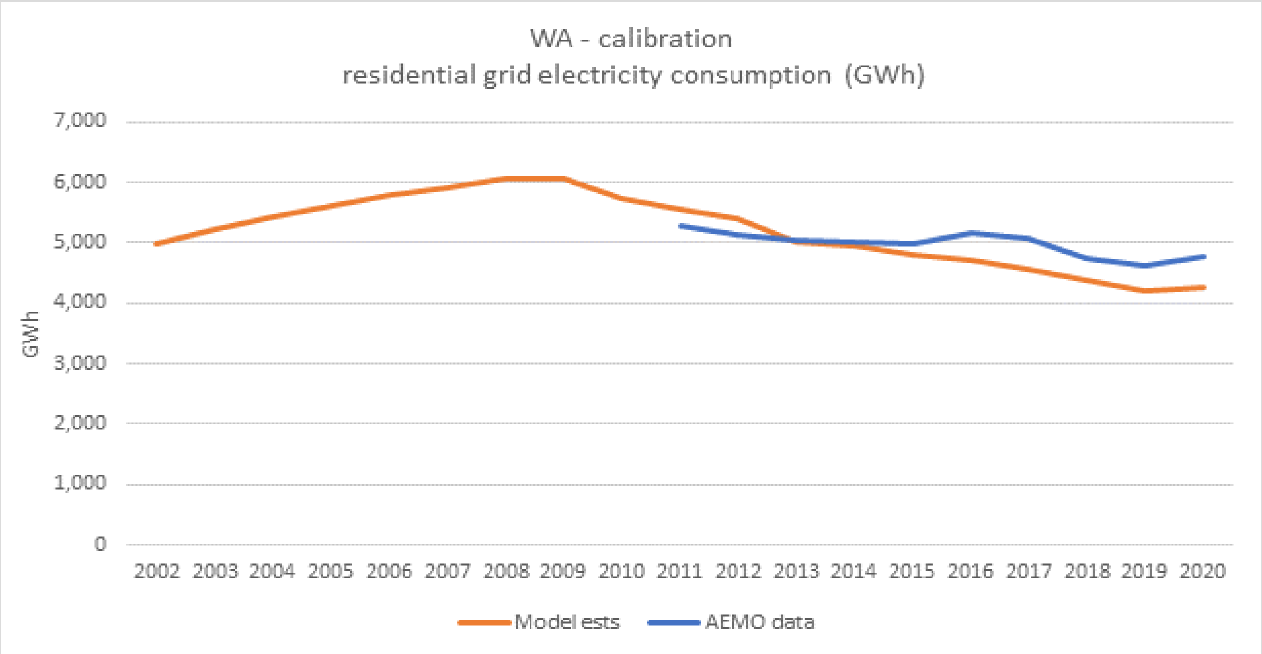
Final model parameters and the concordance adopted for WA appear in Table 13 and Figure 3 below.

In addition, to achieve good agreement between the model estimate for residential electricity consumption from the SWIS and the AEMO data series, a dwelling utilisation factor of 55% was applied. That is, the energy use requirement (per square metre of living area) for space heating and cooling was set at 55% of the underlying NatHERS estimate – which assumes comfort levels are maintained all day, all year round. As noted, values around 50% are commonly observed for actual household use under normal conditions. A result of 55% could indicate that comfort levels are being maintained for a bit more than half the hours assumed within the NatHERS calculation, and/ or a higher level of thermal comfort is being sought. Higher utilisation factors indicate more hours and/or more comfort than the NatHERS median.

Table 13: (SWIS) WA model calibration parameters

Climate zone	1	2	3	4	5	6	7
System coverage of households	100%	na	100%	100%	100%	70%	na
AEEI for period 2010 to 2020 (% improvement per year)	0.3%						
GEMS savings discount factor (% discount per year, compounding after 2010)	2.5%						
PV share of total residential electricity consumption by 2020	24.9%						
Dwelling utilisation factor (% discount applied to NatHERS ests)	55%						

Figure 3: SWIS residential grid electricity consumption, modelled vs observed



Overall, the model estimate for grid electricity consumption within the SWIS for the period from July 2011 to March 2020, matches the corresponding AEMO consumption total at a rate of 96.0%. That is there is only a 4% discrepancy between the model prediction of household electricity consumption from the grid, and that actually observed for the period.

Alignment with AEMO's estimate of total electricity consumption per connection was also targeted. This measure aggregates both grid electricity and residential rooftop solar in the electricity use total. For WA, the modelling produced a 2020-21 estimate of 6.35 MWh per household versus the AEMO estimate of 6.16 MWh per household.

National Electricity Market (NEM): NSW+ACT, VIC, QLD, SA, TAS

The NEM is modelled at a State level, with the ACT combined with NSW for AEMO data reporting purposes. This convention is followed in the report. However, to generate estimates that are consistent with the AEMO definition of "NSW" energy use, this region is built up from ABS data on NSW and the ACT that follows the traditional jurisdictional definition. These State and Territory estimates are then added together to give energy use (and savings) estimates that align with the AEMO definition.

Parameter details and the concordance of estimated distributed electricity consumption with that generated by our bottom-up model for each jurisdiction is shown below. For the NEM regions, available AEMO electricity data was limited to the period from 1 July 2016 to 1 March 2020. That is, three full financial years and a part year result for FY2020 which encompasses only nine months of metered consumption records.

Table 14: NEM region model calibration parameters

	NSW						
Climate zone	**1**	**2**	**3**	**4**	**5**	**6**	**7**
System coverage of households	na	100%	na	100%	100%	100%	100%
AEEI for period 2010 to 2020 (% improvement per year)				0.3%			
GEMS savings discount factor (% discount per year, compounding after 2010)				2.5%			
PV share of total residential electricity consumption by 2020				11.4%			
Dwelling utilisation factor (% multiple applied to NatHERS ests)				55%			

ACT

Climate zone	1	2	3	4	5	6	7
System coverage of households	na	na	na	na	na	na	100%
AEEI for period 2010 to 2020 (% improvement per year)				0.3%			
GEMS savings discount factor (% discount per year, compounding after 2010)				2.5%			
PV share of total residential electricity consumption by 2020				11.4%*(assume mirrors NSW est)			
Dwelling utilisation factor (% multiple applied to NatHERS ests)				60%			

VIC

Climate zone	1	2	3	4	5	6	7
System coverage of households	na	na	na	100%	na	100%	100%
AEEI for period 2010 to 2020 (% improvement per year)				0.3%			
GEMS savings discount factor (% discount per year, compounding after 2010)				2.5%			
PV share of total residential electricity consumption by 2020				14.4%			
Dwelling utilisation factor (% multiple applied to NatHERS ests)				55%			

QLD

Climate zone	1	2	3	4	5	6	7
System coverage of households	100%	na	80%	na	100%	na	na
AEEI for period 2010 to 2020 (% improvement per year)				0.3%			
GEMS savings discount factor (% discount per year, compounding after 2010)				2.5%			
PV share of total residential electricity consumption by 2020				26.2%			
Dwelling utilisation factor (% multiple applied to NatHERS ests)				55%			

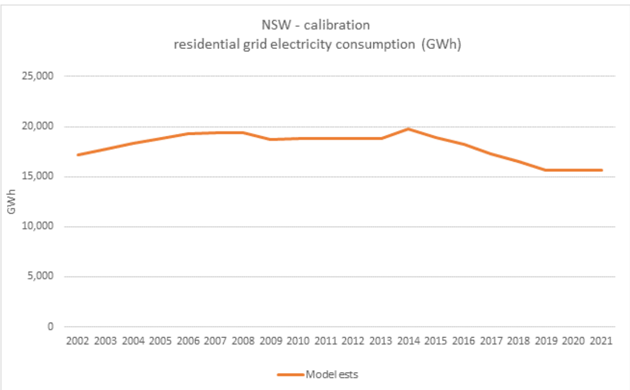
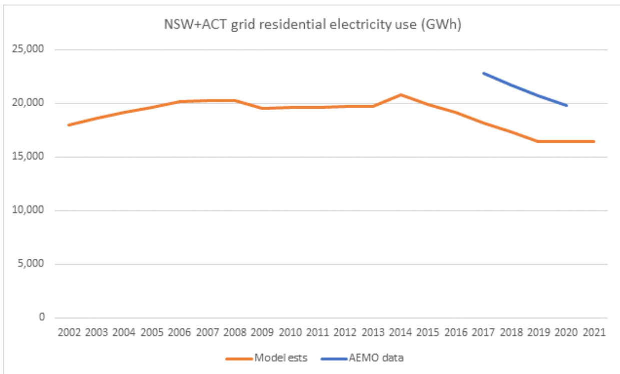
SA

Climate zone	1	2	3	4	5	6	7
System coverage of households	na	na	na	100%	100%	100%	na
AEEI for period 2010 to 2020 (% improvement per year)				0.3%			

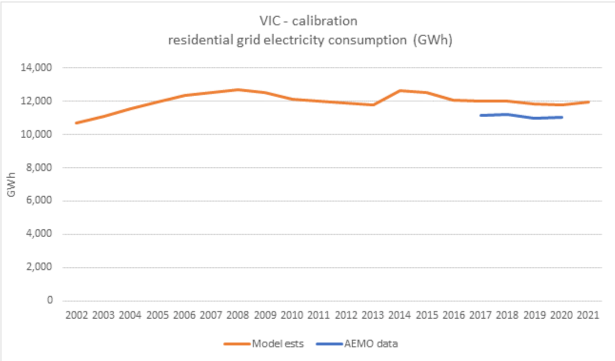
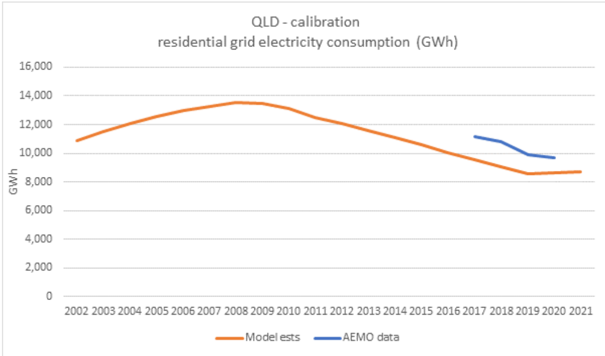
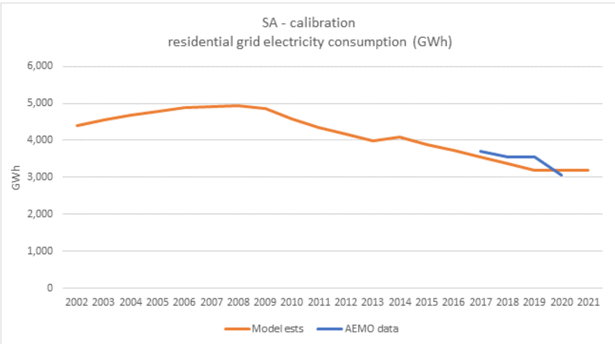
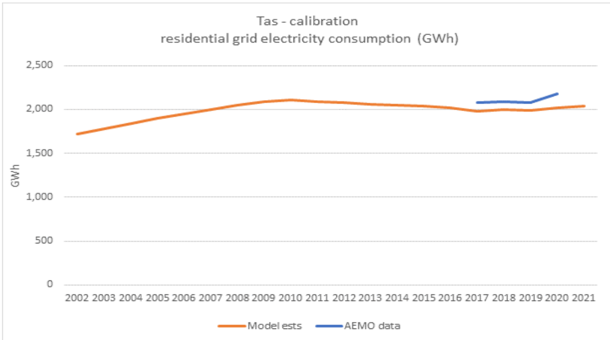
GEMS savings discount factor (% discount per year, compounding after 2010)	2.5%						
PV share of total residential electricity consumption by 2020	29.6%						
Dwelling utilisation factor (% multiple applied to NatHERS ests)	55%						
	TAS						
Climate zone	**1**	**2**	**3**	**4**	**5**	**6**	**7**
System coverage of households	na	na	na	na	na	na	100%
AEEI for period 2010 to 2020 (% improvement per year)	0.3%						
GEMS savings discount factor (% discount per year, compounding after 2010)	2.5%						
PV share of total residential electricity consumption by 2020	6.5%						
Dwelling utilisation factor (% multiple applied to NatHERS ests)	50%						

The resultant NCC calibration outcomes are shown in Figure 4. These show the modelled effect of GEMS and the NCC on State household electricity consumption outcomes from the NEM. Note that AEMO grid electricity data was only available for the combined consumption of households in NSW and the ACT.

Figure 4: NEM jurisdiction residential grid electricity consumption, modelled vs observed

NSW	NSW + ACT (= AEMO "NSW")
	
2017-2020 GWh grid alignment = na	2017-2020 grid GWh alignment = 80.4%
AEMO MWh/hhld = na Model MWh/hhld = na	AEMO MWh/hhld = 6.31 Model MWh/hhld = 7.30

cont. overleaf

VIC	QLD
	
2017-2020 GWh grid alignment = 92.7%	2017-2020 grid GWh alignment = 86.4%
AEMO MWh/hhld = 4.90 Model MWh/hhld = 5.87	AEMO MWh/hhld = 6.36 Model MWh/hhld = 7.31
SA	**TAS**
	
2017-2020 grid GWh alignment = 96.1%	2017-2020 grid GWh alignment = 94.9%
AEMO MWh/hhld = 5.13 Model MWh/hhld = 6.70	AEMO MWh/hhld = 7.80 Model MWh/hhld = 9.38

Modelled network electricity consumption, as described, provides a reasonable alignment with observed outcomes for most States, and for the NEM overall – noting that AEEI and State measures are not reflected in the early calibration. However, the contribution of these factors to overall State electricity consumption outcomes in FY2021 is small alongside measures such as GEMS and the NCC. For AEMO NSW, the modelled estimate for electricity consumption from the grid is about 20% below the outcome reported by AEMO.

When PV contributions are added, the modelling tends to over-estimate total electricity use per household – indicating outcomes that are higher than those advised by AEMO, generally by around 15-20%, though for South Australia the over-estimate reaches 30%.

The reasons for these mismatches are unclear, but could include:

- Greater or less reliance on electricity (as opposed to gas) for heating and cooking than assumed in the modelling (which applies the energy mix observed in 2014 by the Residential baseline study). This mix may have changed due to policies introduced in the interim period.

- extreme heat events during the period, leading to higher household electricity consumption in some States than a 2014 usage profile would suggest
- differences in usage patterns between NSW and the ACT that have been overlooked due to data aggregation.

This disparity highlights the inherent uncertainty in this projections exercise, and the need for periodic review and recalibration.

Finally, for compatibility with its own modelling and forecasting, AEMO required the electricity savings estimates generated by our modelling exercise to align with the residential load splits they currently observe in the meter data. If, say, residential cooling within a State was observed to consume around 2.0 MWh of electricity per household per year, then an incompatibility would arise if cooling savings of more than 2.0 MWh per household were projected by the end of the forecast period. AEMO electricity load splits for 2021 are presented below in Table 15.

Table 15: AEMO guidance on average annual residential electricity consumption, by load type

Region	Year	Baseload	Heating	Cooling	Total
	Share of annual residential electricity consumption by load type				
NSW (incl ACT)	2021	82.9%	10.4%	6.7%	100%
QLD	2021	83.0%	3.7%	13.3%	100%
SA	2021	76.0%	15.8%	8.3%	100%
VIC	2021	78.7%	17.8%	3.5%	100%
TAS	2021	70.6%	29.4%	0.0%	100%
SWIS	2021	89.8%	4.5%	5.8%	100%

This posed difficulties for our modelling because AEMO's estimates of per household heating and cooling needs were generally much lower than those indicated by both the Residential Baseline Study and by NatHERS. Most studies capture heating and cooling energy use as a function of the annual energy use of heating and cooling equipment. However, AEMO's interest is in the portion of the load that is temperature-responsive, and this can be less than the annual energy consumption of space conditioning equipment, as this equipment – particularly in commercial buildings – can operate even at mild temperatures. Our perception, however, is that this much less common in dwellings.

In 2016, CSIRO examined the residential air conditioner cooling use in Australia. If found that the key technical determinants of energy use were a) air infiltration rates and b) the conditioned area. However, it also found that occupant behaviours were much more important than these factors, with almost half of those surveyed using air conditioning every day in summer, and less than 20% only using it on very hot days. Those more likely to use air conditioners were those in higher income brackets, younger people and those living in newer buildings (even though these – sometimes – had higher thermal performance ratings). Older and wealthier householders were, however, more likely to leave a/c systems running, regardless of external temperatures, and overnight.[19] We could posit a potentially weaker linkage between air conditioning energy use and ambient temperatures over time, as cooling becomes more affordable (including due to higher incomes, lower A/C costs and a higher incidence of PV on roofs) and with an ageing population. However, it was beyond the scope of the current study to investigate these issues more closely.

As a way forward, total projected electricity savings were preserved - reflecting estimates generated by our modelling. This total was then apportioned according to the load splits estimated by AEMO. As a consequence, the total annual energy savings due to energy efficiency measures take primacy in the discussion below. The jurisdictional baseload, heating and cooling savings are a simple fraction of that. Generally, our modelling shows higher levels of heating and cooling savings for residential electricity than is indicated below, and lower savings against residential baseload consumption.

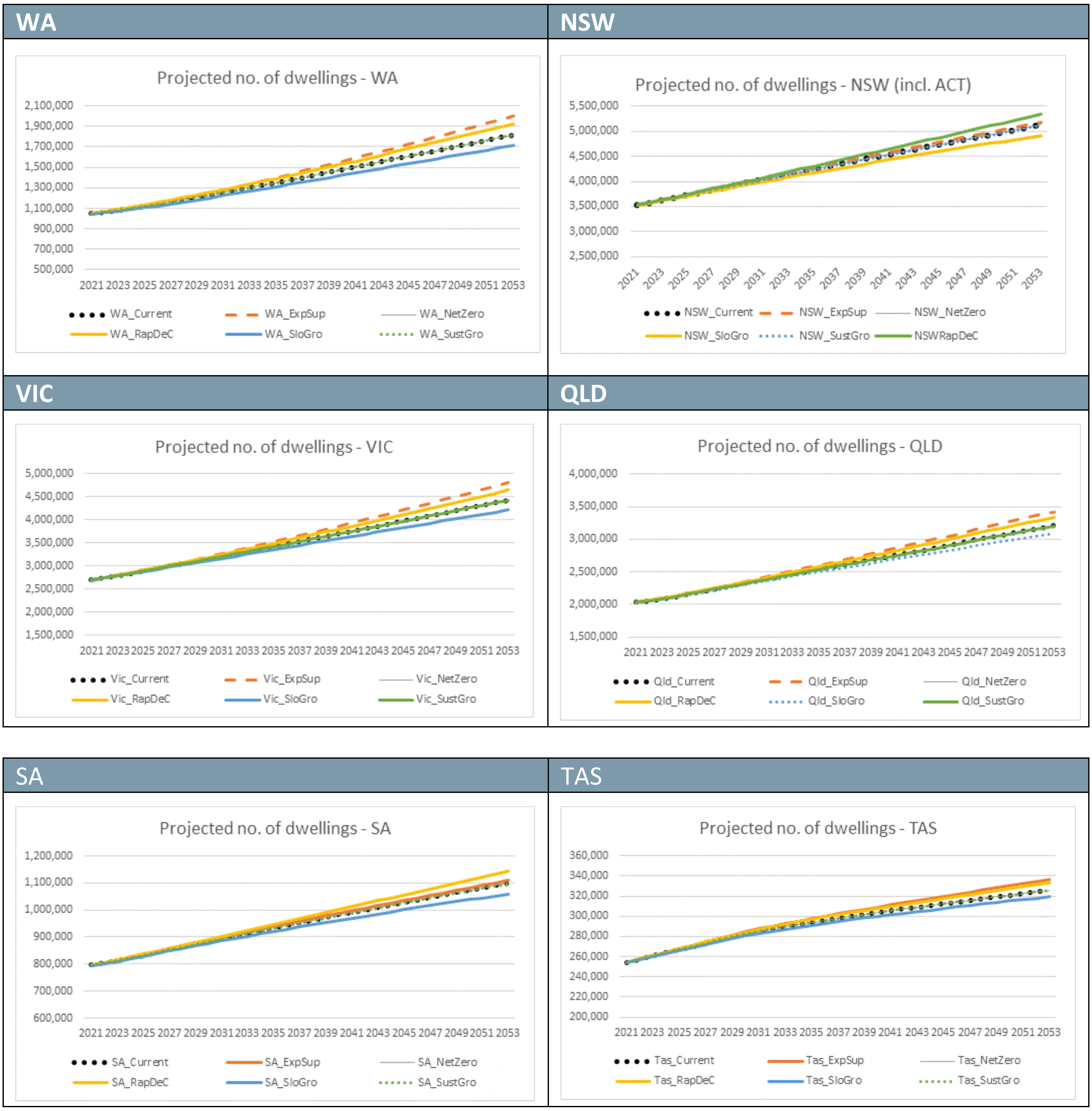
3.1.3 Projected energy savings

The modelling for residential energy consumption is driven by changes in the number and mix of dwellings and household appliance use. Trends in these characteristics, reflecting changes over the last three Census periods (Census 2006, 2011 and 2016), are carried forward within each State climate zone. The projected number of dwellings at State level from FY2021 onward follows estimates developed by AEMO. These estimates can vary according to the scenario being modelled. Growth in the number of dwellings in each State under the AEMO scenarios is show in the figures below.

All scenario series are identical for the period to FY2021, but there is some divergence beyond that. In the main, the Net Zero and Sustainable Growth scenarios follow similar dwelling growth paths to that of Current Trajectory. In contrast, Slow Growth – as the name suggests – reflects a more subdued growth trajectory, while Rapid Decarbonisation and Export Superpower exhibit a slightly higher level of growth in the State dwelling stock.

[19] M. Goldsworthy et al (CSIRO), *Predictors of residential air conditioner cooling behaviour*, June 2016, prepared for the Department of Industry, Innovation and Science.

Figure 5: Dwelling population trajectories, by AEMO scenario and State



For NSW, the number of dwellings projected for FY2053 varies from 4.4 million under Slow Growth to almost 4.8 million under Rapid Decarbonisation. For Victoria, strongest growth is exhibited under Export Superpower (to over 4.7 million dwellings by FY2053), but just under 4.2 million dwellings are projected under Slow Growth. Both Queensland and Western Australia (ie. SWIS) exhibit strongest growth under Export Superpower (with dwellings increasing to around 3.4 million and 2.0 million respectively by FY2053), while all jurisdictions record their lowest outyear housing figures under Slow Growth.

Based on these plausible patterns of growth in the dwelling stock and past and anticipated energy efficiency policy changes, our empirical modelling suggests the following level of efficiency savings that will impact residential electricity and gas consumption in the years ahead.

South West Interconnected System (SWIS - Western Australia)

Our modelling of energy efficiency measures impacting SWIS connected households in WA suggests that, relative to a FY2000 starting point, total electricity savings of around 5,677 GWh per annum could be achieved by FY2053, the end of the outlook period. This is under assumptions consistent with the Current Trajectory scenario. Relative to a FY2010 base year, this saving equates to around 4,547 GWh of electricity. And relative to present day, it represents a saving of just over 3,227 GWh pa by FY2053. This pattern of savings is depicted in Figure 6.

As expected, savings under the Current Trajectory lie between those generated for the Rapid Decarbonisation and Export Superpower scenarios and the Slow Growth scenario. Under more ambitious energy efficiency objectives, electricity savings rise to almost 9,940 GWh by FY2053, an increase of just over 8,800 GWh relative to 2010 (estimated 1130.7 GWh in that year) or about 7,394 GWh relative to current (FY2021) annual savings. In contrast, under the Slow Growth scenario electricity savings rise to a little over 5,063 GWh pa by 2053, or 3,933 GWh pa relative to FY2010 savings levels. These outcomes are shown in Figure 7.

Figure 6: Projected electricity savings in the SWIS, Current Trajectory

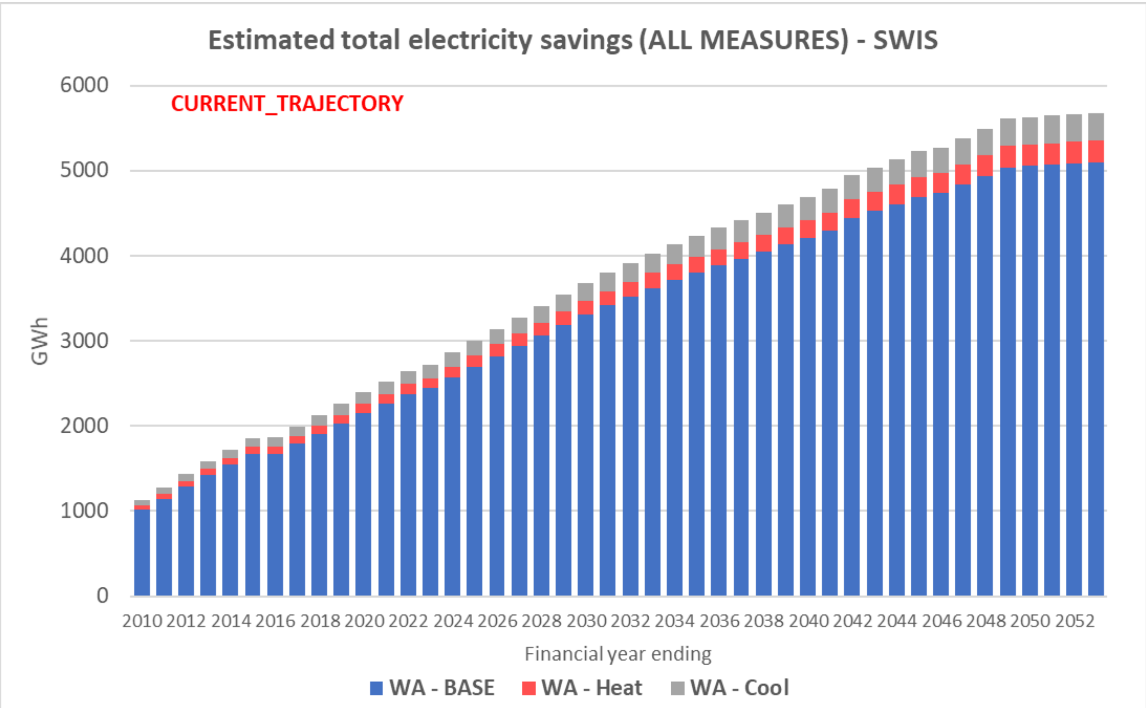


Figure 7: Projected electricity savings in the SWIS, under alternative scenarios

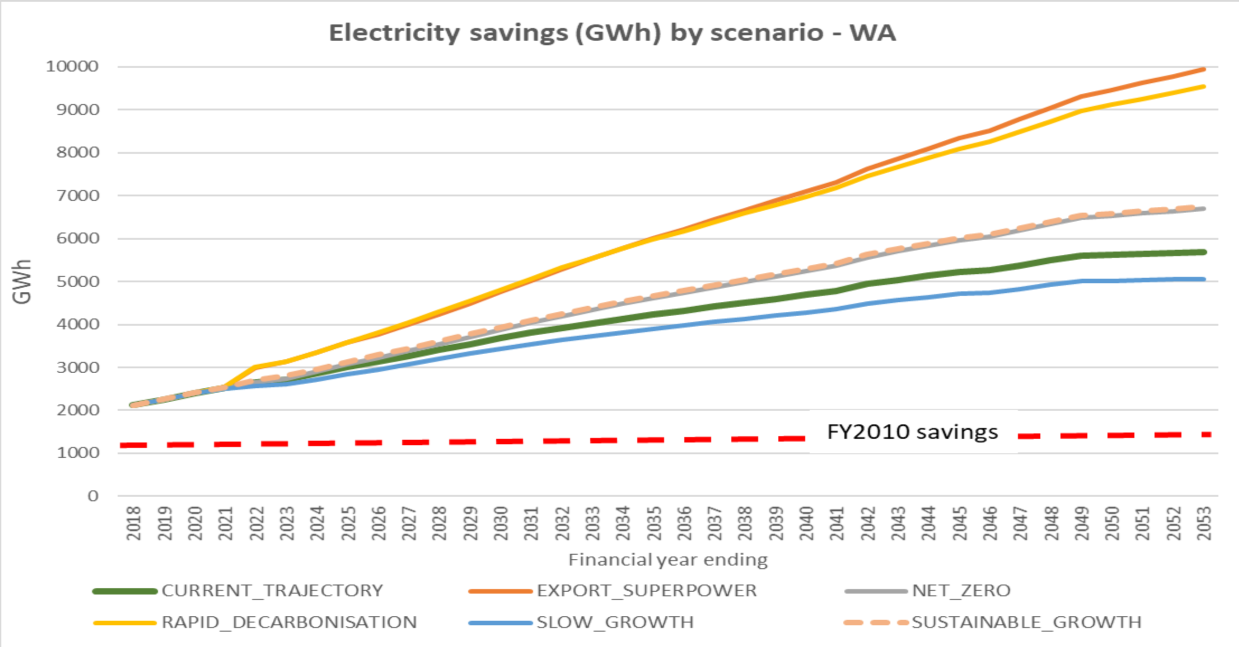
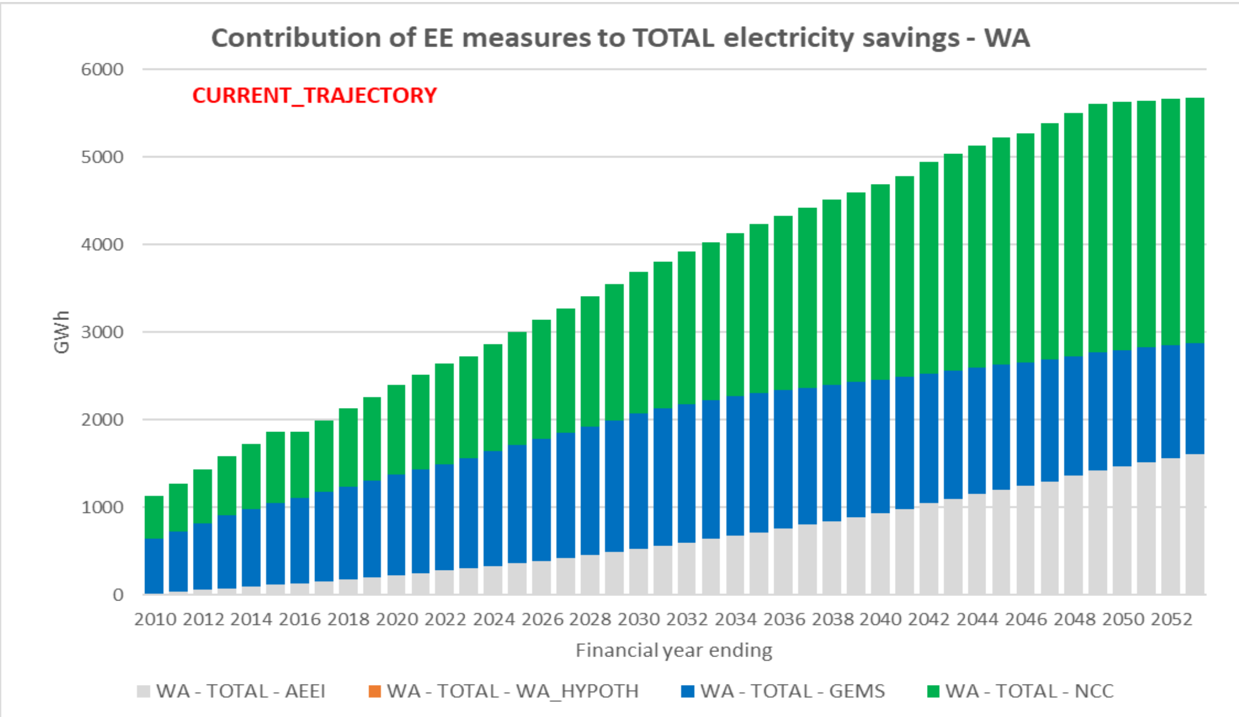


Figure 8: SWIS electricity savings due to EE measures, Current Trajectory



As can be seen from Figure 8, most of the savings in the SWIS are attributable to the residential energy efficiency standards that apply under the National Construction Code (NCC). It accounts for about 47% of the total electricity savings expected to be achieved in the period from 2010 to 2053 under the Current policy trajectory. The GEMS program delivers about 35% of savings, and market driven improvements (AEEI) account for about 18%. The hypothetical WA efficiency program envisioned as part of a possible future national energy savings drive is not activated under this scenario.

Figure 9 depicts outcomes for the Export Superpower and Slow Growth scenarios. These represent 'high' and 'low' energy efficiency savings outcomes for household electricity consumption in the SWIS. Under Export Superpower, hypothetical State measures add to expansion of existing measures to generate total electricity savings of around 9,939 GWh pa by FY2053 against a FY2000 savings base (8,808 GWh pa relative to FY2010 savings), noting that – in addition to stronger measures - bigger household savings are being achieved from a bigger base, commensurate with the dwelling stock growth assumptions of that scenario. The hypothetical State measure introduced in this scenario from FY2022 contributes about 8.0% of the total savings for the period from FY2010 to FY2053.

Under Slow Growth, as noted, total savings are around 5,064 GWh pa by FY2053 (relative to FY2000) and 3,933 GWh relative to a FY2010 savings base, with relative contributions from measures similar to those generated under the Current Trajectory scenario.

Figure 9: SWIS electricity savings due to EE measures, alternative scenarios

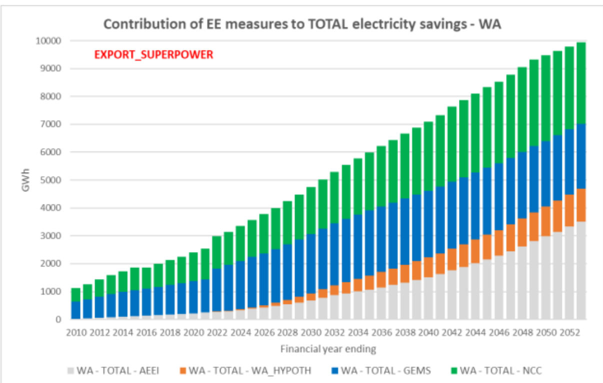
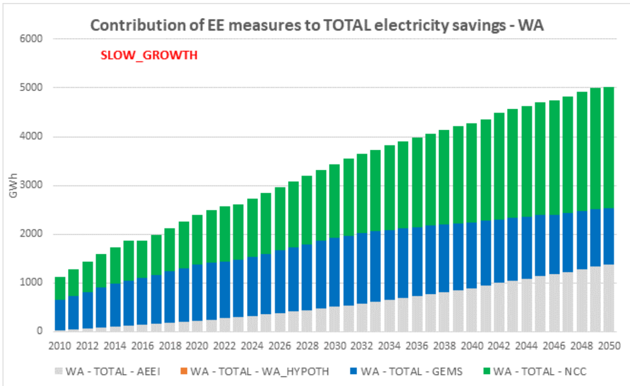
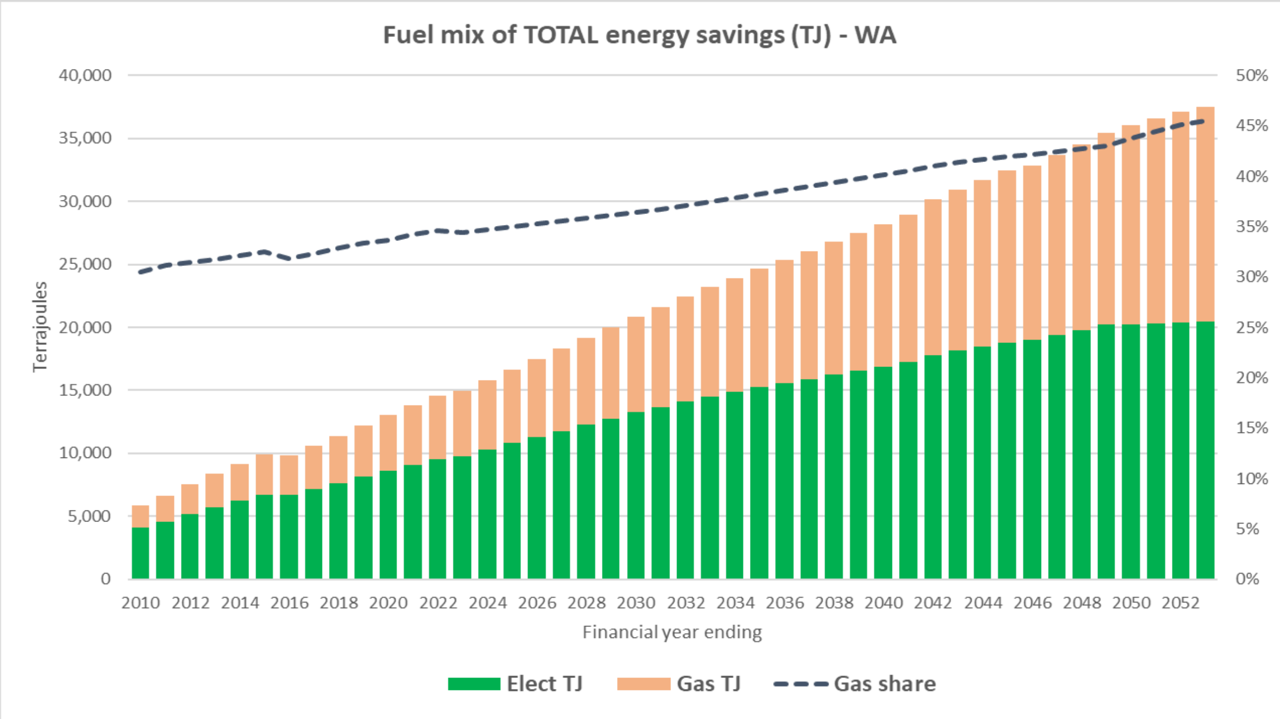
Export Superpower	**Slow Growth**
	

Figure 10: Gas and electricity shares in total energy efficiency savings, Current Trajectory



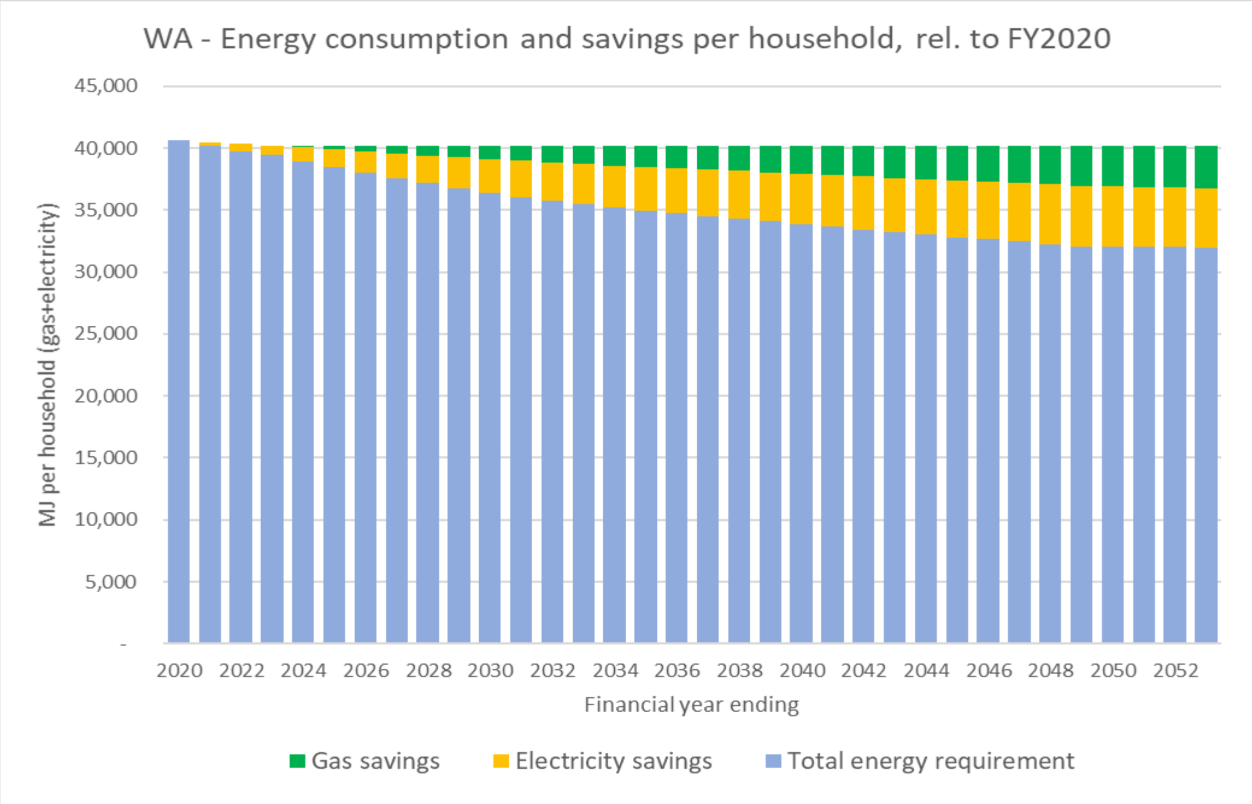
Gas savings are also driven by the measures (other than GEMS, which focuses only on electric appliances), and under the Current Trajectory scenario increase from an estimated 1,783 TJ in FY2010 to around 17,098 TJ in FY2053.[20] As shown in Figure 10, the contribution of gas savings to total energy savings rises from around to 30% to about 46% by FY2053. Scenarios exhibit similar savings contributions from measures as those depicted in Figure 10.

As noted, the system-wide energy savings are driven by planned and existing energy efficiency measures and their leverage of an expanding stock of dwellings, appliances and energy demands. However, it can also be informative to consider these energy savings on a per household basis. This is shown in Figure 11, which depicts the declining average energy requirement of a typical household serviced by the WA electricity and gas networks and the relative (average) share of gas and electricity in the energy savings achieved.

From a notional average energy requirement of about 40,652 MJ per household in FY2020 (according to our residential modelling), current measures are estimated to reduce average residential energy consumption in the SWIS to around 31,960 MJ per household by FY2053. This is a reduction of around 21% on current levels. Electricity savings are estimated to make up about 64% of the total energy savings achieved over the period from FY2020 to FY2053.

[20] GEMS can have an indirect effect on gas consumption via its impact on the economics of electric appliance purchase and operation versus competing gas options.

Figure 11: Efficiency impact on average household energy needs, SWIS -Current Trajectory



High ambition EE scenarios (eg. Export Superpower) could theoretically see total per household energy requirements decline by over 44% in the next 30 years (ie. to 22,315 MJ per dwelling in 2053), although the economic case for measures as stringent as these would need to be closely examined - as would the performance of alternative policy options.

National Electricity Market (Eastern States)

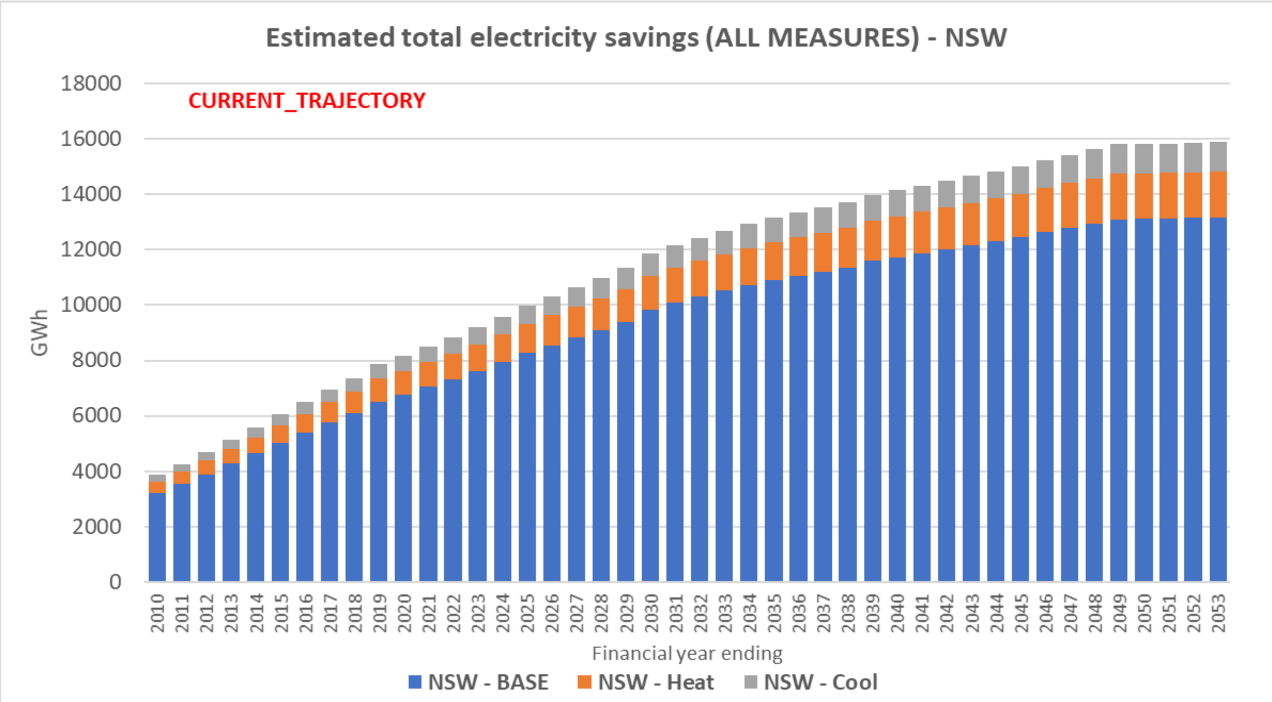
Modelling suggests significant energy savings are in prospect across the NEM in the years ahead due to residential efficiency gains. Under the 'central' projection represented by Current Trajectory, electricity savings in FY2053 totalling 40,143 GWh are indicated (relative to a FY2000 frozen efficiency base year), and under high and low scenarios annual electricity savings by 2053 could feasibly lie within a range of 36,477 GWh pa and 65,064 GWh pa.

NSW (and the ACT)

Modelling for States serviced by the NEM also shows growing energy efficiency savings, although under the Current Trajectory annual growth in savings is expected to slow slightly beyond 2030. This reflects an assumed wind down of many current measures (pending renewal announcements).

Relative to FY2010, total electricity savings of around 12,001 GWh per annum are estimated by 2053 in NSW (incorporating ACT) under the Current Trajectory scenario settings (15,869 GWh relative to FY2000). Projected NSW savings by load type are shown in Figure 12.

Figure 12: Projected electricity savings in NSW, Current Trajectory



Analysis of measures suggests that, for Current Trajectory, GEMS is the major contributor to electricity savings until around 2030, at which time NCC begins to dominate. By FY2053, the NCC is estimated to deliver about 5,347 GWh pa in savings (relative to FY2010), while GEMS delivers 1,480 GWh. The contribution of the NSW Energy Saving Scheme (ESS) peaks around FY2038, delivering 990 GWh of electricity savings in that year (relative to FY2010 outcomes). Nevertheless, the analysis suggests that ESS will still be delivering around 864 GWh of electricity savings in FY2053 – relative to the FY2010 outcome (see Figure 13). The total electricity savings examined here incorporate heating, cooling and baseload demands. Overall, for the period FY2010 to FY2053, NSW ESS accounts for around 6.6% of total electricity savings, AEEI is projected to deliver about 17%, GEMS delivers 34.6% of savings and NCC accounts for the rest (41.7%).

Figure 13: NSW (incl. ACT) electricity savings due to EE measures, Current Trajectory

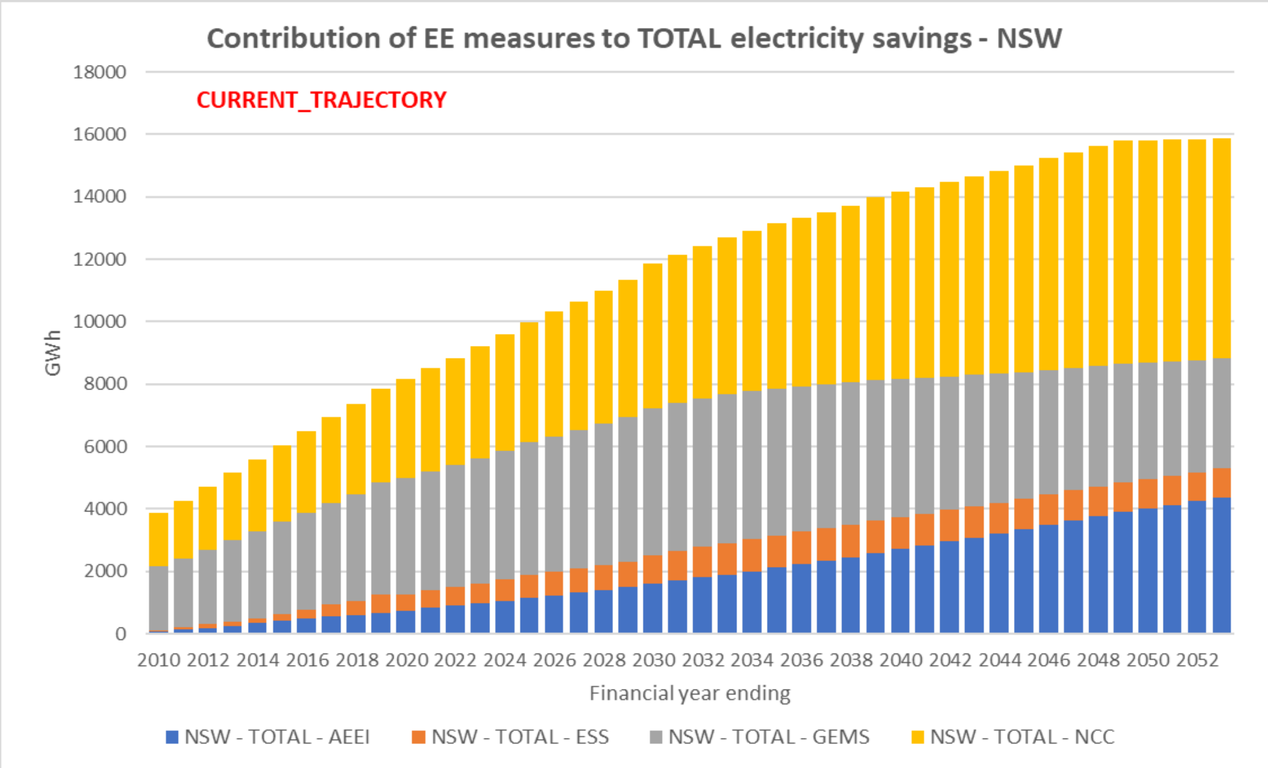


Figure 14 shows estimated savings for the Export Superpower and Slow Growth scenarios. These span the 'high' and 'low' growth scenarios for NSW. Under the Export Superpower scenario, total savings (relative to FY2010) grow to 19,543 GWh pa by FY2053. Over the FY2010-53 period, total savings of 624,748 GWh are achieved with GEMS contributing about 39.4% of this. NCC accounts for a further 32.5% of the 2010 to 2053 savings total, and ESS contributes 6.6%. Market driven efficiency gains (AEEI) are estimated to contribute the remaining 21.5% of projected electricity savings.

With Slow Growth, energy efficiency savings in FY2053 are reduced to 10,612 GWh (relative to FY2010), and total electricity savings for the FY2010-53 period amount to 470,168 GWh, of which NCC contributes about 42% and GEMS contributes about 33.5%. ESS's contribution remains at about 7%, with AEEI making up the remainder.

Gas savings make up a substantial part of total energy savings across all scenarios – with the NCC impact on heating requirements accounting for about 81% of the total gas savings achieved in NSW in the period from FY2020 onward. AEEI contributes a further 18.7%, with NSW ESS making up the remainder. Within the Current Trajectory, gas increases its share of total energy savings from 47.6% in 2010 to about 61.4% in FY2053. Total energy savings (gas + electricity) in that year (relative to the 2010 outcome) are estimated at 121,618 TJ (see Figure 15).

Figure 14: NSW electricity savings due to EE measures, ‘high’ and ‘low’ outcome scenarios

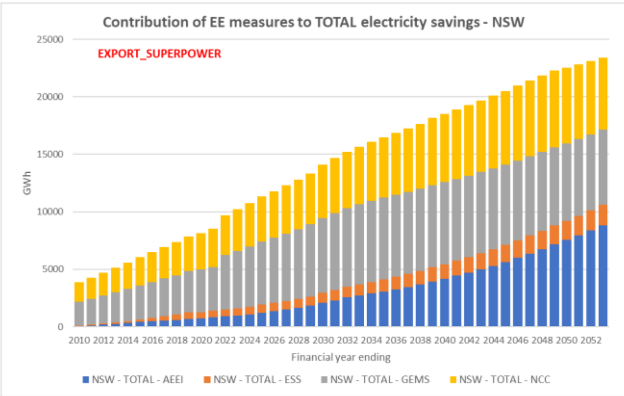
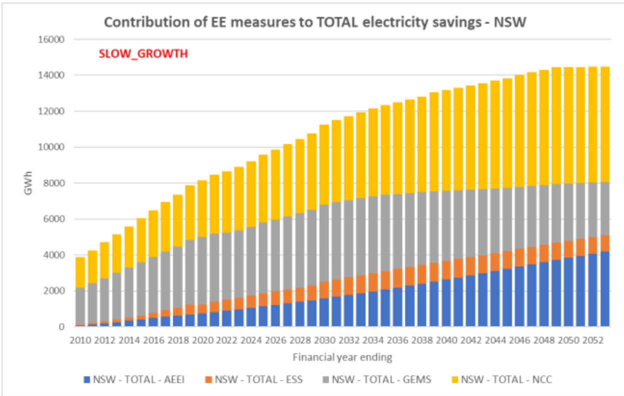
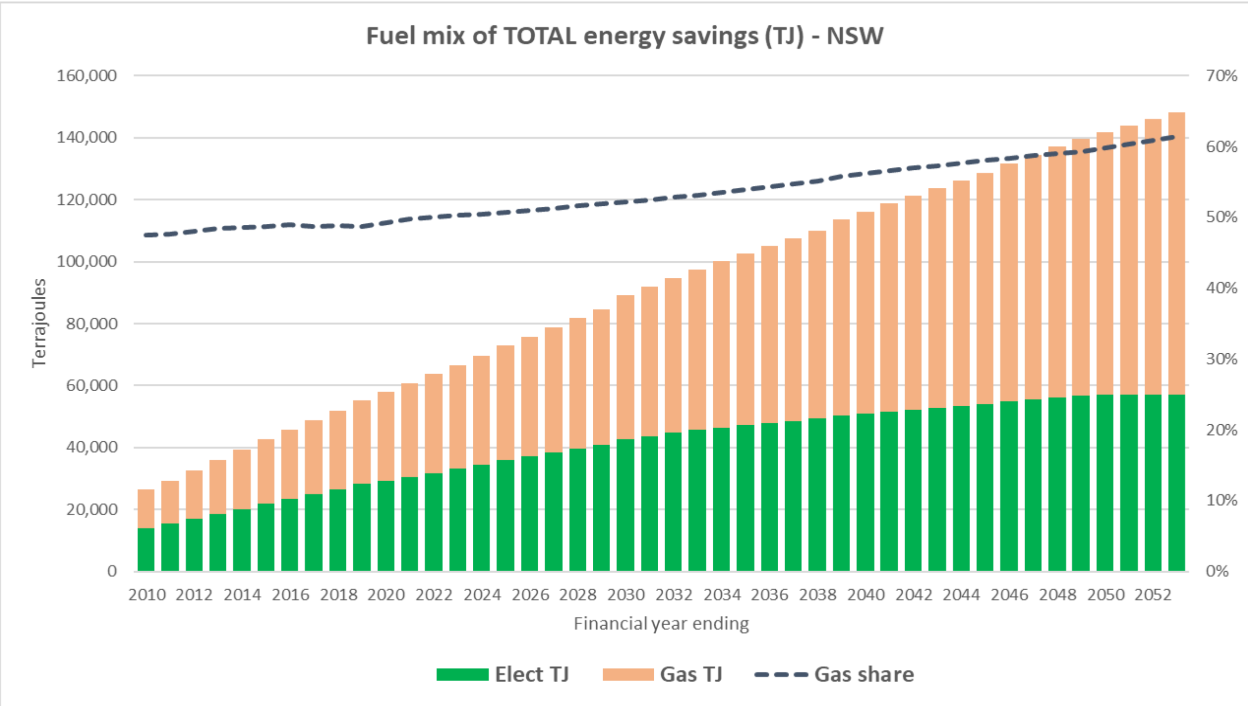
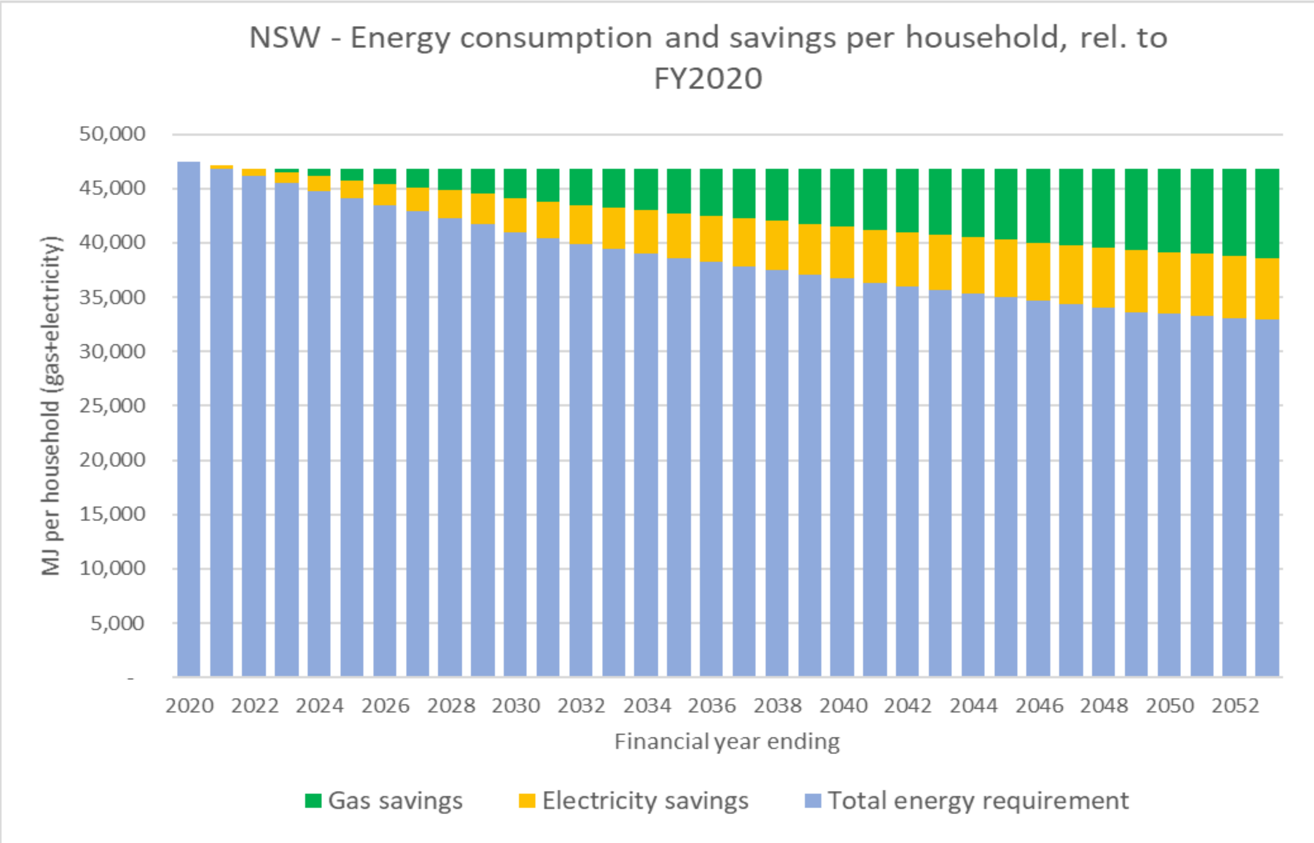
Export Superpower	Slow Growth
	

Figure 15: NSW gas and electricity savings, Current Trajectory



Savings attributable to gas are also evident when energy consumption is viewed on a per household basis (which abstracts from growth in the stock of dwellings, and the aggregate consumption base). Figure 16 depicts the impact of gas and electricity savings relative to average 2010 household consumption levels. According to our own residential energy consumption forecasts (which may differ from those of AEMO), estimated savings are expected to drive down total annual household energy needs from around 47,469 MJ per house currently to 32,919 MJ by 2053. This is a saving of around 29.6%. Between now and 2053, around 56% of the estimated total energy savings achieved in NSW homes are attributable to reductions in gas consumption associated with efficiency improvements.

Figure 16: Efficiency impact on average household energy needs, NSW - Current Trajectory



Victoria

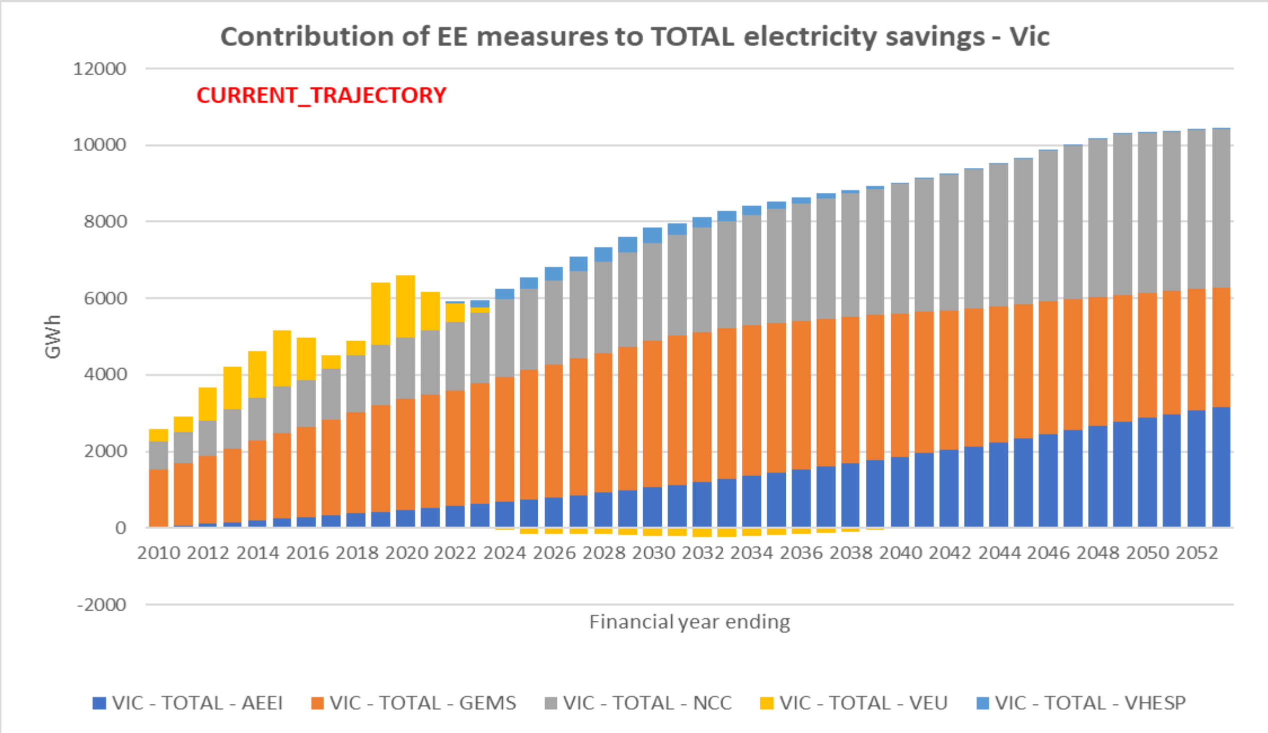
Victoria's energy savings projections are impacted by the operation of the Victorian Energy Upgrades (VEU) program, and the newly announced Victorian Household Energy Savings Package (VHESP) which will be rolled out in coming months. Savings estimates for the VEU and VHESP were provided by the Victorian Department of Environment, Land, Water and Planning and these have been reflected in our forecasts (see Appendix B). The historical volatility in savings that can be seen in Figure 17 reflects over-achievement, relative to targets, to varying degrees. In effect, such extra savings are carried over into later years, somewhat reducing the requirement of certificate surrender, and hence creation, in future periods.

Modelling of VHESP relies on detailed energy savings projections for the period FY2021 to FY2031 provided by the relevant Department. The detail allowed categorisation of electricity and gas savings into baseload (eg. hot water and appliances) and heating and cooling (eg. insulation, heater upgrades, reverse cycle air conditioner installation, etc) impacts. Where annual energy savings from electric appliances were indicated, these were discounted by 10% to avoid duplication of savings already scheduled in the modelling under GEMS. Other estimates were accepted without adjustment. VHESP is subject to review and its future beyond 2031 is uncertain. Nevertheless, upgrades made under the program - and the associated annual energy savings - can be expected to endure for several years. In estimating savings beyond FY2031, we assumed that the savings from appliance upgrades would wind down over a period of 10 years while improvements to insulation would deliver savings for around 50 years.

The data received from the Victorian Government projects an increasing focus on electrification under VEU in future years. This can have the effect of producing lower or even negative electricity savings in future (ie. consumption increases), offset by higher and substantial gas savings. The combined impact of energy efficiency measures on projected annual electricity savings for Victorian households is shown below. This reported level of program savings was assumed for the Current Trajectory, Net Zero and Slow Growth AEMO trajectories. For the Sustainable Growth scenario, the level of savings was assumed to increase by an additional 10%. For the Export Superpower and Rapid Decarbonisation scenarios and increase on current estimates of 20% was assumed.

This suggests that under the Current Trajectory scenario, residential electricity savings (relative to FY2000 consumption levels) rising to 10,421 GWh pa are projected by 2053. This is a saving of 7,822 GWh pa relative to annual savings delivered in FY2010. Figure 17 also shows, as with other States, the significant contribution of the NCC and GEMS to these expected savings. For the period from FY2010 to FY2053, total electricity savings of around 329,866 GWh are projected, 43% of which is attributable to GEMS and 35% is due to NCC requirements. Together, VEU and VHESP are estimated to contribute around 4.3% of these savings, with AEEI making up the rest.

Figure 17: Projected electricity savings in VIC, Current Trajectory

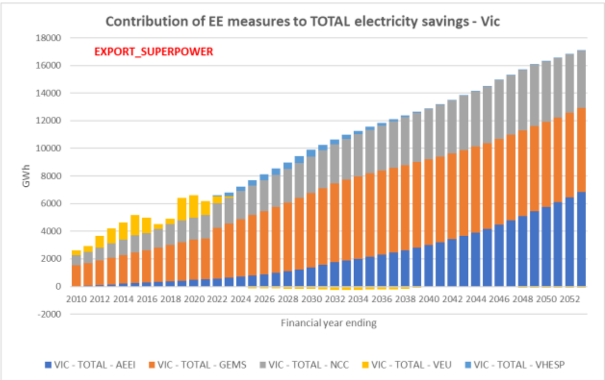
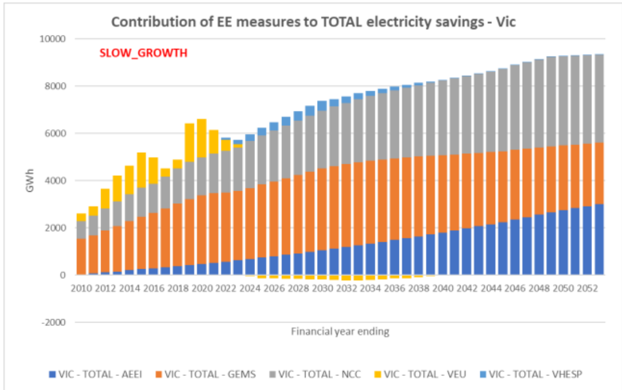


As with NSW and WA, the Export Superpower and Slow Growth scenarios represent the high- and low-end electricity savings outcomes projected for Victoria. The contribution of measures under these scenarios is shown in Figure 18.

More ambitious energy efficiency measures, in combination with expanded housing growth, lead to increased energy savings under Export Superpower. Estimated annual savings (relative to 2010) grow to 14,401 GWh in 2053 in this scenario, and total over 440,726 GWh for the period 2010 to 2053. GEMS is responsible for 47.2% of this saving, with VEU and VHESP combined accounting for about 3.2%.

Under the Slow Growth settings, annual electricity savings over the FY201-53 period peak at 6,722 GWh pa (relative to a 2010 consumption base year), with total savings between FY2010 and FY2053 estimated at 307,591 GWh. GEMS delivers 41.5% of this total; NCC 35.4%; and State measures, 4.6%. AEEI makes up the remaining 18.5%.

Figure 18: VIC electricity savings due to EE measures, alternative scenarios

Export Superpower	Slow Growth
	

Gas savings dominate electricity savings in Victoria, notwithstanding the volatility of electricity associated with the VEU program over the last 10 years or so. According to our modelling, under Current Trajectory settings, gas savings have been accounting for an increasing share of total energy savings - rising from around 73% of savings in 2010 to about 85% of projected savings in 2053. Estimated gas savings between 2010 and 2053 total nearly 5,065 petajoules (1 PJ = 1,000 TJ), and account for 81% of the combined gas and electricity savings total over the period. This is illustrated in Figure 19.

Figure 19: Vic combined gas and electricity savings, Current Trajectory

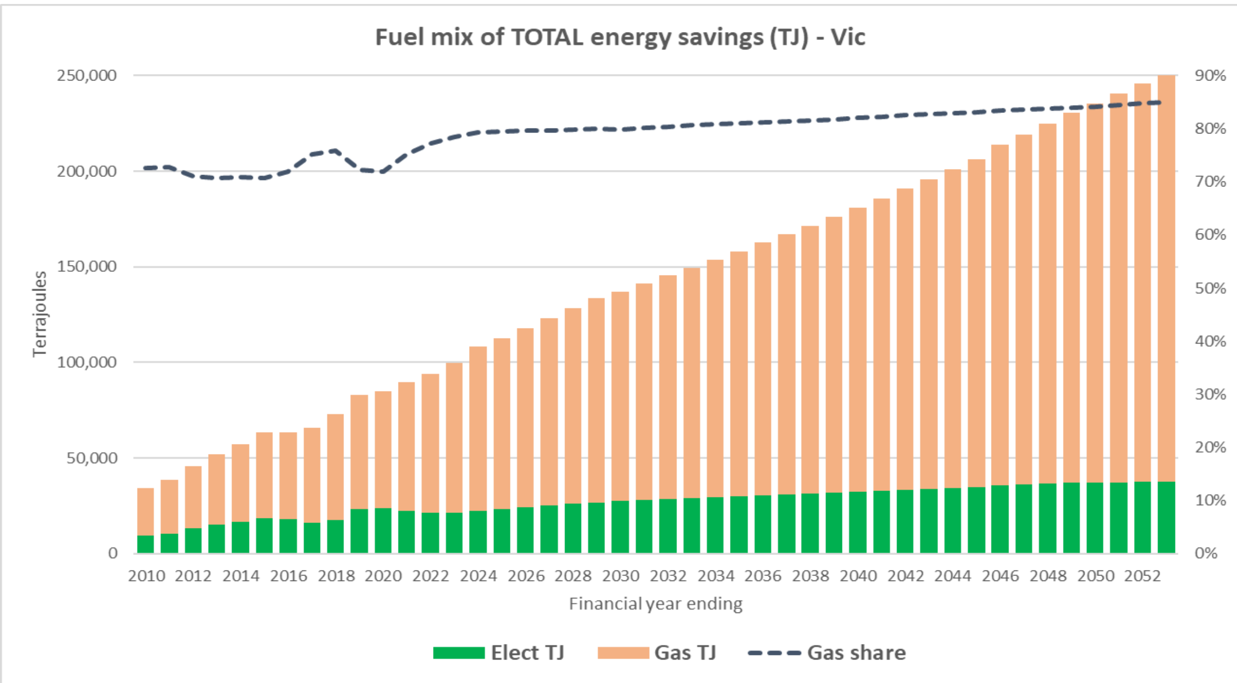
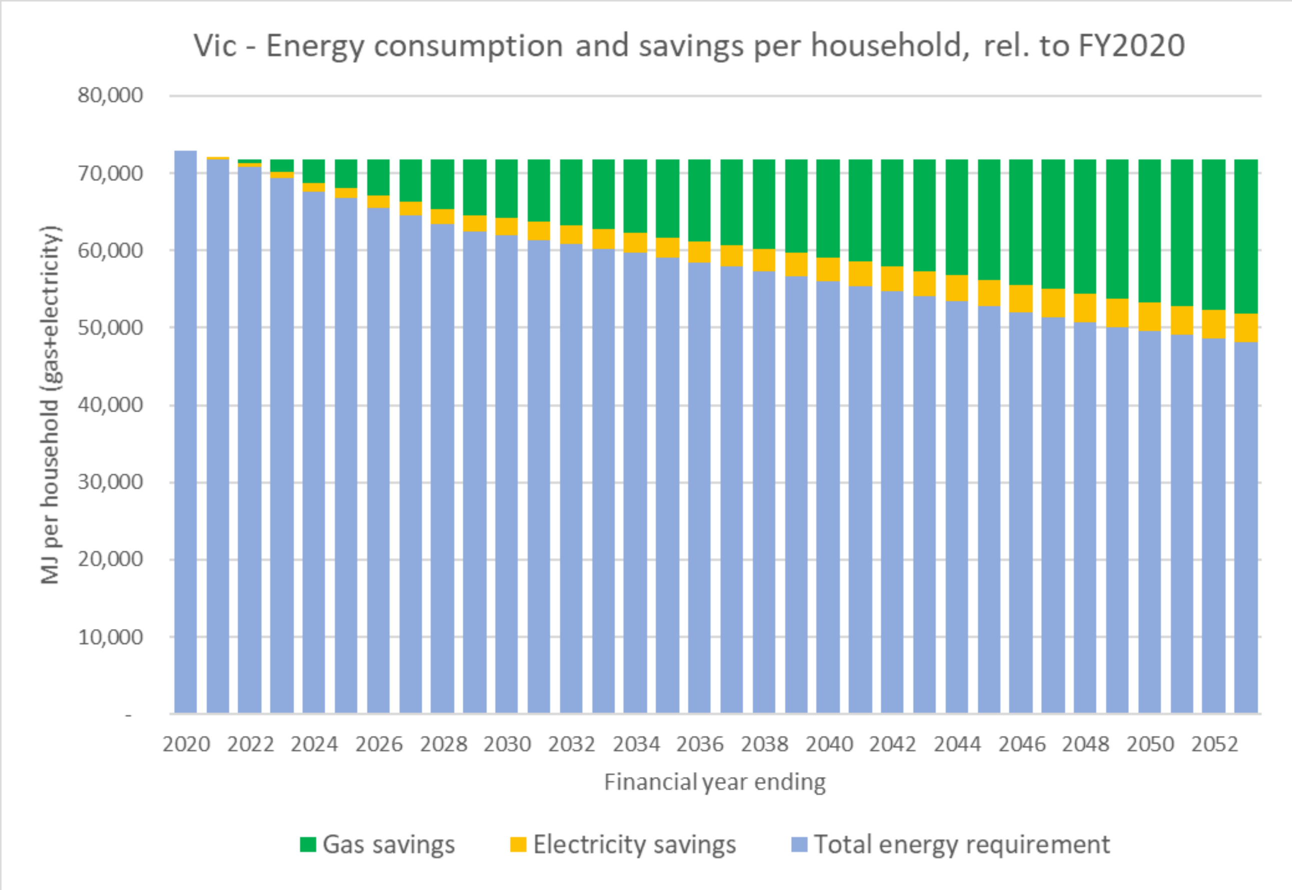


Figure 20: Efficiency impact on average household energy needs, NSW - Current Trajectory

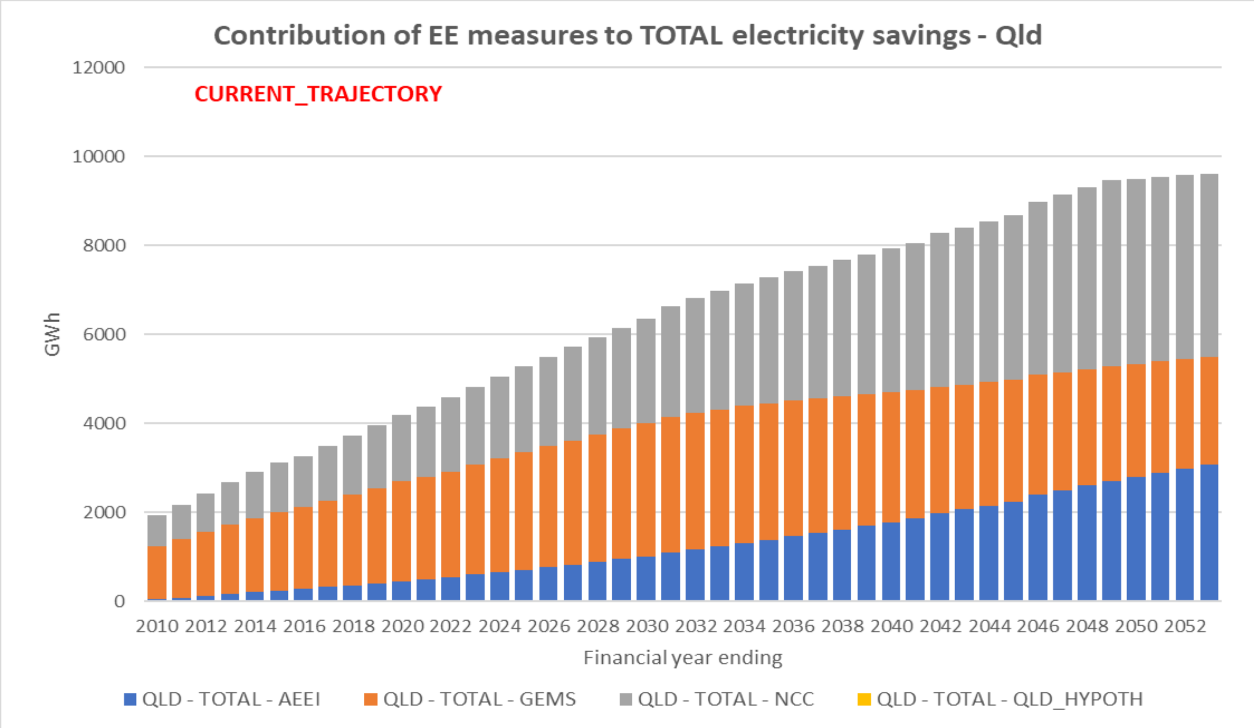


Gas and electricity savings per household, and their impact on average consumption - taking FY2020 consumption levels (estimated by our model) as a base - are shown in Figure 20. Under the Current Trajectory, combined energy consumption (gas + electricity) is projected to fall from around 72,969 MJ per year per household in 2020 to around 48,076 MJ pa by 2053. Reduced gas consumption arising from the efficiency drivers depicted represents about 82% of the total per household energy saving estimated for the period 2020 to 2053.

Queensland

Under policies and housing growth aligned to the Current Trajectory, electricity savings for Queensland homes serviced by the NEM are expected to reach 7,676 GWh per year, relative to a 2010 base year (9,609 GWh relative to FY2000). Electricity savings due to efficiency improvements in the period FY2010 to FY2053 are estimated to total about 277,803 GWh. GEMS and NCC contribute approximately equal shares of the total FY2010-50 saving (about 39.8% each), with AEEI making up the balance (20.4%). These core outcomes are shown in Figure 21.

Figure 21: Projected electricity savings in QLD by EE measure, Current Trajectory

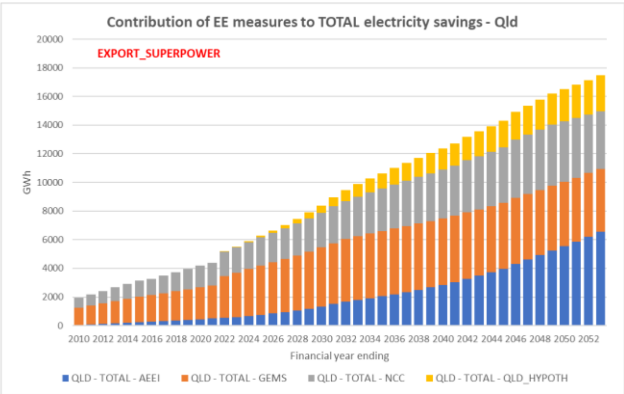
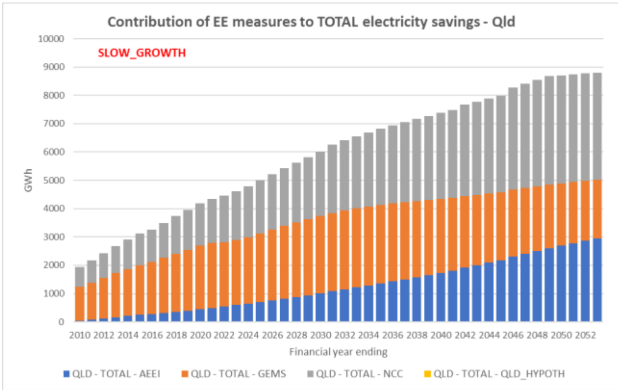


The hypothetical State measure developed for Queensland analysis (see *Other States' Schemes* in Section 3.2.4 for details of this measure) is not activated under Current Trajectory but is relevant to the Export Superpower scenario - results of which are shown in Figure 22. The Export Superpower scenario results in the highest estimated long term electricity savings for Queensland and is presented as the high impact scenario. By contrast, Slow Growth results in the lowest level of aggregate electricity savings of the scenarios analysed.

The Export Superpower scenario, coupling strong growth in the housing stock with ambitious energy efficiency policies, results in electricity savings of 17,466 GWh pa year for Queensland households in FY2053, relative to 2000 base levels. This is equal to a saving of 15,533 GWh pa relative to a 2010 base year. GEMS contributes about 39% of the savings for the period FY2010 to FY2053 (totalling 404,031 GWh), while NCC contributes just over 28%. The hypothetical State mechanism developed for this scenario generates a further 9.7% of these savings, while AEEI contributes 23.1%.

Slow Growth is estimated to reduce total residential electricity savings over the period from FY2010 to FY2053 to about 261,429 GWh, with a saving of 8,796 GWh pa in FY2053 (relative to a FY2000 base). Against a FY2010 base year, this scenario implies annual electricity savings in FY2053 of about 6,863 GWh for Queensland residential consumption. Under Slow Growth, GEMS and NCC each account for about 40% of induced electricity savings over the FY2010-50 period, while AEEI accounts for the balance.

Figure 22: QLD electricity savings due to EE measures, alternative scenarios

Export Superpower	Slow Growth
	

Gas is not a significant component of residential energy supply in Queensland and contributes little to the energy savings outcome. All reported savings from our modelling are electricity savings. Under Current Trajectory settings, average electricity use per household is projected to fall by about 11.4% from estimated FY2020 levels by FY2053.

South Australia

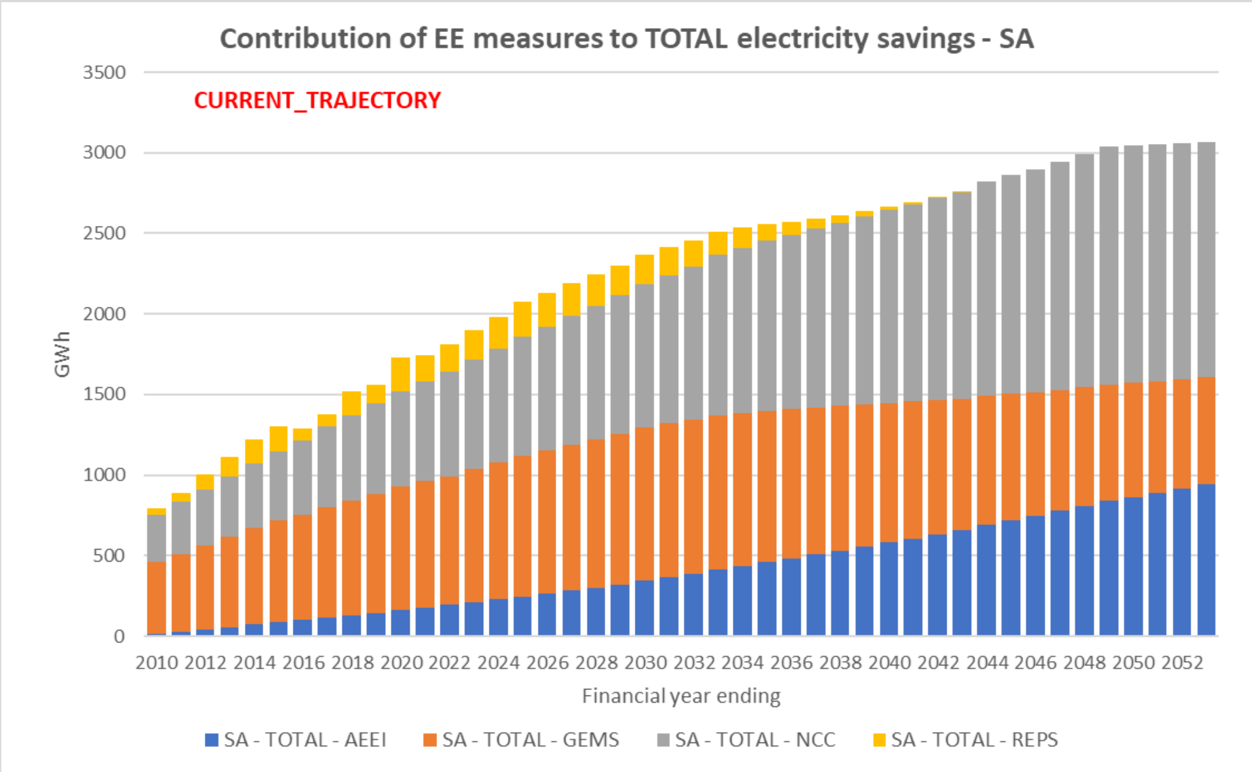
Estimated electricity savings for South Australia under the Current Trajectory scenario are shown in Figure 23. This shows the combined impact of the AEEI, Commonwealth measures and the South Australian REPS program, which updates and extends the former Residential Energy Efficiency Scheme (REES).

Our modelling suggests that energy efficiency measures, in combination with AEEI, will result in electricity savings of around 3,063 GWh per year by 2053 (relative to FY2000 efficiency levels) and 2,269 GWh per year relative to FY2010 savings outcomes. Total savings over the period FY2010 to FY2053 are expected to be around 98,062 GWh under the Current Trajectory scenario.

The NCC delivers the biggest share of these long-term savings, at an estimated 41.8%, with GEMS delivering 35.2%. The REPS program (including its predecessor REES) is estimated to deliver an additional 4.2% of these savings over the FY2010-53 period, and AEEI is expected to account for around 18.8%.

For South Australia, the Rapid Decarbonisation and Export Superpower scenarios deliver very similar levels of energy savings. As with other States, Slow Growth marks the lower bound of savings outcomes under the scenarios. Rapid Decarbonisation and Slow Growth scenario outcomes are shown in Figure 24.

Figure 23: Projected electricity savings in SA, Current Trajectory



The Rapid Decarbonisation scenario sees residential electricity savings in FY2053 of around 5,064 GWh, relative to a FY2000 base year, and 4,268 GWh relative to FY2010 savings outcomes. Total savings of 132,509 GWh are achieved for the period FY2010-53 under this scenario, with about 10.3% of this attributable to the REPS program (which is assumed to expand under this scenario). Under this high ambition energy efficiency scenario, the GEMS program is the biggest contributor accounting for just over 35% of total estimated electricity savings in the FY2010-53 period. NCC accounts for 32.1% of savings and AEEI, about 22.3%.

Slow Growth sees a savings outcome in FY2053 of 2,779 GWh (relative to FY2000 levels), or 1,983 GWh relative to the FY2010 outcome. The contribution of REPS falls to 4.5% under this scenario and NCC is the major EE driver – accounting for 41.7% of the total saving of 92,414 GWh achieved over the period 2010 to 2053. GEMS accounts for 34.4% of total electricity savings in the period from FY2010 under this scenario, while AEEI accounts for 19.4%.

Figure 24: SA electricity savings due to EE measures, alternative scenarios

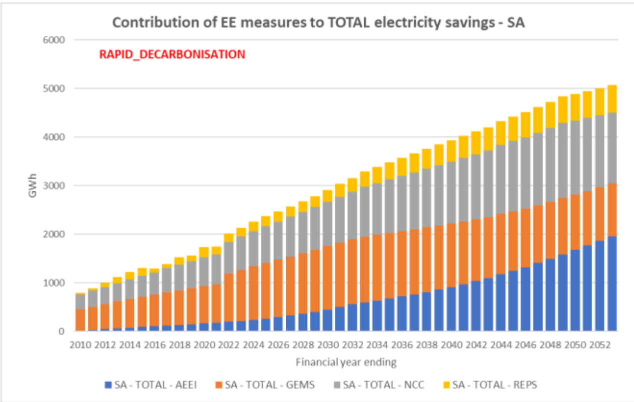
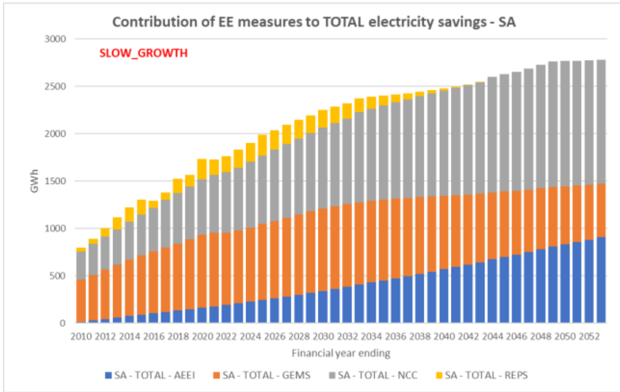
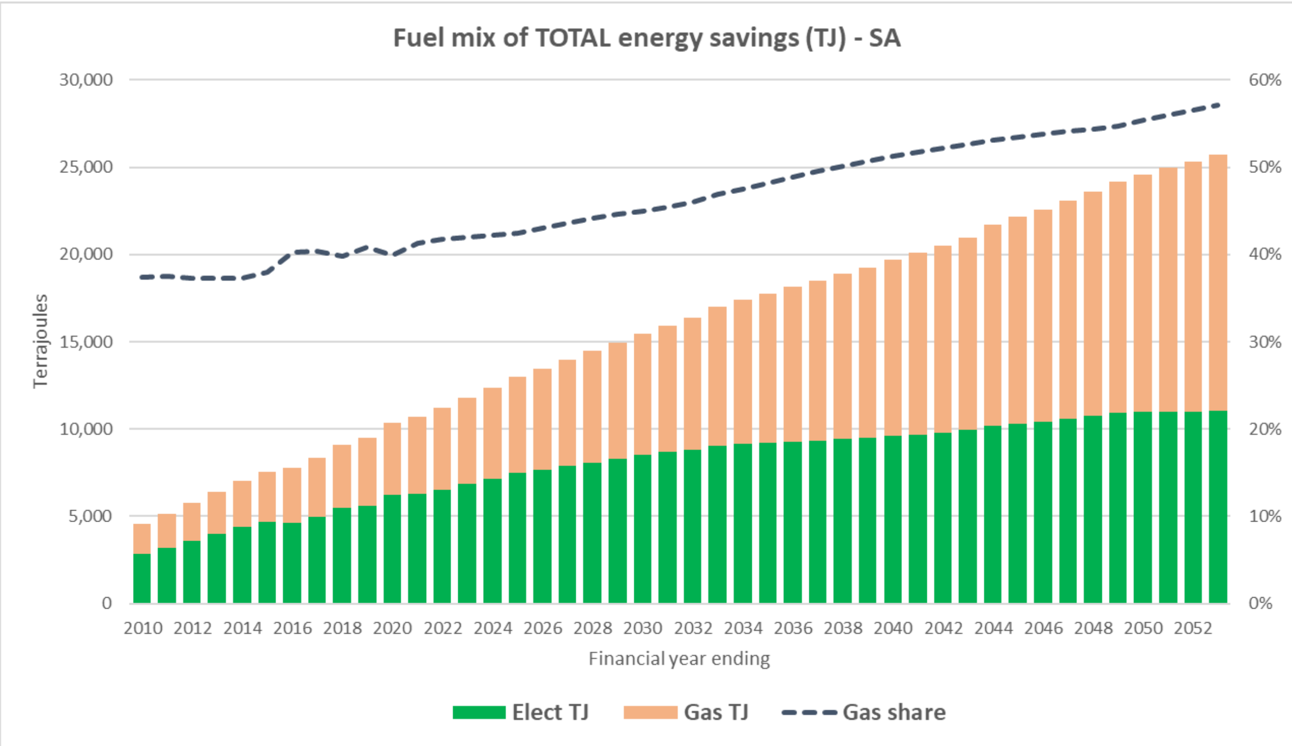
Rapid Decarbonisation	Slow Growth
	

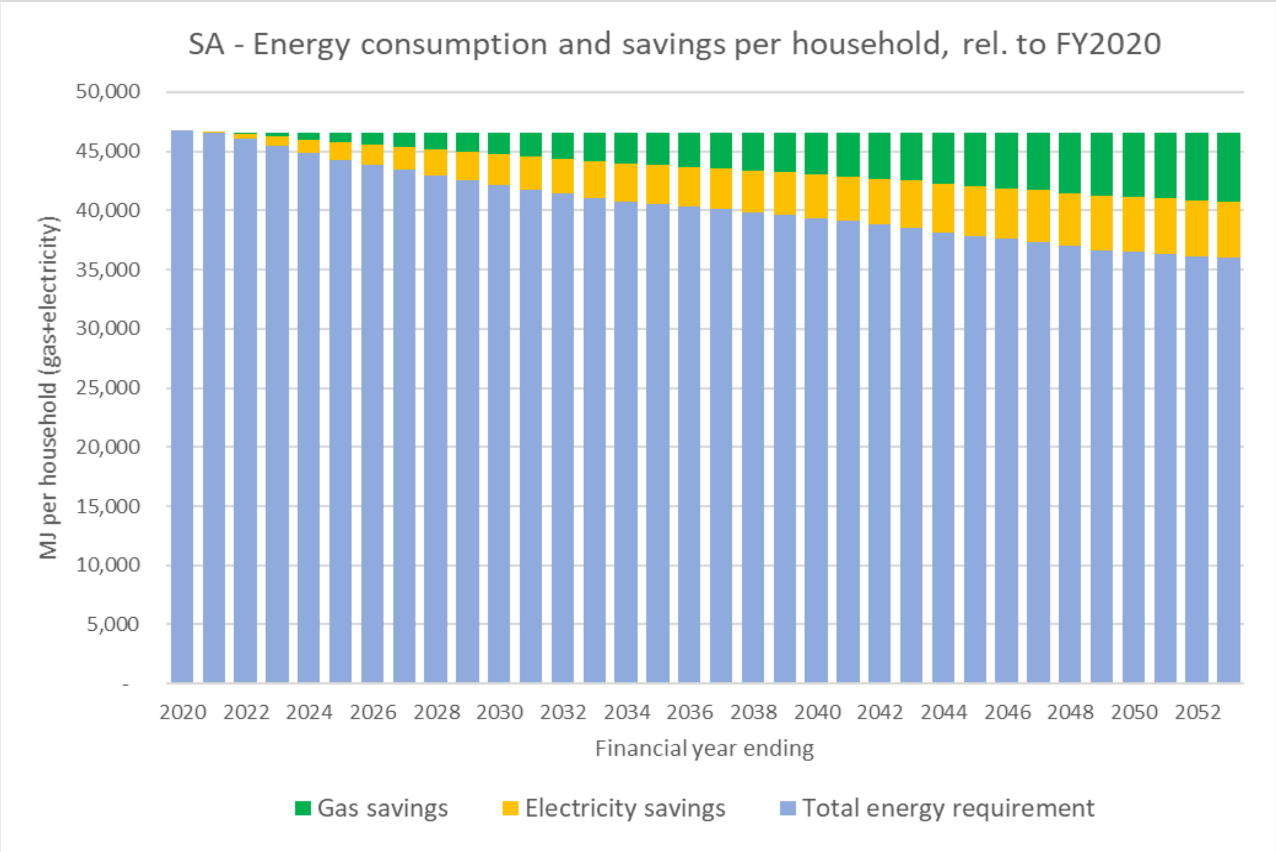
Figure 25: SA gas and electricity savings, Current Trajectory



Gas is also an important contributor to total energy savings in South Australia. Under the Current Trajectory scenario, the gas share of energy savings rises from around 37.4% in 2010 to just over 57% in 2053. Over that period from 2010, total residential energy savings are estimated to be around 691,385 TJ. The annual savings mix of gas and electricity is shown in Figure 25.

As seen in Figure 26, combined gas and electricity savings are expected to reduce energy consumption by NEM-connected South Australian households by about 22.7% between 2020 and 2053. According to our modelling, by the end of the period total energy consumption per household is expected to average around 35,992 MJ per year - acknowledging that our long-term consumption forecasts may differ from those developed by AEMO's in-house modelling team.

Figure 26: Efficiency impact on average household energy needs, SA - Current Trajectory

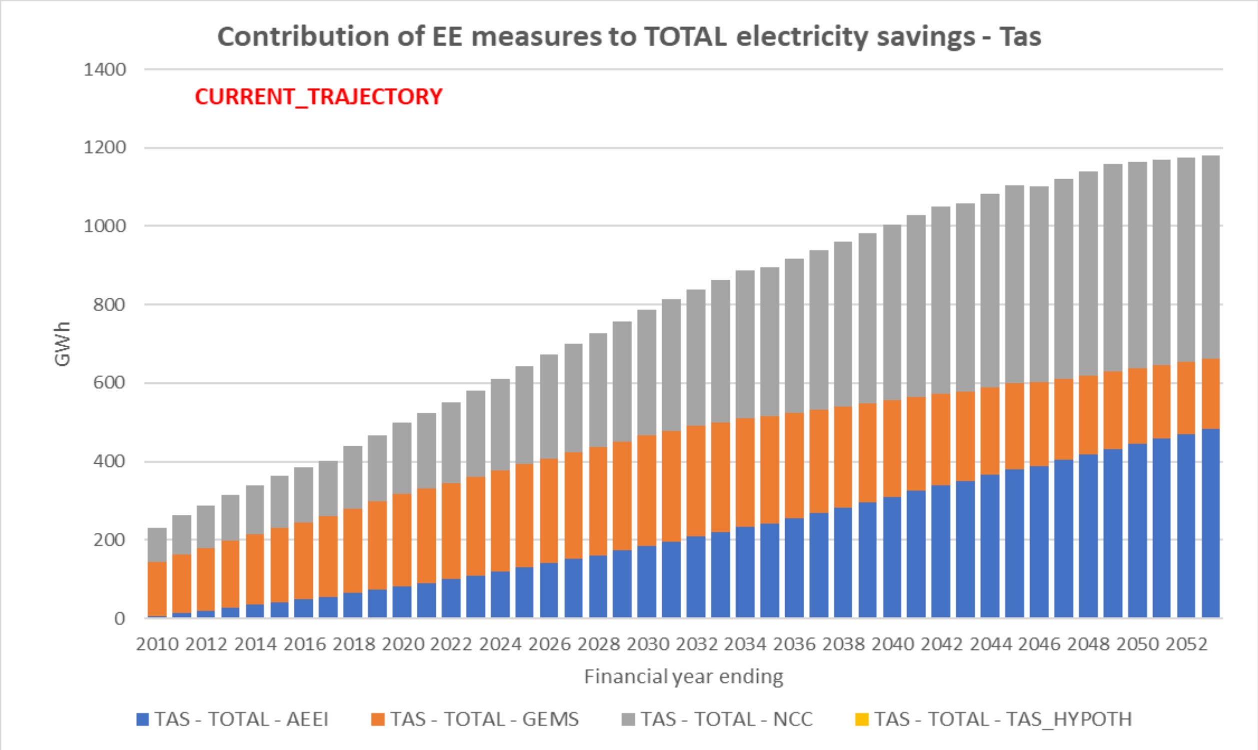


Tasmania

Under Current Trajectory settings, electricity savings among Tasmanian households are estimated to grow to around 1,180 GWh per year by FY2053, relative to FY2000 base levels. Relative to FY2010, annual savings are expected to reach 949 GWh per year. This trajectory is shown in Figure 27.

NCC requirements are forecast to be the main driver of these electricity savings, accounting for about 42.4% of the total (34,175 GWh) between FY2010 and FY2053. GEMS accounts for a further 29.5% and AEEI contributes the balance.

Figure 27: Projected electricity savings in TAS, Current Trajectory



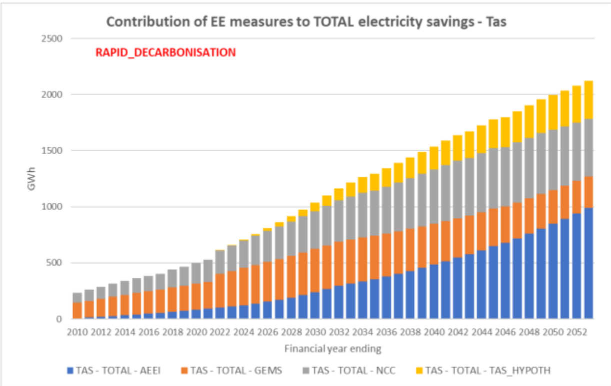
Like South Australia, Tasmanian electricity savings are similar under the Rapid Decarbonisation and Export Superpower scenarios – both of which deliver the largest total savings of all the AEMO scenarios examined. Like other States, Slow Growth was associated with the smallest savings for Tasmanian households. These scenario outcomes are shown in Figure 28.

The Rapid Decarbonisation scenario results in electricity savings for Tasmanian households of 2,122 GWh pa in FY2053 (relative to FY2000) and 1,891 GWh pa relative to a FY2010 base year. In contrast, Slow Growth produces FY2053 savings of around 1,100 GWh relative to FY2000 and 867 GWh relative to FY2010. Savings from NCC building standards make up the largest share under both scenarios (around 30-40%) closely followed by GEMS.

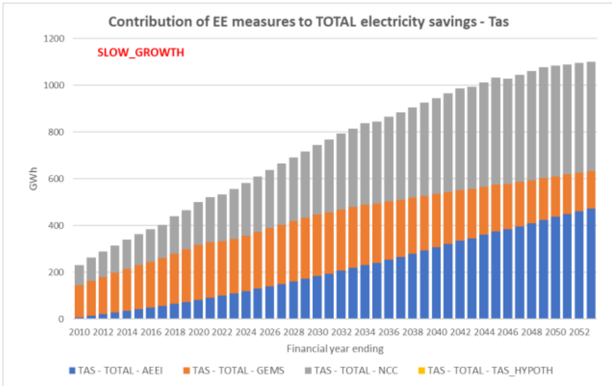
The hypothetical energy efficiency program modelled for Tasmania as a 'high ambition' measure delivers about 11% of the total electricity savings accruing under Rapid Decarbonisation from FY2010 to FY2053.

Figure 28: TAS electricity savings due to EE measures, alternative scenarios

Rapid Decarbonisation

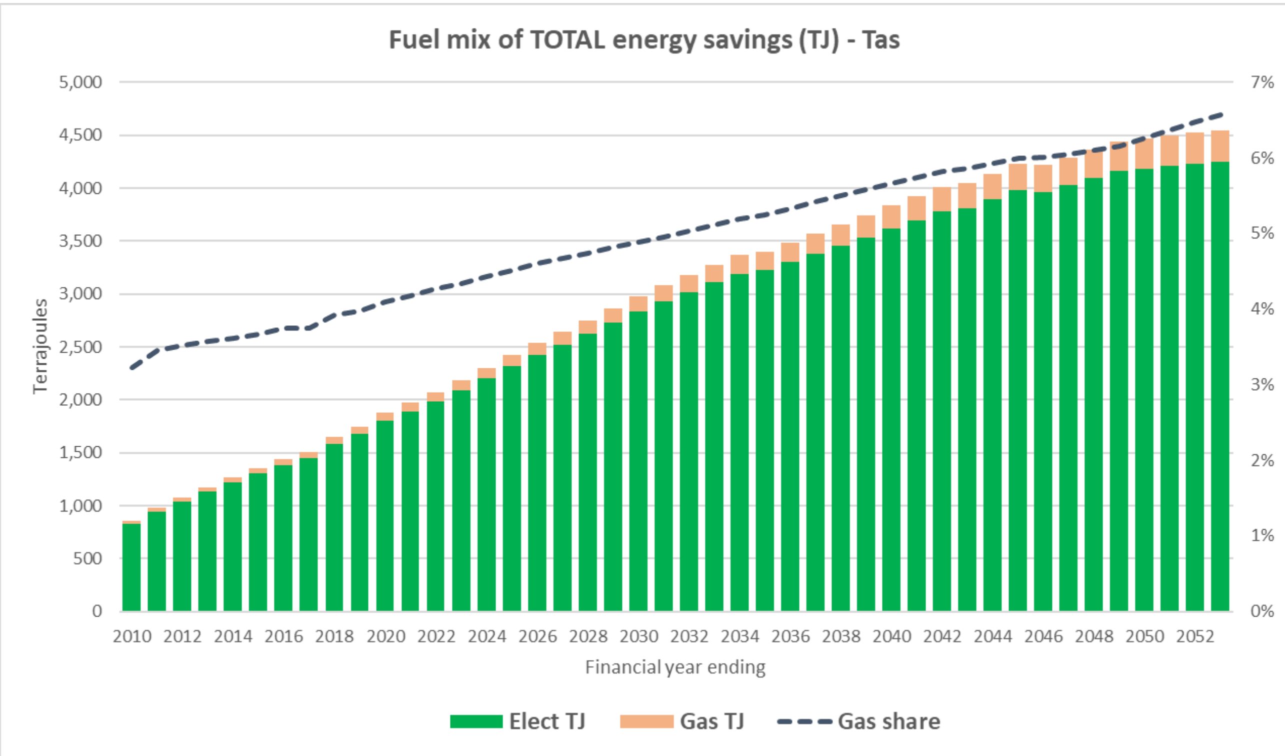


Slow Growth



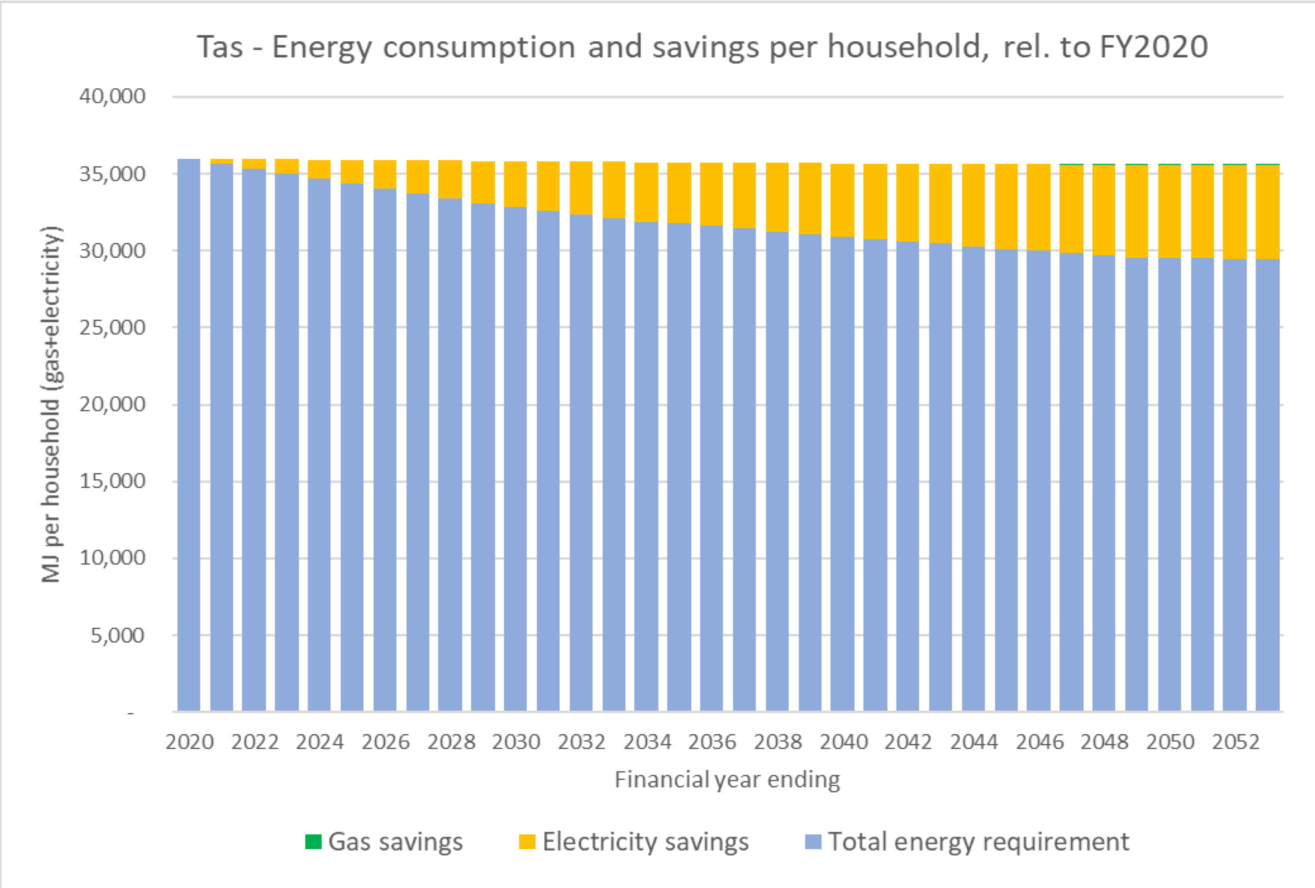
Reticulated gas has a minor share of residential energy consumption in Tasmania, and this is reflected in the analysis of savings. Under the Current Trajectory scenario, gas is estimated to contribute about 3.2% of total residential energy savings in 2010, and by 2053 this is projected to increase to 6.6%. As shown in Figure 29 electricity dominates total energy savings in Tasmania.

Figure 29: TAS gas and electricity savings, Current Trajectory



Outcomes at the individual household level also reflect this result. Figure 30 depicts a projected decline in total annual household energy consumption from around 35,971 MJ pa in 2020 to 29,446 MJ pa by 2053 – a fall of about 17.5%. The gas share of total energy savings over the period (2020 to 2053) is estimated to be around 5.5%.

Figure 30: Efficiency impact on average household energy needs, TAS - Current Trajectory



3.2 BMM Commercial

3.2.1 Total Energy Efficiency Trends

We base our analysis of total energy efficiency trends in BMM Commercial on those measured in the Commercial and services sector only, as defined in Australian Energy Statistics (AES). This is because consumption in other BMM segments, as measured by AES Table F, is:

- volatile from year to year,
- small in volume, and/or
- suppressed (included in state or national totals, typically for smaller states).

These trends are shown in Figure 31: to Figure 33 below.

Figure 31: Division D (28-29, Water supply, sewerage and drainage services) Electricity Consumption by Jurisdiction (AES Table F)

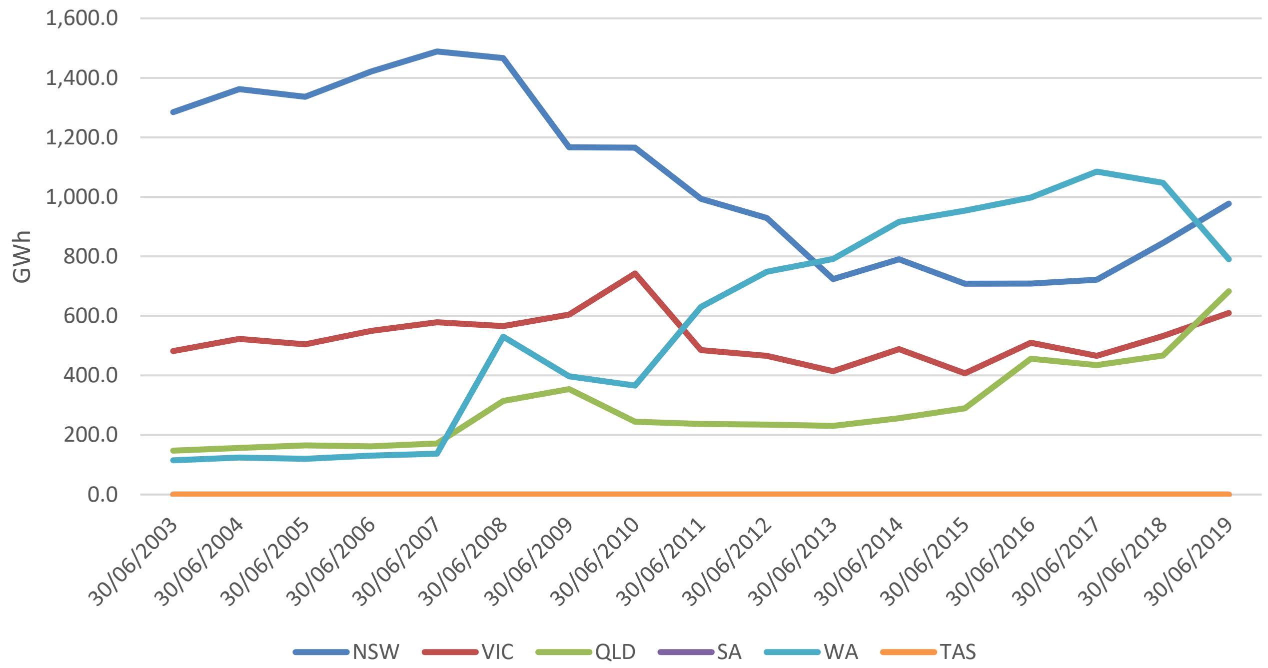


Figure 32: Division E (Construction) Electricity Consumption by Jurisdiction (AES Table F)

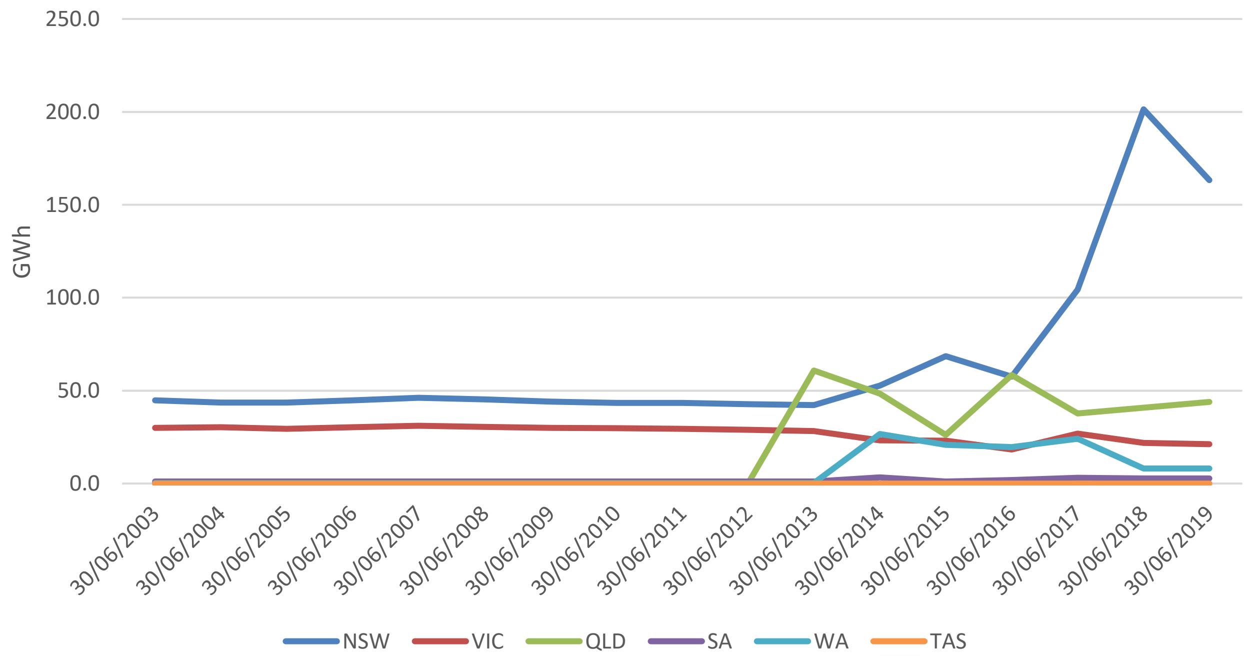
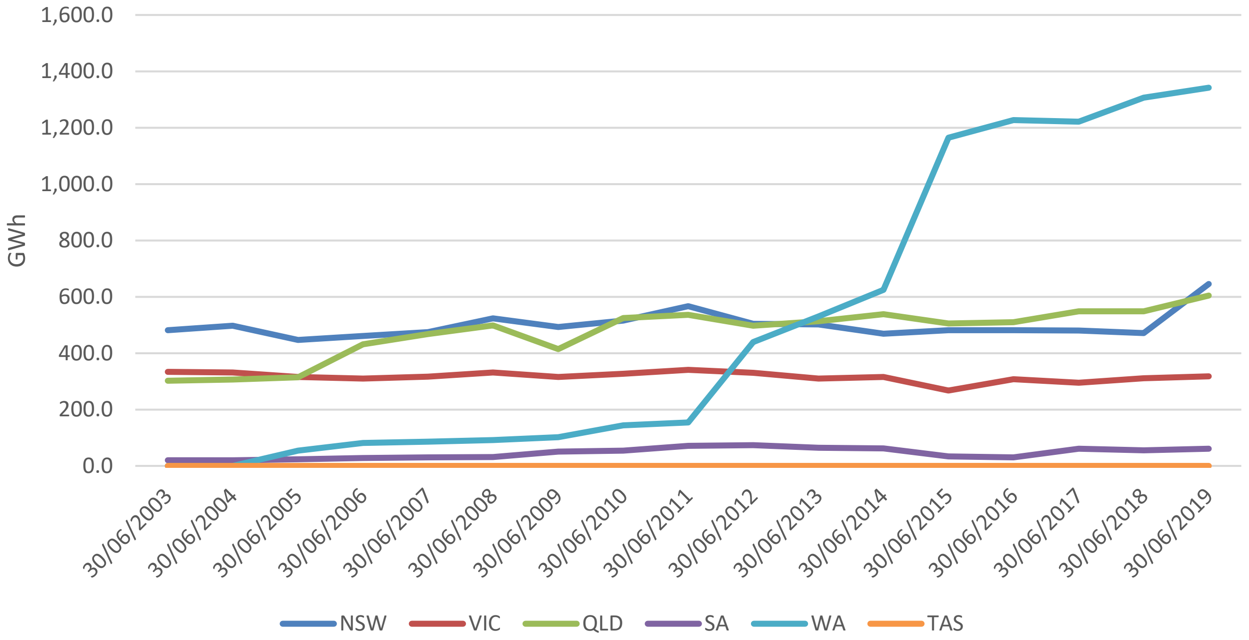


Figure 33: Division I (50 – 53, Other transport, services and storage) Electricity Consumption by Jurisdiction (AES Table F)



By contrast, Commercial and services follows a more consistent consumption path – see Figure 34.

Figure 34: Commercial and services, Energy Consumption (Australian Energy Statistics Table F) - Electricity

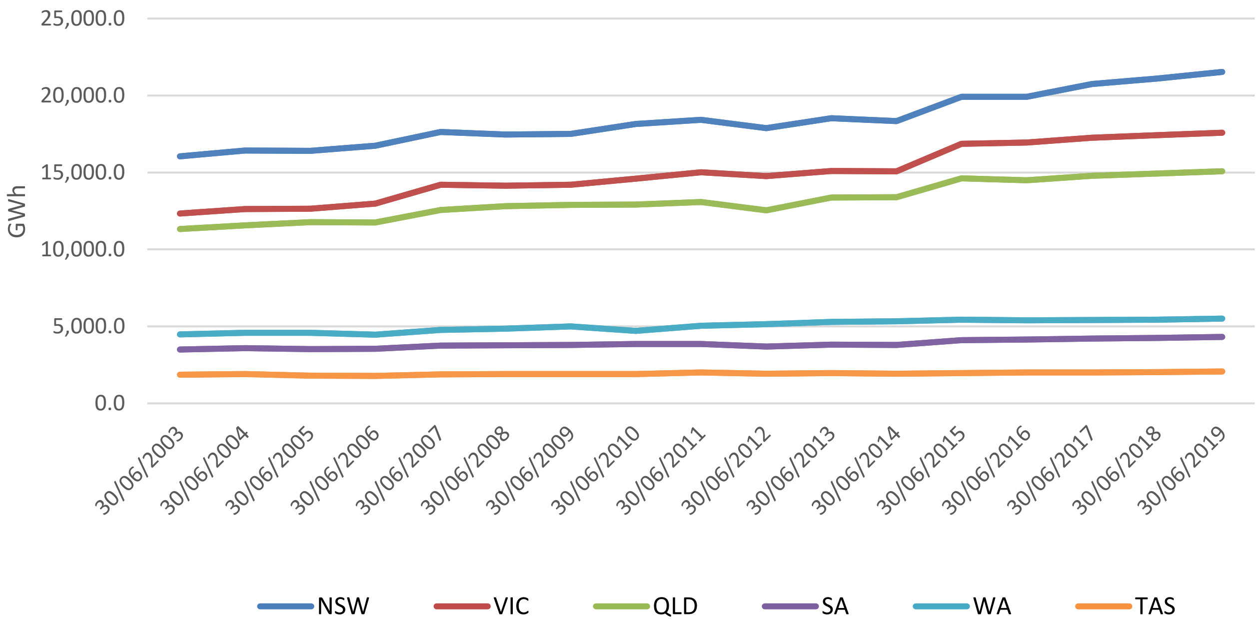
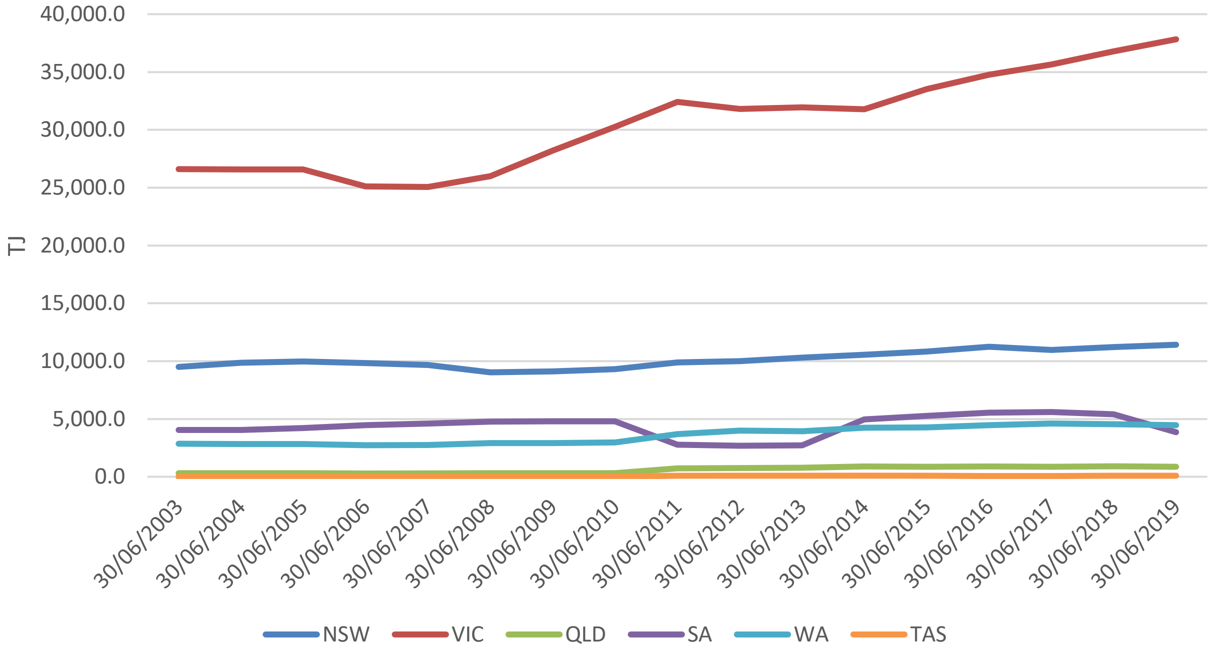


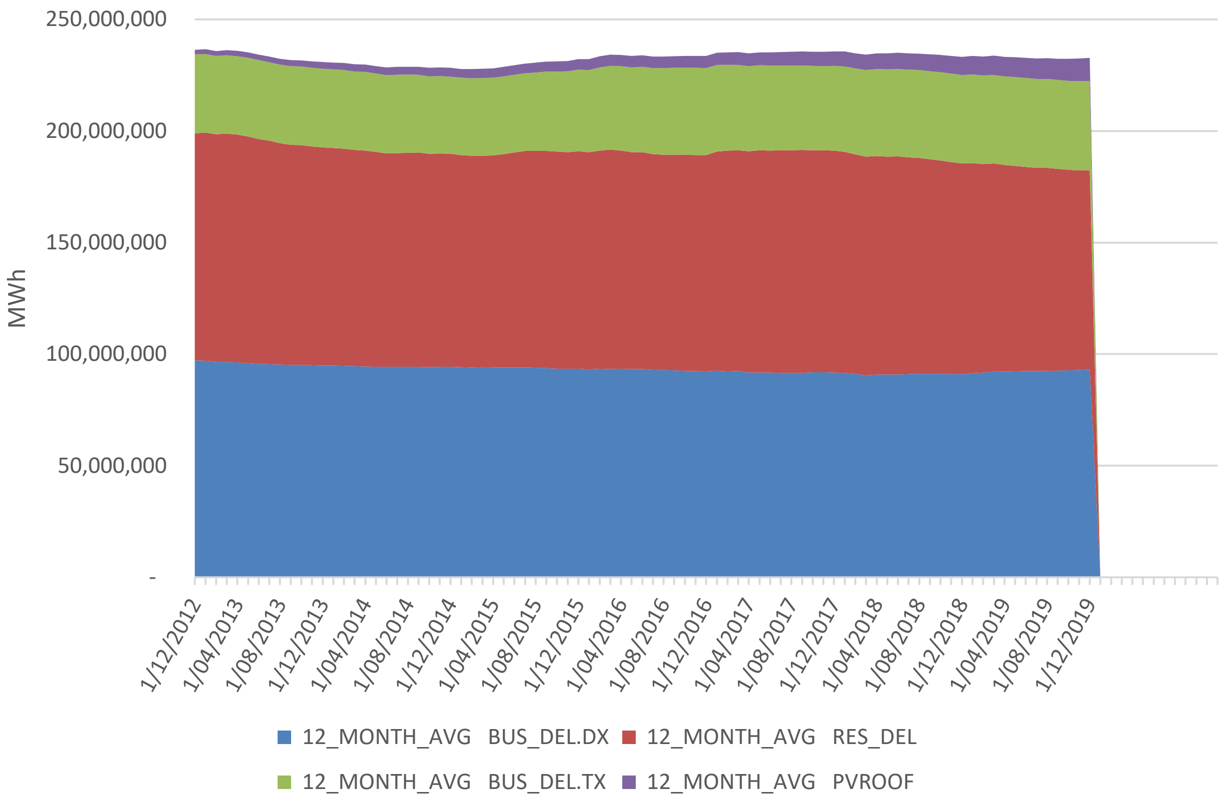
Figure 35 shows gas consumption trends in the Commercial and services sectors, with data again from AES Table F.

Figure 35: Commercial and services, Gas Consumption by Jurisdiction, AES Table F



It may be noted that Figure 34 indicates a significant jump in electricity consumption, in at least NSW, VIC, QLD and SA, between FY2014 and FY2015. We point this out because, as discussed below, our model does not predict this. Also, this trend is not evident in AEMO's own record of electricity consumption for BMM Commercial, as shown in Figure 36, for example. Also, Figure 34 indicates a rising consumption trend, while Figure 36 indicates a falling trend, for most of this period. Generally, the analysis of total energy efficiency trends is hampered by data issues including, as here, a lack of agreement between different sources.

Figure 36: Electricity Consumption, Rolling 12 Month Sum, NEM (Source: AEMO)



Setting aside the data agreement issues for the time being, Figure 37 shows the change in average total energy (electricity + gas) intensity over time and by jurisdiction. This compiles data from Figure 34 and Figure 35 above (that is, from AES) with a model of commercial building floor area net growth over time, which is discussed further below. Figure 38 present the same information rolled up to totals for the jurisdictions covered by these forecasts (ie, excl. NT), to highlight that the average efficiency improvement (reduction in energy intensity) has been ~-0.8% per year over the period FY2003 – FY2019. This value will be affected by the jump in consumption noted above for FY2015. This period was chosen due to a break in the AES Table F series between FY2002 and FY2003, and FY2019 is the latest data year for AES. The rate reduction was a little higher for gas, at -1.1%/year on average, indicating that this data includes fuel switching away from gas.

Figure 37: Commercial and services by Jurisdiction, Change in Average Total Energy (electricity + gas) Intensity

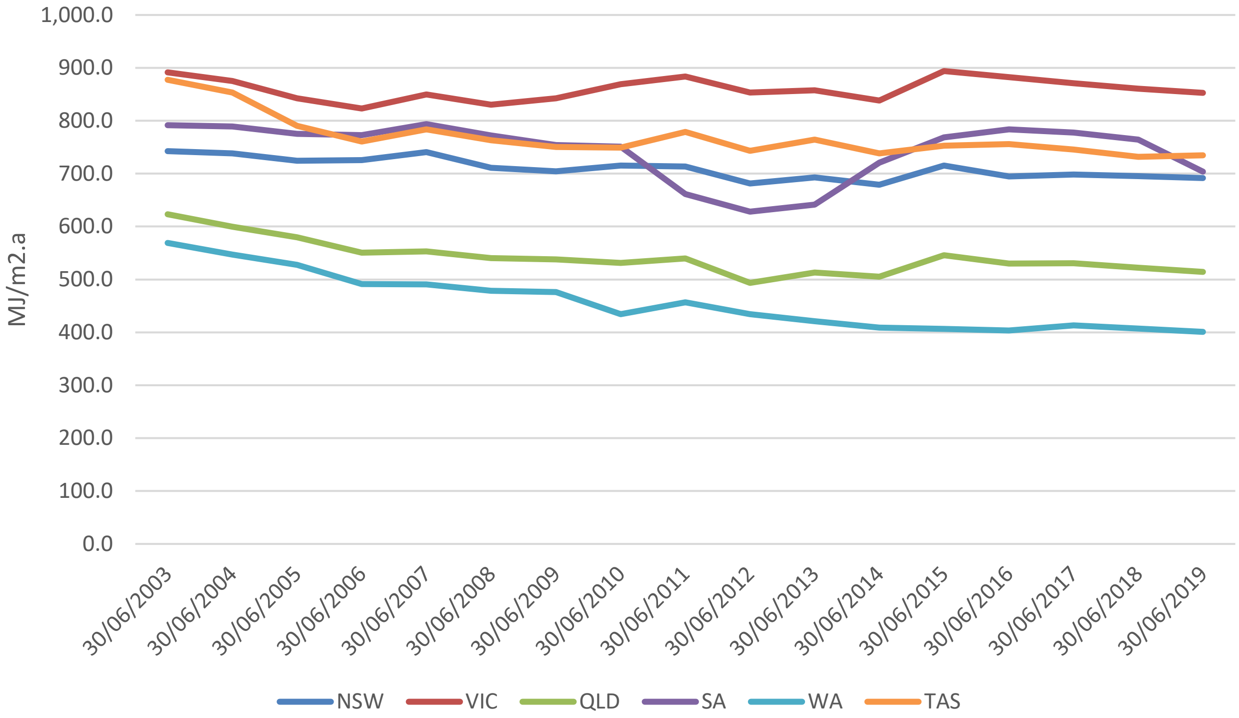
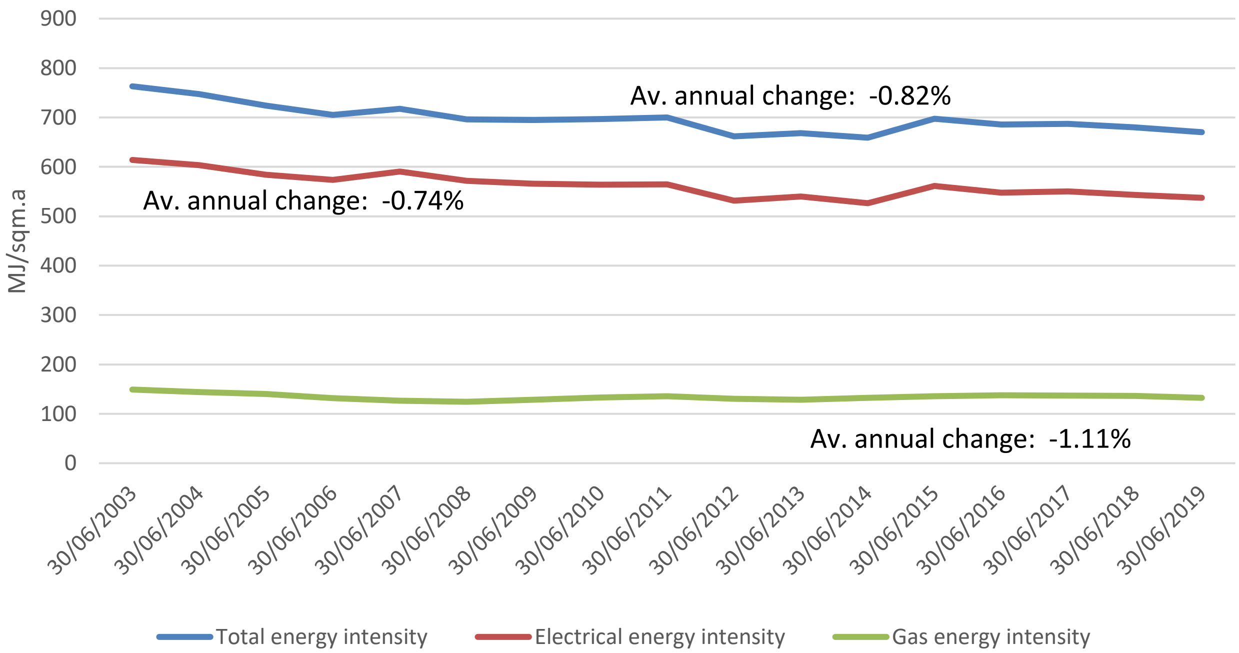


Figure 38: Average Annual Change in Energy Intensity - Commercial and Services - All Regions



Examining these trends more closely, it may be noted that Figure 39 for electricity, and Figure 40 for gas, both show a slowing trend over time, with total change in energy efficiency approaching zero around the middle of the last decade. Gas intensity appears to have resumed its downward course in the latter part of the decade, an effect again attributed to fuel switching.

Figure 39: Average Annual Change in Electrical Intensity, Commercial and services

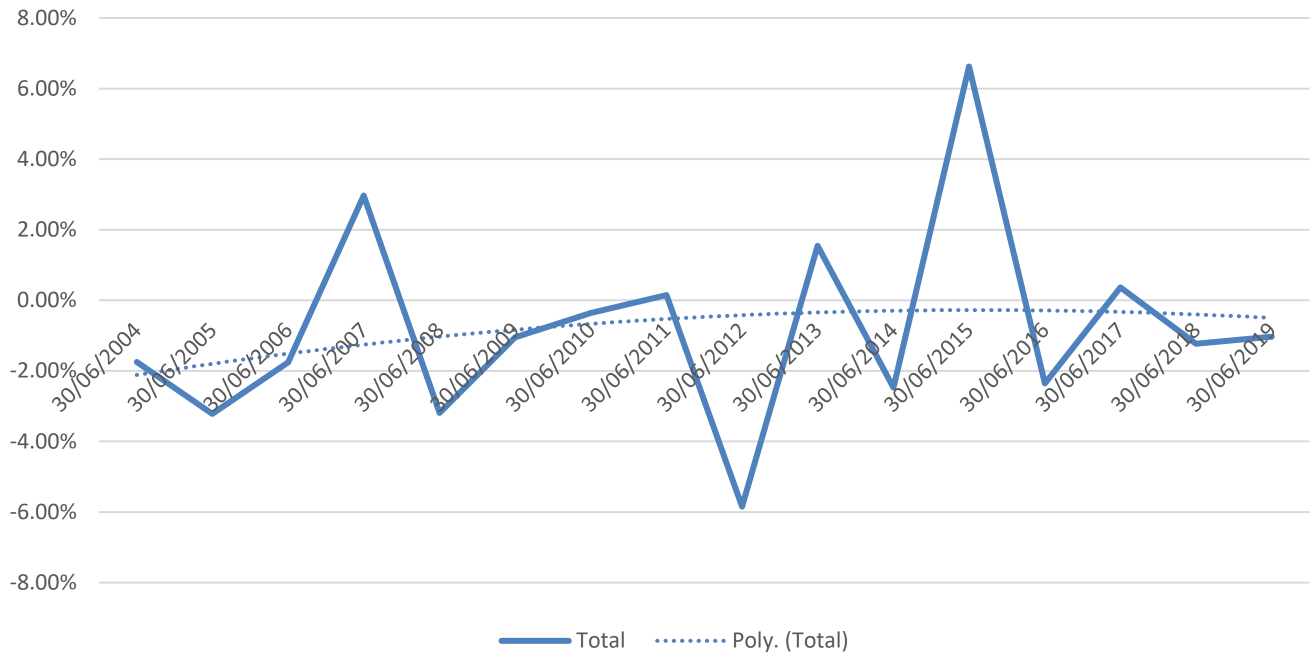
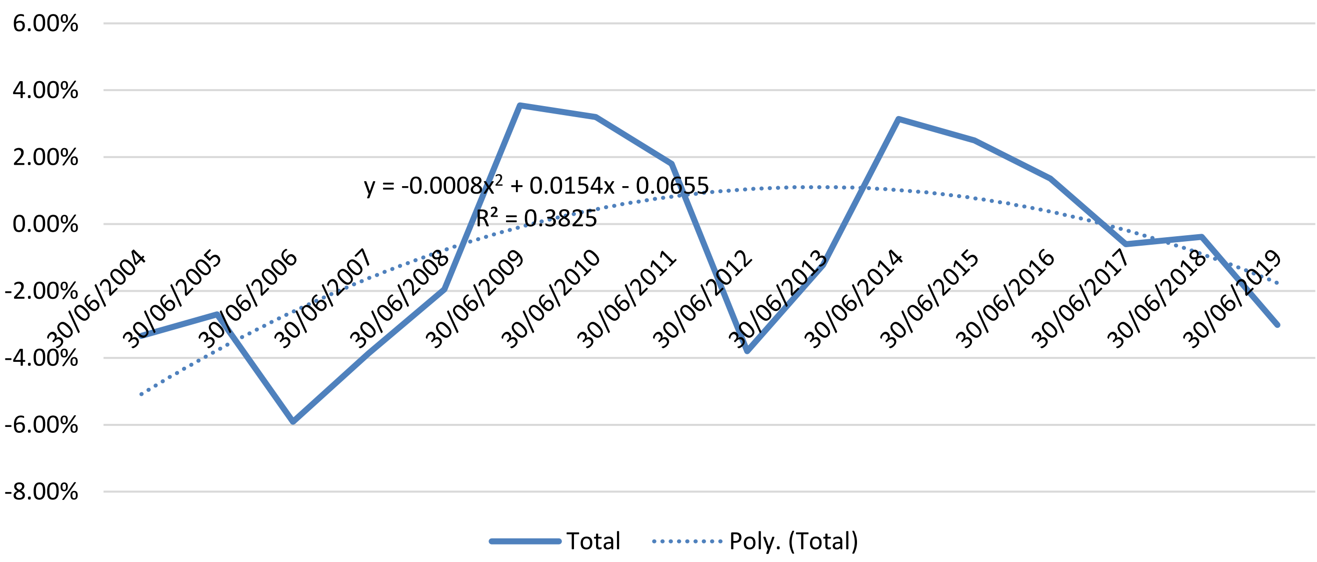


Figure 40: Average Annual Change in Gas Intensity, Commercial and services

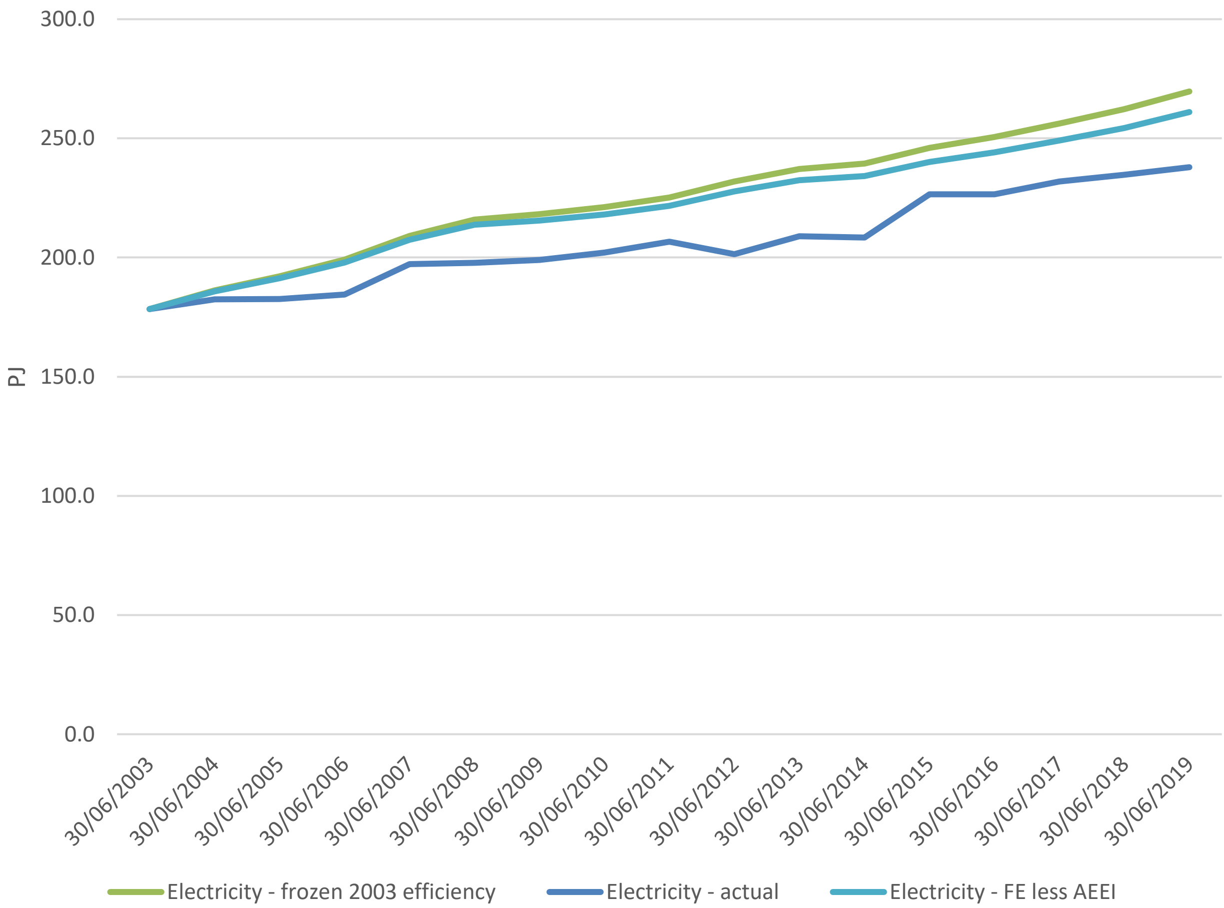


The modest and slowing rates of efficiency change in the commercial and services sectors represents a significant finding from this project. The interpretation of this finding is discussed in Chapter 4. However, here we note that this finding suggests only modest 'room' for the combination of policy-led and market-led energy efficiency change over this period. This has led to a requirement to discount both policy and market-led efficiency impacts significantly to achieve a reasonable degree of fit with historical consumption values.

3.2.2 Frozen (FY2003) Efficiency and Market-led or Autonomous Energy Efficiency Improvement

As noted above, we use FY2003 as a base year as it is the earlier year, giving the longest consistent historical timeseries that is possible using AES. Figure 41 indicates two counter-factual historical projections – first with frozen FY2003 efficiency, and second with an assumed rate of AEEI of just 0.1% per annum, compared to actual electricity consumption.

Figure 41: Frozen FY2003 Electricity Consumption, Autonomous Energy Efficiency Improvement, and Actual Consumption, Commercial and services (NEM + SWIS)



As touched on in the previous section, this AEEI assumption is considerably lower than normally assumed, with figures around 0.4% or 0.5% per annum more commonly assumed – for example in the COAG Energy Council Trajectory for Low Energy Buildings project.[21]. As noted, this lower value has been selected reflecting the apparently modest (and slowing) rate of total energy intensity reduction in this sector, as presented above. It is important to note that AEEI describes the change in average energy *intensity* over time, and these changes include behavioural and structural factors, and not only technical energy efficiency change, which undoubtedly has continued over this period (LED lighting being a prominent example).

While it is beyond the scope of this study to investigate, we consider it likely that market trends such as longer trading and building operating hours, intensification of office use (fewer sqm/worker), and potentially enhanced cooling loads due to, on average, higher summer temperatures, have put upward pressure on average energy intensity in this sector. This effect has then been offset to some degree by technical efficiency improvement and (as described further below) by various energy efficiency measures. The net effect of these trends is the modest rate of total efficiency change described above.[22]

For the projections period (from FY2022 on), we assume a continuation of only modest AEEI for the Slow Growth, Current Trajectory and Net Zero scenarios (0.1% per year), but we assume somewhat higher rates of improvement (0.15%/year for Sustainable Growth, and 0.2%/year for other scenarios) for those scenarios associated with faster decarbonisation – see Figure 42.

These trajectories reflect the differing demand/growth drivers by scenario, as noted in Table 4. The other component of frozen efficiency and AEEI projections is the expected net growth in the commercial building stock (new construction less retirements) over time, conventionally measured in square metres of gross floor area (sqm GFA) – noting that many different floor area constructs are used in different sectors in Australia. This data draws on SPR stock models that will be revised following the 2021 Commercial Building Baseline Study Update project, expected to be complete by end-2021. Total floor area by scenario is summarised in Figure 43.

[21] See https://www.energy.gov.au/government-priorities/energy-productivity-and-energy-efficiency/trajectory-low-energy-buildings, viewed 7/7/2021.

[22] We understand that the Green Building Council of Australia is about to publish a major update to its 2013 report, *Achieving the Green Dream – predicted vs actual greenhouse gas performance in Green Star certified office buildings*, and this is expected to confirm that longer operating hours is the single largest factor driving actual energy intensity above that predicted at the project design stage.

Figure 42: Estimated market-led EE savings, Commercial and services, electricity, by Scenario, All Regions, Relative to Frozen (2003) Efficiency

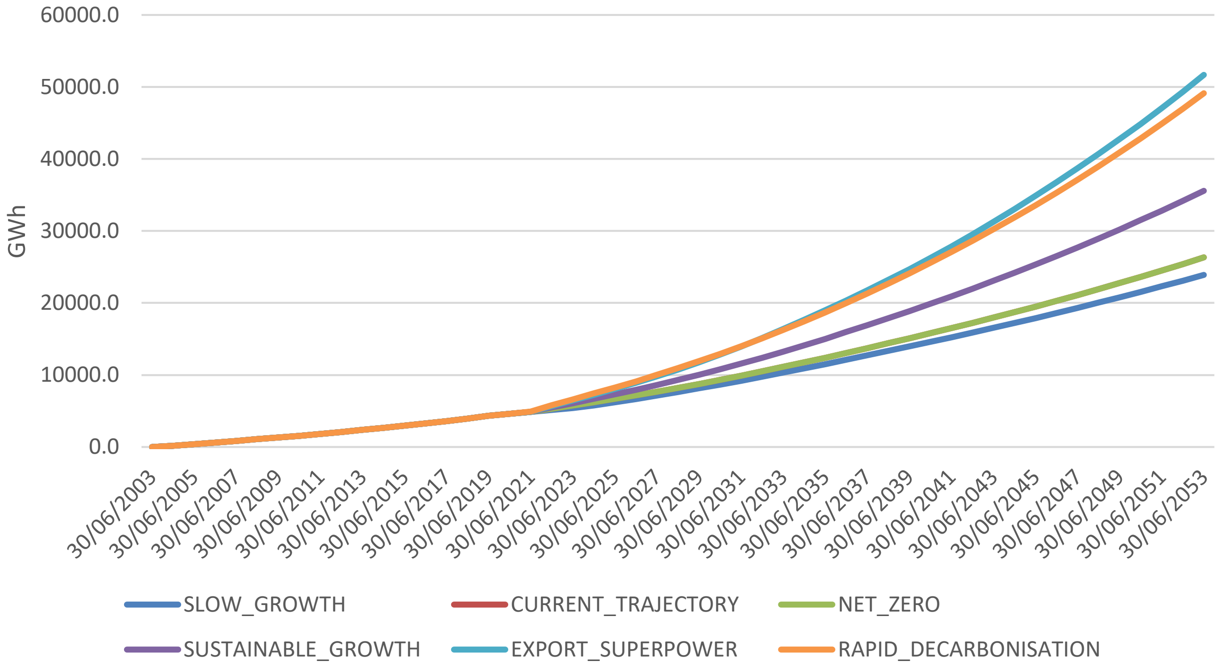
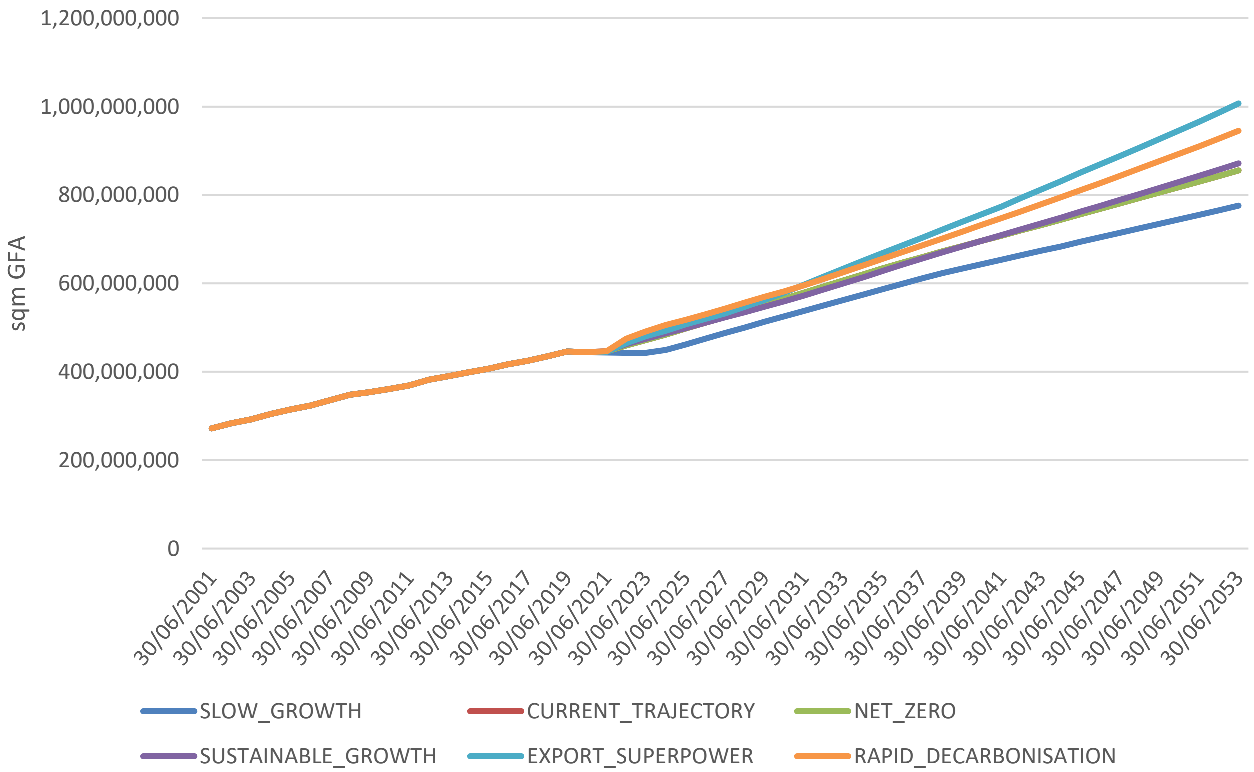


Figure 43: Non-residential Gross Floor Area by Scenario, NEM + SWIS



To correlate stock growth over time with demand drivers, we examined the degree of fit between historical (estimated) stock growth by jurisdiction, on the one hand, with growth over time in gross state product, gross value added – services, and state final demand. As we have done in previous analyses, we found that stock growth best correlates with growth in gross state product, with the net rate of annual stock accumulation generally representing between 92% and 98% of the rate of GSP growth, except in Tasmania where a lower figure of around 81% was found for the FY2003 – FY2019 period. These values by state are used for the stock projections in Figure 43, which impact particularly on savings estimated for the National Construction Code energy performance requirements.

3.2.3 Total Savings

Figure 44 provides an overview of forecast electricity savings to FY2053 under the Current Trajectory, relative to frozen FY2003 efficiency. All effects, including AEEI, are shown. As a 'wedges' chart, the top line shows frozen efficiency, while the bottom line shows the expected consumption after all the savings effects are accounted for (noting that our projections of expected consumption may differ from AEMO's forecasts). Individual measures are discounted as discussed further below. On this scenario, total avoided consumption in FY2053 is projected to reach 52,500 GWh.

The reduction in savings, leading to an upward turn in the bottom line from around FY2048, is due to the retirement of 40-year-old buildings which, when new, represented a large saving compared to earlier (pre-NCC performance standards) buildings. At the same time, new buildings in the FY2048 – FY2053 are expected to save relatively less, due to declining economic potential for savings over time. The net effect of this is to reduce energy savings.

In Figure 44, actual energy consumption in the historical period tracks the combined modelled effects of AEEI and policy measures, until FY2014. As noted in Section 3.2.1 above, AES then shows a significant increase in Commercial and services consumption. However, this is not replicated in AEMO data and not readily explainable from underlying factors such as stock growth, economic demand drivers, fuel switching or climate factors. For example, Figure 45 shows BMM Commercial total consumption from AES (electricity + gas in PJ) and the Bureau of Meteorology's annual mean temperature anomaly (^{o} Celsius) data for Australia over the FY2003 – FY2019 period. This indicates that while 2015 (along with all other years shown, except for 2011) was well above the long-term average for Australia, in terms of mean temperature, 2015 was somewhat cooler, on average, than 2013 or 2014. Also, the data shows that BMM Commercial consumption does not appear to have responded to the significant increase in the annual mean temperature anomaly between 2011 and 2013.

Figure 44: BMM Commercial Electricity, Energy Savings rel. to Frozen Efficiency, Current Trajectory

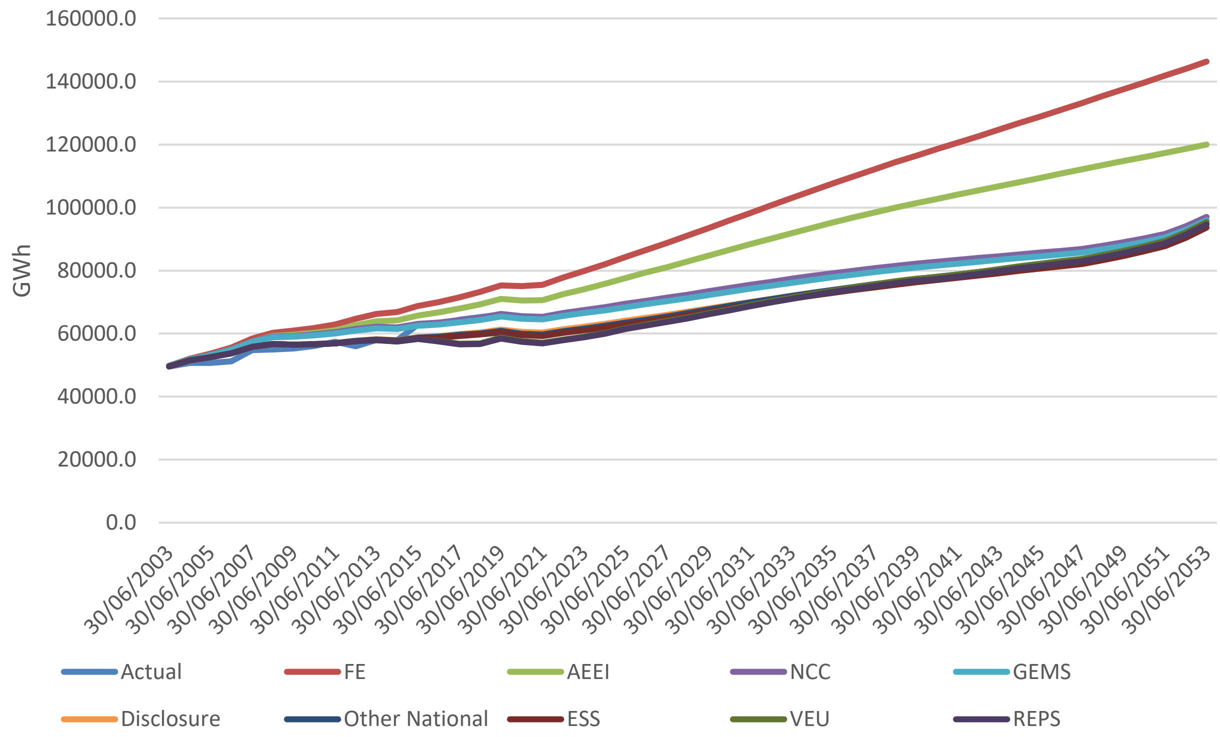
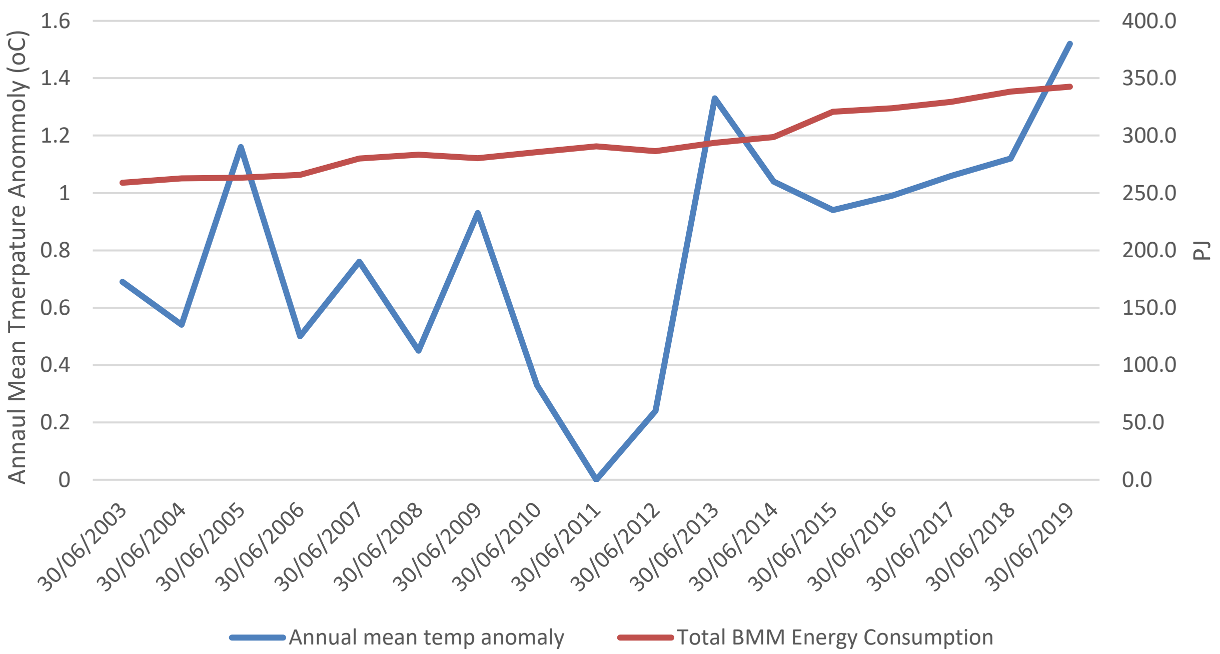


Figure 45: BMM Commercial Total Energy Consumption (AES) and Annual Mean Temperature Anomaly, Australia



Another perspective on the fit of the energy efficiency model with historical data is offered by Figure 46. Overall, we believe that there is sufficient doubt as to the post-2014 'actual' trend that no further model adjustment is warranted (noting, as above with respect to AEEI, and as discussed below with respect to individual policy measures, we have already applied significant discounts to 'headline' energy savings). Clearly it would be preferable if major sources of data on energy consumption in Australia agreed with each other, and we note that DISER (owner of AER) offered to work with AEMO in future to examine this issue further.[23]

Figure 46: BMM Commercial Electricity Consumption, Actual (AES) vs (Frozen Efficiency minus AEEI minus policy-induced savings)

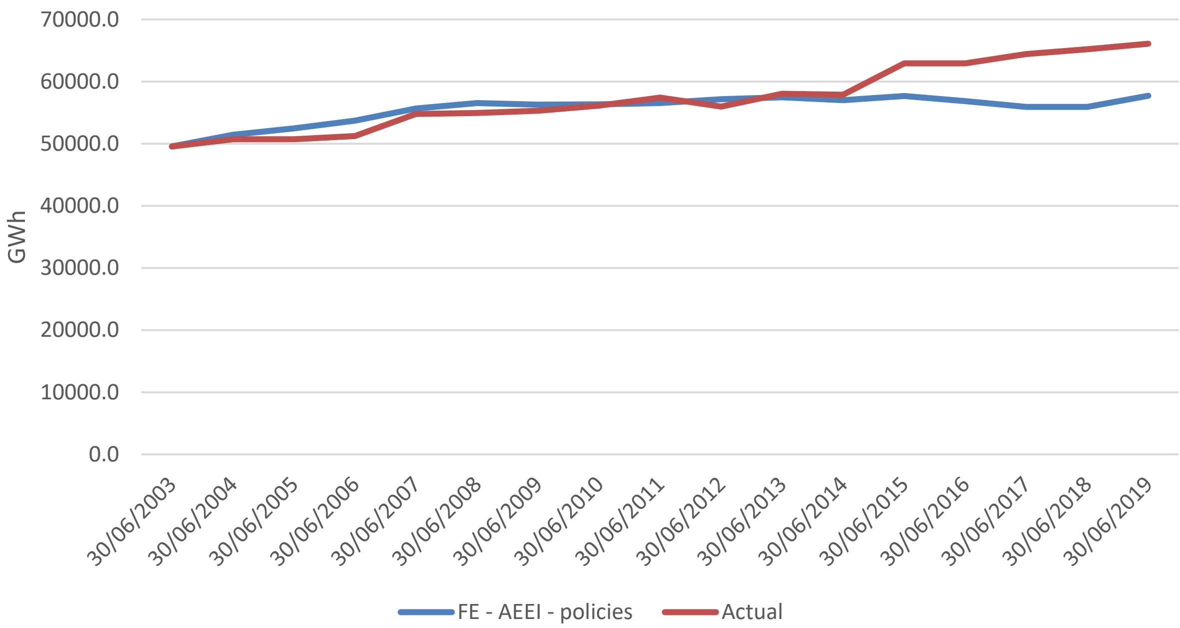


Figure 47 shows similar data as Figure 44 but for gas. Total savings by FY2053 are less than 5 PJ under this scenario. This reflects the fact that BMM Commercial gas consumption only exceeds 20% of the total (of electricity and gas) in Victoria and in South Australia – see Figure 48 – while the technical and economic potentials for gas savings are also lower than for electricity.

[23] This was a direct outcome of the Energy Efficiency Workshop held on 24 March 2021.

Figure 47: BMM Commercial Gas, Energy Savings rel. to Frozen Efficiency, Current Trajectory

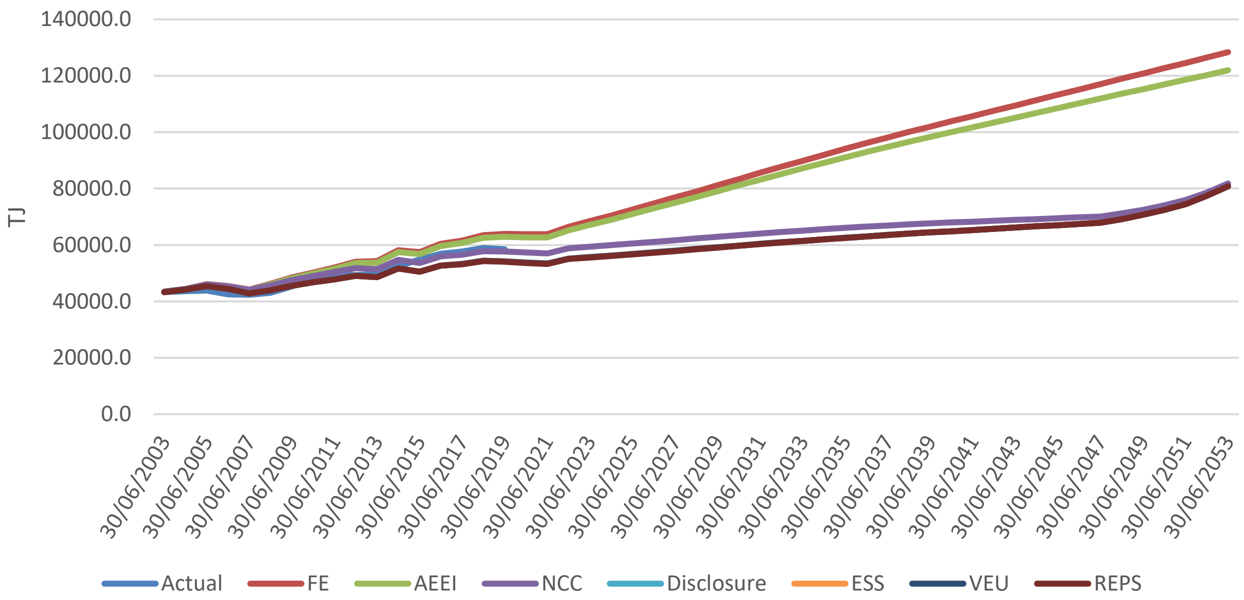
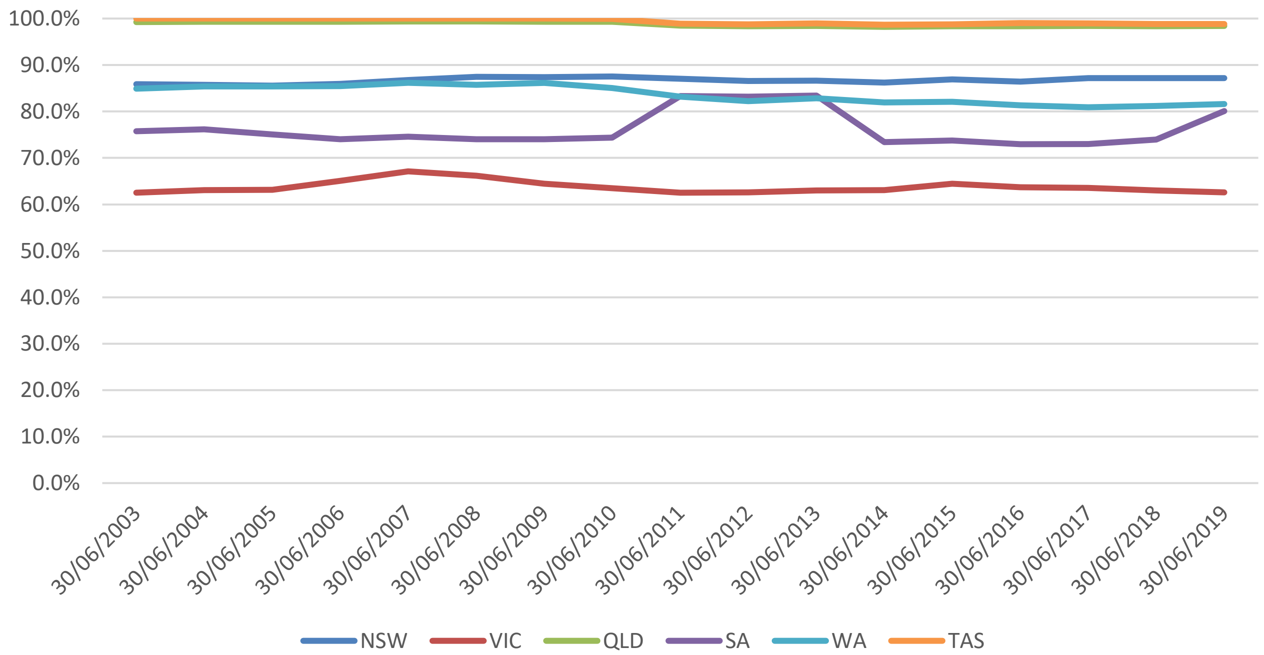


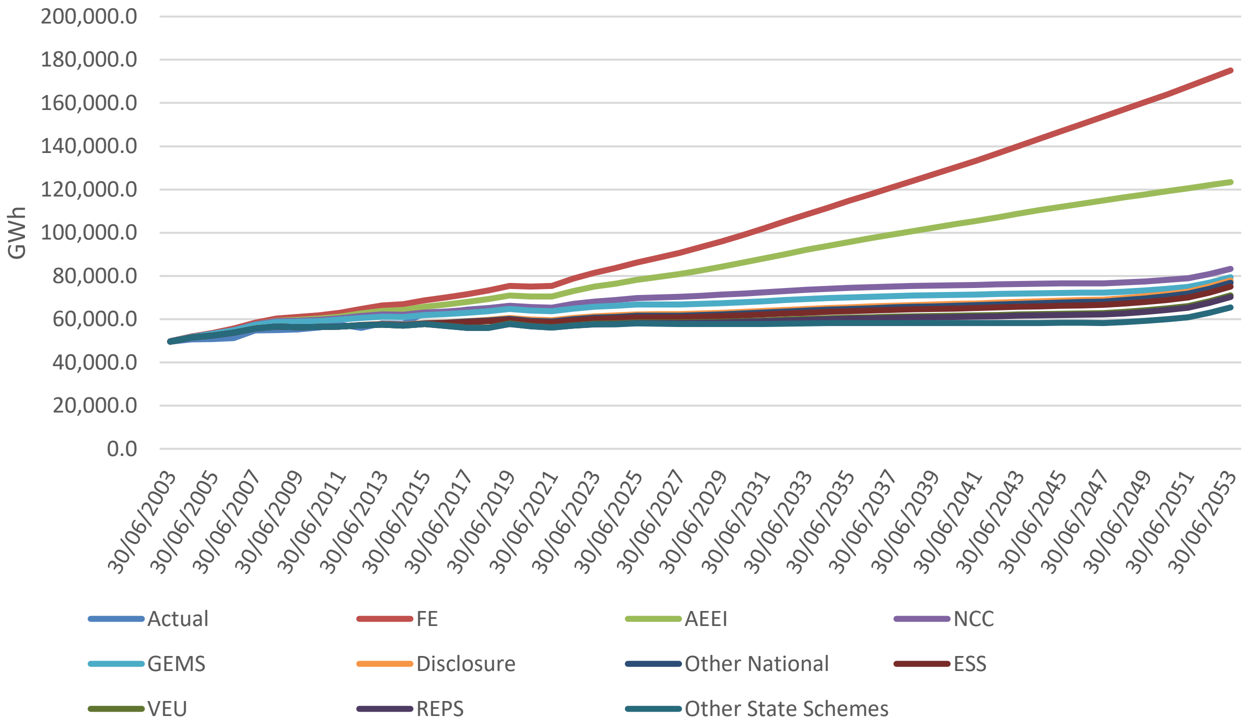
Figure 48: Electricity Share of BMM Commercial Fuel Mix by Region (Australian Energy Statistics)



Note: the rise and subsequent fall in the electricity share in South Australia between 2010 and 2014 *relates to an apparent reduction and recovery in gas consumption, as shown in Australian Energy Statistics data.*[24]

To illustrate the impact of higher ambition (and demand) scenarios, Figure 49 shows the electricity savings, by effect/measure, that are forecast under the Export Superpower scenario. In this case, despite a faster increase in frozen efficiency electricity consumption (due to demand drivers), SPR's estimate of total consumption is projected to remain broadly constant, at somewhat less than 60,000 GWh for the majority of the projections period.[25] Figure 50 shows similar data but for gas. Here gas consumption is shown as rising, due to smaller savings being realised than for electricity. However, as noted above, this study does not purport to examine all fuel switching effects, but only those attributable to energy efficiency measures.

Figure 49: Commercial and services Electricity Consumption, Export Superpower, all effects



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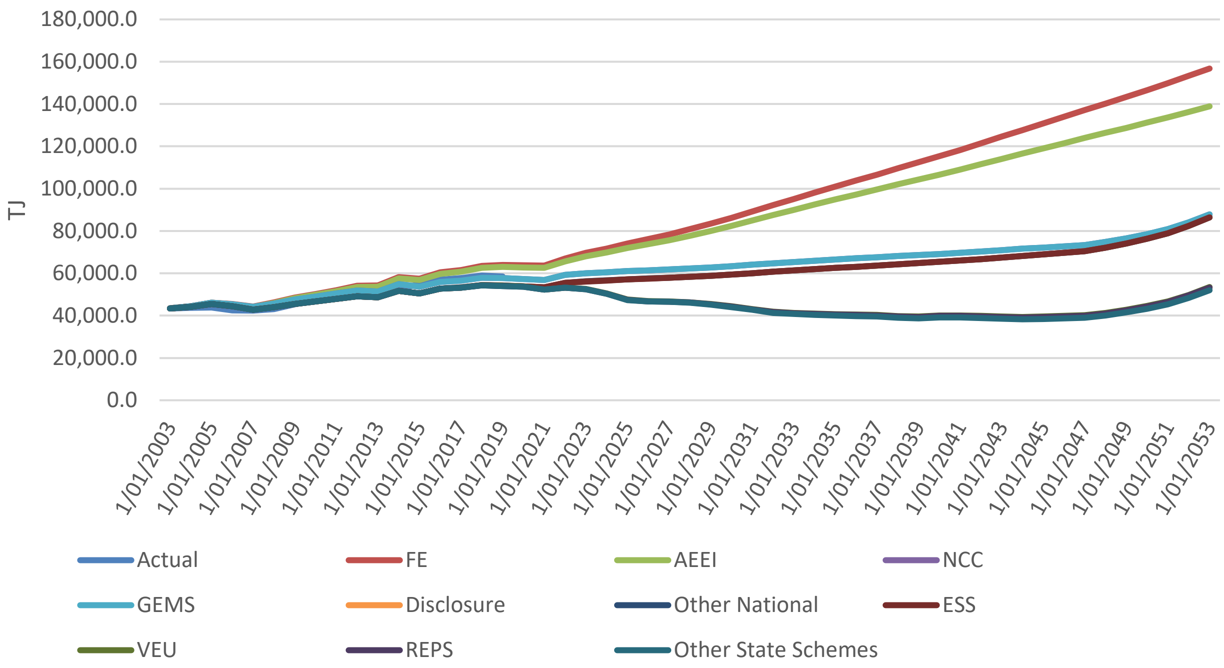
[24] We understand that apparent consumption, as shown in AES, for smaller jurisdictions can be affected by balancing routines within the underlying model. AES consumption for the residential and commercial sectors is modelled and not directly based on metered consumption.

[25] Note that AEMO's consumption forecasts can differ from those emerging from the SPR energy modelling.

Figure 50: Commercial and services Gas Consumption, Export Superpower, all effects



3.2.4 Policy-Induced Savings by Measure

National Construction Code

Figure 44 and Figure 47 above clearly illustrate that the National Construction Code (NCC) energy performance requirements for non-residential (strictly, Class 2 – 9) buildings – also referred to as Section J – represents the largest share of electricity and indeed gas savings of all measures and effects studied. Figure 51 and Figure 52 confirm this, indicating between 22,000 and 40,000 GWh of electricity savings and 35 – 50 PJ of gas savings in FY2053, depending upon the scenario.

Figure 51: National Construction Code Electricity Savings by Scenario

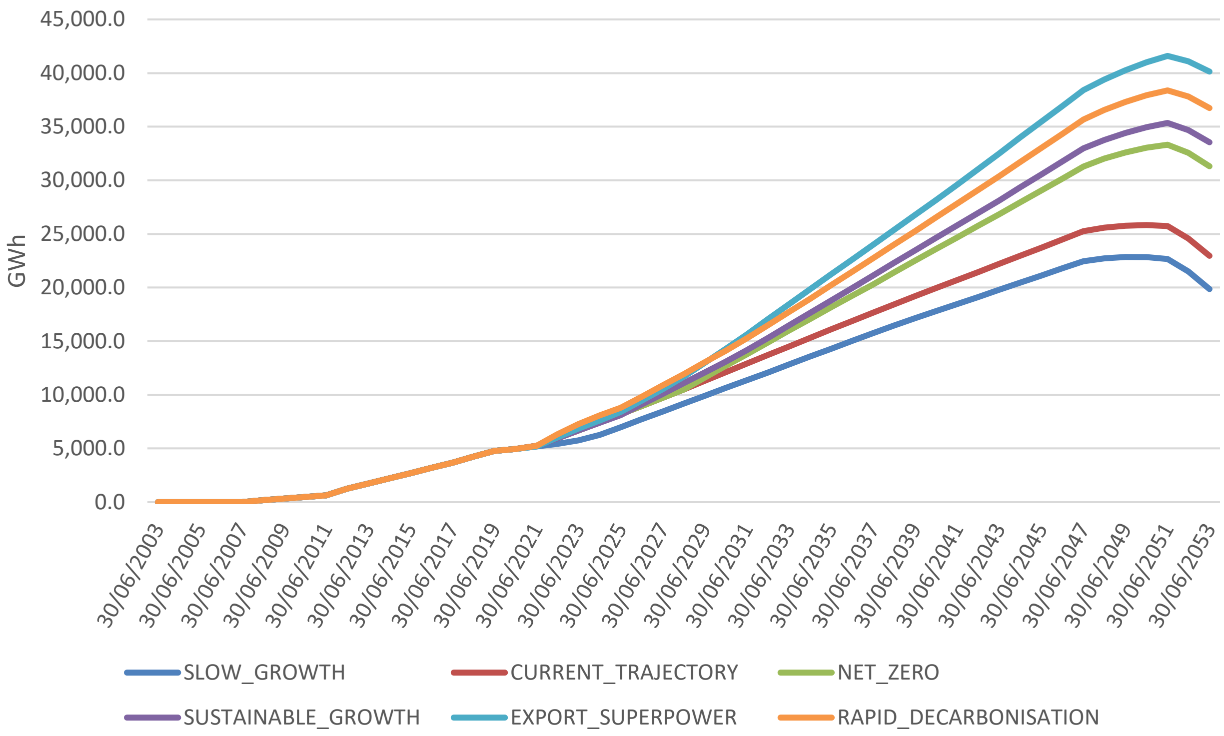
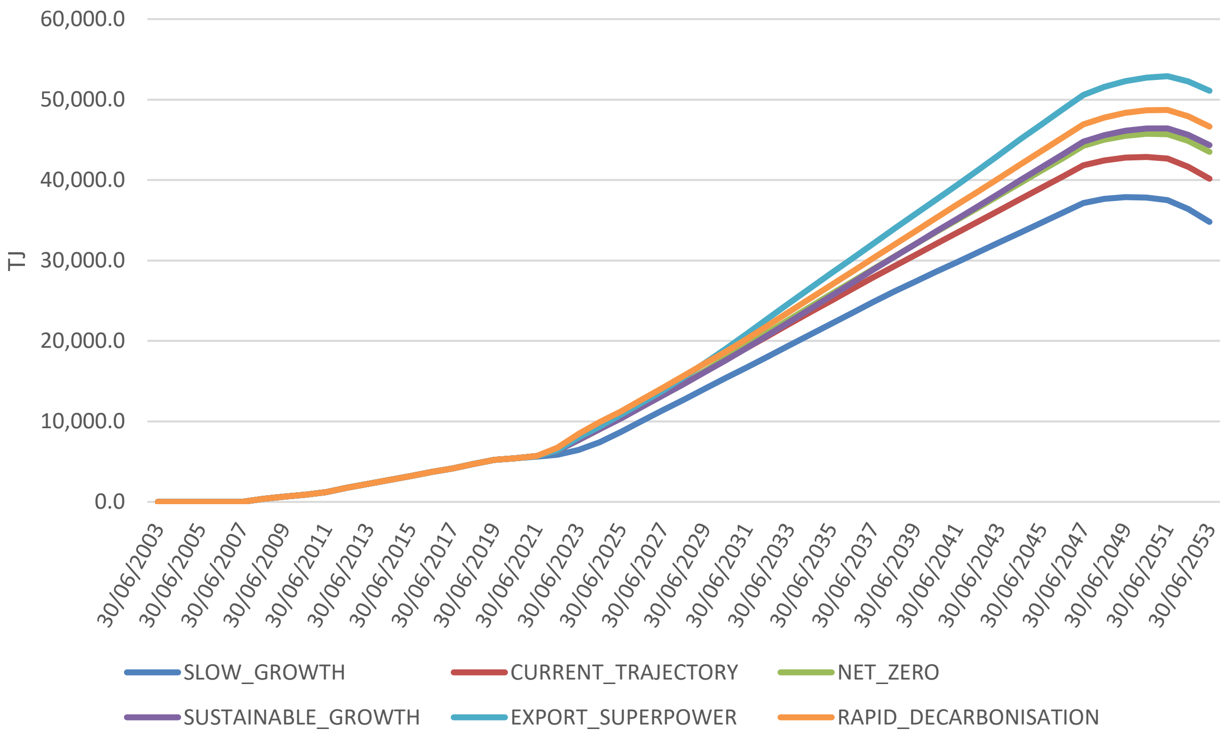


Figure 52: National Construction Code Gas Savings by Scenario



These savings forecasts are based on modelled changes in specific energy intensities for particular building forms and climate zones, as required to comply with past (and anticipated future) Section J requirements, as prepared by SPR for the COAG Energy Council Trajectory for Low Energy Buildings (and for other purposes, such the as the NCC2019 technical solution for the Australian Building Codes Board). A technical treatment of this modelling is documented in Co-operative Research Centre for Low Carbon Living, *SP0016 Building Code Energy Performance Trajectory Final Technical Report*, 2018. The stock modelling was summarised in Figure 43 above. NCC Section J applies to new construction work annually, which is derived as the net increase annually, plus an allowance of the 2% stock annually being retired annually.[26] This means that new construction to Code is higher than implied by the *net* growth in the stock, and this is one reason why the measure generates significant savings on a cumulative basis. The second reason is that the modelled change the specific energy intensity of new buildings is large, particularly when compared to pre-Section J (effectively, pre-2008) buildings.

In the 2018 Decision Regulation Impact Statement undertaken by the Centre for International Economics, there is a substantial Appendix D entitled *Are modelled energy savings realised?* (pp 161 – 173). This notes that there are concerns, around the world, that modelled energy savings associated with building codes may not be fully realised:

- some literature suggests that buildings tend to use more energy in reality than simulation models predict, with the possibility that this effect is (relatively) greater with high-performance, low-energy buildings (potentially due to more complex and/or sensitive building controls)
    - however, other studies show both better and worse than predicted energy use than predicted, with some studies finding, on average, better performance than predicted
- Green Star data (to 2013) suggested 57% of buildings sampled achieved the predicted star rating or better (including 19% that performed better), and a further 26% were within 1 star of the predicted outcomes
- CIE analysis overall concluded that while the Green Star data, in particular, lacked statistical significance, there was a case for assuming that, on average, between 25% and up to 50% of modelled savings were not realised. Key reasons for this 'performance gap' included:
    - deviations between 'as designed' and 'as constructed' buildings in terms of their specifications and construction techniques
    - poor commissioning and/or maintenance
    - different occupancy patterns and/or occupant behaviours than modelled
    - modelling failures.

[26] Commercial buildings are generally subject to demolition or major refurbishment more frequently than residential dwellings and therefore exhibit a higher stock turnover rate for modelling purposes.

We note that, despite literature of this kind – and other events and reports that have drawn attention to potentially poor standards of compliance with the NCC over many years – we are unaware that *any* compliance audits of non-residential buildings have been undertaken in *any* Australian jurisdiction in recent years. Thus, for this study we feel constrained to be guided by the CIE analysis, and thus we apply a non-realisation discount of 30% to past savings estimates (up from 25% in our 2019 analysis), and 25% from FY2022 in Current Trajectory. Also, as noted in the previous section, non-discounting of savings would lead to far more savings than can be accounted for in the historical consumption record. This in itself lends weight to the theory that, on average, a significant portion of modelled Code savings are not, in fact, realised. In the Sustainable Growth scenario, we assume that a program of Code compliance reduces the loss of expected savings to 15% by FY2053, while in Export Superpower and Rapid Decarbonisation, this is further reduced to 12.5%.

A second form of discounting applied to NCC savings arises from the likelihood that there is effectively double-counting between savings attributed to the NCC and those attributed to the Greenhouse and Energy Minimum Standards (GEMS) program, discussed further below. This arises because NCC energy performance requirements are non-prescriptive and therefore, in effect, discipline the performance of most elements of building (as per 'reference building' requirements in the Code, which in fact exclude certain loads, such as IT equipment, additional tenant lighting or air conditioning (if any), and mechanical transport (lifts, travellators, etc). This includes lighting systems, pumps, fans, chillers and other equipment that are the subject of minimum energy performance standards and/or labelling under GEMS. There was some discussion of this effect at AEMO's Energy Efficiency Workshop, but it appears that the extent of this overlap has never been formally analysed. Here we apply a discount of 20% of the modelled (and already discounted) NCC savings to represent this overlap with GEMS. This discounting is a new feature of 2021 analysis and was not included in our 2019 efficiency forecasts. This is one effect that contributes to 2021 forecasts being somewhat lower than those from 2019, as discussed in Chapter 5.

Finally, for all measures, we apply estimates of the extent to which savings attributed to measures may, in fact, have occurred in the absence of these measures. This can be thought of as non-additionality to AEEI or market-led efficiency improvement. While, again, we are not aware that this effect has been subject to formal research, a recent example is offered by LED lighting. While some programs (GEMS, state energy savings schemes) claim a share of the savings induced by LED lighting, there is also an extent to which this market change may have occurred in any case – perhaps more slowly – because of a) international policy and research efforts, which in effect, Australia gets to free-ride on, and b) price reductions largely associated with economies of scale and lower production costs in China and other countries from which LED lamps are imported. Generally, and also for the NCC, we assume that non-additionalities are ~25% at the commencement of the measure (effectively FY2008 for 'BCA2006', the first iteration of Section J), and grow at 0.5% per annum thereafter for the Slow Growth, Current Trajectory and Net Zero scenarios. For the Sustainable Growth scenario, we increase this to 0.75% per year, and for Export Superpower and

Rapid Decarbonisation by 1%/year, on the grounds that these higher ambition scenarios are expected to be associated with faster development and commercialisation of decarbonisation technologies across the board, including those affecting building performance. This assumption also helps to make more conservative forecasts of higher efficiency outcomes under these high-ambition scenarios, due to both higher demand and stronger policy drivers.

Greenhouse and Energy Minimum Standards (GEMS)

George Wilkenfeld, Principal of George Wilkenfeld & Associates, has prepared a detailed Appendix A that provides more detailed analysis of GEMS program impacts, including changes to those impacts since we last undertook this work for AEMO in 2019. This section provides summary analysis.

GWA finds that some measures have been further delayed or deferred – as has been the pattern now for many years – but also that some measures have been implemented such as:

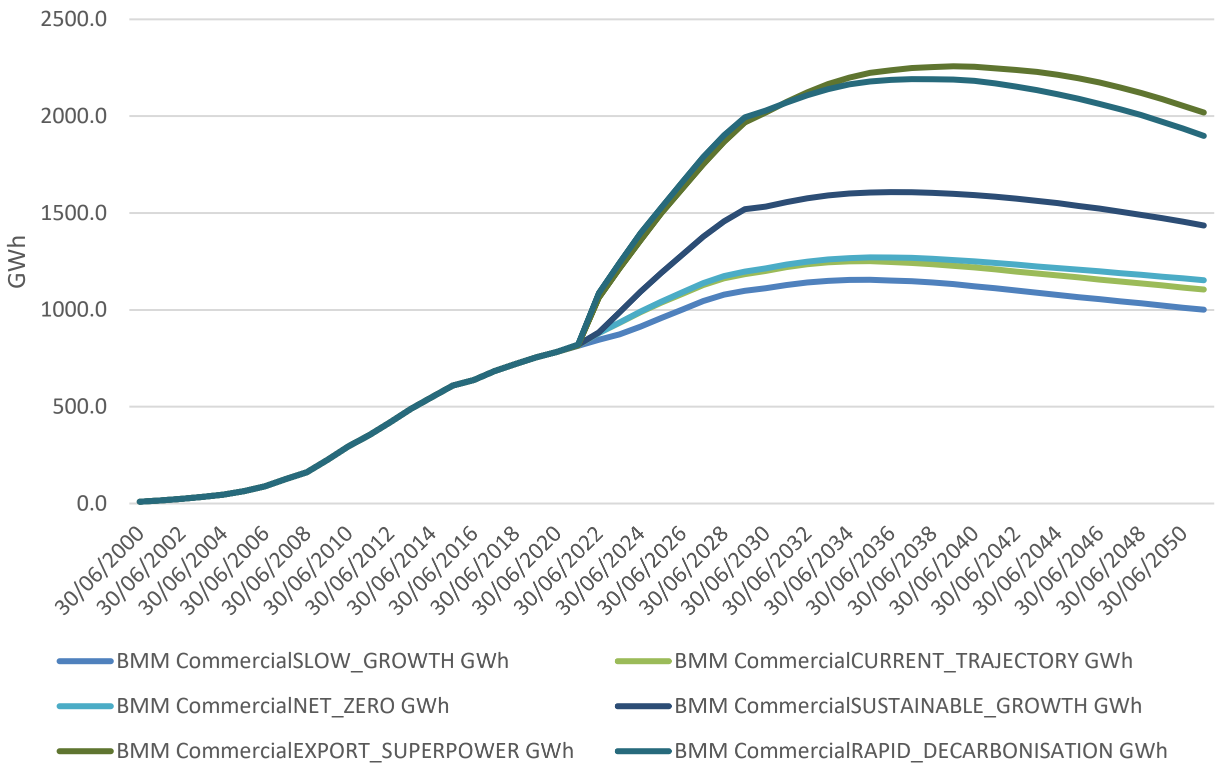
- Residential air conditioners MEPS 2021
- Non-residential air-conditioner MEPS 2022
- Electric motor MEPS 2017
- Household refrigerators & freezers MEPS 2021
- Commercial refrigeration MEPS 2021.

Also, with the passage of time, certain standards have effectively been made redundant by market and technology changes, notably in the lighting area. We have therefore discounted savings from these measures (program designations lighting 10A, 10B, 11A, 11B) by 50% and for no. 12 (triphosphor lamps) by 80%. Also, LED MEPS (36 and 37) are discounted by 25% to represent a degree of non-additionality to market-led change. Note that these discounts were not applied in SPR's 2019 forecasts and are a reflection of the significant market shifts in the lighting market that have occurred in Australia in recent years.

Then, in common with other measures, we apply a non-additionality discount to overall program savings over time, as described for the NCC measure above, which represents an expectation that some of the savings counted under GEMS are likely to have occurred in any case, due to technology change, cost reductions and product improvements. This discount is assumed to reach 25% by 2008 and to grow annually at 0.5%, or somewhat faster under the Sustainable Growth (0.75% per year), Export Superpower and Rapid Decarbonisation scenarios (1% per year). As discussed at AEMO's Energy Efficiency Workshop in March, it would be difficult – but not impossible, with appropriate data access – to evaluate the extent of actual savings associated with individual GEMS measures, and to attribute these to market and policy effects. However, with more than 50 measures in place, and the program spanning four decades, this would require a significant evaluation effort.

The measure is modelled to respond to differential rates of GSP growth (for BMM; and population growth, for residential) in future by scenario. In addition, for the Export Superpower and Rapid Decarbonisation scenarios, we assume additional program expansion and standards renewal effort, leading to an additional 20% energy savings cf Current Trajectory. Expected savings by scenario, for BMM Commercial, are shown in Figure 53. Note that GEMS measures only cover electricity, and that national savings estimates are split by jurisdiction using GSP shares for BMM, and population shares for residential.

Figure 53: BMM Commercial GEMS Electricity Savings by Scenario – NEM + SWIS



Disclosure

Disclosure represents a somewhat newer form of policy intervention, often termed ‘market based’, in that the overall aim is to assist the functioning of efficient markets by ensuring that market participants are well-informed regarding the relative efficiencies of buildings/tenancies. Also, mandatory disclosure can avoid what is termed ‘adverse selection’ of less efficient buildings, where owners have an incentive to withhold information that evidences poor energy performance. Effective disclosure schemes provide an incentive for tenants to select relatively more efficient spaces, and for owners to upgrade spaces to be more attractive to tenants, but they do not compel any action other than information disclosure – market participants determine the actual outcomes that occur, in response to enhanced market signals.

The two disclosure measures covered in these savings estimates are NABERS, which is a voluntary disclosure scheme, and Commercial Buildings Disclosure (CBD) which is a mandatory disclosure scheme limited to primary purpose office spaces greater than 1,000 sqm (since 2017, and previously 2,000sqm). These measures are modelled together, as there is significant overlap between them. Both primarily focus on offices, although NABERS has numerous voluntary tools, and reasonable take-up in shopping centres as well. However, there have been 94 shopping centres energy-rated at least once under NABERS, cf 3586 offices.[27] Given the voluntary nature of non-office ratings, and difficulties in determining the degree of additionality to market outcomes, combined with the smaller number of non-office buildings rated, we confine the estimates savings to offices. This scope decision is something that should be kept under review for future projections.

NABERS office energy has operated since 1999, with CBD commencing in November 2011, leading to a significant increase in the number of ratings. At the same time, the share of all offices rated under NABERS peaked in 2016 and has fallen modestly since. Also, while the program reports growth in the average reduction in energy use after multiple ratings, this has also (currently, at least) levelled off at around 37% after 13 or 14 ratings.[28] For context, it is important to note that many larger offices, owned by major property trusts, are rated annually for corporate disclosure reasons, even though this is not required under CBD (discussed further below). This means that 'saturation effects' – whereby the incremental response to each additional rating for the same building is likely to fall over time – are already apparent and likely to become more and more significant in future.

Another important issue for interpretation of NABERS 'headline' energy savings results is that the key metric presented in the overall change in energy intensity ($MJ/m^2.a$) over time for rated offices. While this is an excellent metric for tracking the overall change in efficiency for individual buildings over time, the attribution or causation of the change over time is not obvious. Factors other than NABERS that would contribute to changes documented by NABERS would include purely market-based efficiency drivers (for corporate or GRESP reporting, for example), NCC energy performance measures (for newer buildings that are rated, and also for refurbished older buildings), government energy efficiency targets (that often require a certain NABERS rating to be obtained), state energy savings schemes (where NABERS upgrades are recognised as a measure), and also CBD.

Also, we need to consider what outcomes are being achieved by offices *not* rated by CBD, even if these are noted in program statistics to represent only 34% of the office market. Generally this cohort is likely to represent offices less than 1,000 sqm (not covered by CBD) and office spaces in non-primary-purpose office buildings (eg, office spaces contained within other buildings). Sometimes this segment is referred to as 'mid-tier' offices, and there is literature that reports

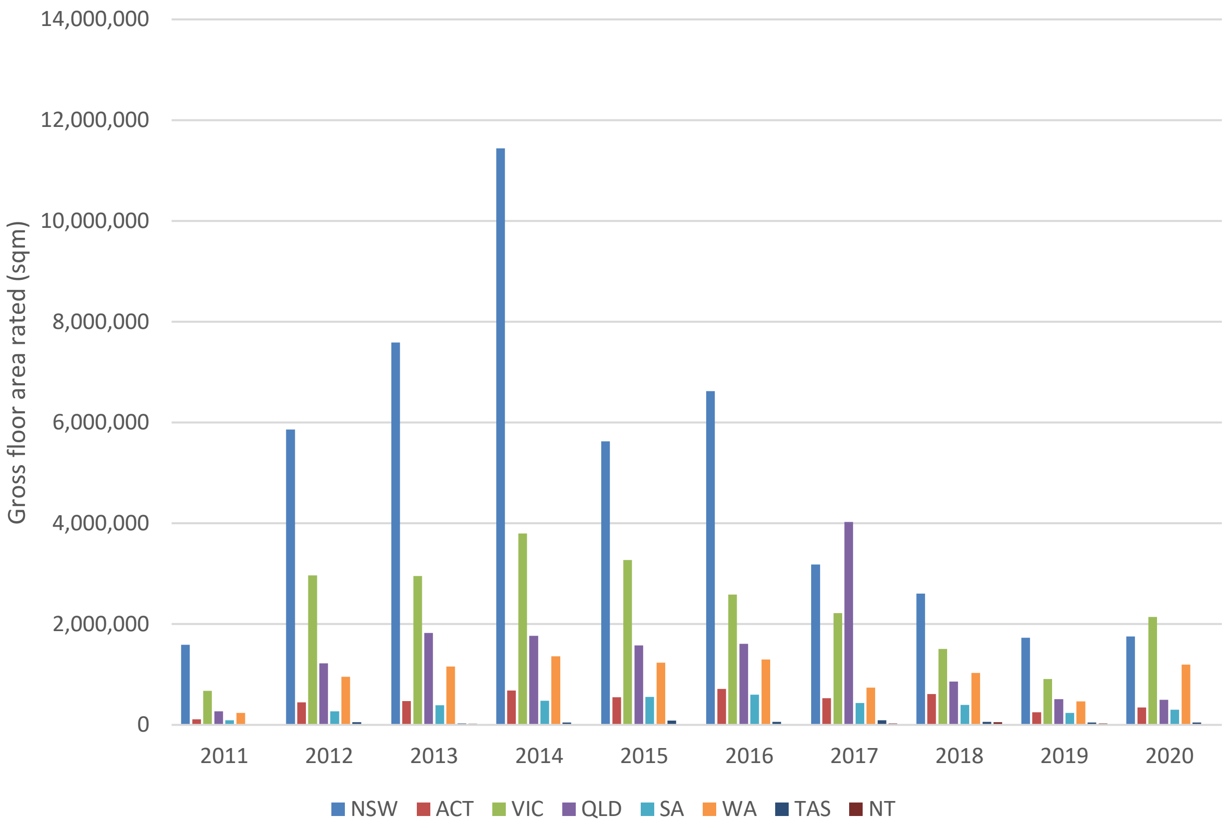
[27] https://nabers.info/annual-report/2019-2020/life-of-program-statistics/
[28] Ibid.

generally worse energy performance for this cohort – which may also tend towards older buildings, in regional markets, with different (private) ownership.[29]

The CBD program – which, as noted, commenced in late 2011 – introduced mandatory disclosure requirements initially for office spaces greater than 2,000 sqm, reduced to 1,000 sqm from July 2017. There have been several reviews of this program, including recommendations to expand it to other building classes, but these have not been acted upon to date. CBD publishes very detailed (building by building) program uptake and impact data – setting a standard in this area that ideally other programs would aspire to meet.[30] This data, however, indicates that the floor area rated annually has fallen markedly and consistently since 2014. It is not immediately apparent why this is so. In principle, the decision to reduce the minimum size threshold should have brought more floor area into the program, but the evidence suggests otherwise. Possibly the restriction of the program to "primary purpose" offices may effectively be preventing the program from accessing particularly (relatively) smaller (but still large) office spaces. The data below would imply that a smaller share of total disclosure savings would be attributable to CBD, and a larger share to NABERS, since 2014. However – and primarily due to the challenges associated with teasing these programs apart – here we forecast the joint impact.

[29] See, for example, Australian Government Department of Industry, Innovation and Science et al, *Mid-Tier Commercial Office Buildings in Australia*, November 2015.
[30] https://www.cbd.gov.au/registers/downloadable-cbd-program-data-set

Figure 54: CBD Floor Area Rated Annually by State (whole buildings and base buildings)



Source: Commercial Building Disclosure downloadable dataset - https://www.cbd.gov.au/registers/downloadable-cbd-program-data-set

As with other measures, these forecasts respond to AEMO scenario demand drivers in future as a function of how different rates of GSP growth are modelled to affect building, including office, stock growth over time. We do not vary key policy drivers – such as the scope of buildings and spaces covered by disclosure measures – but this should also be kept under review for future forecasts.

Figure 55: Disclosure, Electricity Savings by Scenario, NEM + SWIS

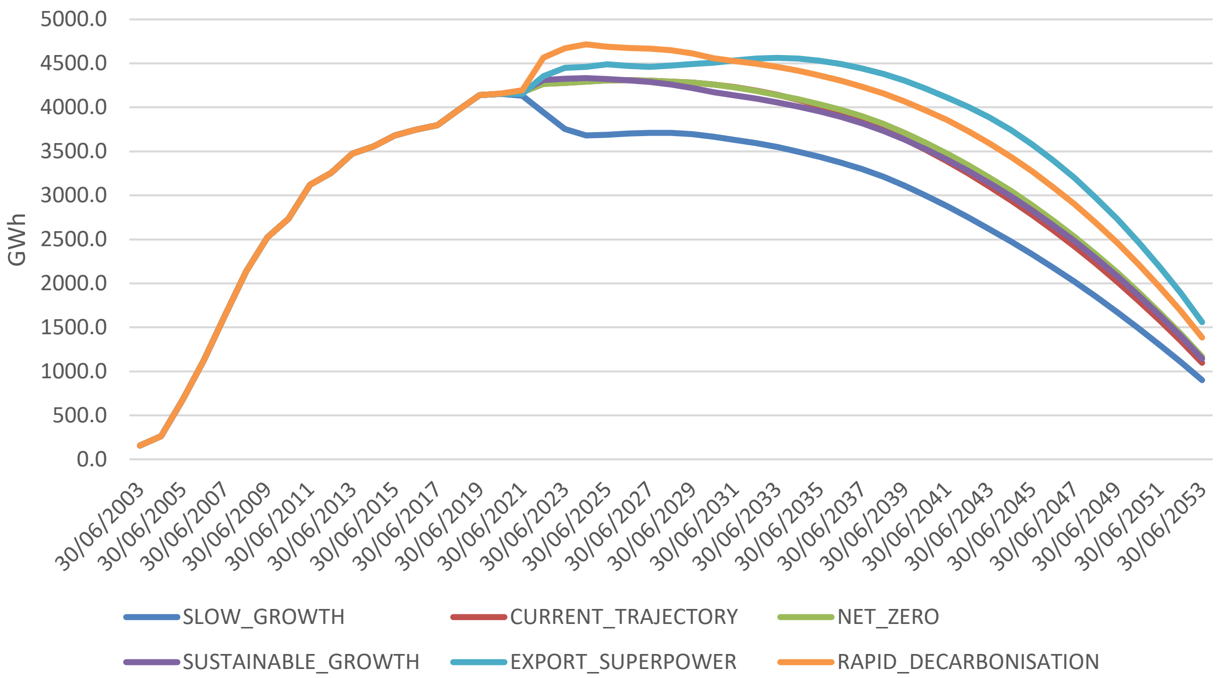


Figure 56: Disclosure, Gas Savings by Scenario, NEM + SWIS

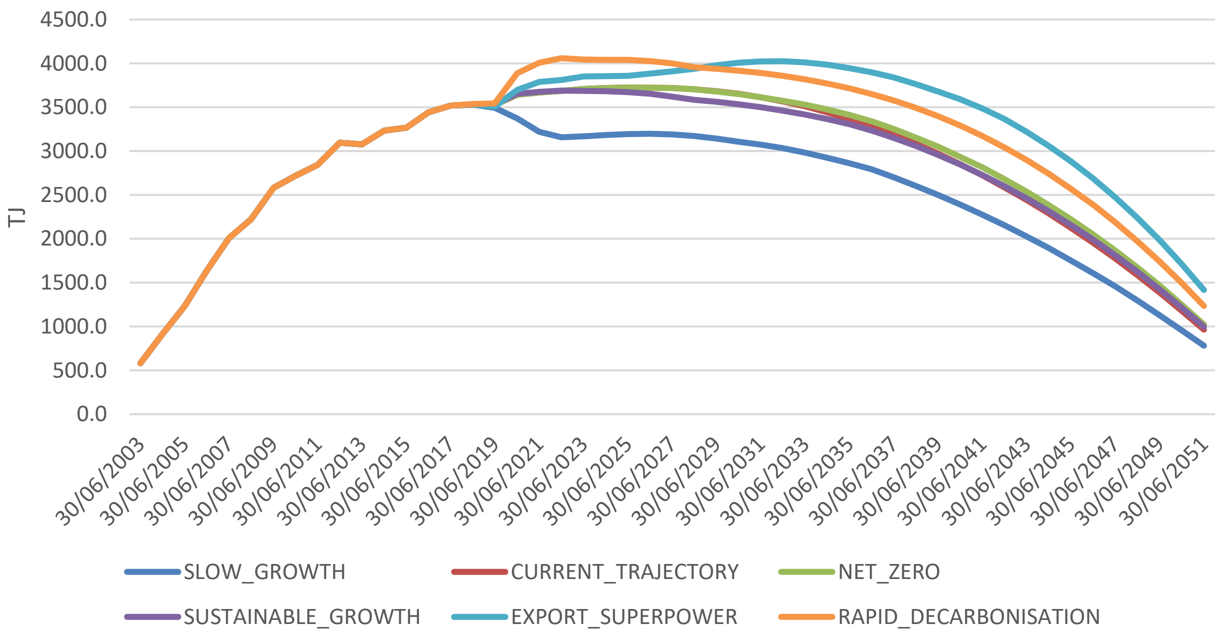


Figure 55 and Figure 56 show the electricity and gas savings forecast by scenario for disclosure measures, and for the whole of the NEM + SWIS regions. The fuel mix of savings follows assumed ‘fuel mix by scenario’ settings as discussed above. Generally, the major influence driving the savings shown is the saturation effect discussed above. When combined with an assumption of an increasing degree of non-additionality to market-led energy savings over time (we apply the same assumptions as above for NCC and GEMS for this factor), we see a forecast of savings which peak over the next 10 years of so, depending upon the scenario, before falling. The primary factor that could offset this trend would be expanded coverage of CBD, and also addressing the limitation to ‘primary purpose’ spaces, or potentially other factors that are leading, as noted, to declining participation in CBD in particular.

Other National Schemes

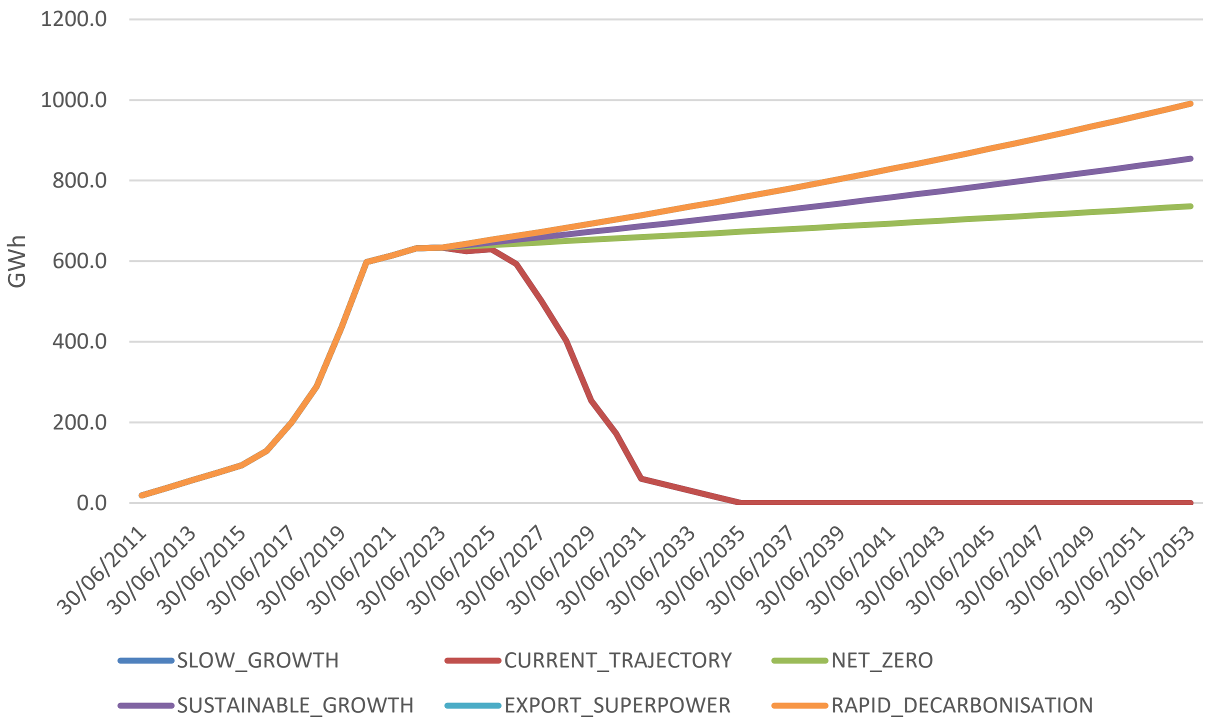
In line with our policy review, described in Section 2.1 above, we included energy efficiency savings from the Emissions Reduction Fund (ERF) and the Clean Energy Finance Corporation’s (CEFC) investment program. In both cases, energy efficiency is not the primary focus of either program. At the same time, their activities do include some energy efficiency activities. Data was provided by both programs, and these have been aggregated on request not to publish individual results. For both programs, national savings data were allocated to states using GSP shares, but we note that, given the modest number of interventions supported by these programs, the actual distribution of savings by region could differ from this.

In the case of ERF, we noted from inspection of the online Emissions Fund Register that while 74 energy efficiency projects have been registered over the life of the program, many have been revoked, while many others fall outside our sectoral scope (eg, in the power generation sector). Others involved savings of fuels other than electricity or gas. To date, only 15 energy efficiency projects have so far led to Australian Climate Change Units (ACCUs) being issued, including none under the NABERS method, none under high efficiency appliances. Some have been issued to LILs and are out of scope for this reason.

For the CEFC, we received data from the program that some gas savings were attributable to a biogas plant (ie, representing fuel switching rather than energy efficiency). We estimate that the majority of other gas savings are likely to have been captured by LILs, in part due to the likelihood that entry barriers to this scheme would loom larger for smaller enterprises. Program managers were not able to confirm an SME/LIL split. We capture the full electricity savings as reported and attribute these to the commercial sector – noting that is possible that some of these savings could be captured by industrial enterprises.

Estimated total energy efficiency savings from these programs under Current Trajectory are modest primarily, as noted, because this is not the main focus of either program – see Figure 57. For Slow Growth and Current Trajectory scenarios, we assume no new savings from these programs, but in Net Zero, we assume modest growth (for example, resulting from funding increases) of 0.5% per year, and up to 1.5% per year for Export Superpower and Rapid Decarbonisation.

Figure 57: Electricity Savings by Scenario, Other National Measures



NSW Energy Savings Scheme (ESS)

ESS has operated since 2009. NSW legislation provides for targets to be set, from year to year, based on a percentage of liable acquisitions (electricity purchases, with some exclusions for trade-exposed sectors). Liable parties are required to acquit certified savings certificates (equivalent to 1 MWh of deemed savings over the life of a given activity), and this supports the activities of energy services companies and others who seek to identify and implement least-cost efficiency projects that generate the certified savings.

For this analysis, the NSW government made available detailed analyses of past savings in the FY2016 – FY2020 period, and also forecasts of key program parameters anticipated out to 2030. These form the basis of our analysis, but we also draw on IPART's annual (2019) *ESS Compliance and Operation Report* (eg, Tables 2.2 and 2.3) and also on past SPR analysis for AEMO covering earlier time-periods for which annualised data is no longer published. Generally, we make the simplifying assumption that the deeming period for certified savings averages 10 years. Other key parameters include the sectoral and fuel mixes of savings. These are based on the historical data, including the analysis provided for 2016 – 2020. In the early years of ESS, the residential sector held the largest share of savings, although this balance has shifted towards commercial, particularly with commercial lighting retrofits being a major activity supported. The fuel mix of savings has been 100% electricity for residential, and close to that for commercial, while for the industrial sector, gas savings are more significant at around 22%. Noting uncertainty about the future fuel mix of savings, we assume a continuation of the 2020 reported mix, as above. Similarly, with respect to the sectoral composition of savings, we assume a continuation of FY2021 shares (just under 30% residential, ~24% commercial and just under 20% industrial – noting that this sums to less than 100%, which reflects the fact that some savings are also captured by LILs and fuels other than electricity or gas).

From a methodological perspective, and by scenario, we model the state energy savings schemes (including VEU and REPS, as below) in a consistent manner. For ESS, and since targets are expressed as a percentage of a parameter that is linked to total electricity consumption in NSW, this implies growing savings over time, and also that the extent of savings is responsive to AEMO demand drivers. This is not the case for either VEU or REPS, as noted below. For future liable acquisitions, we assume NSW Government-supplied projections for Current Trajectory and vary these for other scenarios as a function of the proportionate change in GSP by scenario.

For Slow Growth and Current Trajectory, we use currently-announced targets – rising to from 8.5% in 2021 to 13% of liable acquisitions by 2030, and then staying at that level under FY2053. For the Net Zero and Sustainable Growth scenarios, we assume targets post-2030 rise by 0.25% of liable acquisitions annually, reaching 18.75% by FY2053, while for Export Superpower and Rapid Decarbonisation, we assume 0.5% point increases annually, reaching 24.5% by FY2053.

For ESS and other state schemes, we apply the same discounts for non-additionality to market-led energy efficiency improvement as for other schemes, rising at 0.5% annually. Scheme savings in BMM Commercial are dominated by electricity, as shown in Figure 58. Note that the spike in savings from FY2018 reflects record certificate creation in that year. As described above, the policy assumptions above lead to savings falling away in Slow Growth and, later, Current Trajectory, while other scenarios are also differentiated by demand drivers (relative GSP growth).

Gas savings in this sector are small and fall quickly over time, following the assumption that post-2022 savings are 100% electricity – see Figure 59.

VIC Victorian Energy Upgrades (VEU)

VEU is a broadly similar program to ESS, which also commenced in 2009, with a key difference being that scheme targets are set in carbon units, Mt CO_2-e. This means that a) savings are not sensitive to demand drivers, but only to policy settings (primarily the target size) and b) a conversion factor (time series) must be used to estimate how emissions savings correspond to energy savings. We base the latter on the Victorian average emissions intensity of electricity consumption as indicated (to 2018) in the *National Greenhouse Account Factors Workbook*, while for projections, we assume a steady average decline of 5 kg CO_2-e/GJ to 2025 (the last year for which targets are currently set).

Figure 58: ESS BMM Commercial Electricity Savings by Scenario

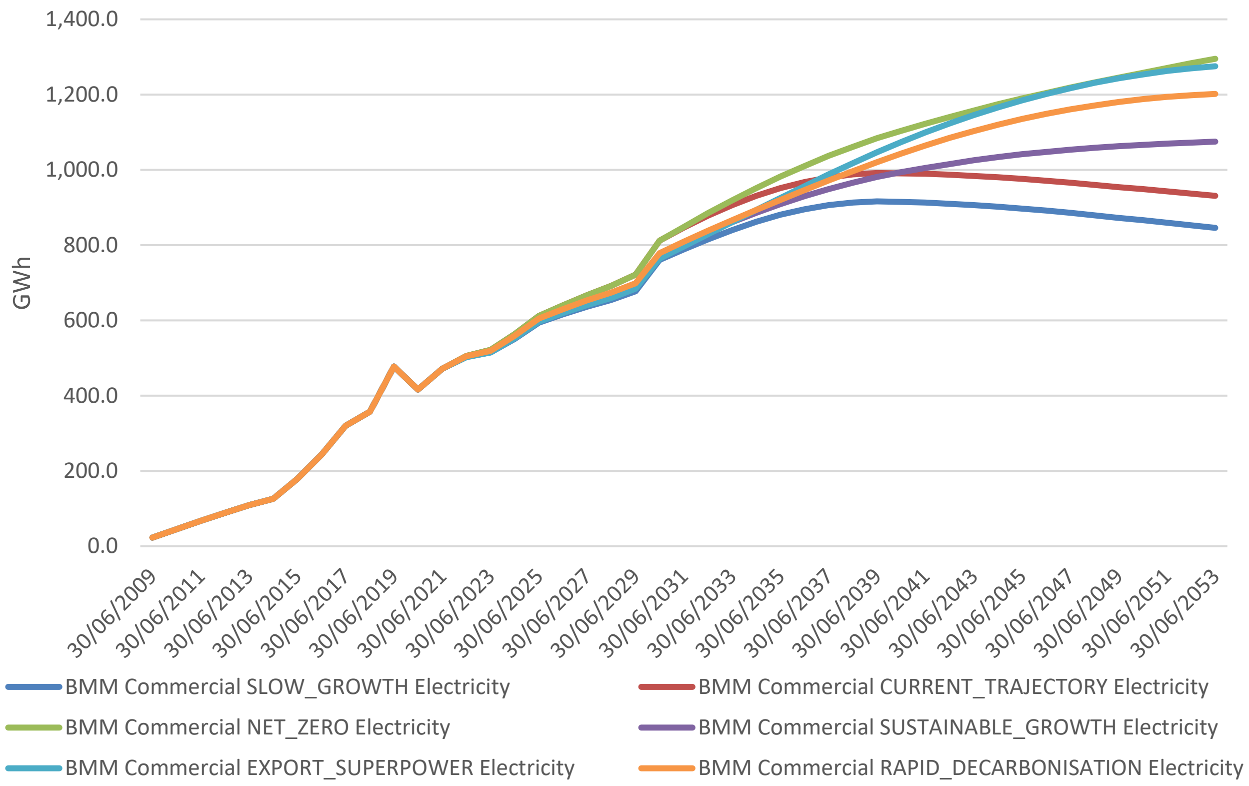
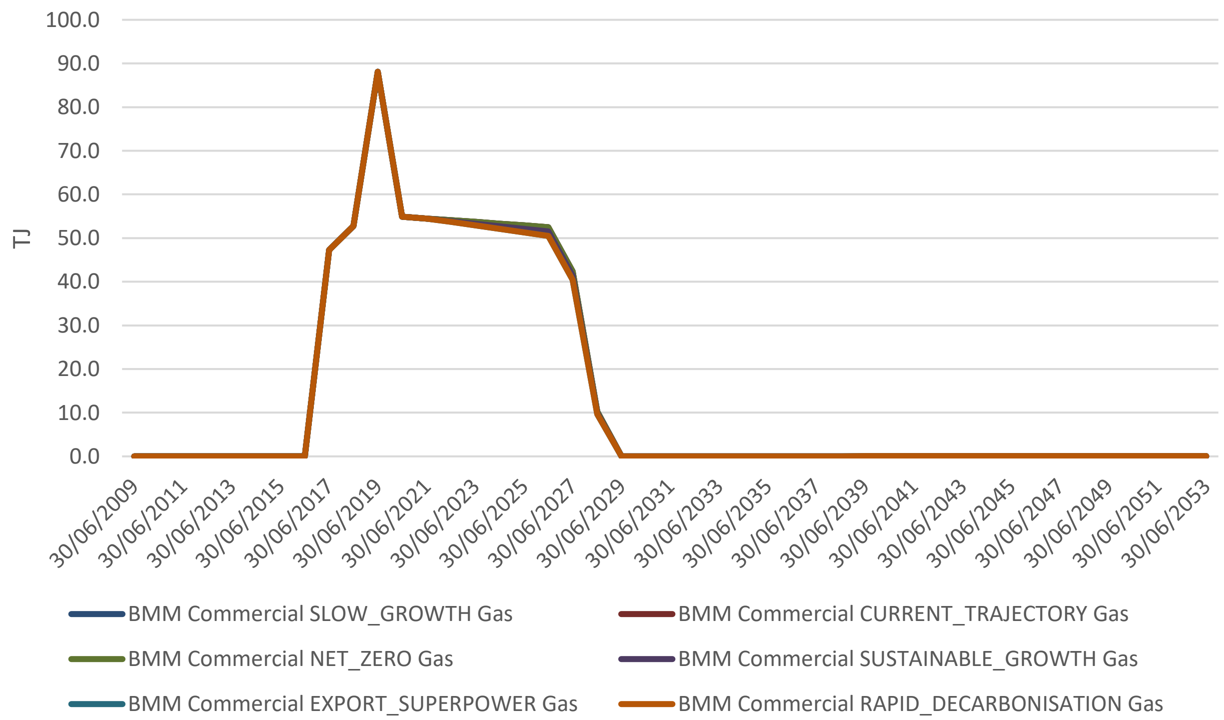


Figure 59: ESS BMM Commercial Gas Savings by Scenario



We assume that Slow Growth and Current Trajectory will see targets rise from 6.1 Mt CO_2-e in 2020 to 7.3 Mt CO_2-e in 2025; Net Zero and Sustainable Growth would see targets lifted annually by 2%; and Export Superpower and Rapid Decarbonisation by 4% per year, with the latter equivalent to around 25,600 GWh in FY2025. VEU targets, on this conversion methodology, are significantly larger than those in NSW or SA. Note that we again assume a 10-year average deeming life.

In terms of the sectoral mix of savings, VEU savings were exclusively residential until 2011, but since then there has been a general shift towards the commercial sector, reaching 51.5% of savings in 2020. As with other schemes, the sectoral mix of future savings is uncertain, particularly as LED lighting in the commercial sector – which has been the dominant generator of savings – is expected to be slowly phased out.

The Victorian Government provided its own forecasts of the expected nature of *new* VEU savings post-2020, both for electricity and gas. These show a more complex pattern than in the past, primarily because there is an expectation that electrification activities will increase in future – and most notably in the BMM Commercial sector. This means that savings are anticipated to shift decisively in favour of gas, with offsetting increases in electricity consumption – albeit that these are far from 1:1. On average, the data supplied implies a gas/electricity substitution factor of around 4.5, which is equivalent to a typical co-efficient of performance or energy efficiency rating for a larger commercial or industrial heat pump, whether used for hot water or space conditioning.

Since the above data only reflects new savings post 2020, we phase in the implied new savings mix over a period of 5 years, as the actual savings in the 2020 – 2030 will also be affected by historical efficiency investments supported by VEU prior to 2021. Also, factors such as sectoral shares of savings and the fuel mix of savings are volatile in both the early and later periods in the Victorian data, reflecting relatively small volumes of (new) savings in these periods. Therefore, we smooth these effects by basing these parameters on the averages revealed in the approximately 2023 – 2038 period. Similarly, the use these smoothed averages to extend the Victorian data from 2050, as supplied, to 2053.

As with other states' schemes, we discount savings for non-additionality to market-led energy efficiency improvement, starting at 25% at scheme commencement and increasing by 0.5% per year.

The resulting savings forecast by scenario for BMM Commercial is shown in Figure 60 for electricity and Figure 61 for gas. Note that the spike in savings in 2017 reflects record certificate creation in that year, equivalent to 7.9 Mt CO2-e in deemed savings, well above requirements for that year. 2016 was also well above target. Such ups and downs are assumed to level out of time due to carry-over provisions, and we model future periods on the basis of annual realisation of deemed targets, looking through likely annual variations.

In the projection period, ongoing electrical efficiency savings are progressively overwhelmed by electrification impacts, leading to much larger gas savings (see Figure 61) and net negative electricity savings from around 2030. As may be expected, these net negative electricity savings are largest in the Rapid Decarbonisation scenario.

Figure 60: VEU BMM Commercial Electricity Savings by Scenario

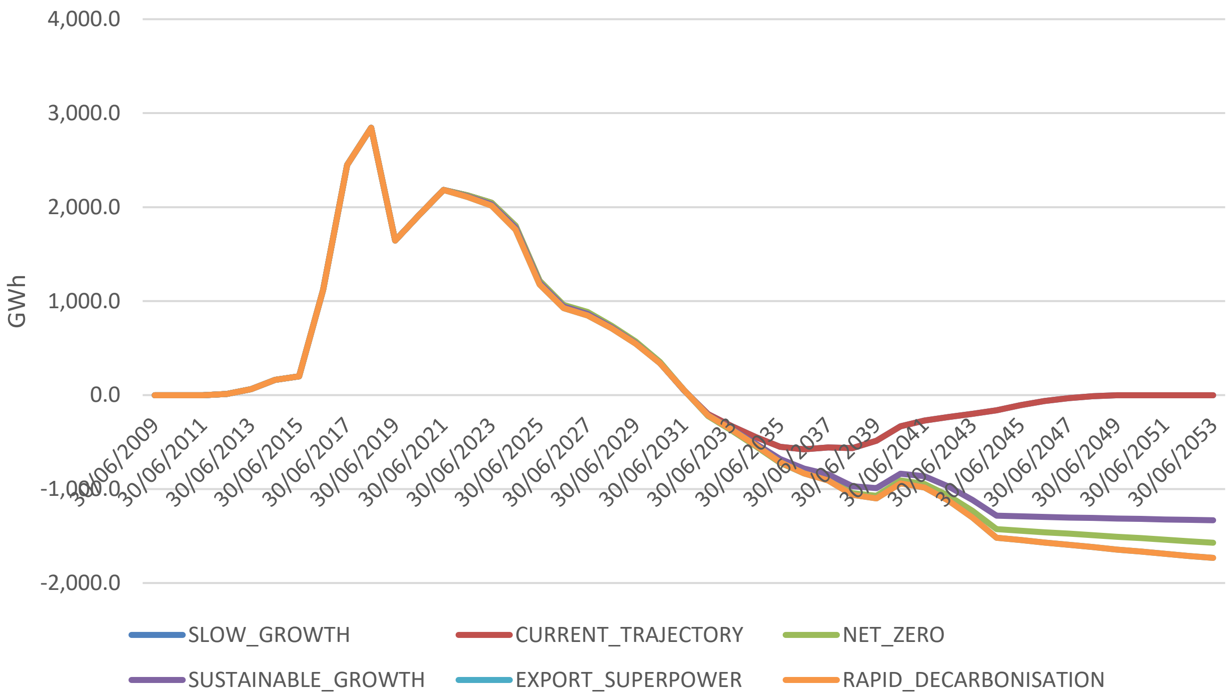
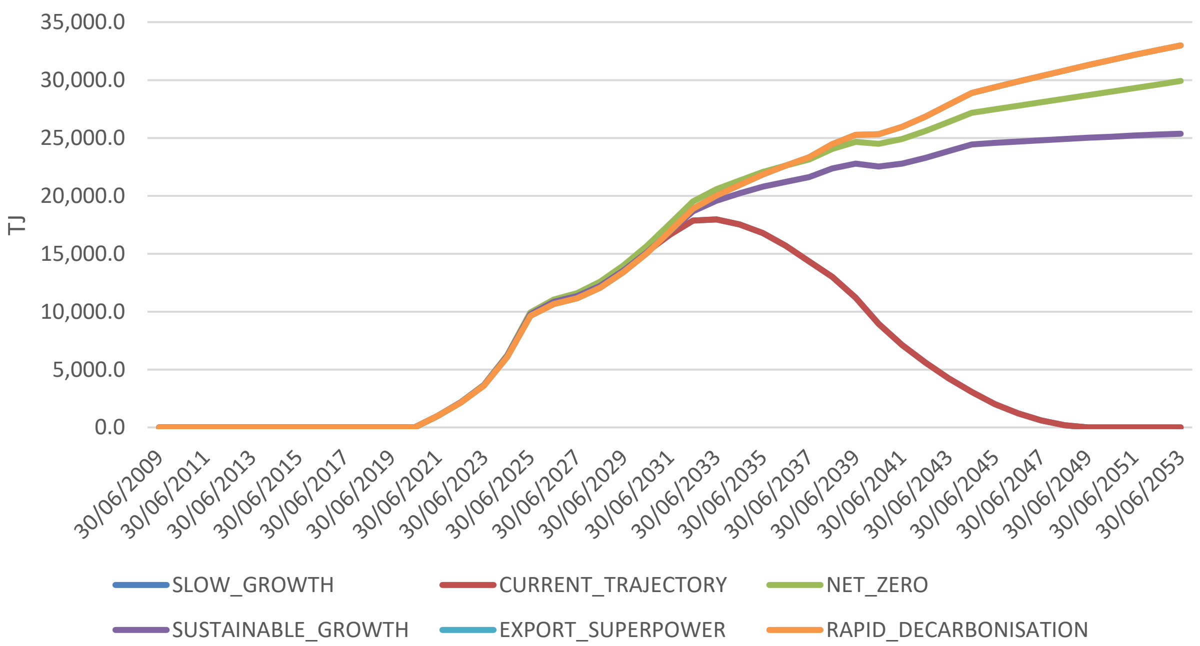


Figure 61: VEU BMM Commercial Gas Savings by Scenario



SA Retailer Energy Productivity Scheme (REPS)

REPS also commenced in 2009 and has evolved from an initially fully-residential scheme to embrace commercial and limited industrial savings from 2015. It is conceptually more similar to VEU than to ESS in that it has fixed annual targets, albeit specified in energy units (GJ). This also means that REPS is not sensitive to the demand drivers in AEMO scenarios, but only to policy targets and related assumptions. REPS has subsidiary targets relating to low-income housing and to energy assessments, but these are not relevant to the BMM Commercial sector.

Our analysis of REPS is based on an excellent historical reporting data set, *20200703-REES-PerformanceReport2019-TimeSeriesData*, available online, as well as clarifying discussions with program managers. REPS policy assumptions by scenario align with those for other schemes, current targets (set to 2025 only) for Slow Growth and Current Trajectory, which rise from 2.5 million GJ in 2020 to 3.75 million GJ in 2025; steady annual increases of 375,000 GJ in Net Zero and Sustainable Growth post 2025 (reaching 12.85 million GJ in 2053); and steady annual increases of 500,000 GJ in Export Superpower and Rapid Decarbonisation.

The sectoral composition of savings has been volatile in recent years (noting that 2020 was not reported at the time of writing), so we make projections based on 5-year rolling averages. These assume the residential sector will account for 33.5% of savings in 2021, rising to almost 36% over time. This reflects an expectation of ongoing sub-targets within REPS for low-income housing. The commercial sector share levels out at just under 53% and the industrial share rises to almost 12%. Based on conversations with program managers, industrials savings are unlikely to include LILs.

The fuel mix of savings is not directly reported and is estimated based on inspection of the activities supported by the program by sector. On this basis we assume 100% of residential savings are electricity, while on average 90% of commercial and industrial savings are also assumed to be electricity. As with other schemes, we assume an average deeming period of 10 years. Headline savings are discounted as with other schemes to allow for a degree of non-additionality to market-led efficiency improvement – see Figure 62 for electricity savings and Figure 63 for the much smaller gas savings.

Figure 62: REPS Electricity Savings, BMM Commercial, by Scenario

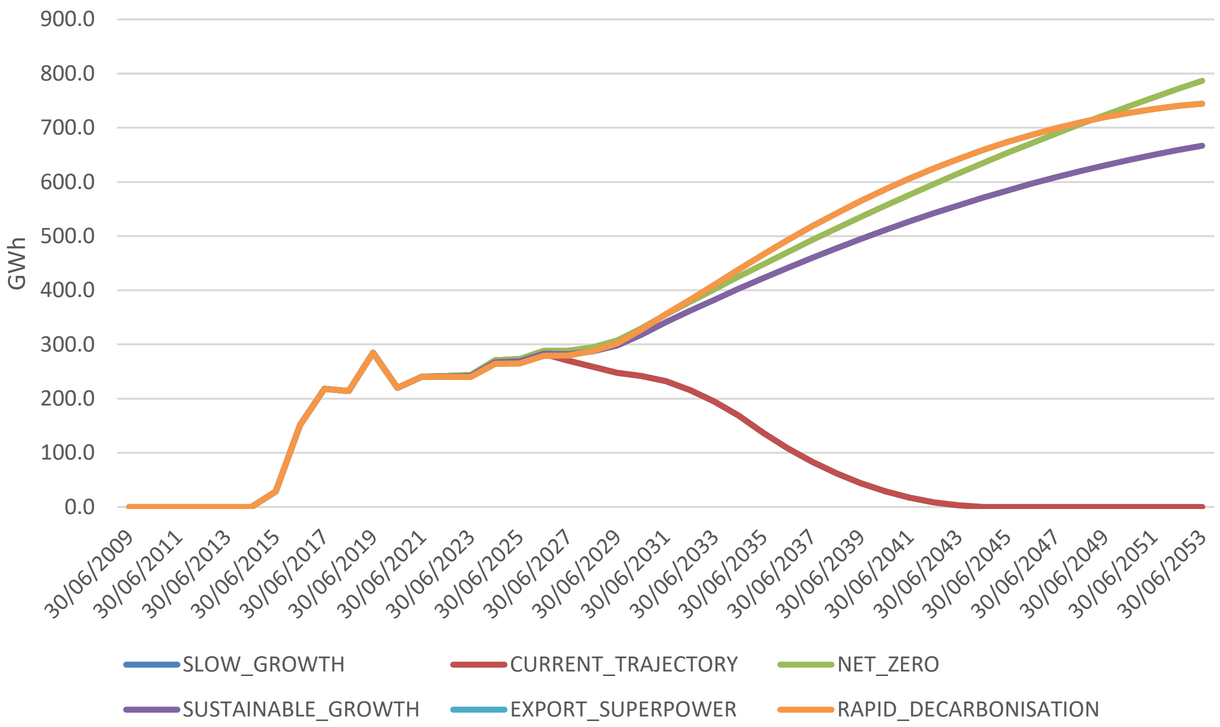
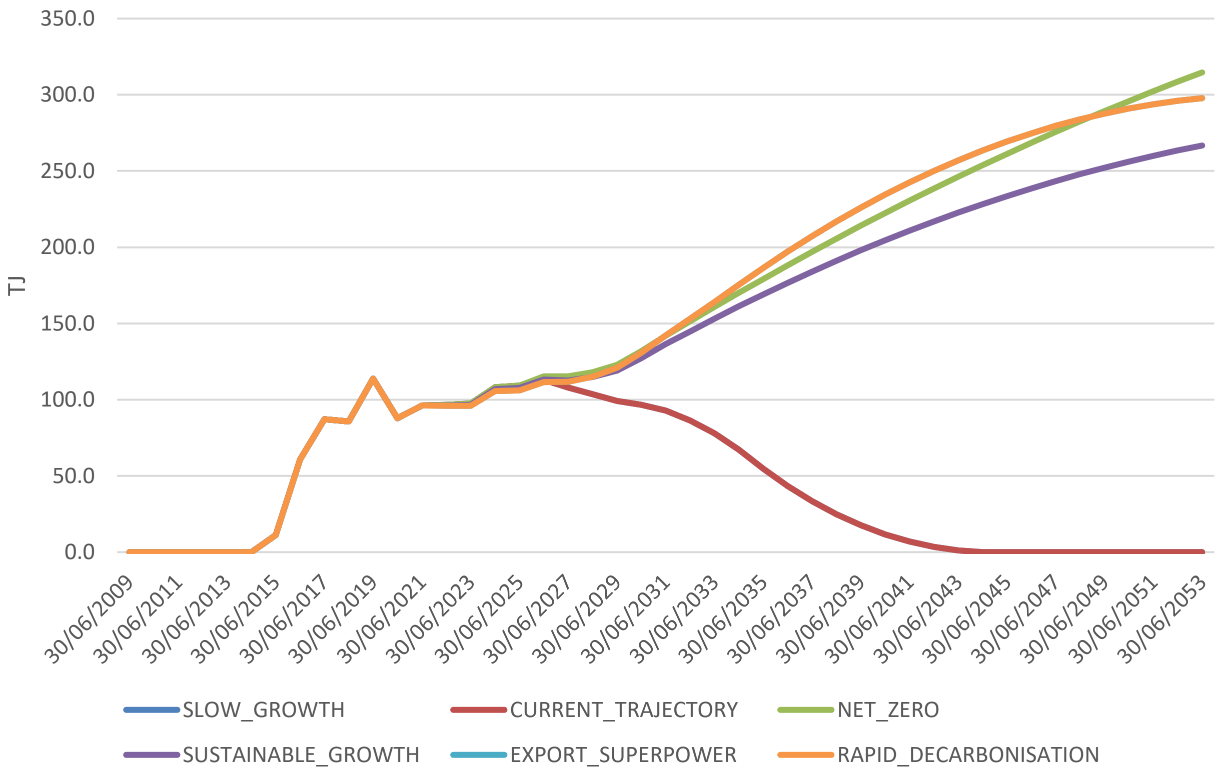


Figure 63: REPS Gas Savings, BMM Commercial, by Scenario



Other States Schemes

NSW, VIC, SA and also the ACT (not modelled in this study) already have state energy savings schemes. To represent possible policy pathways to higher ambition energy efficiency scenarios, we model similar schemes for WA, QLD and TAS. These savings are represented from FY2022 and for the Net Zero to Rapid Decarbonisation scenarios.

We model such possible schemes in an identical manner, broadly based on ESS. That is, we assume 'reference energy consumption', based on historical actual consumption escalated in future by scenario, linked to rates of GSP growth. This enables the measure to respond to demand drivers by scenario.

We then apply annual targets from FY2022 on. These are 0% for Slow Growth and Current Trajectory (that is, no 'other schemes' are assumed to exist in these scenarios); 0.5% annually in Net Zero and Sustainable Growth (reaching 16% by 2053); and for Export Superpower and Rapid Decarbonisation, 1% per year until 2030, and 0.5% per year thereafter, reaching 20.5% by 2053, broadly comparable with existing state schemes.

We assume a 40%/50%/10% split for residential, commercial and industrial for all states. The fuel mix, however, varies by jurisdiction, reflecting the differing starting points. For QLD, we assume that 99% of residential savings are electricity; 95% electricity for commercial; and 90% electricity for industrial, given limited gas penetration in that state. For WA, we assume 95% of residential savings are electricity, along with 90% of commercial savings but only 75% of industrial savings (and 25% gas). For TAS, we assume 100% of residential savings are electricity, along with 99% of commercial savings and 95% of industrial.

Figure 64 summarises electricity savings under these assumptions, and Figure 65 summarises gas savings.

Figure 64: Other State Schemes, Electricity Savings, BMM Commercial

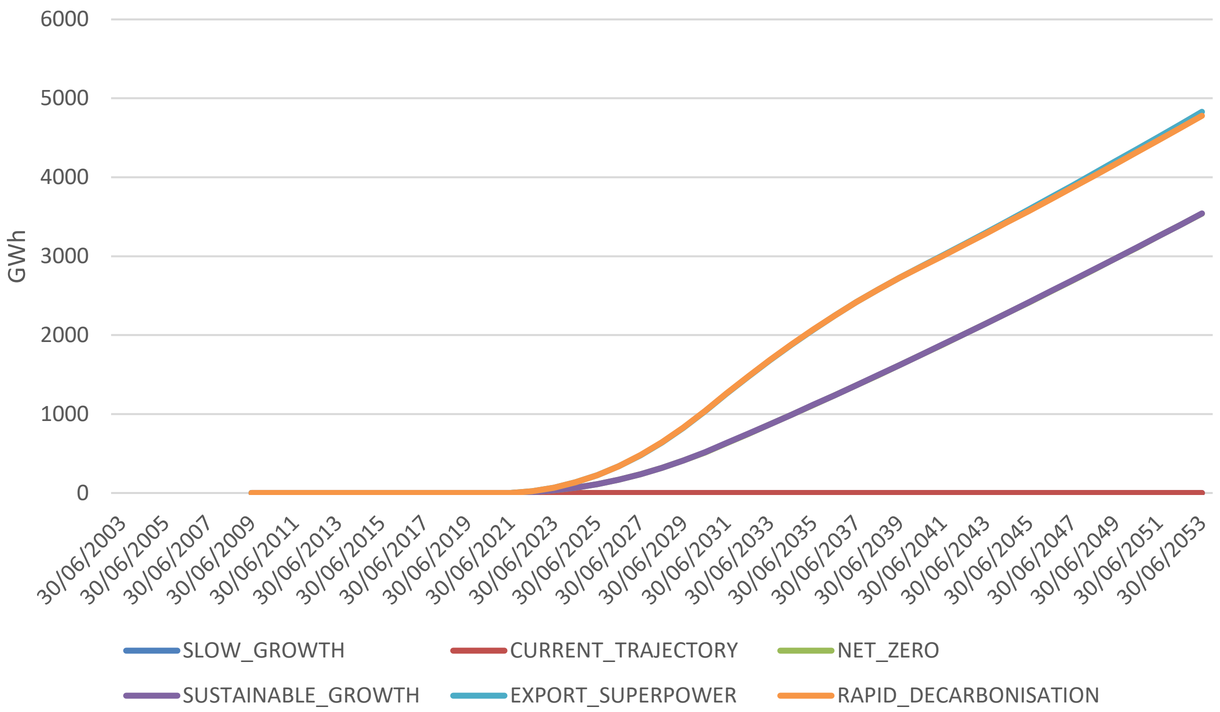
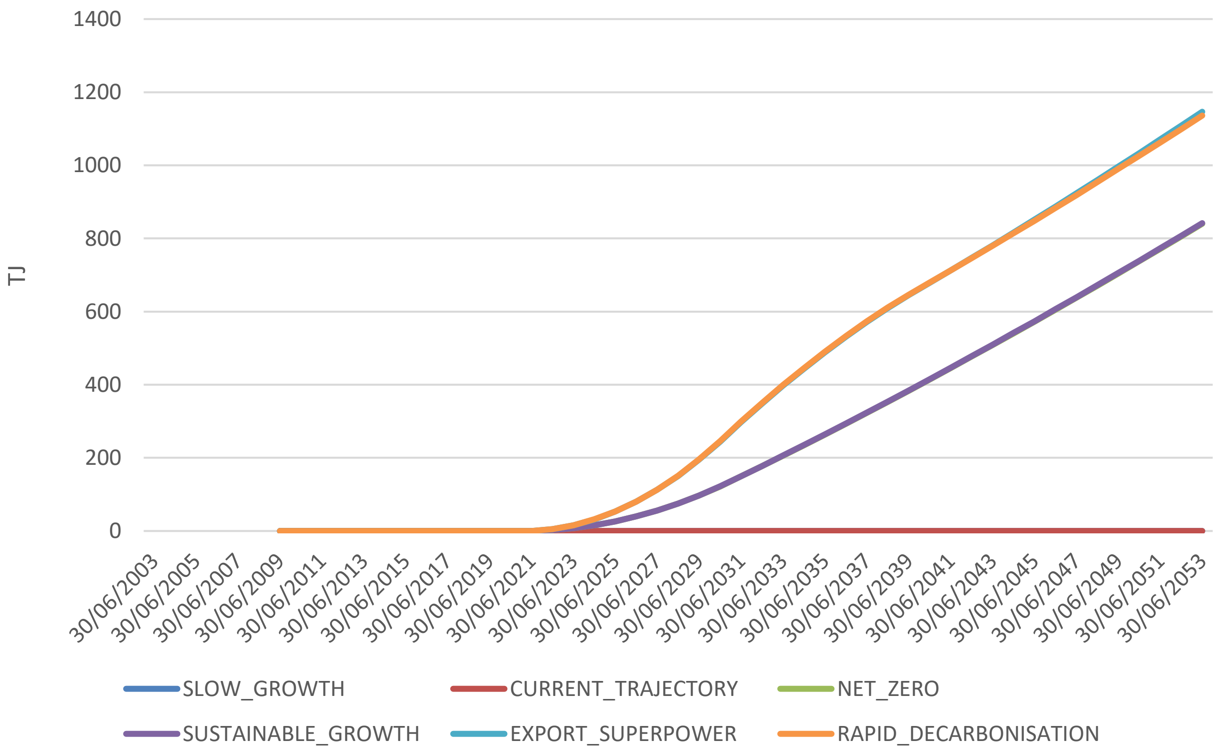


Figure 65: Other State Schemes, Gas Savings, BMM Commercial



3.3 BMM Industrial

3.3.1 Introduction

To recap from Section 2.3.2, energy efficiency improvement in the BMM Industrial sector is inherently more challenging to quantify than for other sectors, due to the significant data limitations that characterise this sector. These stem from a combination of factors:

1. AEMO's segmentation of the Industrial sector, which is by energy consumption size (Large Industrial Loads, or LILs, vs smaller consumers comprising the Business Mass Market, or BMMs)
2. Energy consumption by enterprise energy consumption size is not published (although is known for those enterprises that report under the National Greenhouse and Energy Reporting system, NGER – these are likely to include most if not all LILs)
3. Industrial energy consumption is published by AES by ANZSIC Divisions and some sub-Divisions, but data is suppressed (included in state or national totals) wherever there are so few enterprises in a sub-sector/state that their individual energy consumption may be revealed if the sub-sector total were published
4. Finally, for energy efficiency analysis, a reliable (and common) indicator of the physical output (or productivity) of the sectors in question must be available, but this is not the case. The physical output of industrial enterprises is highly diverse, and common output metrics - such as tonnes of product – have little meaning when comparing mineral ores and elaborately transformed manufactured products. In practice, only economic indicators – such as gross value added – are available using the ANZSIC frame, but then not at sub-sectoral levels, and not layered by LILs and BMM consumers.

This means that it is not feasible to assess total energy efficiency change in the BMM Industrial sector. As a result, the market-led component of change is also not known. It is feasible to capture the policy-induced efficiency impacts of particular measures, and this is done below. We note that most of the relevant measures are described in detail in the previous section, and therefore we do not repeat that material below.

3.3.2 Total Consumption

As above, determining both the gas and electricity consumption of the BMM Industrial segment is not straightforward. AEMO provided observations of underlying consumption (that is, including any behind-the-meter renewable energy generation) for the total BMM (that is, excluding LIL consumption) for FY2017 – 2019. BMM Commercial electricity consumption was then estimated as described in Section 3.2.3 above; that is, drawing on AES. In principle, the difference between these two observations should be the BMM Industrial consumption, and the results are shown in Table 16. However, this methodology generates negative numbers for Tasmania. We speculate that differences in the treatment of LILs between AEMO and AES are likely to account for these results, but further investigation of this is recommended.

Table 16: Derived BMM Industrial Electricity Consumption (GWh)

Region	FY2017	FY2018	FY2019
NSW	5,817.3	6,225.8	6,613.6
VIC	4,778.3	4,288.7	3,845.2
QLD	2,751.1	2,803.0	2,761.9
SA	991.3	946.3	708.2
SWIS	2,059.5	1,823.7	1,890.7
TAS	-221.1	-188.4	-241.1
Total (NT not incl.)	16,176	15,899	15,578

A similar methodology was applied for gas, with the results as shown in Table 17.

Table 17: Derived BMM Industrial Gas Consumption (TJ)

Region	FY2016	FY2017	FY2018	FY2019
NSW	28,344.6	29,471.6	31,744.5	30,871.7
VIC	14,374.2	13,119.1	11,698.8	10,470.0
QLD	8,985.2	9,141.0	8,617.2	8,601.7
SA	4,462.0	4,451.9	4,413.3	5,533.3
WA	15,231.6	14,958.2	13,997.4	14,646.9
TAS	2,091.0	2,071.5	2,097.3	2,054.2
Total (NT not incl.)	71,397.6	71,141.7	70,471.3	70,123.6

There would appear to be value in AEMO exploring in future with the Office of the Chief Economist (which prepares AES) the reasons behind the apparent differences– noting such collaboration was proposed by OCE at the March Energy Efficiency Workshop. In addition, the time-series is too short for trend (including efficiency) analysis – noting that longer time series were available for WA SWIS.

3.3.3 Total Policy-Induced Savings

Total BMM Industrial savings are summarised in Figure 66 below, for electricity, and indicate FY2053 savings of between 1,543 GWh, for Slow Growth, and up to 5,800 GWh for Rapid Decarbonisation. These values were updated to reflect expected electrification impacts under VEU, and these have shifted the balance of savings towards gas (see Figure 67). Gas savings are forecast to be significant, reaching ~9 PJ by 2053.

Figure 66: Total BMM Industrial Electricity Savings by Scenario

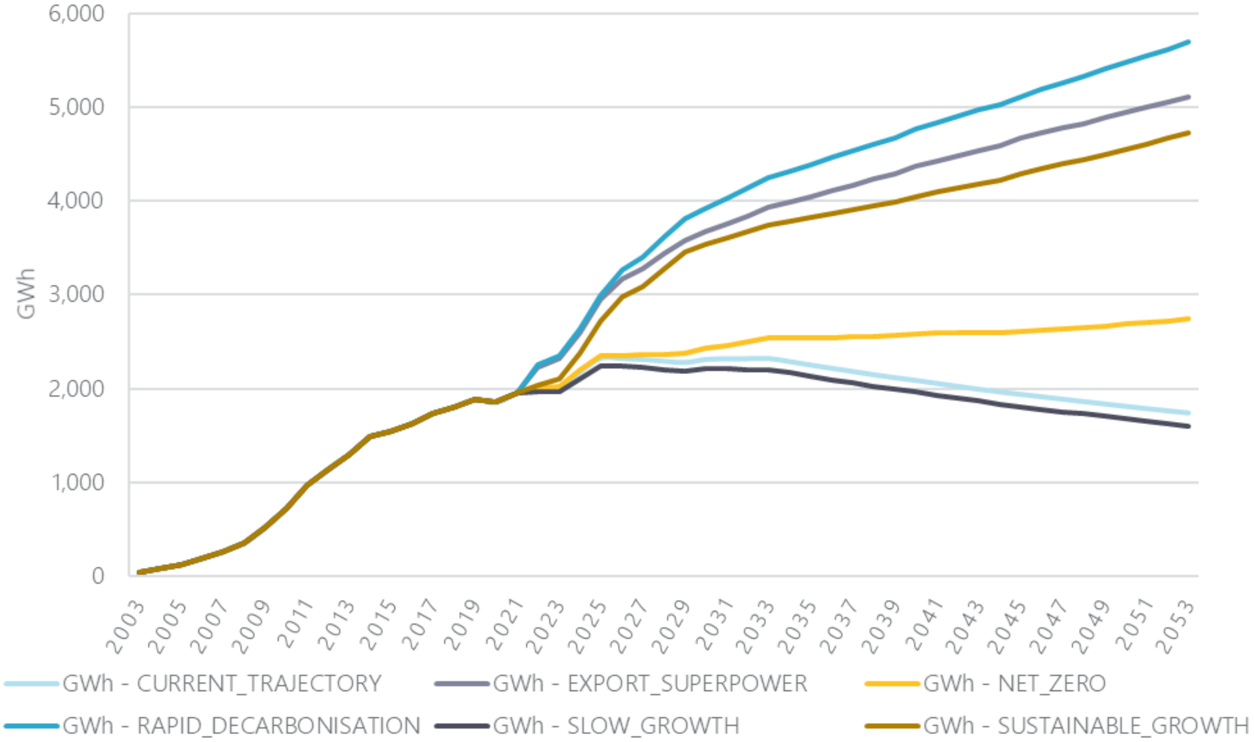
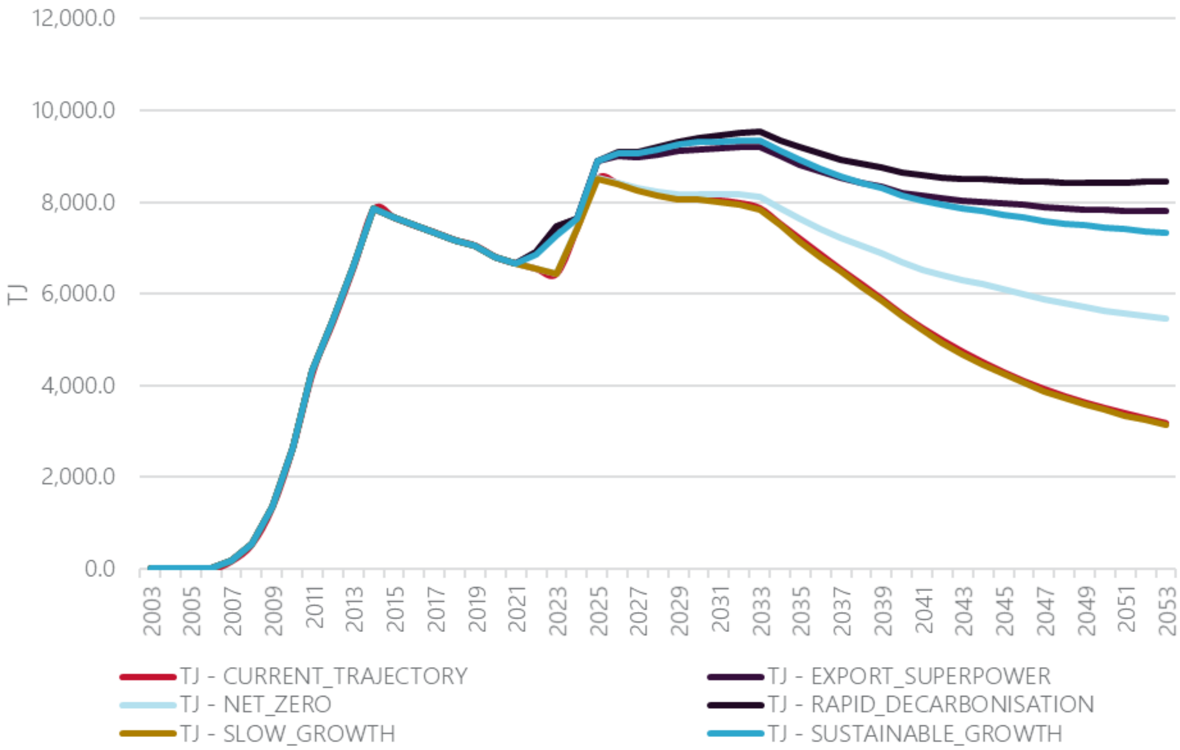


Figure 67: Total BMM Industrial Gas Savings by Scenario

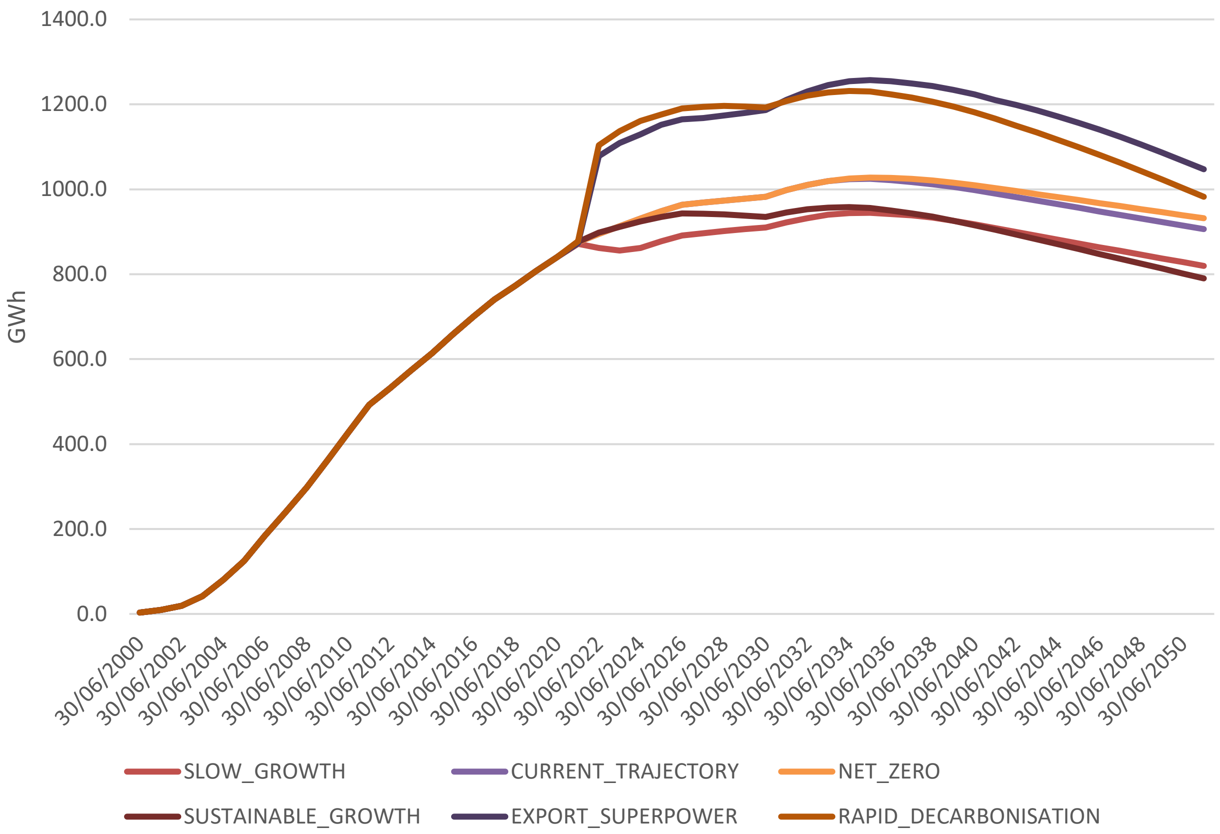


3.3.4 Savings by Measure

Greenhouse and Energy Minimum Standards (GEMS)

GEMS covers a number of (electrical) products used in the BMM Industrial sector, such as electric motors, fan units, boilers, compressors and pumps, as well as more generic equipment such as lighting. Savings attributable to the industrial sector are identified by George Wilkenfeld & Associates and described in more detail in Appendix A. These savings are shown in Figure 68. This highlights that we assume a 20% boost to savings (at least) would be achievable under the high-ambition scenarios. We note that these savings are not factored down for the share that may be captured by LILs.

Figure 68: BMM Industrial GEMS Electricity Savings by Scenario (NEM + SWIS)



NSW Energy Savings Scheme (ESS)

ESS is one of the few current measures that has covered the industrial sector, capturing around 20% of the total energy savings from that scheme, including electricity (Figure 69) and gas (Figure 70). While overall savings are small relative to the size of the sector, they are significant for the NSW region.

Figure 69: ESS BMM Industrial Electricity Savings by Scenario

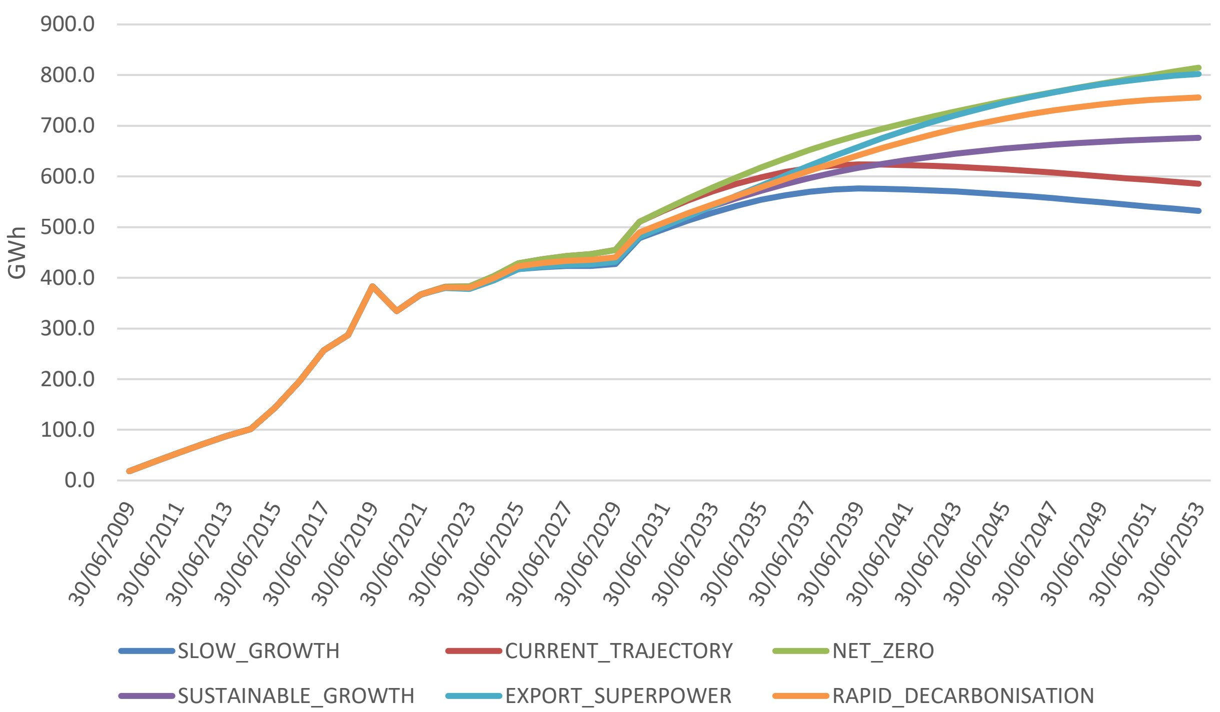
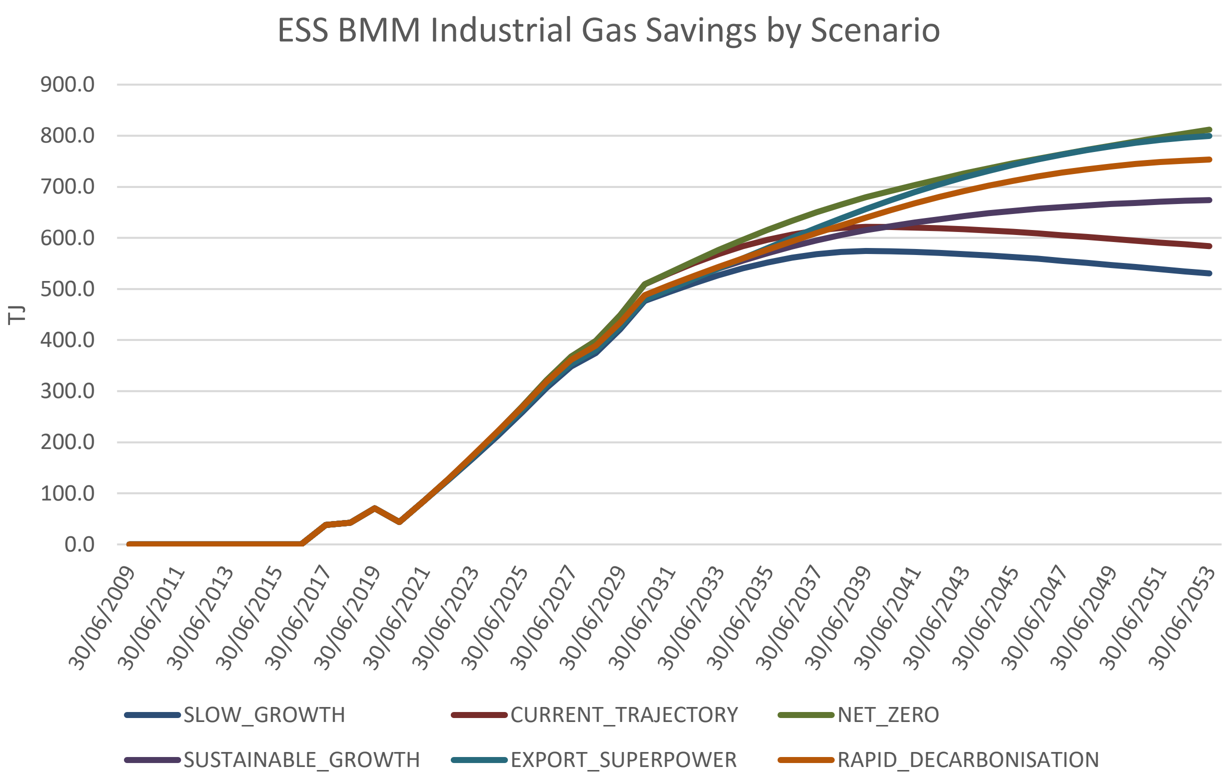


Figure 70: ESS BMM Industrial Gas Savings by Scenario



Industrial Assessments

This measure combines the legacy impacts of the former Energy Efficiency Opportunities (EEO) program with the possibility of a new 'industrial assessments' program under high-ambition scenarios only.

EEO operated between 2007 and 2014, and required enterprises consuming at least 0.5 PJ of energy to undertake careful energy efficiency assessments, including simple payback analysis on opportunities, and to publicly report their findings. While there was no compulsion to act on these findings, the high-profile nature of the program and public reporting created significant peer pressure. Senior executives and Boards, for example, were alerted to opportunities to reduce cost and/or improve productivity, and were able to support lower-level staff to enable these projects to occur. An *EEO Program Review*, conducted by ACIL Tasman in 2013, found the program had been highly effective and cost effective. It assessed the additionality of reported savings conservatively at at-least 50%, and this value is used in these forecasts.

It is important to note that many of EEO's clients were LILs, and savings were also made in liquid and other fuels, and not only electricity and gas. We make use of the ACIL Allen assessment, and program reporting such as *EEO The First Five Years, 2006 – 2011* to estimate overall energy savings, the sectoral mix and fuel mix. This notes, for example, that 54% of savings (at that time) were attributable to mining and manufacturing, and 5% to services (with the balance for transport and oil/gas). Based on AEMO estimates (for electricity only), we assume that just under 40% of consumption (and, in this context, savings) is attributable to BMMs in mining (rather than LILs) and around 44% in manufacturing. The fuel mix (of all program savings) is given as 48.3% gas, 17.2% electricity, and the balance other fuels.

For Slow Growth, Current Trajectory and also Net Zero, savings are based on the legacy impact of EEO only (and BREEF for Victoria only), as discussed below. That is, no new policy is assumed. For the legacy EEO savings, we make the assumption – for this program only – that the learnings induced by the program are only lost slowly over time, equivalent to a reduction of 3% per year. This is because this program dealt with the biggest energy users in Australia, and actively sought to teach them improvement energy management behaviours. These companies have very strong financial incentives to retain these behaviours, but still it is unlikely that such retention will be total, due to staff/Board turnover, new entrants, takeovers, etc.

For the possible new Industrial Assessment program (which is based on EEO), we assume that savings in the first 8 years that replicate the performance of EEO (over 2007 – 2014) in terms of energy savings per unit of gross value added (Divisions B and C) by state – see Figure 71 for electricity and Figure 72 for gas. For the mooted new program, however, these historical values (which, as may be noted from the two figures, show a bias towards the Tasmanian region) are averaged across the states and territories, as there is no reason to assume that the historical distribution of savings by state would be exactly replicated.

Figure 71: Historical EEO Electricity Savings GWh/$m value added (Div B + C)

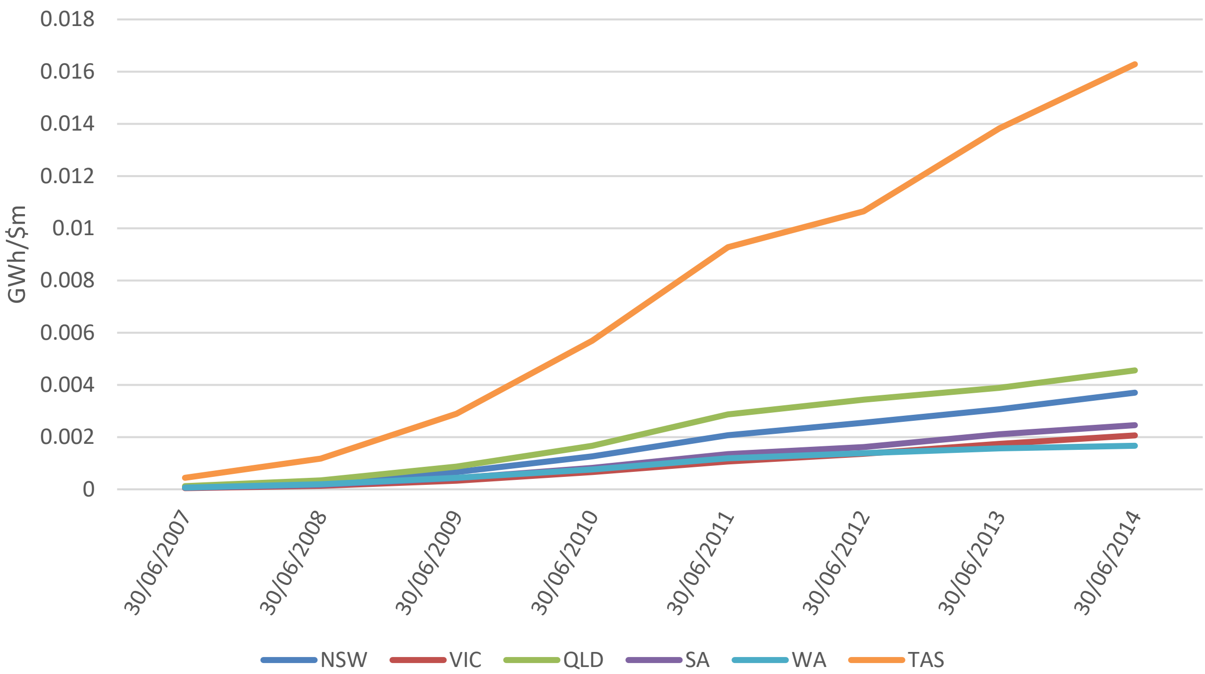
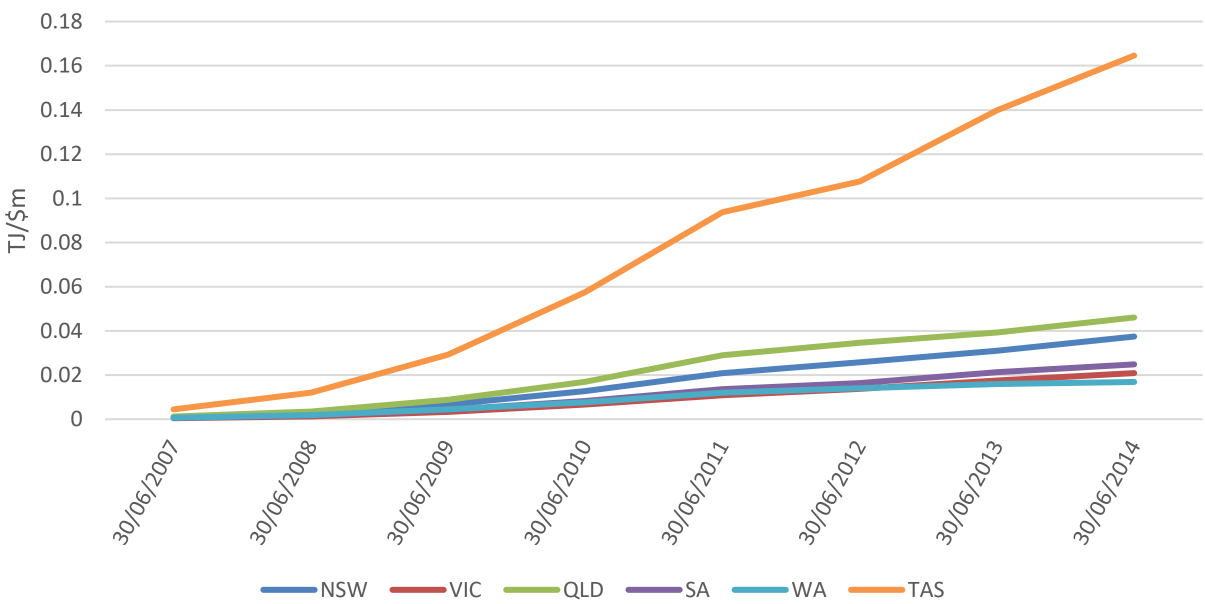


Figure 72: Historical EEO Gas Savings TJ/$m value added (Div B + C)



For future years, savings are assumed to be escalated by sectoral value added by scenario, noting that this means that the results are sensitive to demand drivers by scenario. Overall, we would argue that this approach represents a conservative savings estimate, as EEO savings appeared to be on a strong growth trend at the time the program was wound up. No further non-additionality discounts are applied to EEO, as a 50% discount has been applied to the headline savings, in line with ACIL Allen (2013).

In the case of Victoria only, we model additional savings generated by the Business Recovery Energy Efficiency Fund (BREEF) as part of the Industrial Assessments measure, as they are similar interventions. The Victorian Government supplied forecast total gas savings for this program, but not electricity, although electricity is also eligible. The relevant aspect of this program is the expected uptake of energy management systems by up to 100 companies, at sites where at least 100 TJ of energy (electricity or gas) is consumption annually, with the measure taking effect from FY2024. Gas savings estimates are consistent with key assumptions such as an average site consuming 200 TJ/year and saving 10% of their gas consumption as a result of the program. We apply the same assumptions for electricity. Other assumptions applied for this program are that 50% of the savings accrue to consumers in the BMM Industrial sector, with the balance assumed to accrue to LILs. We apply a 50% discount to savings in the first year, noting that it may not be realistic for all 100 sites to implement energy management systems within a 12-month window, so as to achieve the full expected savings in year 1. Finally, noting that energy management systems for larger energy users would also fall within the scope of the modelled Industrial Assessments measure, we discount Victorian savings from that measure by 20%, to represent the non-additionality with BREEF.

For the Industrial Assessments program, and as with other measures, we assume that 25% of the first-year savings may not be additional to market-led savings, with this value growing by 0.5% per year to 2021, for all scenarios, and then at 0.75% for Sustainable Growth and 1% for Export Superpower and Rapid Decarbonisation. These amount to substantial discounts of 55.5% in 2053 for Sustainable Growth, and 63.5% for Export Superpower and Rapid Decarbonisation, although these are broadly consistent with the additionality findings for EEO, as noted above. The historical values for EEO's savings by state showed a bias towards Tasmania in particular, but we have no reason to suppose that this same pattern would be reproduced with a future Industrial Assessments scheme. Therefore, we average the values (in GWh or TJ per $million value added) and apply these as the assumed take-up rate across the jurisdictions, with an additional allowance for Victoria due to the BREEF program.

On the basis of these assumptions, combined EEO/Industrial Assessments savings are as shown in Figure 73 (electricity) and Figure 74 (gas). EEO related savings are projected to decline steadily, with new Industrial Assessments savings entering from FY2022 for higher ambition scenarios. The BREEF program increases savings (in Victoria) from FY2024, but this effect starts fall away after 10 years. All savings are discounted for non-additionality to AEEI, and this effect partially offsets electricity savings in the out-years for electricity, even in the higher ambition scenarios, while gas savings fall in these same scenarios. As noted, the Industrial Assessments measure is modelled conservatively, and it is feasible that larger savings could be achieved.

Figure 73: EEO/Industrial Assessments, Electricity Savings by Scenario

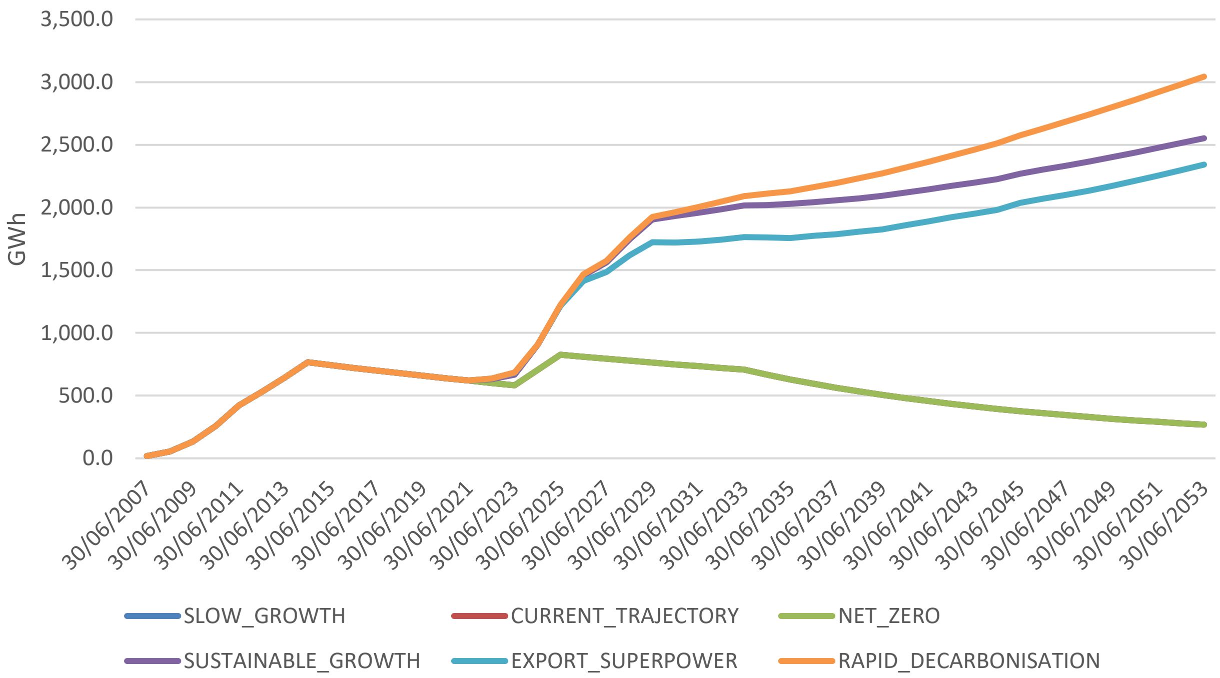
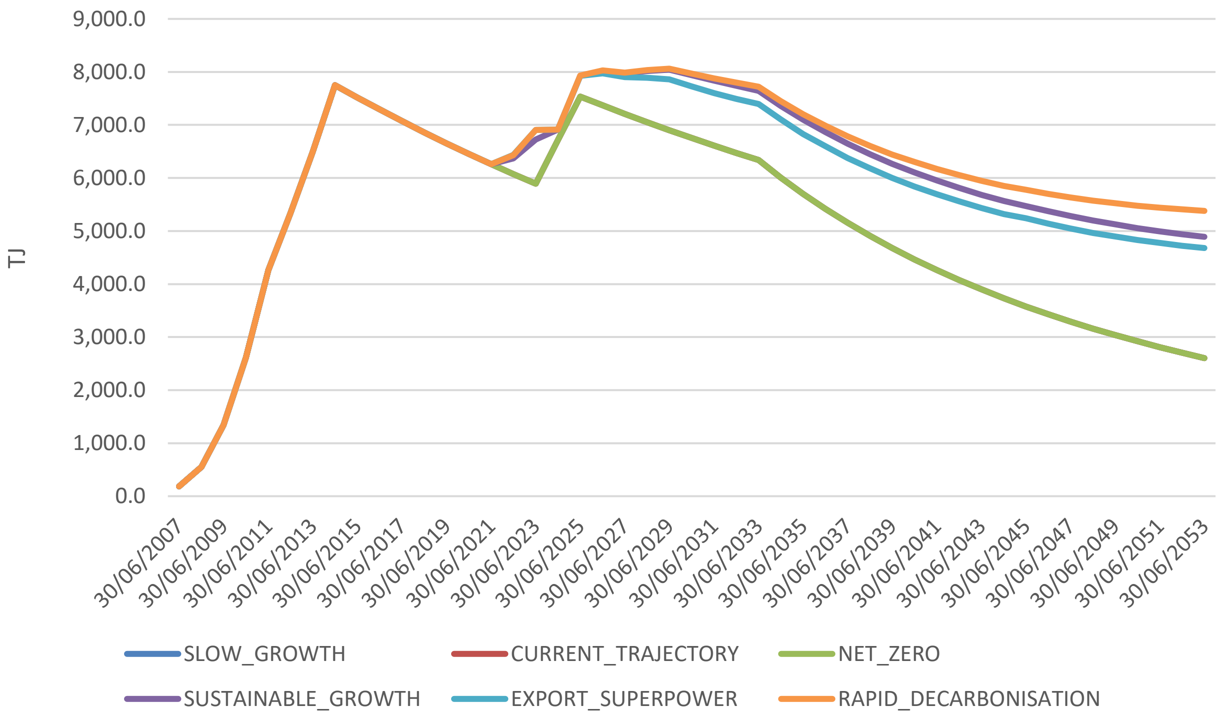


Figure 74: EEO/Industrial Assessments, Gas Savings by Scenario



Victorian Energy Upgrades (VEU)

For VEU, and as noted in Section 3.2, industrial sector savings are not apparent in the historical record but are indicated (by program data) for the future. These are driven primarily by electrification, with some efficiency gains as well. This leads to electricity savings turning net negative from around 2030 (as legacy efficiency savings are overtaken by new electrification impacts). See Figure 75 for electricity and Figure 76 for gas. Overall, the energy savings in the industrial sector are assumed to be significantly smaller than in the commercial sector, based on recent program history. In the data supplied by the Victorian Government, future expected savings are not split into separate observations for industrial and commercial.

Figure 75: VEU BMM Industrial Electricity Savings by Scenario

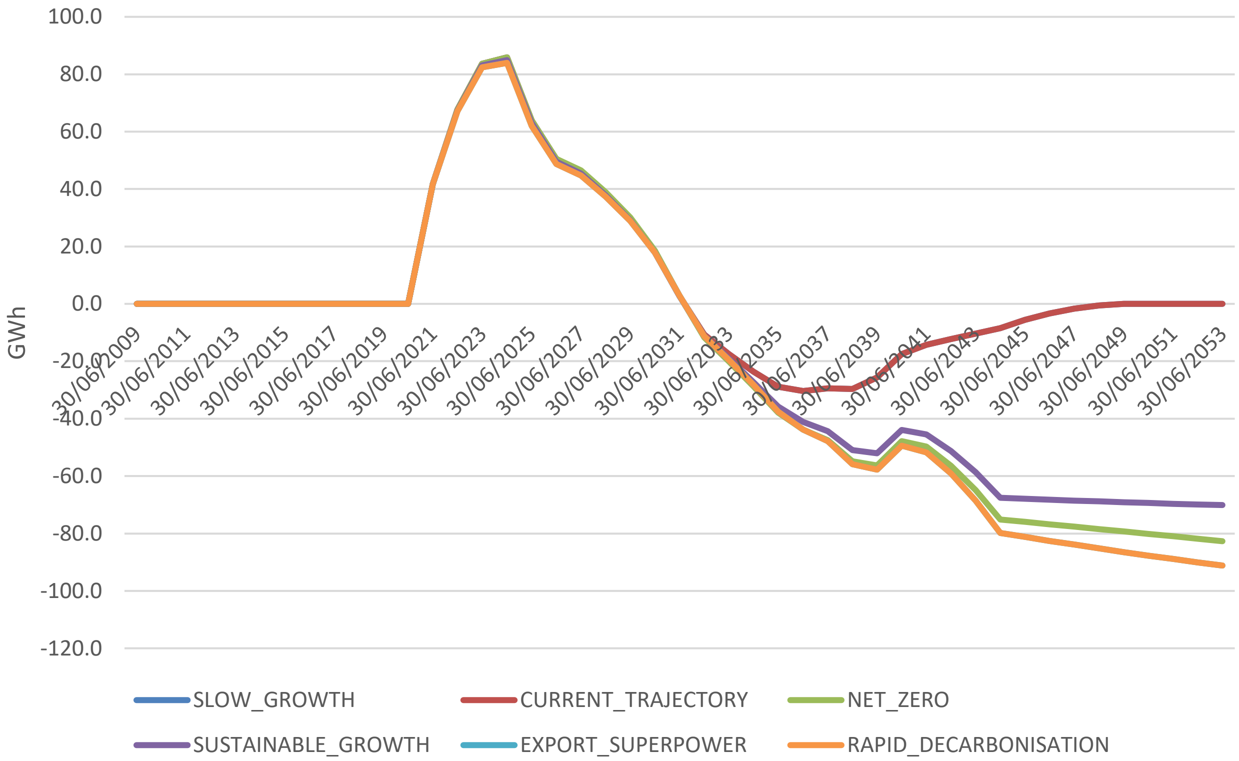
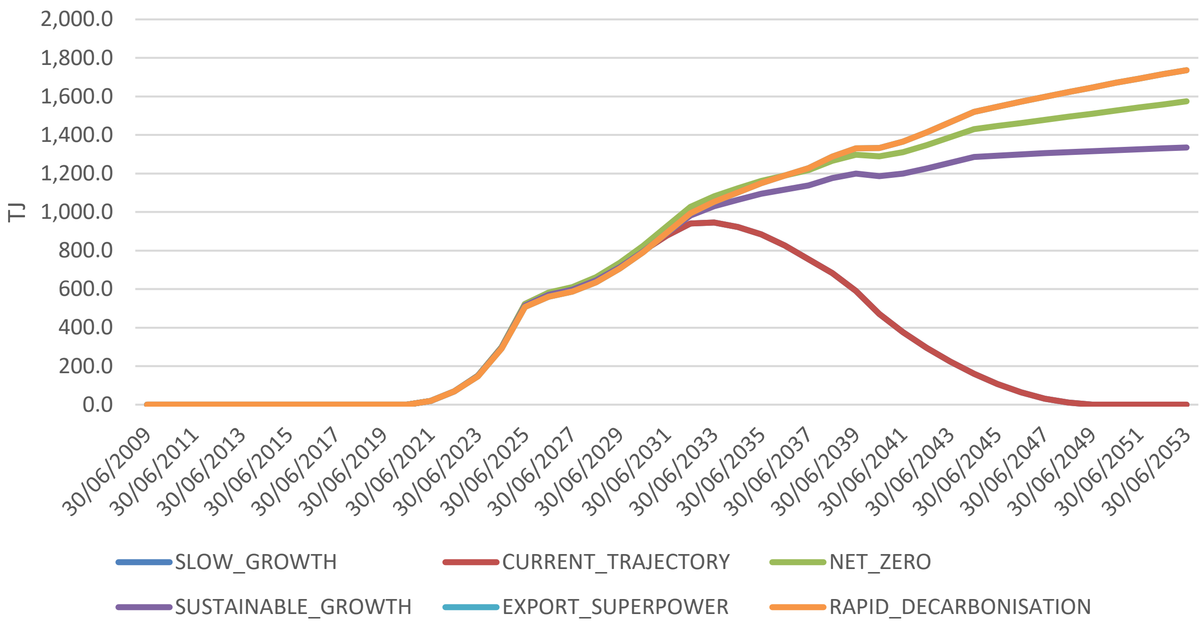


Figure 76: VEU BMM Industrial Gas Savings by Scenario



SA Retailer Energy Productivity Scheme

As noted in Section 3.2, REPS also covers the industrial sector, and this is understood (for liaison with the program manager) to be largely SMEs, and hence covered by BMM Industrial. Our savings estimation methodology is documented in that section. The forecast savings for electricity are shown in Figure 77 and gas in Figure 78.

Figure 77: REPS Electricity Savings, BMM Industrial, by Scenario

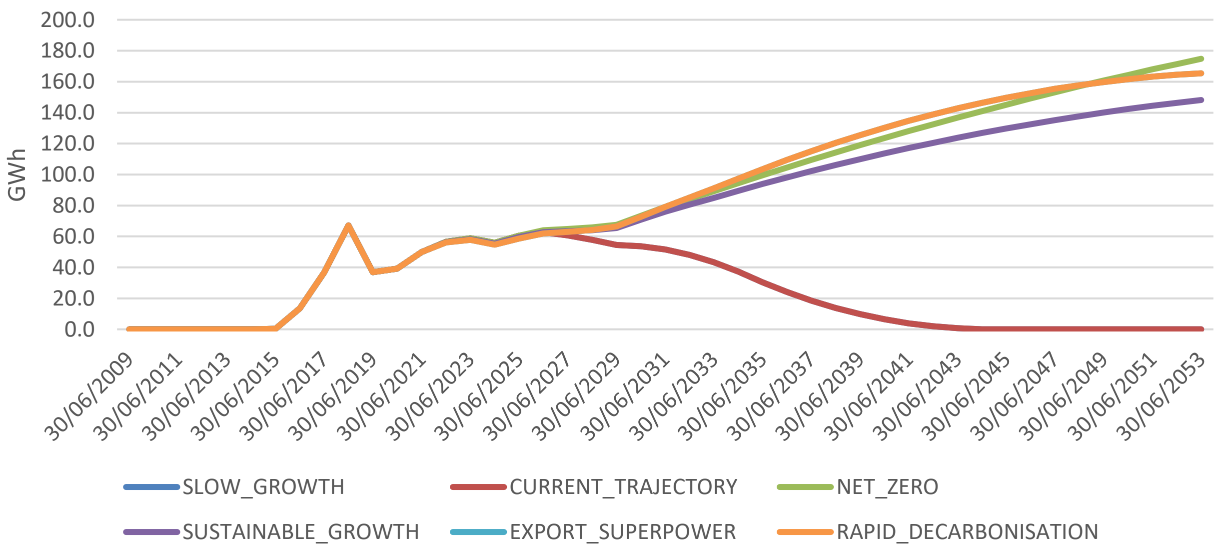
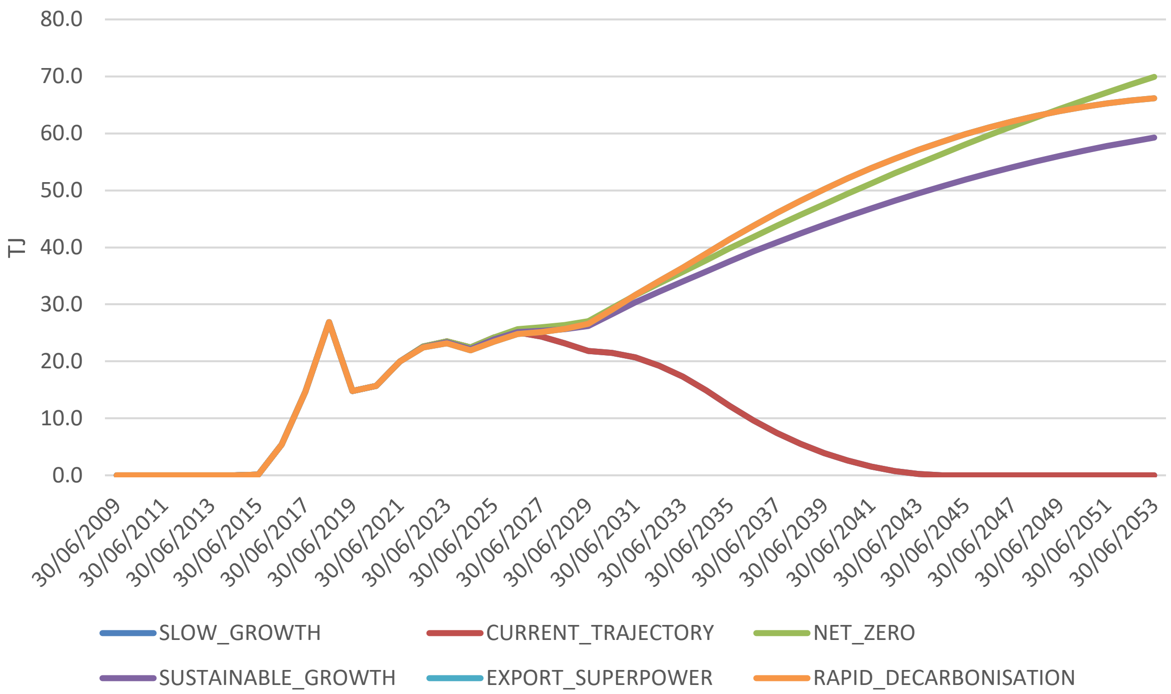


Figure 78: REPS Gas Savings, BMM Industrial, by Scenario



4. Opportunities for Quality Assurance, Validation and Improvement of Forecasts

4.1 Quality Assurance Processes

QA processes associated with the modelling and forecasts primarily include:

- engaging directly with stakeholders to capture program data and other relevant information, and to help in assessing the impacts associated with measures, including additionality, fuel switching impacts and other performance dimensions for measures
- explicit representation of reported program impacts and then application of discount factors as required, including to balance models with observed consumption in the historical period
- internal review of projections models.

Other strategies including compiling and comparing energy consumption data from both AEMO and Australian Energy Statistics, and attempting to reconcile the two. AEMO (consultant generated) housing projections were compared against ABS Census data and household and family projections. While these were broadly consistent, use of ABS data enabled greater resolution of housing types (distinguished semi-detached housing, for example, from attached, where growth trends in the two segments are increasingly distinct). Other key modelling parameters are aligned with current best practices, such as the use of stock turnover models from recent COAG Energy Council Trajectory studies. The non-residential building stock is relatively poorly described statistically, but SPR is currently undertaking an update to the 2012 Commercial Building Baseline Study, including so far compiling detailed building stock data on 215 local government areas (LGAs) in Australia, or 40% of all LGAs. We have as much confidence as it is possible to have regarding stock characteristics in Australia, while also being aware of the data limitations. Generally, and as discussed further below, there remain uncertainties in estimating energy efficiency changes in Australia that stem both from the fact that avoided energy consumption is, by definition, not metered and must always be estimated, and second, from data limitations.

4.2 Validation Opportunities

Validation opportunities for avoided energy consumption are rare. For policy-induced savings, only policy/program evaluations that are independent, professional and which explicitly examine non-additionalities, are likely to be relevant. Such evaluations are completed infrequently, and generally only for regulatory measures, but occasionally for other policy designs including financial incentives.[31] Also, such evaluations are not always published, particularly where findings are less

[31] For example, in 2012, Energy Efficient Strategies undertook an evaluation of the Household Insulation Scheme, although that does not appear to be currently published online.

than flattering. There have been formal evaluations for the CBD program, for example;[32] for GEMS (but not at a detailed, measure-by-measure level for some time)[33]; and for some state energy savings targets (at least in SA). We are unaware of any formal evaluation of NCC energy performance requirements, at least at a national level, at least since CSIRO's evaluation of 5-star housing – a standard that was applied in BCA2009.[34]

Generally, we encourage governments to undertake and publish regular, independent evaluations of all significant policy or budgetary measures, around once every five years, consistent with what is sometimes called 'good program hygiene'. While it is not within AEMO's remit to make this happen, it can – for example through its Energy Efficiency Workshops and potentially in other ways (eg, publications) – highlight the importance of this for improving demand and consumption forecasting.

With respect to quantifying market-induced efficiency change, and indeed for quantifying total energy efficiency change, the critical requirement is reliable and appropriate data. This project has highlighted that there is uncertainty about fundamental aspects of energy consumption and the efficiency of energy use in Australia – particularly the commercial and industrial sectors – and also uncertainty regarding the output of these sectors. As a result, the *productivity*, as well as efficiency, of energy use must be estimated, rather than known with reasonable certainty. Given the economic and wider environmental costs associated with energy use, correcting this knowledge deficit would appear worthwhile and – as noted below – feasible to achieve.

4.3 Improvement of Forecasts

The primary constraint on the accuracy of energy efficiency forecasts in Australia is the lack of access to authoritative data, and independent quantitative research and analysis based on such data, with respect to at least:

- evidence regarding actual rates of autonomous or market-led efficiency change in Australia by sector
- independent program evaluations, particularly for non-regulatory measures, that include explicit consideration of non-additionality to market-led and other policy-induced efficiency effects

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[32] The CIE, Draft Report (never finalised), *Independent Review of the Commercial Building Disclosure Program*, September 2019. Also, ACIL Allen, *Commercial Building Disclosure – Program Review – Final Report*, March 2015.

[33] We note that the *Independent Review of the Greenhouse and Energy Minimum Standards (GEMS) Act 2012 – Final Report*, June 2019, appears to have been undertaken by "Ms Anna Collyer, a partner at law firm Allens" (p. 7), but is published by the Department that administers the Act.

[34] CSIRO (M. Ambrose et al), *Evaluation of the 5-Star Energy Efficiency Standard for Residential Buildings – Report*, December 2013.

- energy consumption data by fuel and building type at sub-sectoral level and at the end-use level; this is particularly the case for gas, where very little (measured) data is published
- physical output measures for key industrial sectors (matched by energy consumption data at the same level of disaggregation)
- reliance on modelling, rather than measurement, for the residential and commercial sectors in *Australian Energy Statistics*
- reliable data on elements of building stock turnover, particularly retirements
- reliable data on non-residential building counts and floor area estimates, and on energy use (including fuel mix) by building type[35]
- non-continuation of past and important data collections, such as the Household Energy Efficiency Survey (ABS – various names at different time periods, last collected in 2013)[36] and the former ABARE annual Fuel and Electricity Survey (FES) that until 2012 informed *Australian Energy Statistics*.

Particular opportunities identified during this project, that may be practical to advance in the near term, include:

- Collaborating with DISER's Australian Energy Statistics team (and other Australian Government agencies as required) with the aim of:
    - understanding the cause of apparent differences in electricity consumption in at least BMM Commercial (AES Commercial and services) post FY2014, and aligning the two data sources as far as possible (other sources, such as AER RIN data, may also be relevant in this context)
    - investigating the potential for AEMO to utilise NGER data (as used by AES) for SOO purposes – noting that this may require alignment of definitions of 'large industrial loads' (AEMO terminology, but not limited to industrial consumers) and noting that there could be the opportunity to reduce the overall reporting burden on large energy users by avoiding duplication in data collection.
- AEMO could consider whether aligning its market segmentation with ANZSIC would be compatible with its own needs and potentially beneficial for aligning with other data sources.
- Also in this context, AEMO could investigate whether it would be feasible to capture from the ABS (national accounts data) value-added and potentially other economic/output indicators aligned with both the ANZSIC frame and NGER for large energy users – enabling

[35] This gap is currently being addressed through an update to the 2012 Commercial Building Baseline Study – a project commissioned by the Australian Government Department of Industry, Science, Energy and Resources.
[36] ABS, 4670.0, Household Energy Consumption Survey, Australia, September 2014.

both the energy use and the output of all other energy users by ANZSIC Division (eg, SMEs) to be analysed for projections purposes.

- Fuel switching and electrification/decarbonisation programs are likely to become increasingly important at state level. These need to be monitored and reflected. In many cases, pressure on gas consumption is likely to see some increase in electricity use.
- Longer electricity and gas historical consumption times series (eg. 5-10 years) for all jurisdictions (including the ACT) will greatly assist with model accuracy and calibration and provide an important alternative perspective to Australian Energy Statistics.
- Where feasible, allow more time for the forecasting exercise, including contingencies for late arrival of data, information updates and scenario changes.

We note that while data improvement projects may involve a one-off investment, there is significant potential for reduced cost over time from rationalising and avoiding duplication in data collection effort, along with other benefits such as reduced reporting burden for the private sector. The primary requirement is for key agencies that collect and hold data to engage with each other, determine where data alignment opportunities exist, and reaching agreements around data sharing and protection.

5. Analysis of Findings

5.1 Comparison with 2020 Forecasts

To contextualise the overall findings for 2021, we first compare these with equivalent scenarios from 2020 and 2019, at least for electricity. BMM Commercial and Industrial sectors were not separated in the 2019 and 2020 so, to facilitate comparison, we add these together here for 2021 as well. Also, we remove SWIS savings from the 2021 draft forecasts, to compare with the earlier data, which is NEM-only, and we align the different projection dates onto a common basis. It should be noted that scenario narratives, economic projections and other factors will all have changed across the three periods.

5.1.1 Residential

SPR's residential modelling embodies some significant extensions to past analysis. These include:

- Detailed analysis of three household types (houses, townhouses and apartments) using Census data to aggregate dwellings at the local government area (LGA) level, and from there allocate these groups to State based climate zones
- Identify and track dwelling energy consumption - and structural trends - in all NCC climate zones, which are distinguished at State level (ie. Climate Zone 4 in NSW has heating and cooling needs that are distinct from a household in Climate Zone 4 in another State),
- Apply an autonomous efficiency improvement (AEEI) measure to future energy consumption - and commensurate savings - for the first time, and
- including new Victorian budget measures.

In conjunction with these initiatives, we have applied a range of discounts in an effort to minimise double counting of savings outcomes across energy efficiency programs. These are summarised in Appendix B.

Our estimates bear comparison with past measures. Results for the NEM are shown in Figure 79. The chart indicates that our residential savings estimates for electricity (SPR 2021) are slightly lower than those submitted to AEMO in 2019 and 2020 for the years prior to 2030 but begin to significantly exceed Central 2019 and Central 2020 thereafter.

Our analysis indicates that this is primarily due to the inclusion of new estimates and measures in our updated analysis. As can be seen from Figure 80, when AEEI, VEU and Victorian Budget measures are omitted, our analysis tracks previous advice to AEMO quite closely. Note that these are omitted, in the comparison, since AEEI was not quantified in past years, VEU has significantly changed its focus (as discussed in Chapter 3), and the Budget measures referred to were not present in 2019 and 2020 forecasts.

Given that AEEI, VEU and Victorian Budget measures (the Victorian Household Energy Savings Package in particular) are clearly relevant to consideration of future energy demand and potential savings we view this as a demonstration of the potential value that our current analysis can add to AEMO's network planning efforts.

Figure 79: Comparison of NEM residential savings results, 2019, 2020 and 2021

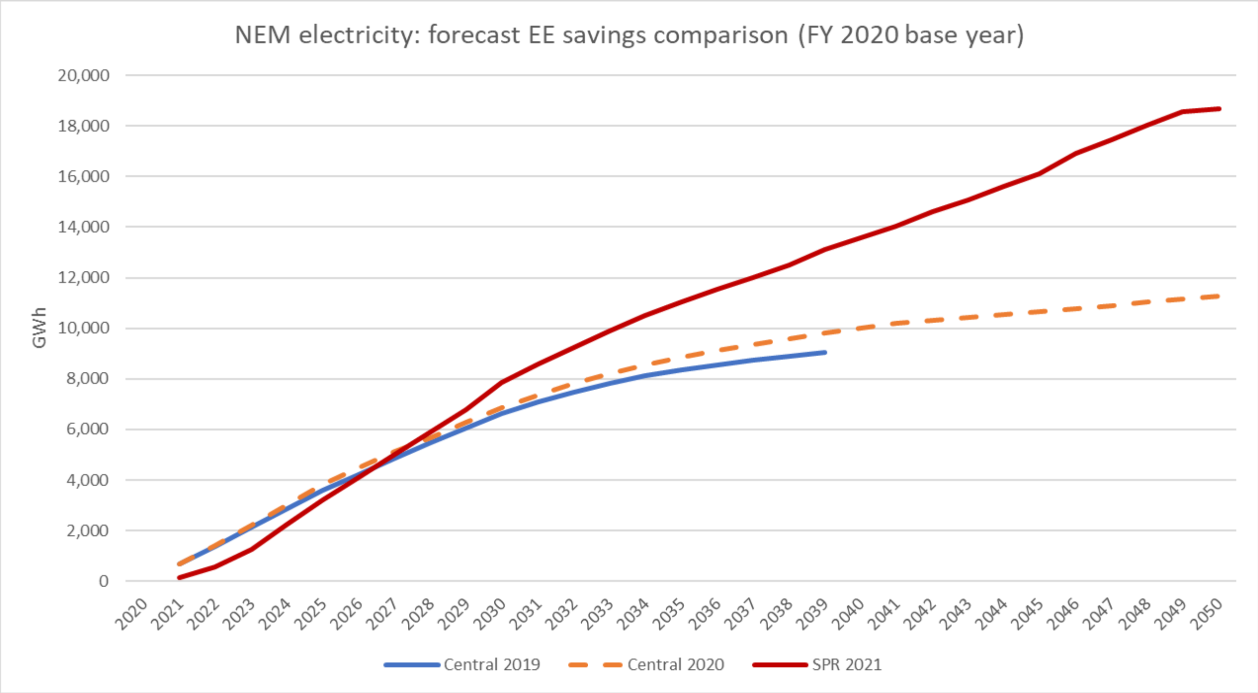
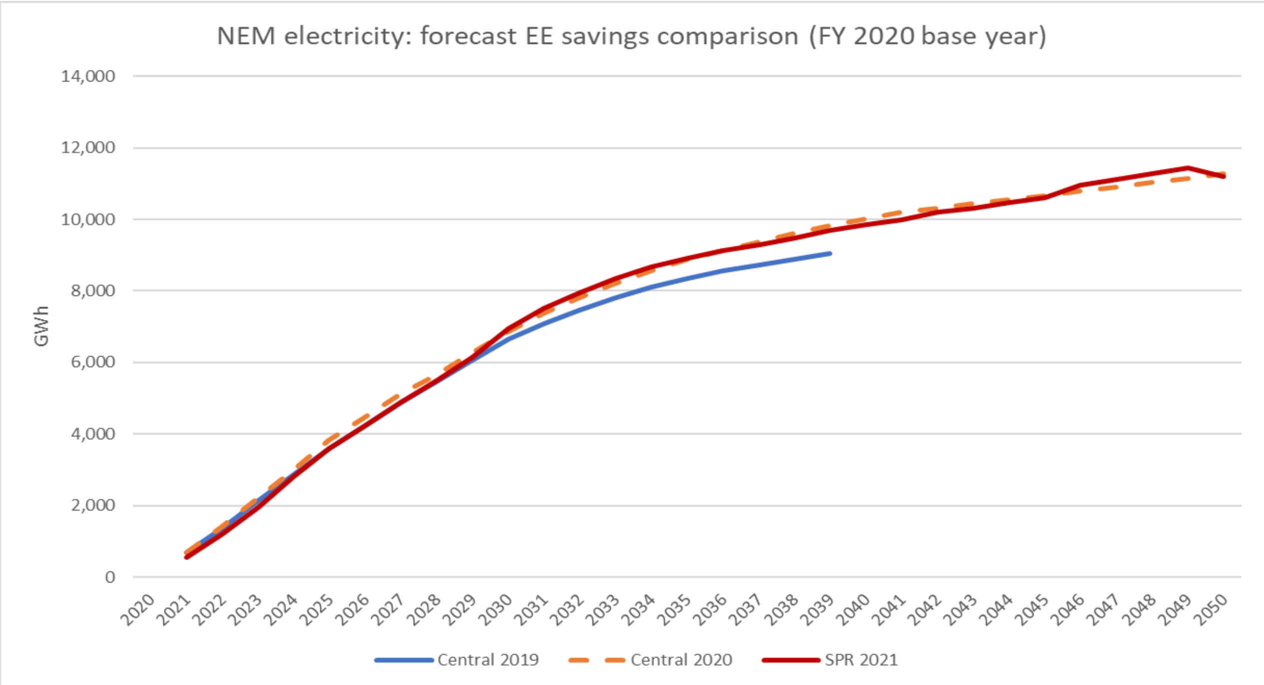


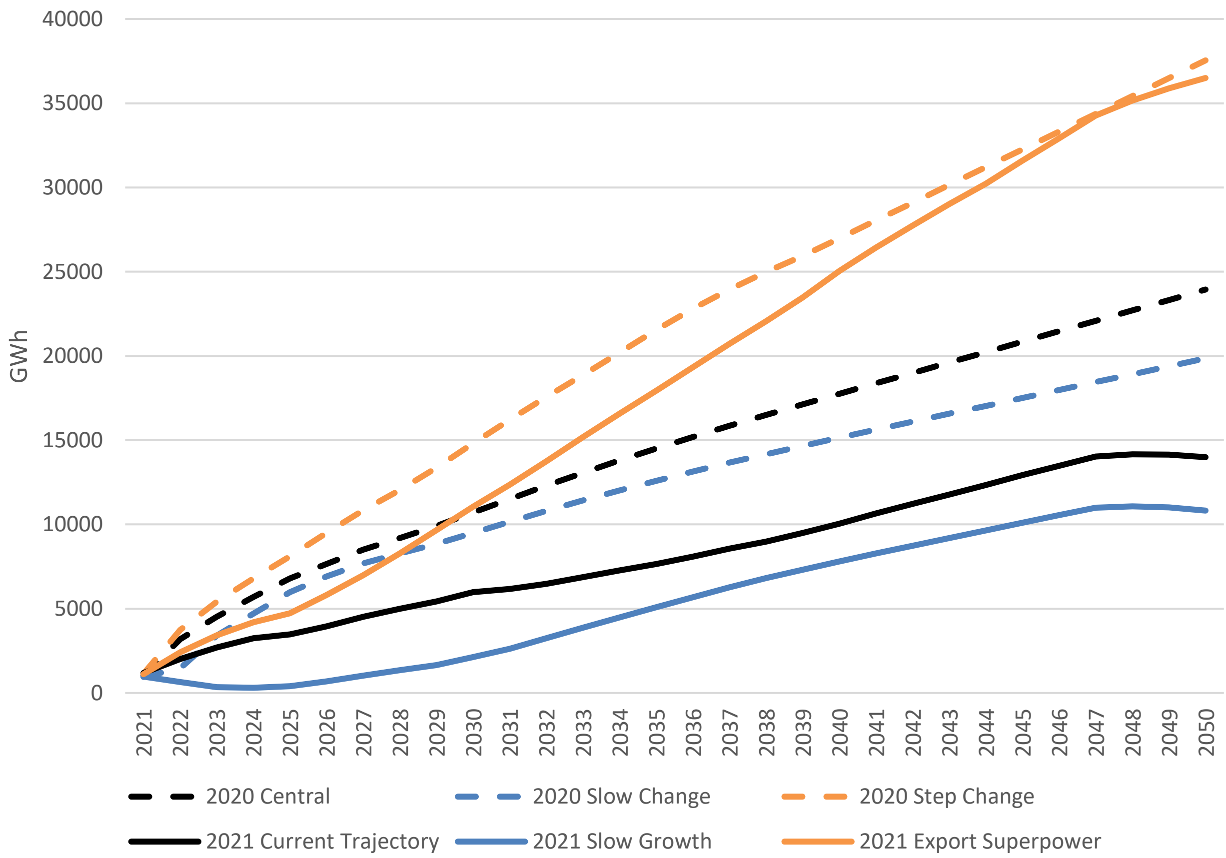
Figure 80: Comparison – after new measures (AEEI, VEU and VHESP) are omitted



5.1.2 Business Mass Market

Figure 81 indicates that for the BMM sectors, the 2021 forecasts are notably lower than they were in 2020, and particularly for Current Trajectory and Slow Growth.

Figure 81: 2020 vs 2021 EE (Electricity) Forecasts, Business Mass Market, NEM



The key reasons include:

- The model underpinning the 2021 forecasts reconciles estimates of market-led and policy-induced energy efficiency in the historical period (from FY2003) with actual consumption. This was not done in 2020, but was added to the scope of the analysis for 2021. This new analysis revealed a slowing efficiency improvement trend, leading to higher discounts being applied to both market and policy components than was the case in 2020.
- Relatedly, in 2021 we develop estimates for market-led or Autonomous Energy Efficiency Improvement. AEEI is not an efficiency 'measure' but is important and should be recognised as a driver for overall efficiency change. Further, it is important to discount the claimed or 'headline' impact of policies for the component of change that would have been delivered in any case, without the policy intervention. This component is AEEI.

- There have been additional implementations delays in at least the two major energy efficiency policies – the NCC and GEMS.
- More explicit and additional modelling of future policy settings, and of the potential for additional policy measures in higher-ambition scenarios, than in earlier forecasts.
- A lesser contributing factor is the COVID-19 'flat-spot' in economic growth (affecting stock growth, inter alia).

5.2 Summary and Conclusions – Residential

Residential energy efficiency savings are forecast to continue to accumulate steadily under Current Trajectory. These savings represent a base level that applies nationally, generated by the National Construction Code energy performance requirements (BASIX in NSW), Greenhouse and Energy Minimum Standards including product labelling, and market-led or autonomous energy efficiency improvement. In NSW, VIC and SA, state energy savings schemes, and new budget measures in VIC, add to this base. Relative to a FY2010 base year, we forecast NEM savings in FY2053 of around 30,715 GWh under the Current Trajectory, or up to 55,636 GWh under Export Superpower. FY2053 savings in the SWIS (against a FY2010 base year) add between 4,546 – 8,808 GWh in these scenarios.

Figure 82: Summary of NEM Residential Energy Efficiency Forecasts by Scenario - Electricity

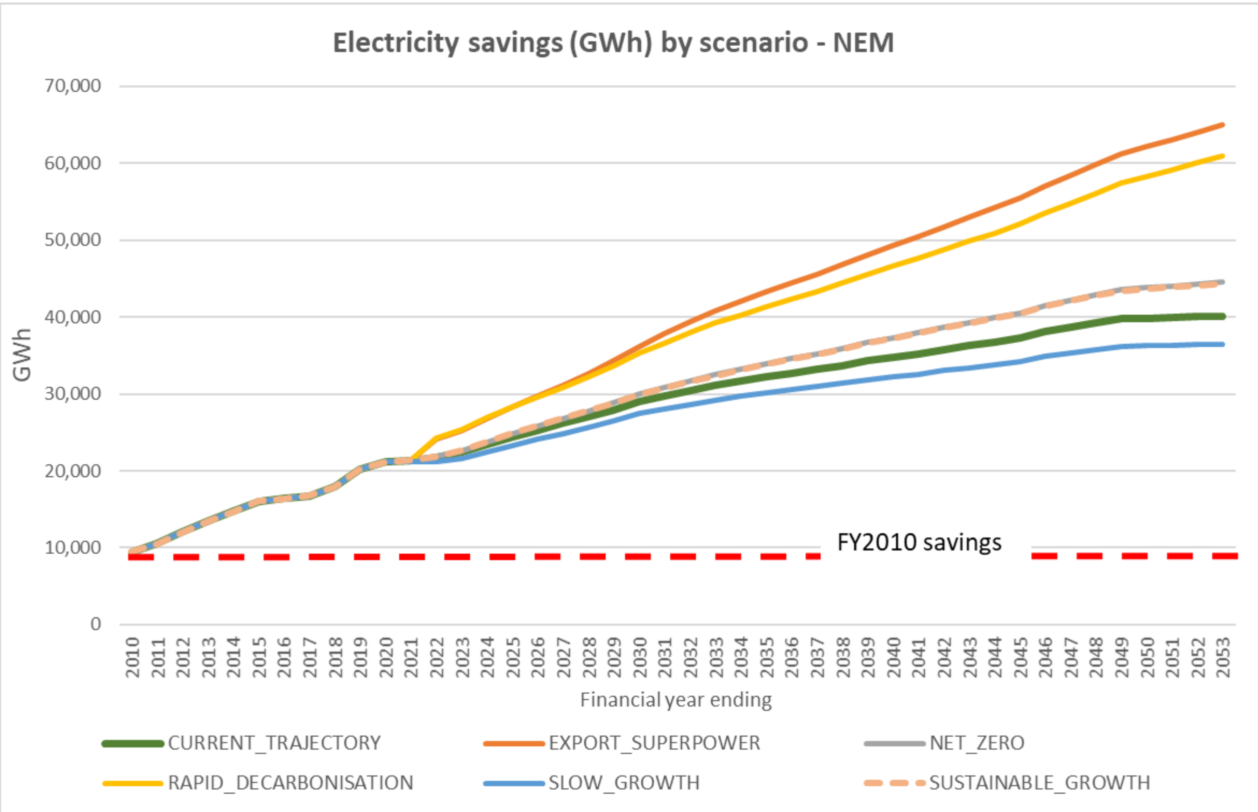
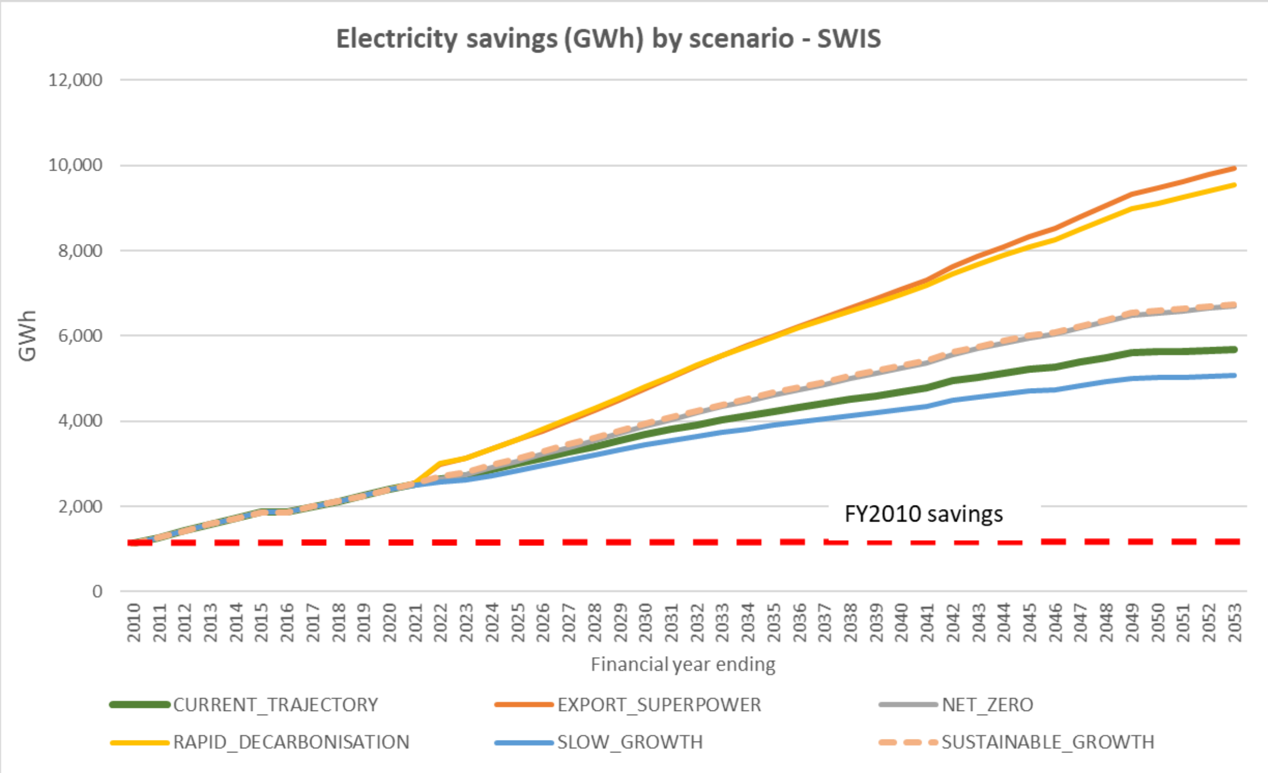


Figure 83: Summary of SWIS Residential Energy Efficiency Forecasts by Scenario - Electricity



Gas savings are also significant; indeed, future energy savings are expected to be increasingly dominated by gas. This is primarily due to fuel switching towards electricity, particularly anticipating continued increases in the efficiency of heat pumps for space conditioning, and rising consumer demand. Heat pump technologies deliver thermal comfort with a fractional electrical energy requirement (ie. 1 MJ of heat energy may only require about 0.25 MJ of electrical input), whereas gas technologies have energy requirements that exceed their delivered energy output. The relative efficiency of these technologies is a key reason for the high expected share of gas savings. When 100 MJ less energy is required to warm a home, this results in a future electricity saving of say 25 MJ. In a home heated by gas, the induced gas saving could be 120 MJ.

For the NEM, we estimate that by 2053 about 69% of the savings achieved in that year will be gas. For the SWIS, we estimate that gas will account for about 46% of annual energy efficiency savings by 2053.

By 2053, we expect residential gas consumption to be around 23,000 TJ in the SWIS due to the influence of policy measures and market induced innovation (AEEI). In the absence of such efficiency drivers, we estimate that gas consumption would have grown to almost 35,000 TJ. In the NEM, estimated gas consumption in 2053 indicated by our modelling is around 246,000 TJ, and without measures and autonomous efficiency improvement it would be over 492,850 TJ.

Figure 84: Summary of Total Residential Gas Savings by Scenario, NEM

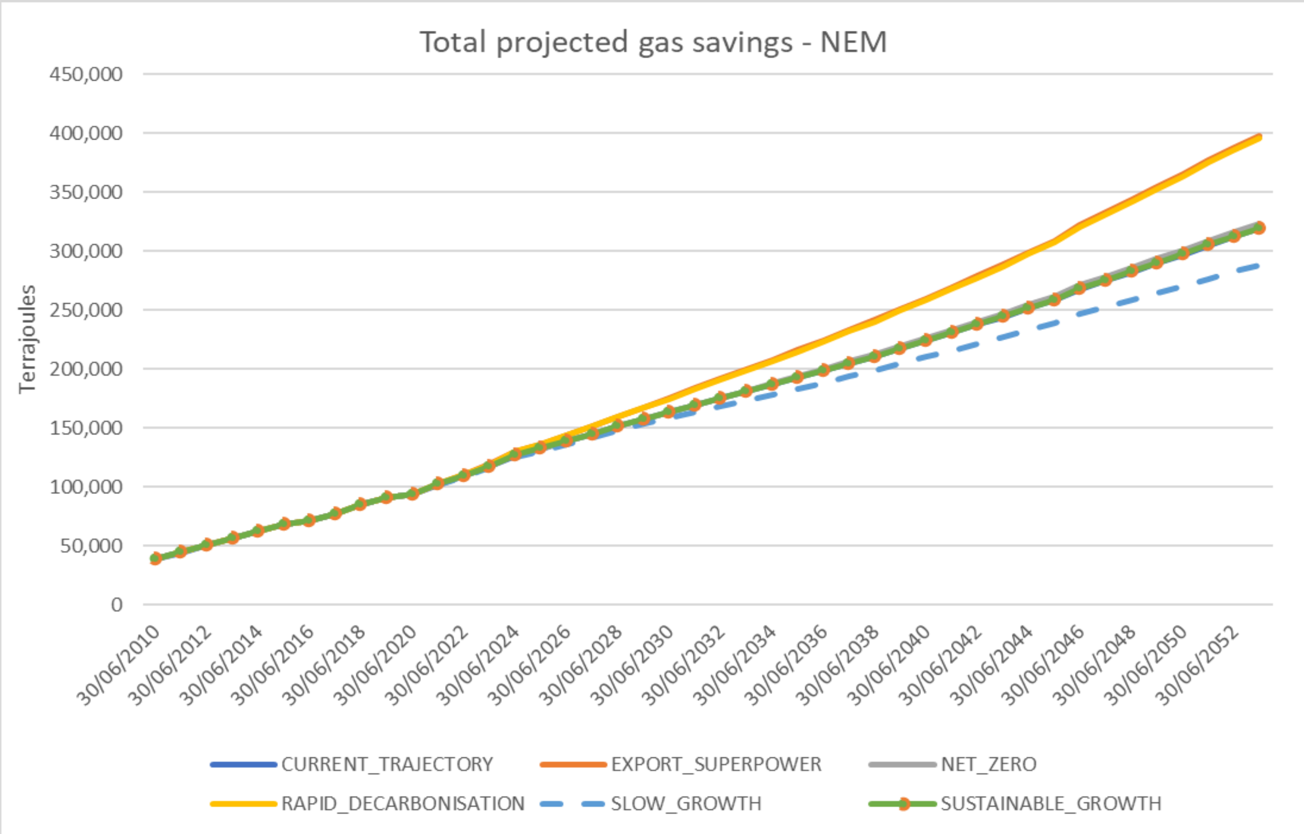
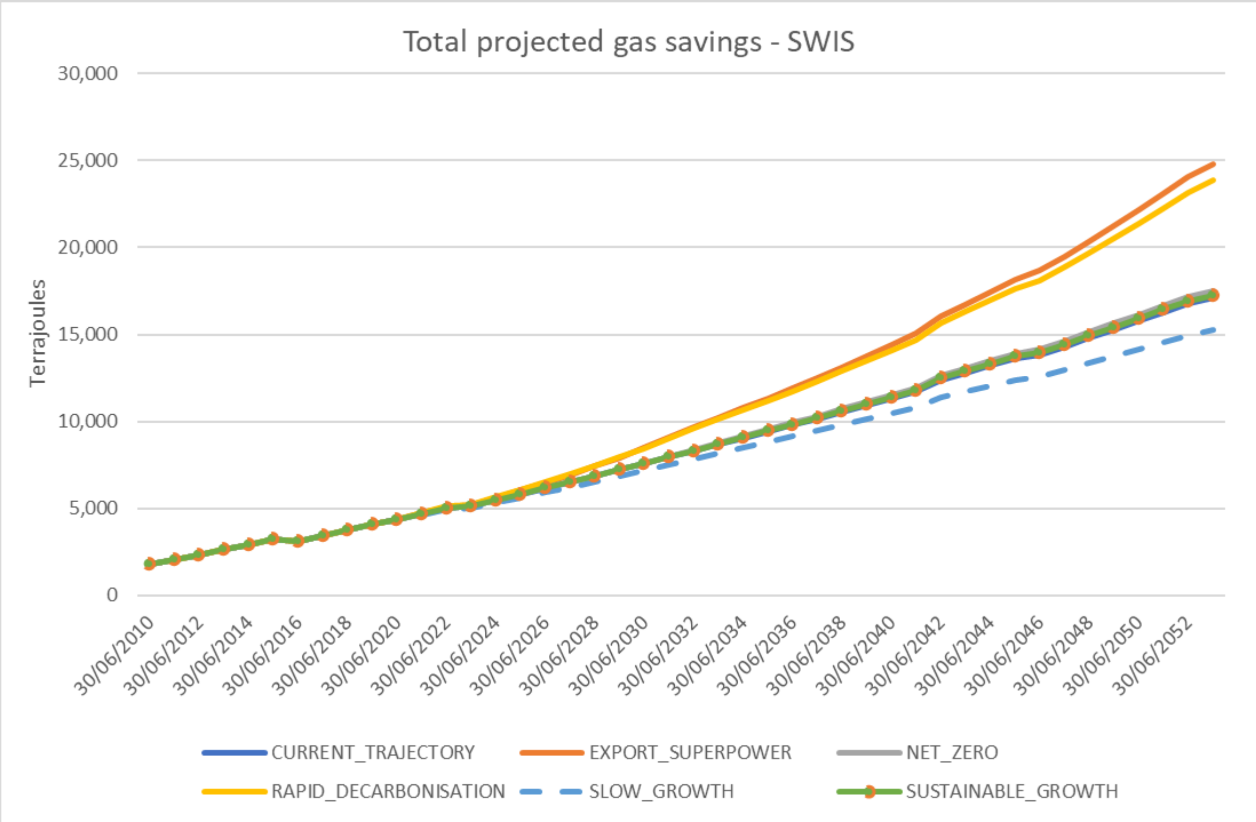


Figure 85: Summary of Total Residential Gas Savings by Scenario, SWIS



Total forecast electricity savings are a little higher this year than in 2019 (or 2020), notably in the out-years, and this reflects three main factors:

- the inclusion of AEEI in this year's forecasts for the first time
- new budget measures in Victoria
- expansion/extension of state energy savings schemes.

When these three effects are removed from the forecasts, they align fairly closely with those from previous years.

The impact of stronger demand and population growth, and more ambitious policy settings, in scenarios such as Export Superpower and Rapid Decarbonisation is to increase savings by 20% - 30% relative to Current Trajectory. Of course, energy consumption will also be higher in these scenarios. We stress that these scenarios are not intended to define the full economic, let alone technical, potentials for energy efficiency improvement, but rather represent the expected savings if modest and achievable policy enhancements were made (in combination with the demand drivers).

Of the sectors covered by this study, the residential sector is the best described, with reasonably high confidence regarding key savings drivers, including housing stock size, composition, growth and turnover, and the degree of realisation of Code savings. That said, the rate of demolition of housing (the replacement of which adds greater Code savings than is apparent from the *net* increase in the housing stock annually) is not captured in national statistics and must be estimated. With most new homes using the NatHERS method of demonstrating Code compliance, there is a data trail that indicates that most homes meet, or even exceed, minimum requirements. However, these are 'as designed' efficiency ratings, and only Victoria is known to have a program of compliance audits underway to determine the extent to which the design intent is realised in practice.[37]

To improve confidence in future residential energy efficiency forecasts, the main factors would include:

- independent evaluations of the residential energy performance requirements in the NCC and BASIX in NSW, including quantifying the extent of realisation of expected savings and the degree of additionality to market-led efficiency improvement
- independent evaluation of actual GEMS impacts in the sector – noting that measures date from many different time periods, with different assumptions having been made about their expected future impact – again taking into account the degree of additionality to market-led efficiency improvement
- research to quantify the actual extent of market-led efficiency improvement in the residential sector.[38]

5.3 Summary and Conclusions – Business Mass Market

Figure 86 shows that electricity savings due to energy efficiency measures are projected to be significant, reaching around 50,000 GWh in Export Superpower (relative to a 2003 base year), but less than half that value under the Slow Growth scenario, due to the combined effect of slower economic growth and weaker policy settings.

[37] Results were expected to be released by June 2020, according to the Victorian Building Authority's website, but do not yet appear to have been available.
[38] This was discussed at the Energy Efficiency Workshop in March and would require access to data on product sales by efficiency class, *inter alia*, which can be obtained for most products from commercial sources.

Figure 86: BMM Commercial Electricity, Energy Savings by Scenario

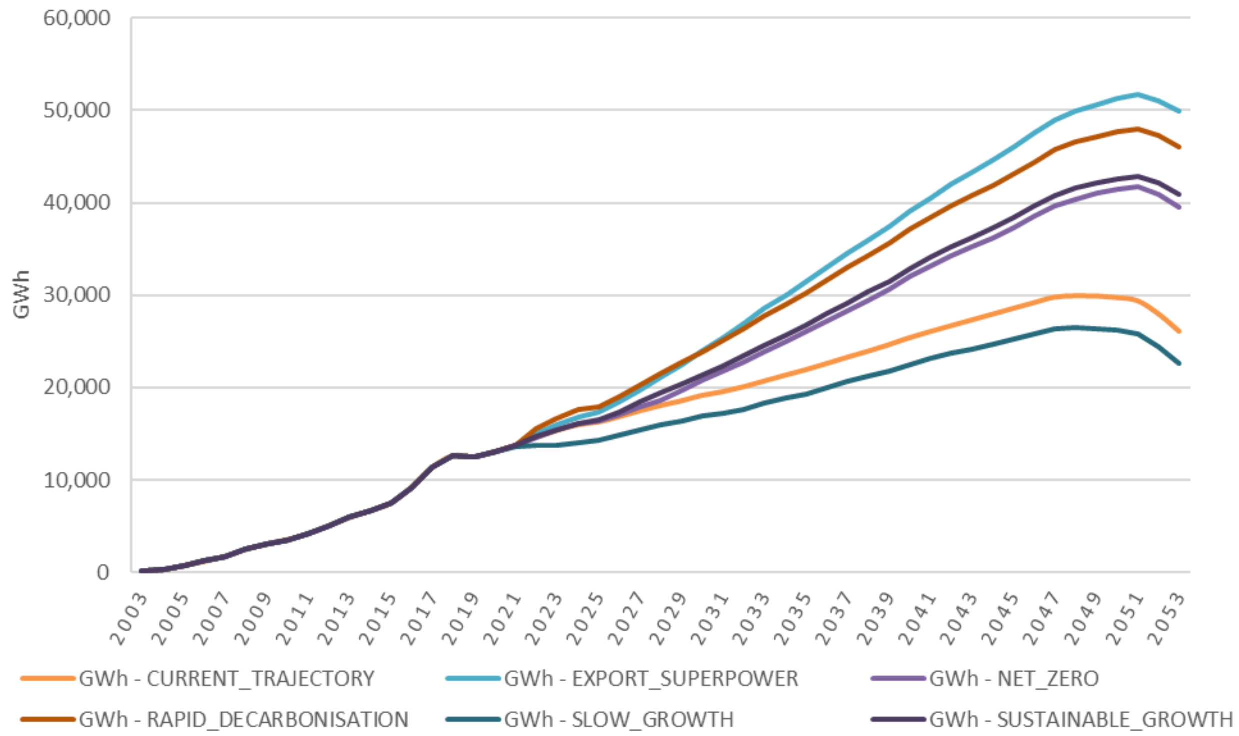


Figure 87: BMM Commercial Gas, Energy Savings rel. to Frozen Efficiency, Current Trajectory

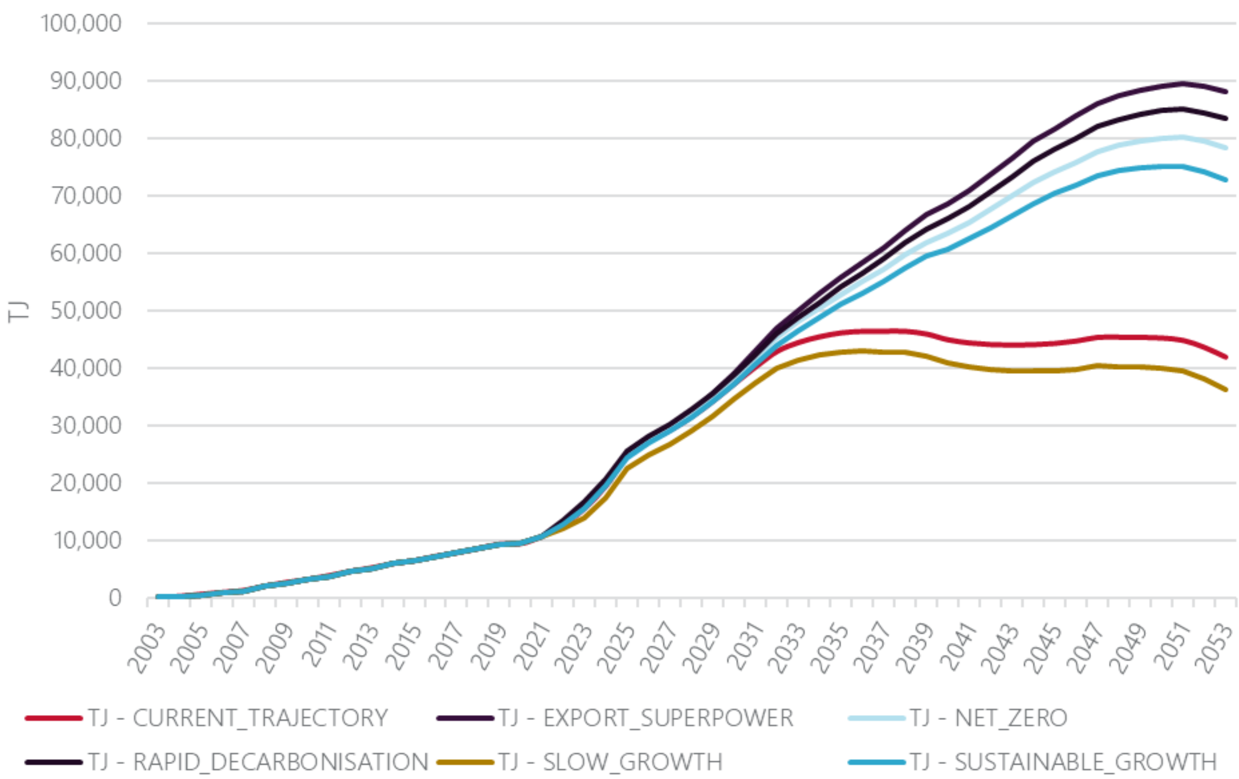


Figure 87 indicates that gas savings are also expected to be significant, reaching around 88 PJ by 2053 under Export Superpower or only 36 PJ under Slow Growth.

Figure 81 above showed that efficiency forecasts for BMM Commercial are considerably lower this year than in previous years. For this year's forecasts, we analysed the rate of change in *total* energy efficiency (the sum of market-led and policy-induced efficiency) in this sector and found evidence that it has slowed appreciably during the last decade.[39] This suggests that one or both of these effects have been less effective in improving efficiency than previously understood.

While further and more detailed analysis would be required to fully explore the underlying causes, potential contributors to this outcome from market-led change could include factors tending to intensifying energy use in commercial buildings, such as longer trading/operating hours, more persons per floor, and rising cooling demands. At the same time, such trends will have been counteracted to some degree by some clear efficiency improvements, notably LED lighting. On the policy side, there were no new energy performance standards for buildings during the decade (after BCA2010, which took effect around 2012) – and this is the largest single energy efficiency measure by far in BMM Commercial – and there is also a literature around the 'performance gap', or non-realisation of expected savings.

In addition, at the policy level, the two major national drivers of stationary energy efficiency improvement – the National Construction Code energy performance requirements and the Greenhouse and Energy Minimum Standards program – have delivered little in the way of new standards for many years. The formation of new energy performance requirements for non-residential buildings in NCC2019 is acknowledged as an important exception to this rule, albeit that this update standards from 2011, and the delayed start to this measure means it may be some time before its impact becomes apparent. For residential buildings, 2011 energy performance standards remain in place today, although proposals are being developed for government consideration that, if agreed, may apply from 2022 or later. For GEMS, we have documented annual delays and deferments of expected development over many years now, and again this year – see Appendix A. Also, with the passage of time, some past GEMS measures (eg, for fluorescent lighting and ballasts) have been overtaken by technology and market change.

We have documented in this study a counter-intuitive reduction in savings from CBD program, and a levelling off in the take-up and savings rates for NABERS Energy for Offices (which we interpret as potential saturation effects, although these trends may or may not be sustained in coming years). At state level, ESS targets remained constant over FY2019 – FY2021, but there was modest growth in targets for other schemes, and also in other time periods for ESS.

[39] The strength of this conclusion is tempered by conflicting energy consumption observations from different sources. If we had forced our model of efficiency improvement to agree fully with Australian Energy Statistics data, then efficiency improvement in the historical period would have had to have been discounted still further.

At the state level, while some states have increased savings targets over the last decade, these have been modest in scale, although in absolute size, Victoria's scheme is larger than the others.

Market-led efficiency change has been evident in areas such as LED lighting and increasing coefficients of performance in heat pumps. Overall, however, the data reviewed in this study appear to show a slowing trend in commercial sector energy efficiency overall. More detailed research would be required to determine key elements of this apparent change, and also to reconcile conflicting energy consumption data which are directly impacting on this question.

In the BMM industrial sector, efficiency trends cannot be established with confidence due to data limitations – primarily related to confidentiality, but also the segmentation of BMM by enterprise size means that energy consumption and economic value of output data, which are organised on the ANZSIC frame, cannot easily be aligned with AEMO's preferred market segmentation. We therefore estimate energy efficiency savings bottom-up, measure by measure, but we have no opportunity to compare or reconcile these with top-down data.

Figure 88: Total Electricity Savings, BMM Industrial

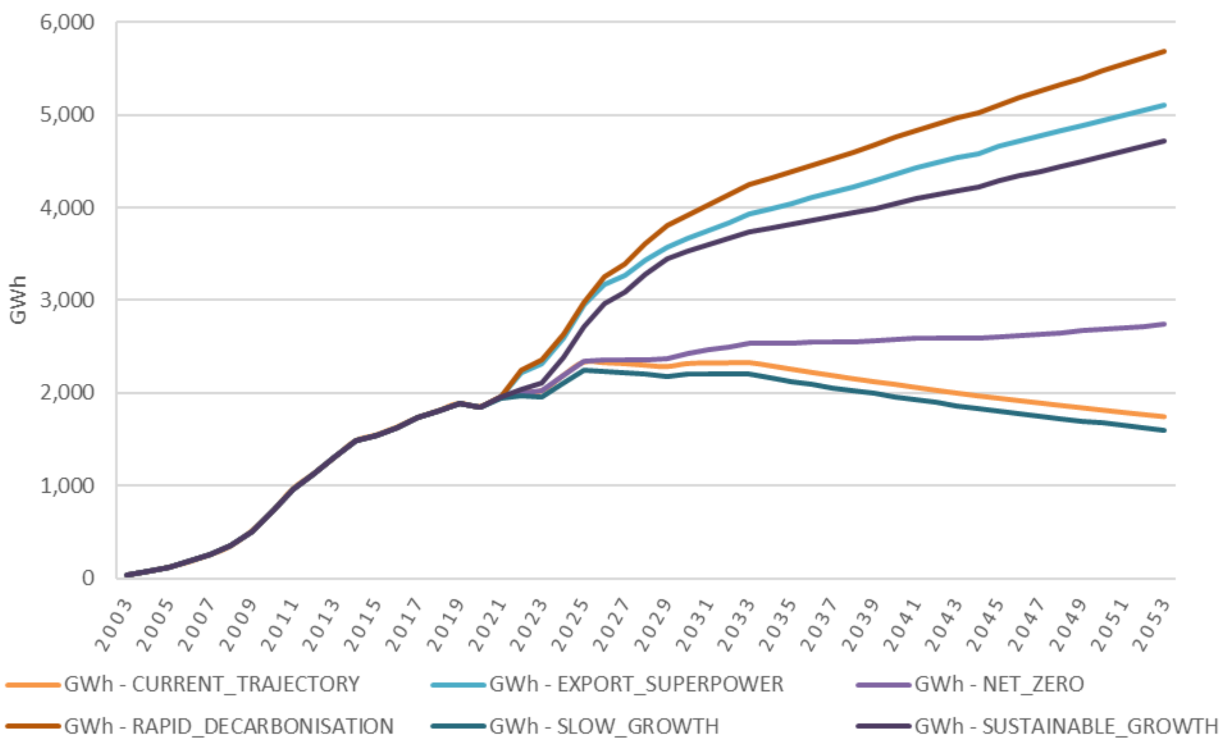


Figure 89: Total Gas Savings, BMM Industrial

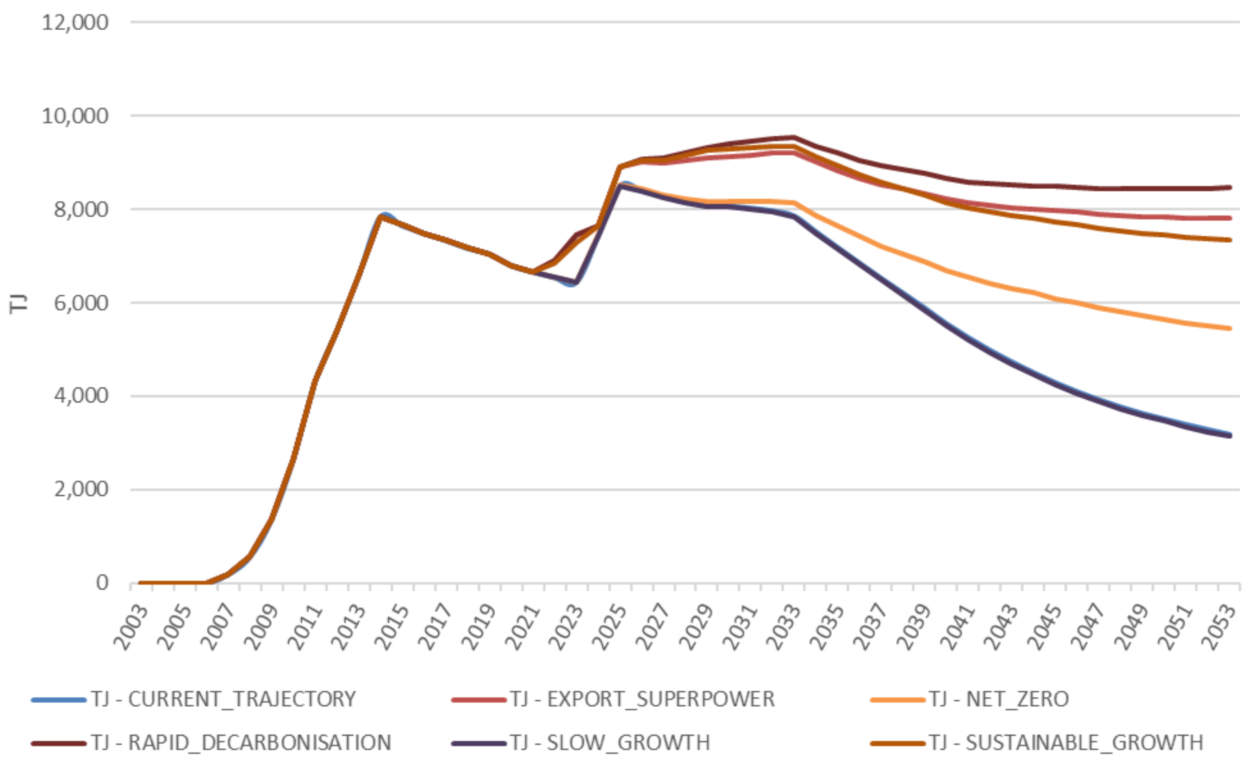


Figure 88 and Figure 89 show that policy-induced electricity and gas savings are expected to be quite modest in scale, and much lower than in BMM Commercial. This reflects the relative paucity of policy measures in the industrial sector, despite its very high energy use, but also the fact that some of the policy savings will accrue to large industrial loads, and these are not represented in these forecasts. These charts do not show estimated market-led savings in this sector, although these are estimated. However, as noted above, these estimates cannot easily be validated.

5.4 Overall Conclusions and Recommendations

While the conceptual approach to forecasting this year represents an enhancement on past years, the extent of data challenges was greater – and more limiting on the conclusions – than expected. In principle, it should be feasible to establish the total change in energy efficiency at the sectoral (or sub-sectoral) level with reasonable precision. However, diverging electricity consumption data series make this unexpectedly challenging. Data on gas consumption is only available from one source – Australian Energy Statistics. Also, AEMO's market segmentation – while reflecting its operational – nevertheless does not align with statistical data sources.

An overall conclusion from the 2021 analysis is that there appears to be a case for AEMO to regularly forecast market-led or autonomous energy efficiency improvement (AEEI), as policy impacts only explain part of the total efficiency change. Also, from a practical perspective, measuring total efficiency change, and then apportioning this into policy-induced and market-led segments, is an effective way of ensuring that neither savings element is over-estimated. That said, quantitative analysis of market-led efficiency change would require more detailed analysis of efficiency trends at the sub-sectoral and end-use levels, and practically this work would have to be done outside the annual forecasting cycle.

For the policy-induced component of efficiency change, independent evaluations of the two major efficiency measures – the National Construction Code and GEMS – with a brief to quantify additionality to other policy measures and to AEEI – could be encouraged. For the NCC, key questions such as the apparent non-realisation of modelled savings, or the 'performance gap', may require the collection of audit-based data. This in turn would require that a suitable agency or set of agencies undertook a statistically-significant audit program; however, we are not aware that such a program is currently underway. Other partial evaluation methodologies could be designed as a stop-gap, for example by examining a set of newer buildings (post BCA-2010) for which both original reference building and subsequent NABERS energy intensity values can be established.

For GEMS, and as discussed at the Energy Efficiency Workshop in March, a key element of a retrospective analysis would be to ensure that the current (and projected future) impact of individual GEMS measures is placed onto a single and internally-consistent conceptual basis – either adjusting for discrepancies between past RIS assumptions and the subsequent reality, or else abandoning those sources entirely and creating a new and consistent 'without policy' counterfactual scenario – including AEEI – against which to quantify incremental energy savings.

Most of the significant uncertainties noted in this report relate to data limitations. In some cases, these are program reporting issues that could at least potentially be addressed by program managers and/or reporting agencies (eg, ESC in Victoria, IPART in NSW). This could extend, for example, to unambiguous statements of annualised energy savings by fuel and sector from state energy savings schemes, in particular for schemes that use carbon metrics, as this entails an additional layer of interpolation between targets and energy savings impacts.

Further, we note above that VEU already – and no doubt ESS and REPS in future – and even other measures such as NCC or GEMS provisions – may all be moving increasingly away from simple 'energy savings' impacts towards impacts that are more subtle and complex. These may include fuel switching (potentially in favour of, as well as away from, gas) and various kinds of demand management, with effects on annual energy consumption that may be ambiguous, if they are not carefully monitored and reported in individual cases.

5.4.1 Recommendations

We recommend that AEMO:

1. Engages with the Dept of Industry, Science, Energy and Resources (with respect to *Australian Energy Statistics* and the *National Greenhouse and Energy Reporting* system), and with the Australian Energy Regulator (with respect to RIN data), to seek to reconcile energy consumption data, and potentially to align data sources and constructs.
2. Considers whether changes to its market segmentation would be feasible, to support greater alignment with data sources based on the ANZSIC frame.
3. Encourages or commissions additional research, outside the annual forecasting process, on *total* energy efficiency change, particularly in the BMM Commercial sector (but also Industrial, if data challenges can be overcome), seeking to clarify not only the total change (informed by recommendation 1 above) but also the separate contributions of market-led and policy-induced components.
4. Encourages more transparent program impact reporting, including explicit statements of annual energy savings impacts by fuel and market segment.
5. Encourages governments to commission independent evaluations of key policy measures, including the NCC energy performance requirements and GEMS, with a particular focus on the realisation of expected savings and on additionality to market-led efficiency change.

Appendix A: Equipment Energy Efficiency Program Impacts

This Appendix has been prepared by George Wilkenfeld and Associates. It offers greater analysis of the impacts – including recent changes to impacts – associated with the GEMS (also known as the Equipment Energy Efficiency, or E3) program.

Background

The Equipment Energy Efficiency (E3) program comprises a range of energy labelling and minimum energy performance standards (MEPS) measures, legislated under the Commonwealth Greenhouse and Energy Minimum Standards (GEMS) Act 2012. Many of the measures were implemented under state legislation decades before the GEMS Act. For example, the energy labelling of refrigerators and freezers started in NSW in 1986.

The E3 program is managed under an agreement between the Commonwealth, State, Territory and New Zealand governments. After many departmental changes, it is currently administered by the Commonwealth Department of Industry, Science, Energy and Resources (DISER).

George Wilkenfeld and Associates (GWA) prepared an estimate of the impact of some 50 distinct E3 appliance and lighting product measure for SPR's report to AEMO in June 2019.

For this report, GWA has updated those projections, based on the following information:

- The publication of actual GEMS determinations, which mark the implementation of a program (although the impacts may only commence later, since most determinations take effect after a lead time);
- The publication of draft GEMS determinations, which indicate that a program is in the process of implementation;
- E3 program work plans and priorities published from time to time;
- The publication of Product Profiles, which represent the first stage of detailed development of measures;
- The publication of Regulation Impact Statements (RISs, usually prepared for E3 by external consultants), which represent the best estimates of projected impacts;
- GWA's knowledge of work under way within DISER.

Some 50 distinct programs are covered in the E3 projections, as summarised in Table 1. The Program numbers refer to an identifier in the source spreadsheets. The Category classifications have the following meanings:

A: MEPS & labelling regulations in place (already implemented);

C: MEPS & labelling projects in train (where details are settled and they are in the process of implementation);

D: Possible projects – identified as high priority but not yet fully developed;

EF: Projects that have been on the E3 work program in the past, are currently suspended, but could be reactivated.

For this report, Categories A and C measures are considered as base case measures. The combination of Category A, C and D measures is considered the medium impact scenario, while the addition of Category EF measures constitutes the high impact scenario (most aggressive policy position possible based on current data). Each program has an impact on a particular product and products are then grouped into the end-uses shown. In some cases, the same product is used in both the residential and business sector, so the energy impacts are distributed across sectors based on the best available sector split. The sector impacts are classified as follows: R = Residential, C = Commercial, I = Industrial, HW: Hot water, T = Transformer. Transformer savings are distributed across all end uses but are allocated to business for this study. Commercial and industrial are classified as business for this study. Hot water is classified as primarily residential for this study, but there will be minor effects in the business sector.

Table 18: List of E3 Programs

Program #	Category	End-Use	Sector	Program Description	Status
1	A	Refrigeration	R	Household Refrigerators & Freezers - Labelling 1986 to MEPS 2005	Implemented
2A	A	Water heating	HW	Large electric water heaters	Implemented
2B	A	Water heating	HW	Small electric storage water heaters	Implemented
3	A	Washers/ Dryers	R	Clothes washers, dishwashers, clothes dryers (Plug loads only)	Implemented
4	A	Heating/ Cooling	C	Close Control ACs - MEPS 2009	Implemented
5	A	Heating/ Cooling	C	AC Chillers - MEPS 2009	Implemented
6	A	Lifestyle/ Electronics	R	Televisions - labelling & MEPS 2009	Implemented
7	A	Lifestyle/ Electronics	R	Set Top Boxes - MEPS	Implemented
8A	A	Lifestyle/ Electronics	R	External Power Supplies MEPS (Residential)	Implemented
8B	A	Lifestyle/ Electronics	C	External Power Supplies MEPS (Non-Res)	Implemented
9	A	Refrigeration	C	Refrigerated Display Cabinets MEPS	Implemented
10A	A	Lighting	R	Lamp efficacy, (Res use)	Implemented
10B	A	Lighting	C	Lamp efficacy, (Commercial use)	Implemented
11A	A	Lighting	R	Ballast MEPS (Res use)	Implemented
11B	A	Lighting	C	Ballast MEPS (Commercial use)	Implemented
12	A	Lighting	C	Tri-Phosphor Lamps (Commercial use)	Implemented
13	A	Motors/ Pumps	I	Motors - MEPS 2001, 2006	Implemented
14	A	Transformers	T	Distribution Transformers (2004 MEPS)	Implemented
15	A	Water heating	R	WELS Impacts	Implemented
15	A	Water heating	C	WELS Impacts	Implemented
15	A	Water heating	I	WELS Impacts	Implemented
22	D	Water heating	HW	Heat Pump Water Heaters	Possible
22	D	Water heating	HW	Electric, solar & other electric storage water heaters - heat loss MEPS	Possible
23	D	Water heating	HW	Solar-electric water heaters - all measures other than heat loss	Possible
24	A	Heating/ Cooling	R	Air conditioners - Res MEPS 2004-2010	Implemented

Program #	Category	End-Use	Sector	Program Description	Status
24A	A	Heating/ Cooling	R	Air conditioners - Res MEPS 2011	Implemented
25	A	Heating/ Cooling	C	Air conditioners - Non-Res MEPS 2001-2007	Implemented
25A	A	Heating/ Cooling	C	Air conditioners - Non-Res MEPS 2011	Implemented
26	EF	Transformers	T	Distribution Transformers (2017 MEPS)	Suspended
27	EF	Lifestyle/ Electronics	R	Standby - range of products	Suspended
30	C	Motors/ Pumps	R	Swimming pool pump-units labelling + MEPS	In train
33A	A	Lifestyle/ Electronics	C	PCs and Monitors (Business Use)	Implemented
33B	A	Lifestyle/ Electronics	R	PCs and Monitors (Residential Use)	Implemented
34	D	Heating/ Cooling	C	AC Chillers - MEPS 2017	Possible
35A	A	Heating/ Cooling	R	Air conditioners (Residential - fixed) - MEPS 2017 (now 2020)	Implemented
35B	EF	Lifestyle/ Electronics	R	Battery Chargers (Small consumer)	Suspended
35C	A	Heating/ Cooling	C	Air conditioners (Non-residential) - MEPS 2017 (now 2021)	Implemented
36	C	Lighting	C	LED MEPS (Commercial use – replaces ballasts)	In train
37	C	Lighting	R	LED MEPS (Residential use – replaces Linear fluorescent lamps)	In train
38	A	Motors/ Pumps	I	Motors - MEPS 2017 (now 2020)	Implemented
39	A	Refrigeration	R	Household Refrigerators & Freezers - MEPS 2021	Implemented
40	A	Lifestyle/ Electronics	R	Televisions - labelling upgrade & MEPS – 2013	Implemented
42	A	Refrigeration	C	Commercial refrigeration - MEPS 2015 (now 2021)	Implemented
47	A	Heating/ Cooling	R	Portable air conditioners (impacts now included with 35A)	Implemented
42A	EF	Refrigeration	C	Commercial Refrigeration Compressor MEPS	Suspended
42B	EF	Other	C	Self-contained food-service	Suspended
55	D	Refrigeration	C	Additional Commercial Refrigeration equipment	Possible
56-59	D	Motors/Pumps	I	Process & Industrial equipment: fan-units, boilers, compressors, pumps	Possible
60-62	D	Other	C	Commercial Catering Equipment	Possible
63-65	C	Lighting	R	Phase-out of halogen lamps	In train

Table notes: The year nominated for each program was as originally proposed by E3, actual implementation dates may have changed for programs in the process of implementation. Sectors are R = Residential, C = Commercial, I = Industrial, HW: Hot water, T = Transformer. See text for more detailed explanation of category and sector. Cells in grey indicate change of program status since 2019.

Changes in past year

The impact estimates for the programs in Table 19 have changed since our previous report to AEMO (SPR 2019). The overall adjustment is relatively minor. The reasons for the changes are covered in the following sections.

Table 19: Programs with status and/or impact estimates changed since 2019

Program #	Program Description	Adjustment
22-24	Water heaters	Retain status D Delay impacts by 1 year
30	Swimming pool pump-units labelling and MEPS (projected to start FY 2021)(b)	Retain status C. Delay impacts by 1 year
35A, 47	Air conditioners – Res MEPS 2021 (a)	Status change from C to A. Same impact projections
35C	Air conditioners – Non-Res MEPS 2022 (a)	Status change from C to A. Same impact projections
38	Motors – MEPS 2017	Change status from EF to A
39	Household Refrigerators & Freezers - MEPS 2021 (a)	Status change from C to A. Same impact projections
42	Commercial refrigeration – MEPS 2021 (a)	Status change from C to A. Same impact projections
56-59	Process & Industrial Equipment Fan-units	Change status from C to D. Delay impacts by 2 years
55	Additional Commercial Refrigeration equipment	Change status from EF to D Reduce impact projections (ice-makers only)
56-59	Process & Industrial Equipment Fan-units, boilers, compressors & pumps	Change status from C to D. Delay impacts by 2 years
60-62	Commercial Catering Equipment	Change status from EF to D
26, 27, 35B,42A,42B	All Programs with EF status	Delay impacts to begin FY2023 earliest possible implementation

(a) New GEMS Determination published since SPR (2019).

(b) New Draft GEMS Determination published since SPR (2019).

Post-implementation indicators

Full impact evaluations of E3 measures after they have been in place for some years, as distinct from projections, are rare. Only two have been done, for refrigerators and freezers (Harrington & Lane 2010) and for residential air conditioners (EnergyConsult 2010). These indicated that the prior impact estimates were conservative, which lead to the subsequent upward revision of impact estimates (E3 2011).

However, one indicator of program effectiveness is compliance by suppliers. If suppliers do not register products, there is no way of checking whether they comply with the required MEPS. In addition, if a significant share of products remains unlabelled, consumers will find it harder to exercise preference for more efficient models.

Table 20 summarises the share of residential product models found to be unregistered in random store surveys. Non-registration rates have been low for whitegoods and air conditioners but creeping up in recent surveys. The non-registration rates for televisions and computer monitors have fallen in recent years. CFLs have not been surveyed since 2013, but in any case their share of the lighting market is rapidly giving way to LEDs.

Table 20: Registration non-compliance rates, selected products

Products	% of models without valid registration						
	2013	2015-16	2016-17	2017	2017-18	2018-19	2019-20
Refrigerators & freezers	NS	3.0%	3.2%	2.6%	2.4%	3.4%	4.1%
Clothes washers (a)	NS	0.8%	1.7%	3.9%	1.1%	1.0%	1.6%
Clothes dryers	NS	0.8%	1.0%	0%	0.6%	2.6%	1.1%
Dishwashers	NS	5.2%	1.9%	2.7%	2.1%	1.4%	4.9%
Whitegoods (all of above)	NS	2.4%	2.2%	2.6%	1.8%	2.4%	3.4%
Televisions	NS	0%	1.7%	1.2%	2.8%	0.7%	0%
Computer monitors	NS	16.7%	13.7%	4.2%	7.3%	6.2%	5.0%
Air conditioners	NS	3.2%	7.0%	0%	2.8%	1.4%	7.1%
Compact Fluoro Lamps	22.4%	NA	NA	NA	NA	NA	NA
Linear fluorescent lamps	16.0%	NA	NA	NA	NA	NA	NA
Incandescent lamps	26.8%	NA	NA	NA	NA	NA	NA
Number of units examined	1,203	2,768	3,591	416	4,337	8,499	1,715

Sources: Australian Refrigeration Council (2009), E3 (2013a), Department of the Environment and Energy (2016, 2018a, 2018b), GEMS (2018), GEM (2019c), GEMS (2020a). Notes: NS = Not surveyed this year. NSR = Not separately reported. (a) Includes washer-dryers.

Table 21 shows the share of displayed products that were correctly labelled. The ratio has been steady or improving for most products, and markedly so in the case of televisions and computer monitors. This may reflect a more effective approach to compliance monitoring and enforcement by the GEMS Regulator.

Table 21: Labelling compliance rates, selected products

	% of models correctly labelled				
Products	2015-16	2016-17	2017	2018-19	2019-20
Refrigerators & freezers	95%	86%	90%	95%	96%
Clothes washers (a)	97%	94%	85%	98%	99%
Clothes dryers	95%	88%	94%	97%	98%
Dishwashers	92%	83%	77%	95%	96%
Whitegoods (all of above)	92%	87%	88%	96%	97%

Televisions	61%	48%	55%	87%	91%
Computer monitors	35%	37%	83%	81%	78%
Air conditioners	93%	74%	82%	82%	88%
Number of units examined	2,347	3,367	423	32,970	14,231

Sources: As for 18

Key end uses

- ***Televisions and image processing***

Televisions were first subject to energy labelling in 2009 and MEPS in 2010 (Program 6). Products are tested and labelled in accordance with AS/NZS 62087. This was the first use of the additional 7 to 10 star 'super-efficient coronet' option on the label. The rate of increase in efficiency was so rapid (most likely due to underestimates of technical developments already under way) that the scheme was revised in 2013 (Program 40). The label scales were changed so that a product with the same level of efficiency scored three fewer stars, and the MEPS levels were made more stringent (the so-called 'Tier 2' MEPS, equal to the original four-star line).

The introduction of MEPS and energy labelling coincided with major changes in the TV market:

- The phase-out of cathode ray tube (CRT) models in favour of flat screen technologies, hastened by the end of analogue broadcasting, a fall in new model costs due to the high Australian dollar and sustained growth in household disposable incomes;
- The trend toward the most efficient category of flat screen products (i.e. LCD/LED);
- Lower standby power consumption;
- The availability of alternative screens (e.g. tablets, computer screens and games consoles) for some forms of home entertainment, possibly reducing the viewing hours for televisions;
- The trend to larger screen sizes, which partly counteracted the energy savings from the other factors. Between 2014 and 2018, the average screen size of the models on the market (i.e. all models on the register in those years, irrespective of year of registration) increased by 22% while energy intensity (W per cm2) fell by 41%.

Some of the apparent reduction in energy intensity would have been due to the increase in screen size, since the fixed energy of tuners etc. is distributed across a greater screen area, and some to technical improvement. Most of the improvement in efficiency has been taken up in greater screen size and the transition to higher definition image quality – the model-weighted energy use (on the label cycle) fell by only 8.5%, from 317 to 290 kWh/year.

All televisions are imported, so technical improvements under way in the global market would most likely have found their way to Australia in any case. The extent to which the process was accelerated by the impact of E3 programs on suppliers (who would have been motivated to import more efficient products than otherwise) and on consumers (who would have been motivated to prefer the more efficient of what was on the market) is uncertain.

It was widely acknowledged that the energy saving projections in the original 2009 RIS were significantly over-estimated, and the later E3 projections (E3 2014a) use significantly lower impact projections than in the RIS. The relatively low early compliance rates for television energy labelling in Table 4 indicates that the assumption of a reduced impact was justified. Energy labelling programs tend to have a higher impact at the beginning, when differences between models are greatest, but the window of opportunity may have been compromised by low labelling rates, even though they have improved markedly since.

The trend to larger screen sizes may saturate, since viewing distance from the screen is partly limited by room dimensions. The average floor area of new houses appears to have reached a limit and more households are living in apartments. On the other hand, higher screen resolution technologies such as 8K, require more energy, so if take-up increases, then the rate of energy growth may be steeper. Whether this could be counteracted by increasing MEPS and raising the effectiveness of energy labelling is a matter for government. Many new televisions have automatic brightness control (ABC) which changes the screen brightness according to illuminance levels on the room. This can reduce energy consumption by as much as 50% during the evening in normal use. However, the test method to assess this technology for energy labelling has not yet been implemented and no energy saving estimates for ABC have been modelled.

DISER has advised that it intends to review the Australian test methods for televisions, and this may in due course lead to revisions of the MEPS and labelling rules. For the time being, however, it is not possible to speculate on the impacts.

The traditional image transmission pathways used to be free-to-air broadcast (terrestrial and satellite), subscription (cable and satellite) and image recording and play back media (videotapes and then DVDs). These involve other devices connected to the television, each with its own energy demand. Internet streaming has now become another common pathway.

Ownership of image recording and playback devices (video cassette recorders and DVD players) is nearly universal, but actual use has fallen away with the collapse of the video rental and sales industry (although most homes retain them to play legacy collections of media). Subscription services such as Foxtel supply subscription set top boxes (SSTBs) which process and decode the provider's signals (whether delivered by coaxial cable, copper or satellite) and have program storage and playback capability. The last few years has seen rapid growth in the number of internet-based "streaming" services such as Netflix which use the home's router to communicate with software embedded in so-called "smart" TVs, and do not require SSTBs. Even so, a handful of new SSTB models continue to be registered with GEMS each year.

In June 2020, the oldest remaining traditional pay TV service (Foxtel) had around 2.46 million subscribers down from a peak of about 2.8 million in 2016. It was estimated that Netflix, the largest streaming service, had 5.3 million Australian subscribers in January 2020. Many households subscribe to more than one service.

Free-to-air set top boxes (FTA STBs) were introduced in 2010 to enable older televisions with analogue signal tuners to receive digital signals during the transition to digital-only broadcasting. The last analogue signal was switched off at the end of 2013. The changeover was accompanied by the introduction of flat-screen televisions with integrated digital tuners, so the number of FTA STBs in use is falling as old CRT televisions are replaced. FTA STBs are effectively obsolete in Australia, although some new models are still registered for the New Zealand market.

- ***Air conditioners and Chillers***

Air conditioners have been energy labelled since 1987. The first MEPS were phased in between October 2004 and increased between April 2006 and October 2007 (different product types on different dates). The energy label was regraded in 2010 and MEPS were applied to the heating function (E3 2008a, 2009c) and expanded to non-operating (standby) energy. The energy label scale was also changed to permit up to 10 stars to be displayed (E3 2011). Between April 2010 and October 2011, MEPS were increased again in several steps.

Another group of changes was proposed in 2016 (E3 2016a). These included:

- Basing MEPS for products up to 30kW cooling capacity on Seasonal Energy Efficiency Ratings (SEER) rather than on fixed rating points
- Replacing the existing energy label design with a climate-zoned energy label
- Including portable units in the scheme for the first time
- Extending the scheme to air conditioners of greater than 65kW cooling capacity
- Increasing the MEPS levels for chillers and adding smaller chillers (<350 kW) to the scheme.

These measures were delayed pending further consultations with industry. A set of revised proposals was published in late 2016 (E3 2016b), and a Decision RIS was published in 2018 (E3 2018a). The Decision RIS also included lower estimates of the impacts of the 2011 MEPS. A final GEMS Determination was published in 2019 (GEMS 2019).

The final Determination modified the original proposals in a number of ways, including the removal of chillers pending further consultation. No date has been set for resuming the chiller program, so its “possible” status has been retained.

- ***Lighting***

The first E3 lighting programs targeted fluorescent lighting technologies. MEPS for ballasts were introduced in 2001 (E3 2001) and efficacy standards for linear fluorescent lamps (LFLs) were implemented in 2004, The latter led to the exclusion of all LFLs other than tri-phosphor types. The energy saving estimates assume that some of the initial benefits of higher efficacy LFLs were taken as greater light output, because when existing fittings are re-lamped, a brighter LFL is substituted for another of the same wattage. As new lighting installations are installed over time, the luminaire spacing can be increased, so reducing the energy density per unit of floor area.

The second round of lighting programs targeted single-socket GLS lamps, with the aim of phasing out tungsten filament lamps (E3 2008b). Part of this strategy was based on encouraging the adoption of compact fluorescent lamps (CFLs), which were also heavily promoted by State programs.

In addition, the energy use of multiple downlighting installations was targeted though the introduction of MEPS for low voltage (LV) transformers under AS/NZS4879.2. Both CFLs and LV halogen downlights have now been substantially displaced from the market by LEDs. There is considerable uncertainty about both the attribution and persistence of energy savings associated with the displacement of incandescent lamps by CFLs, especially as CFLs were themselves are being rapidly displaced by LEDs in accordance with global technology trends.

In the latest RIS for lighting (E3 2018c), there are no measures targeting fluorescent lamp technologies, because suppliers have switched development efforts to LEDs, which are coming to dominate the commercial lighting market even more than the residential. The ballasts market has largely changed from ferromagnetic to electronic designs, which are inherently more energy-efficient. Very few CFL, ballast and or linear fluorescent lamp models are being registered each year.

The latest RIS proposals are to introduce MEPS for LED lamps (harmonised with European standards) and to increase the MEPS levels for incandescent lamps (of the configurations still permitted to be imported, including halogen lamps). It is questionable to what extent such measures would reduce lighting energy use below the BAU trend.

The uncertainties regarding lighting programs have been addressed in modelling by allowing separate discount factors to be set for each lighting program. The effect of excluding all lighting program impacts (i.e. setting the discount factors to 100%) is to reduce the projected savings from all GEMS programs, in the neutral scenario, from 32,581 to 27,363 GWh/yr in 2041. In reality the reduction is likely to be significantly less than this.

- ***Household refrigerators***

Energy labelling for refrigerators and freezers was introduced in NSW and Victoria in 1986 and nationally in 1992. Revisions of the energy labelling algorithm led to re-scaling of the labels in 2000 and again in 2010. MEPS were first introduced in October 1999 and made more stringent again in 2005, to match US 2001 MEPS levels. Program 1 covers all measures from 1986 to 2005. The MEPS definitions were adjusted in 2010, but this did not increase their stringency.

By 2017, the average energy consumption (kWh per year) of refrigerators and freezers was about 52% of the 1993 levels (E3 2017c). Given that average volumes had increased, the average energy efficiency (kWh per adjusted litre) had increased by over 80% (Energy Efficient Strategies 2016). Nearly all of this improvement occurred between 1996 and 2005, coinciding with MEPS changes.

Proposals to increase Australian MEPS levels again, to match those announced for the US in 2014, were first discussed by E3 in 2011, with the aim of introducing them in 2015 (Harrington & Brown 2012). The planned implementation (Program 39) was later delayed to 2017. In 2017 E3 published a Consultation RIS (E3 2017d) and then a Decision RIS (E3 2017c), which COAG Energy Council accepted. It was eventually implemented in 2021, following the publication of a final Determination in 2019 (GEMS 2019b). However, the Decision RIS, which used the latest data, found that Australian suppliers responded to the 2012 announcement and that average efficiency was already increasing at the same rate as if implementation had occurred in 2015 as originally planned.

- ***Commercial refrigeration***

Australia and New Zealand introduced MEPS and high efficiency performance standards (HEPS) for refrigerated display cabinets in 2004, as specified in AS1731. The potential for further measures was investigated by the E3 Committee in 2009, in 2013 (E3 2013b) and then again in 2017 (E3 2017e). The options included more stringent MEPS levels and alignment of the AS1731 test standards with ISO23953, which were in draft at the time (this was published in 2015, so removing one potential barrier to implementing new measures).

A guide to the proposals published in 2018 (GEMS 2018a) confirmed that they were essentially unchanged. A final GEMS Determination was been published in 2020 (GEMS 2020b), with that implementation to take effect in 2021.

Further programs for commercial refrigeration have been proposed (42A and 55 in Table 1) and cost-benefit modelling has been undertaken for one specific product, commercial ice makers. These are now included in the projections as a “possible” (Category D).

- ***Swimming Pool Pumps***

There are three main technology groups on the market – singe-speed, dual/multi-speed and variable-speed. Variable speed pumps as a group are the most energy-efficient, since they can adapt flow rates as required and use the lowest pump speed for each situation. However, single-speed pumps are much cheaper to buy and are preferred by price-sensitive buyers, even if their lifetime costs are higher. There is a range in efficiency within each pump type, so it is not necessary to force buyers to a more expensive type to make energy savings.

In April 2010, E3 introduced a voluntary energy labelling scheme in order to motivate buyers to prefer more efficient models. This was only a limited success, since suppliers chose to label only their most efficient models. There is a 10 star rating scale (the basic 6 plus up to 4 more for a ‘super-efficient’ model). As is usual with voluntary programs, suppliers chose to label their more efficient models only. DEE estimated that the models registered for the voluntary labelling scheme made up about a quarter of all pump-units sold (E3 2016c). This left the majority of the market untouched by energy efficiency measures.

E3 first proposed MEPS and mandatory energy labelling for pumps in 2010, but the project was shelved in 2013. It was revived, with the publication of Consultation RIS in late 2016 (E3 2016c) and then a Decision RIS in 2018 (E3 2018b). The modelling in the Decision RIS projected higher energy savings than in the Consultation RIS. A draft GEMS Determination was published in 2020 (GEMS 2020) indicating that the project is in train.

- ***Water Heating***

E3 has not implemented any new measures for water heaters using electricity since 2005, when the MEPS recommended for small water heaters in 1996 were finally implemented and heat exchange systems were included in the scope. There was some activity in 2013, with the publication of Consultation RISs proposing MEPS for heat pump water heaters (E3 2013c) and more stringent heat loss MEPS for all tanks used in electric systems (E3 2013d). In 2014, E3 published a product profile raising the possibility of MEPS or labelling for solar water heaters, covering the efficiency of collectors and circulation pumps (E3 2014b).

These programs were all suspended following the change of federal government in 2013. In 2018 however, E3 published a ''Policy Framework'' (E3 2018) for water heaters. This introduced a set of "principles, including:

- Moving all water heater types to a "new method of testing that is technology neutral, to enable direct and fair comparisons between technologies, and to make it possible to develop a technology neutral MEPS in future"
- Implementing energy efficiency measures (MEPS and labelling) across all hot water technologies.

The Policy Framework included some preliminary impact estimates, which were less than half the estimates included for new water heater measures (programs 22 and 23 in Table 1). These have been adjusted downward accordingly. Given the delays, the first feasible year of impact would be FY 2022, and that would depend on GEMS Determinations in 2021.

The Federal government operates the Small-scale Renewable Energy Scheme, which allows users to earn Small Scale Technology Certificates (SSTCs, also called Renewable Energy Certificates or RECs) when a solar water heater or heat pump water heater is installed. RECs are a tradeable item that can be sold. This is part of the national Renewable Energy Target (RET). ACT and NSW have requirements under their local regulations (BASIX in NSW and BCA in the ACT) that restrict the type of water heater that can be installed in a new residential dwelling, so SSTCs are not always additional relative to the base case. The operation of these schemes is factored into the base case for water heating.

- ***Industrial Equipment***

The specific products under consideration for Program 56-59 are fan-units, boilers, compressors and pump-units.

A fan-unit is the combination of an electric motor and a fan or impeller, intended for the purpose of moving air. There is a vast range of sizes and capacities on the market, from a few watts (e.g. for circulating cold air in domestic frost-free refrigerators) to hundreds of kW (e.g. for moving air through the HVAC ducts of large buildings).

The energy efficiency of a fan-unit is the ratio of the power output from the fan to the electrical power input of the motor driving the fan. The energy efficiency of a fan-unit varies over its operating range, defined by the air pressure against which the fan operates and the air flow rate.

As with electric motors, fan-units are a basic component of many types of industrial equipment and domestic appliances. This complicates the supply chain, as the fan-unit manufacturer or importer may supply to either an original equipment manufacturer (OEM), an installer, an assembler or (more rarely) direct to the end user.

If the fan-unit is powered by a 3-phase cage-induction electric motor with output in the range 0.73 kW to 185 kW, then the motor is already subject to MEPS. However, this does not guarantee the performance of the fan-unit as a whole if the fan and its housing are poorly designed. Conversely, many fan-units are installed in products that are themselves subject to MEPS, such as packaged air conditioners.

Fan-unit energy was analysed in detail in a 2017 Consultation RIS (E3 2017). The proposals were:

- No energy efficiency regulation for fan-units incorporated into products whose overall performance is subject to MEPS (currently, only air conditioners are in this category);
- Fan-units incorporated into all other products (except gas ducted heaters) would be subject to MEPS (provided the motor has an output power of 0.125 to 185 kW);
- Fan-units sold as individual units would not be subject to MEPS;
- MEPS would not be applied to fan-units incorporated into gas ducted heaters. These products would be required to carry an electrical energy rating label. The electricity consumption reported on the label, and used to derive the rating, is largely determined by the energy use of the main air circulation fan.

There would some energy savings impact on the residential sector through MEPS for fan-units in evaporative coolers, and energy labelling (not MEPS) for fan-units in ducted gas heaters. There would also be some use of larger fans in manufacturing, mining and other industrial applications. However, the great majority of the impact is expected to be in the commercial sector (building HVAC and cold storage).

There is no new information on this program, but given the passage of time, the earliest feasible implementation date has slipped to FY2023.

In 2020, E3 published “Technical Discussion Papers” for industrial pumps, air compressors and boilers. These documents were less detailed than traditional Product Profiles, so represent an early phase of program development. Pumps and compressors are motor-driven, so the same double-regulation and double-counting issues would apply as for fan-units. Any boiler measures would mainly impact on fuel-using boilers, although apparently there are also some electric boilers on the market.

- *Electric Motors*

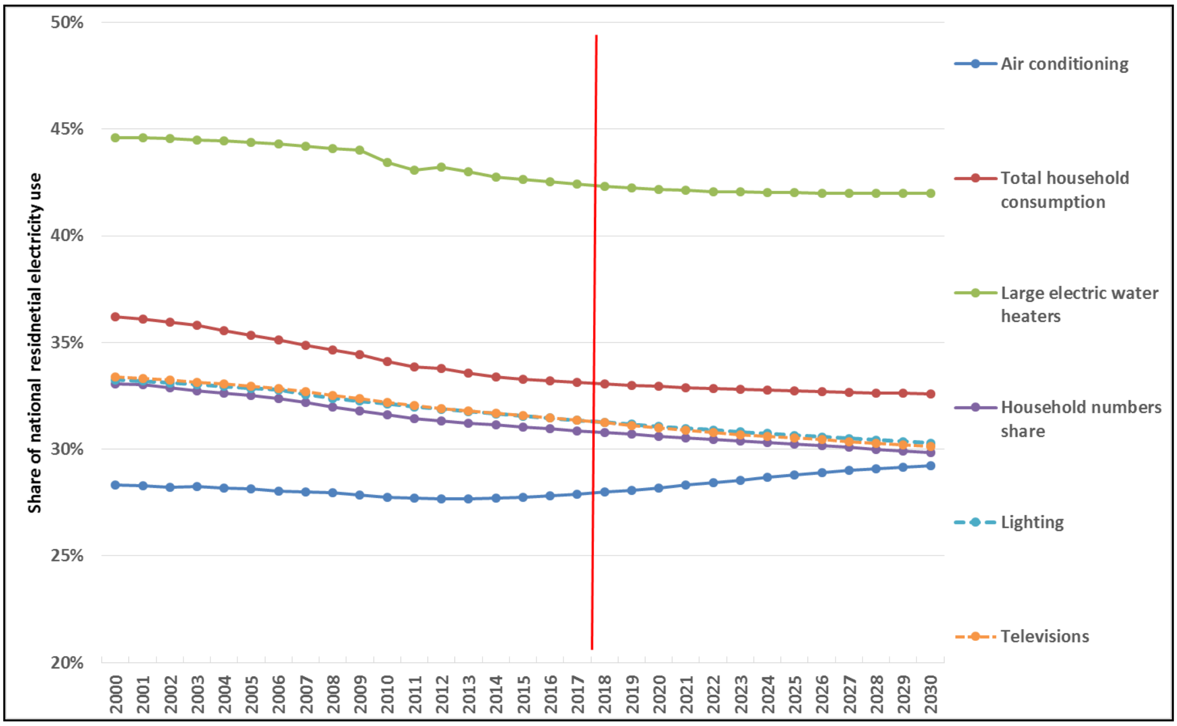
The proposed changes in MEPS levels (program 38) were previously classified as in train, but with the publication of a Final GEMS determination (GEMS 2019a) they have been reclassified as implemented.

Allocation and Extension of National Projections

This section reviews the factors used to allocate the national E3 impact projections to States and Territories. The share of residential end use energy allocated each depends on the pattern of appliance ownership. For example, electric storage water heating is more common in NSW than in some other states, where gas water heating is more common. Therefore, the energy savings of E3 measures impacting electric storage water heaters will flow disproportionately to NSW.

The latest projections of household electricity use published by E3 (EnergyConsult 2015) break down national electricity use by end use and by State and Territory for each year of the projections. These shares have been used to allocate projected energy savings to NSW, on the assumption that the impact of E3 measures in each jurisdiction is proportional to the energy use in that jurisdiction by the targeted products. As an example, the percentage of national residential product electricity savings allocated to one jurisdiction (NSW) are illustrated in Figure 90.

Figure 90: NSW allocation shares for residential electricity use and key end uses



We have investigated the latest Australian Energy Statistics published by the Department of Industry, Innovation and Science (DISER 2020). Although the department no longer publishes detailed projections of energy end use, the historical data are broken down by economic sector and State/Territory and this provides a basis for allocating non-residential emissions. The latest data are for 2018-19.

The national energy statistics combine NSW and ACT data (unlike the residential sector data in the residential baseline study, which disaggregate NSW and ACT). It is assumed that commercial sector electricity use is allocated to NSW and ACT by relative population shares. According to the 2016 census, NSW accounted for 95.0% of the combined NSW+ACT population. Th ACT's share of industrial energy use is assumed to be significantly less.

The final allocation factors for non-residential electricity savings are shown in Table 5.

Table 22: Allocation Factors for electricity saved by commercial and industrial product programs

	Comm	Industrial	Res (a)	Other	Total	Total use	Previous
NSW	29.9%	22.3%	34.8%	25.7%	29.2%	27.8%	28.1%
ACT	1.9%	0.2%	1.9%	1.0%	0.1%	1.2%	1.2%
NT	2.3%	2.3%	0.7%	0.5%	1.7%	1.8%	1.2%
QLD	22.3%	28.3%	20.0%	24.2%	24.7%	24.3%	24.9%
SA	6.4%	4.2%	7.9%	6.8%	5.9%	5.9%	6.0%
TAS	3.1%	6.9%	3.8%	1.6%	4.5%	4.8%	4.9%
VIC	26.0%	11.2%	18.5%	17.3%	18.1%	17.5%	17.4%
WA	8.1%	24.6%	12.5%	22.9%	15.9%	16.8%	16.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Derived from DISER (2020) (a) For information only –historical breakdown of residential electricity use in 2018-19. Residential product impact projections using the factors in EnergyConsult (2015).

E3 References

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E3 (2018c) Decision regulation impact statement: Lighting, 2018

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E3 (2020b) Industrial Pumps: Technical Discussion Paper

GEMS (2018) Market Surveillance Results: July 2017 To June 2018, GEMS Regulator

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GEMS (2018g) Greenhouse and Energy Minimum Standards (Household Refrigerating Appliances) Determination Exposure Draft September 2018

GEMS (2018h) Greenhouse and Energy Minimum Standards (Refrigerated Cabinets) Determination Exposure Draft November 2018

GEMS (2019) Greenhouse and Energy Minimum Standards (Air Conditioners up to 65kW) Determination 2019

GEMS (2019a) Greenhouse and Energy Minimum Standards (Three-phase Cage Induction Motors) Determination 2019

GEMS (2019b) Greenhouse and Energy Minimum Standards (Household Refrigerated Appliances) Determination 2019

GEMS (2019c) Market Surveillance Results: July 2018 to June 2019, GEMS Regulator

GEMS (2020) Greenhouse and Energy Minimum Standards (Swimming Pool Pump-Units) Exposure Draft Determination 2020

GEMS (2020a) Market Surveillance Results: July 2019 to June 2020, GEMS Regulator

GEMS (2020b) Greenhouse and Energy Minimum Standards (Refrigerated Cabinets) Determination 2020

Appendix B – Summary of discounts applied to reported energy efficiency savings

Table 23: Summary of discounts applied to energy efficiency savings

Parameter/Measure	Sector	Discounts Applied	Notes/Rationale
Thermal load 'utilisation factors'	Residential	50% - 60%, depending upon the jurisdiction	Constraint factors better represent real-world space conditioning behaviours. Values by jurisdiction are derived experimentally, balancing modelled and actual energy consumption in the historical period.
Autonomous energy efficiency improvement (AEEI)	Residential	AEE! 0.3% per annum for all Scenarios, except for Export Super Power and Rapid Decarbonisation where the BAU AEEI rate increased by 10% for the period FY2014-32 and maintained at 5% above BAU for the remainder of the projection period.	Reviewed past literature and also tested historical model fit. These values are uncertain and ideally would be derived using a bottom-up methodology by end-use. AEEI represents 'background' levels of tech change and innovation not explicitly captured in modelling of specific measures.
Residential energy efficiency policy measures	Residential	All measures are discounted for AEEI, as above – with additional discounts in specific cases, as noted below.	Program reporting generally does not estimate the extent to which savings reported may have happened without the program in place. To determine the 'additional' savings attributable to each measure, reported savings must be discounted for non-additionality to AEEI (noting that AEEI is separately accounted for, and there must not be double-counted).
Greenhouse and Energy Minimum Standards (GEMS) - lighting	Residential/ BMM	Lighting measures (10A – 11B, fluorescent lamps and ballasts): 50%; and 12, tri-phosphor lamps: 80%; and 36/37 (LED lamps): 25%; 63-65 (halogens): 25%.[40]	Reflecting limited sales of these equipment types, following rise of LED lamps in particular. LED lamps are also discounted due to an expectation of rising efficiency of this lamp type under BAU conditions.
AEEI	BMM	0.1% per annum as reference rate in historical period (cf 0.4% in other studies); from FY2022, Sustainable Growth increases to 0.15% per annum; and Export Superpower and	Lower rate (than other references) in historical period required to improve historical model fit – which we interpret as indicating behavioural and structural changes that have tended to push up energy intensity in this sector (Commercial) over at least the last decade. In

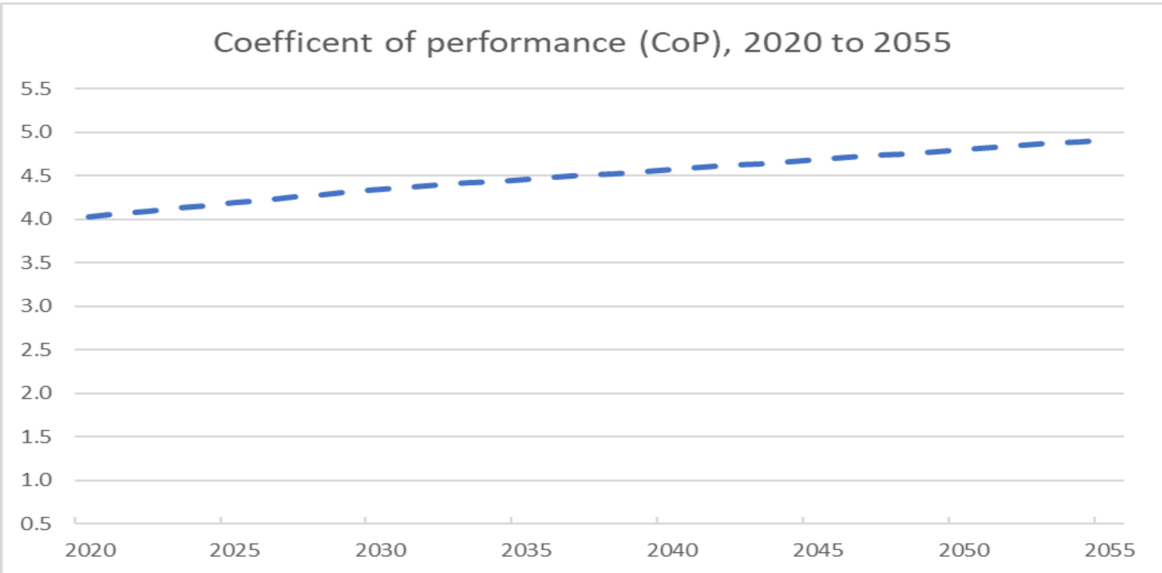
[40] See Appendix A for details of specific GEMS measures.

Parameter/Measure	Sector	Discounts Applied	Notes/Rationale
		Rapid Decarbonisation rise to 0.2% per annum.	future, we expect saturation of these factors (eg, increasing operating hours); also, in higher-ambition scenarios, faster market-led efficiency innovation.
BMM energy efficiency measures	BMM	For Slow Growth, Current Trajectory and Net Zero: 25% in FY2008, rising by 0.5% per annum; for Sustainable Growth, rising by 0.75% per annum from FY2022; for Export Superpower and Rapid Decarbonisation: rising by 1% per annum from FY2022. Where additional discounts are applied for specific measures, these are noted above (lighting) and below.	All efficiency measures in this sector are discounted for the extent to which reported savings are likely to include savings which would have occurred under BAU conditions. While the magnitude of this non-additionality is uncertain, and may vary from measure to measure, failure to apply such discounts would risk double-counting savings (from AEEI). In addition, these discounts are necessary to ensure model fit in the historical period. Ie, if savings were not discounted, this would imply lower energy consumption than actually occurred.
National Construction Code energy performance requirements (Section J) – non-realisation of modelled savings, or 'the performance gap'	BMM (Commercial)	25%, as a reference rate, but falling to 15% by FY2053 for Sustainable Growth and to 12.5% by FY2053 for Export Superpower and Rapid Decarbonisation.	Savings estimates are based on RIS estimates, which in turn draw on building simulations. In a manner *analogous* to the 'constraint factors' applied for residential, discounts are applied to non-residential savings to represent what is referred to in literature as the 'performance gap'. As noted in Chapter 3, this phenomenon is complex, uncertain in degree, and attributable to many unrelated effects. However, as with other factors applied, failure to apply a discount of 25% in the historical period leads to modelled historical energy consumption that is significantly lower than actual energy consumption. 25% was adopted in The CIE (2018) RIS for NCC2019 as the central estimate of the performance gap.
National Construction Code energy performance requirements (Section J) – non-additionality to GEMS	BMM (Commercial)	20%	Estimate of the extent to which energy savings from Section J (new construction work) may double-count savings from GEMS (ie, in building services covered by GEMS, including lighting, electric motors, pumps/fan drive systems, air conditioners, chillers).

Appendix C - Residential energy requirements in State specific climate zones

The following energy use estimates are based on NatHERS thermal comfort load requirements for different Australian areas, the contribution of different technologies to household heating and cooling (as indicated by the 2014 Residential Baseline Study), representative coefficients of performance (COP) for those technologies (ie. the amount of useful energy output relative to the amount of gas or electricity input) and the incidence of gas usage in different climate zones. This is based on a stock average COP of around 3.8 from around 2010. A COP improvement trajectory - shown in the figure below – is applied that reduces these energy requirements over time and applies to all new homes entering the building stock. We note that this is a conservative projection, and COP may in fact rise more quickly. If so, space conditioning energy consumption would be lower, other things being equal.

Figure C1: Assumed future energy efficiency of heat pump technology (electric heating & cooling)



Source: Australian Government, Department of the Environment (2020)

Further, NatHERS thermal load limits (MJ per square metre), refer to the energy needed to maintain comfortable conditions in living areas. The COPs of heating and cooling technologies will impact on the actual level of energy purchased in order to fulfil household comfort requirements. The implied electricity and gas consumption requirements needed to maintain comfort for households at various efficiency levels (ie. star ratings) are shown below. These underpin our NCC energy savings estimates. These energy consumption estimates are also discounted (on a state by state basis) to scale back NatHERS' implicit assumption of constant maintenance of comfort levels (ie. 24/7 conditioning in all living areas). 'Constraint factors' of between 45% and 55% are applied, depending upon the state.

Table C1: Estimated gas and electricity requirements by State climate zone and NatHERS Star rating level (ELECTRIC HEATING, MJ/sqm/year)

			Star Rating																			
State	Zone	Analogue	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
NSW	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSW	CZ2	Coffs Harbour	**42.4**	**34.4**	**27.9**	**22.7**	**18.6**	**15.3**	**12.8**	**10.8**	**9.4**	**8.2**	**7.3**	**6.5**	**5.8**	**5.0**	**4.3**	**3.6**	**2.8**	**2.2**	**1.6**	**1.0**
NSW	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSW	CZ4	Wagga	**149.2**	**123.0**	**101.7**	**84.4**	**70.5**	**59.6**	**50.6**	**43.6**	**37.8**	**33.0**	**28.9**	**25.4**	**21.9**	**18.6**	**15.2**	**11.9**	**8.7**	**5.6**	**2.8**	**0.6**
NSW	CZ5	Mascot	**65.3**	**52.7**	**42.7**	**34.5**	**28.0**	**23.2**	**19.3**	**16.3**	**13.9**	**12.2**	**10.8**	**9.5**	**8.3**	**7.2**	**5.9**	**4.8**	**3.7**	**2.6**	**1.7**	**0.9**
NSW	CZ6	Richmond (NSW)	**103.0**	**83.5**	**67.7**	**55.3**	**45.5**	**37.7**	**31.7**	**27.1**	**23.6**	**20.8**	**18.4**	**16.1**	**14.3**	**12.2**	**10.2**	**8.2**	**6.3**	**4.3**	**2.6**	**1.3**
NSW	CZ7	Orange	**214.5**	**178.8**	**149.7**	**126.0**	**106.7**	**91.3**	**78.7**	**68.5**	**60.1**	**52.9**	**46.4**	**40.6**	**35.1**	**29.5**	**24.1**	**18.7**	**13.4**	**8.5**	**4.1**	**0.4**
NSW	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ4	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ5	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ6	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ7	Canberra	**88.2**	**73.0**	**60.5**	**50.4**	**42.2**	**35.6**	**30.4**	**26.2**	**22.8**	**19.9**	**17.4**	**15.2**	**13.1**	**11.1**	**9.1**	**7.1**	**5.2**	**3.2**	**1.6**	**0.2**
ACT	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VIC	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VIC	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VIC	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

			Star Rating																			
State	Zone	Analogue	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
VIC	CZ4	Wagga	**149.2**	**123.0**	**101.7**	**84.4**	**70.5**	**59.6**	**50.6**	**43.6**	**37.8**	**33.0**	**28.9**	**25.4**	**21.9**	**18.6**	**15.2**	**11.9**	**8.7**	**5.6**	**2.8**	**0.6**
VIC	CZ5	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VIC	CZ6	Melbourne	**17.0**	**14.1**	**11.6**	**9.7**	**8.1**	**6.8**	**5.8**	**5.0**	**4.3**	**3.8**	**3.3**	**2.9**	**2.5**	**2.1**	**1.7**	**1.4**	**1.0**	**0.6**	**0.3**	**0.1**
VIC	CZ7	Ballarat	**26.3**	**22.0**	**18.5**	**15.6**	**13.2**	**11.3**	**9.7**	**8.4**	**7.4**	**6.5**	**5.7**	**5.0**	**4.3**	**3.6**	**2.9**	**2.3**	**1.7**	**1.1**	**0.5**	**0.1**
VIC	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QLD	CZ1	Cairns	**1.9**	**1.7**	**1.6**	**1.4**	**1.3**	**1.2**	**1.1**	**1.0**	**0.9**	**0.9**	**0.8**	**0.7**	**0.7**	**0.6**	**0.5**	**0.5**	**0.4**	**0.4**	**0.3**	**0.3**
QLD	CZ2	Brisbane	**55.0**	**45.6**	**37.5**	**31.2**	**26.0**	**21.8**	**18.6**	**15.9**	**13.9**	**12.3**	**10.8**	**9.7**	**8.5**	**7.6**	**6.7**	**5.6**	**4.7**	**3.8**	**2.9**	**2.2**
QLD	CZ3	Mt Isa	**55.2**	**47.1**	**40.5**	**35.1**	**30.6**	**26.9**	**23.9**	**21.3**	**19.1**	**17.3**	**15.5**	**13.8**	**12.2**	**10.6**	**9.1**	**7.6**	**6.1**	**4.6**	**3.4**	**2.4**
QLD	CZ4	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QLD	CZ5	Oakey	**136.1**	**109.7**	**88.4**	**71.8**	**58.9**	**48.8**	**41.2**	**35.4**	**30.9**	**27.5**	**24.4**	**21.9**	**19.4**	**16.8**	**14.0**	**11.5**	**8.7**	**6.2**	**3.9**	**2.2**
QLD	CZ6	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QLD	CZ7	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QLD	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ4	Oodnadatta	**96.5**	**80.1**	**66.7**	**55.7**	**46.8**	**39.5**	**33.7**	**29.0**	**25.1**	**21.9**	**19.1**	**16.7**	**14.6**	**12.5**	**10.4**	**8.3**	**6.3**	**4.4**	**2.6**	**1.1**
SA	CZ5	Adelaide	**94.6**	**77.7**	**63.8**	**52.6**	**43.7**	**36.8**	**31.1**	**26.7**	**23.2**	**20.2**	**17.6**	**15.5**	**13.4**	**11.3**	**9.4**	**7.4**	**5.3**	**3.6**	**1.8**	**0.5**
SA	CZ6	Mt Gambier	**137.5**	**113.7**	**94.2**	**78.4**	**65.6**	**55.2**	**47.0**	**40.5**	**35.0**	**30.6**	**26.7**	**23.3**	**20.1**	**17.0**	**13.9**	**10.8**	**7.8**	**5.0**	**2.4**	**0.2**
SA	CZ7	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WA	CZ1	Broome	**4.2**	**3.7**	**3.3**	**3.0**	**2.8**	**2.6**	**2.4**	**2.2**	**2.1**	**1.9**	**1.8**	**1.6**	**1.5**	**1.3**	**1.2**	**1.0**	**0.9**	**0.8**	**0.7**	**0.6**

			Star Rating																			
State	Zone	Analogue	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
WA	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WA	CZ3	Carnarvon	**17.9**	**15.5**	**13.4**	**11.7**	**10.3**	**9.0**	**7.9**	**7.0**	**6.2**	**5.6**	**5.0**	**4.5**	**4.0**	**3.5**	**3.1**	**2.6**	**2.3**	**1.9**	**1.5**	**1.2**
WA	CZ4	Geraldton	**62.9**	**51.3**	**42.0**	**34.4**	**28.5**	**23.8**	**20.2**	**17.3**	**14.9**	**13.1**	**11.5**	**10.3**	**9.0**	**7.7**	**6.5**	**5.2**	**4.0**	**2.9**	**1.8**	**0.9**
WA	CZ5	Perth	**87.0**	**69.7**	**56.0**	**45.2**	**36.7**	**30.1**	**25.0**	**21.3**	**18.4**	**16.0**	**14.2**	**12.6**	**11.0**	**9.4**	**7.9**	**6.1**	**4.5**	**3.1**	**1.6**	**0.7**
WA	CZ6	Manjimup	**123.7**	**101.8**	**83.7**	**69.2**	**57.3**	**47.9**	**40.3**	**34.4**	**29.5**	**25.8**	**22.3**	**19.5**	**16.7**	**14.2**	**11.7**	**9.2**	**6.8**	**4.3**	**2.2**	**0.4**
WA	CZ7	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WA	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ4	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ5	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ6	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ7	Hobart	**362.4**	**299.1**	**247.4**	**206.0**	**172.5**	**146.4**	**125.3**	**108.4**	**94.7**	**83.6**	**73.2**	**64.1**	**55.4**	**46.7**	**38.1**	**29.4**	**21.1**	**12.8**	**5.8**	**0.0**
TAS	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table C1 (cont'd): Estimated gas and electricity requirements by State climate zone and NatHERS Star rating level (ELECTRIC COOLING, MJ/sqm/year)

			Star Rating																			
State	Zone	Analogue	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
NSW	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSW	CZ2	Coffs Harbour	**81.6**	**66.2**	**53.6**	**43.6**	**35.6**	**29.4**	**24.5**	**20.8**	**18.0**	**15.7**	**14.0**	**12.5**	**11.1**	**9.7**	**8.3**	**6.8**	**5.4**	**4.3**	**3.1**	**2.0**
NSW	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSW	CZ4	Wagga	**229.3**	**189.1**	**156.3**	**129.7**	**108.4**	**91.5**	**77.8**	**67.0**	**58.2**	**50.8**	**44.5**	**39.1**	**33.6**	**28.5**	**23.4**	**18.2**	**13.4**	**8.6**	**4.3**	**0.9**
NSW	CZ5	Mascot	**100.4**	**81.0**	**65.6**	**53.0**	**43.1**	**35.6**	**29.7**	**25.1**	**21.4**	**18.8**	**16.5**	**14.5**	**12.8**	**11.1**	**9.1**	**7.4**	**5.7**	**4.0**	**2.6**	**1.4**
NSW	CZ6	Richmond (NSW)	**63.3**	**51.3**	**41.6**	**34.0**	**27.9**	**23.2**	**19.5**	**16.7**	**14.5**	**12.8**	**11.3**	**9.9**	**8.8**	**7.5**	**6.3**	**5.0**	**3.9**	**2.6**	**1.6**	**0.8**
NSW	CZ7	Orange	**49.4**	**41.2**	**34.5**	**29.0**	**24.6**	**21.0**	**18.1**	**15.8**	**13.9**	**12.2**	**10.7**	**9.4**	**8.1**	**6.8**	**5.6**	**4.3**	**3.1**	**2.0**	**0.9**	**0.1**
NSW	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ4	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ5	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ6	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ7	Canberra	**44.1**	**36.5**	**30.3**	**25.2**	**21.1**	**17.8**	**15.2**	**13.1**	**11.4**	**9.9**	**8.7**	**7.6**	**6.5**	**5.5**	**4.6**	**3.5**	**2.6**	**1.6**	**0.8**	**0.1**
ACT	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VIC	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VIC	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

			Star Rating																			
State	Zone	Analogue	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
VIC	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VIC	CZ4	Wagga	229.3	189.1	156.3	129.7	108.4	91.5	77.8	67.0	58.2	50.8	44.5	39.1	33.6	28.5	23.4	18.2	13.4	8.6	4.3	0.9
VIC	CZ5	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VIC	CZ6	Melbourne	84.0	69.4	57.4	47.7	39.9	33.7	28.6	24.6	21.2	18.5	16.3	14.2	12.2	10.3	8.4	6.7	4.8	3.1	1.6	0.2
VIC	CZ7	Ballarat	48.7	40.7	34.2	28.8	24.5	20.9	18.0	15.6	13.6	12.0	10.5	9.2	7.9	6.7	5.4	4.2	3.1	2.0	0.9	0.1
VIC	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QLD	CZ1	Cairns	91.4	83.6	76.4	70.1	64.3	59.3	54.6	50.1	46.3	42.4	38.8	35.5	32.4	29.1	26.0	23.3	20.5	17.7	15.5	13.3
QLD	CZ2	Brisbane	67.9	56.2	46.3	38.5	32.1	26.9	23.0	19.7	17.2	15.2	13.3	11.9	10.5	9.4	8.3	6.9	5.8	4.7	3.6	2.8
QLD	CZ3	Mt Isa	181.7	155.1	133.2	115.5	100.5	88.6	78.7	70.1	62.9	56.8	51.0	45.4	40.2	34.9	29.9	24.9	19.9	15.2	11.1	7.8
QLD	CZ4	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QLD	CZ5	Oakey	134.3	108.3	87.2	70.9	58.2	48.2	40.7	34.9	30.5	27.1	24.1	21.6	19.1	16.6	13.8	11.4	8.6	6.1	3.9	2.2
QLD	CZ6	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QLD	CZ7	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QLD	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ4	Oodnadatta	185.0	153.7	127.9	106.8	89.7	75.8	64.6	55.6	48.1	41.9	36.6	32.0	27.9	23.9	19.9	15.8	12.1	8.4	5.0	2.2
SA	CZ5	Adelaide	181.3	149.0	122.3	100.9	83.8	70.5	59.6	51.2	44.4	38.8	33.8	29.8	25.8	21.7	18.0	14.3	10.2	6.8	3.4	0.9
SA	CZ6	Mt Gambier	105.4	87.2	72.3	60.1	50.3	42.3	36.0	31.0	26.8	23.5	20.5	17.9	15.4	13.0	10.7	8.3	6.0	3.8	1.9	0.1
SA	CZ7	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

			Star Rating																			
State	Zone	Analogue	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
WA	CZ1	Broome	**228.8**	**203.8**	**182.9**	**166.0**	**151.9**	**140.0**	**130.0**	**121.0**	**112.5**	**104.7**	**96.9**	**89.1**	**81.3**	**73.1**	**65.0**	**56.9**	**49.1**	**41.9**	**35.9**	**30.9**
WA	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WA	CZ3	Carnarvon	**65.3**	**56.6**	**49.1**	**42.8**	**37.5**	**32.8**	**29.1**	**25.6**	**22.8**	**20.6**	**18.4**	**16.6**	**14.7**	**12.8**	**11.3**	**9.7**	**8.4**	**6.9**	**5.6**	**4.4**
WA	CZ4	Geraldton	**109.1**	**89.1**	**72.8**	**59.7**	**49.4**	**41.3**	**35.0**	**30.0**	**25.9**	**22.8**	**20.0**	**17.8**	**15.6**	**13.4**	**11.3**	**9.1**	**6.9**	**5.0**	**3.1**	**1.6**
WA	CZ5	Perth	**151.0**	**121.0**	**97.2**	**78.5**	**63.8**	**52.2**	**43.5**	**36.9**	**31.9**	**27.8**	**24.7**	**21.9**	**19.1**	**16.3**	**13.8**	**10.6**	**7.8**	**5.3**	**2.8**	**1.3**
WA	CZ6	Manjimup	**85.9**	**70.6**	**58.1**	**48.0**	**39.8**	**33.3**	**28.0**	**23.9**	**20.5**	**17.9**	**15.5**	**13.5**	**11.6**	**9.9**	**8.1**	**6.4**	**4.8**	**3.0**	**1.5**	**0.3**
WA	CZ7	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WA	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ4	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ5	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ6	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ7	Hobart	**34.8**	**28.7**	**23.7**	**19.8**	**16.6**	**14.1**	**12.0**	**10.4**	**9.1**	**8.0**	**7.0**	**6.2**	**5.3**	**4.5**	**3.7**	**2.8**	**2.0**	**1.2**	**0.6**	**0.0**
TAS	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table C1 (cont'd): Estimated gas and electricity requirements by State climate zone and NatHERS Star rating level (GAS HEATING, MJ/sqm/year)

			Star Rating																			
State	Zone	Analogue	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
NSW	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSW	CZ2	Coffs Harbour	**161.7**	**131.2**	**106.3**	**86.5**	**70.7**	**58.2**	**48.6**	**41.3**	**35.6**	**31.1**	**27.7**	**24.9**	**22.0**	**19.2**	**16.4**	**13.6**	**10.7**	**8.5**	**6.2**	**4.0**
NSW	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSW	CZ4	Wagga	**568.2**	**468.6**	**387.3**	**321.6**	**268.6**	**226.9**	**192.9**	**166.1**	**144.2**	**125.8**	**110.2**	**96.8**	**83.4**	**70.7**	**58.0**	**45.2**	**33.2**	**21.2**	**10.6**	**2.1**
NSW	CZ5	Mascot	**248.8**	**200.7**	**162.5**	**131.5**	**106.7**	**88.3**	**73.5**	**62.2**	**53.0**	**46.6**	**41.0**	**36.0**	**31.8**	**27.6**	**22.6**	**18.4**	**14.1**	**9.9**	**6.4**	**3.5**
NSW	CZ6	Richmond (NSW)	**392.2**	**318.0**	**258.0**	**210.6**	**173.1**	**143.5**	**120.8**	**103.2**	**89.8**	**79.2**	**70.0**	**61.5**	**54.4**	**46.6**	**38.9**	**31.1**	**24.0**	**16.3**	**9.9**	**4.9**
NSW	CZ7	Orange	**817.0**	**681.3**	**570.3**	**479.9**	**406.4**	**347.7**	**299.7**	**260.8**	**229.0**	**201.4**	**176.7**	**154.8**	**133.6**	**112.4**	**91.9**	**71.4**	**50.9**	**32.5**	**15.5**	**1.4**
NSW	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ4	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ5	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ6	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACT	CZ7	Canberra	**1229.1**	**1017.2**	**843.8**	**702.5**	**588.2**	**497.0**	**423.8**	**364.7**	**317.2**	**277.4**	**242.7**	**211.9**	**182.4**	**154.1**	**127.1**	**98.9**	**71.9**	**44.9**	**21.8**	**2.6**
ACT	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VIC	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VIC	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VIC	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

			Star Rating																			
State	Zone	Analogue	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
VIC	CZ4	Wagga	**568.2**	**468.6**	**387.3**	**321.6**	**268.6**	**226.9**	**192.9**	**166.1**	**144.2**	**125.8**	**110.2**	**96.8**	**83.4**	**70.7**	**58.0**	**45.2**	**33.2**	**21.2**	**10.6**	**2.1**
VIC	CZ5	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VIC	CZ6	Melbourne	**1000.6**	**827.4**	**683.8**	**568.4**	**475.1**	**401.1**	**340.4**	**293.1**	**253.1**	**220.5**	**193.9**	**168.7**	**145.1**	**122.9**	**100.7**	**79.9**	**57.7**	**37.0**	**19.2**	**3.0**
VIC	CZ7	Ballarat	**1546.8**	**1293.7**	**1086.4**	**914.7**	**777.1**	**663.1**	**571.3**	**495.9**	**433.7**	**380.4**	**333.0**	**291.6**	**250.1**	**211.7**	**173.2**	**134.7**	**97.7**	**62.2**	**29.6**	**3.0**
VIC	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QLD	CZ1	Cairns	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
QLD	CZ2	Brisbane	**1.1**	**0.9**	**0.7**	**0.6**	**0.5**	**0.4**	**0.4**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.0**
QLD	CZ3	Mt Isa	**1.1**	**0.9**	**0.8**	**0.7**	**0.6**	**0.5**	**0.5**	**0.4**	**0.4**	**0.3**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.0**
QLD	CZ4	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QLD	CZ5	Oakey	**2.6**	**2.1**	**1.7**	**1.4**	**1.1**	**0.9**	**0.8**	**0.7**	**0.6**	**0.5**	**0.5**	**0.4**	**0.4**	**0.3**	**0.3**	**0.2**	**0.2**	**0.1**	**0.1**	**0.0**
QLD	CZ6	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QLD	CZ7	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QLD	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ4	Oodnadatta	**389.4**	**323.4**	**269.2**	**224.8**	**188.8**	**159.4**	**135.9**	**116.9**	**101.3**	**88.2**	**77.1**	**67.3**	**58.8**	**50.3**	**41.8**	**33.3**	**25.5**	**17.6**	**10.5**	**4.6**
SA	CZ5	Adelaide	**381.6**	**313.6**	**257.4**	**212.3**	**176.4**	**148.3**	**125.4**	**107.8**	**93.4**	**81.7**	**71.2**	**62.7**	**54.2**	**45.7**	**37.9**	**30.1**	**21.6**	**14.4**	**7.2**	**2.0**
SA	CZ6	Mt Gambier	**554.7**	**458.7**	**380.3**	**316.2**	**264.6**	**222.8**	**189.5**	**163.3**	**141.1**	**123.5**	**107.8**	**94.1**	**81.0**	**68.6**	**56.2**	**43.8**	**31.4**	**20.3**	**9.8**	**0.7**
SA	CZ7	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SA	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WA	CZ1	Broome	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

			Star Rating																			
State	Zone	Analogue	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
WA	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WA	CZ3	Carnarvon	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
WA	CZ4	Geraldton	**171.1**	**139.7**	**114.2**	**93.7**	**77.5**	**64.7**	**54.9**	**47.1**	**40.7**	**35.8**	**31.4**	**27.9**	**24.5**	**21.1**	**17.7**	**14.2**	**10.8**	**7.8**	**4.9**	**2.5**
WA	CZ5	Perth	**236.8**	**189.8**	**152.5**	**123.1**	**100.0**	**81.9**	**68.2**	**57.9**	**50.0**	**43.6**	**38.7**	**34.3**	**29.9**	**25.5**	**21.6**	**16.7**	**12.3**	**8.3**	**4.4**	**2.0**
WA	CZ6	Manjimup	**336.9**	**277.0**	**228.0**	**188.3**	**155.9**	**130.4**	**109.8**	**93.7**	**80.4**	**70.1**	**60.8**	**53.0**	**45.6**	**38.7**	**31.9**	**25.0**	**18.6**	**11.8**	**5.9**	**1.0**
WA	CZ7	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WA	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ1	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ2	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ3	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ4	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ5	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ6	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAS	CZ7	Hobart	**33.8**	**27.9**	**23.1**	**19.2**	**16.1**	**13.6**	**11.7**	**10.1**	**8.8**	**7.8**	**6.8**	**6.0**	**5.2**	**4.4**	**3.5**	**2.7**	**2.0**	**1.2**	**0.5**	**0.0**
TAS	CZ8	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix D – Key residential assumptions

The following estimates underpin the heating and cooling energy performance of houses across Australian States and the savings generated as a result of minimum energy performance requirements under the National Construction Code (NCC). NCC requirements began in 2003, and were gradually adopted across jurisdictions.

Energy performance standards are specified according to NatHERS Star ratings. Typically, 2 years is allowed from the time a new standard is announcement until it becomes mandatory.

The NCC impact modelling is based on Star ratings that span 0.5 to 10 Stars, with increments of 0.5. At low Star ratings, the energy saving (eg. MWh per year) associated with a 1 Star increment is many times that achieved from a move from say, 7 to 8 Stars. For calibration purposes, in addition to attributing a representative average Star rating to a State housing stock, a further efficiency adjustment was also undertaken that effectively increased efficiency performance above the rated level. This makes allowance for a State housing stock with an average NCC rating depicted in the modelling as 1.5 Stars when, in fact, it is 1.7 or more.

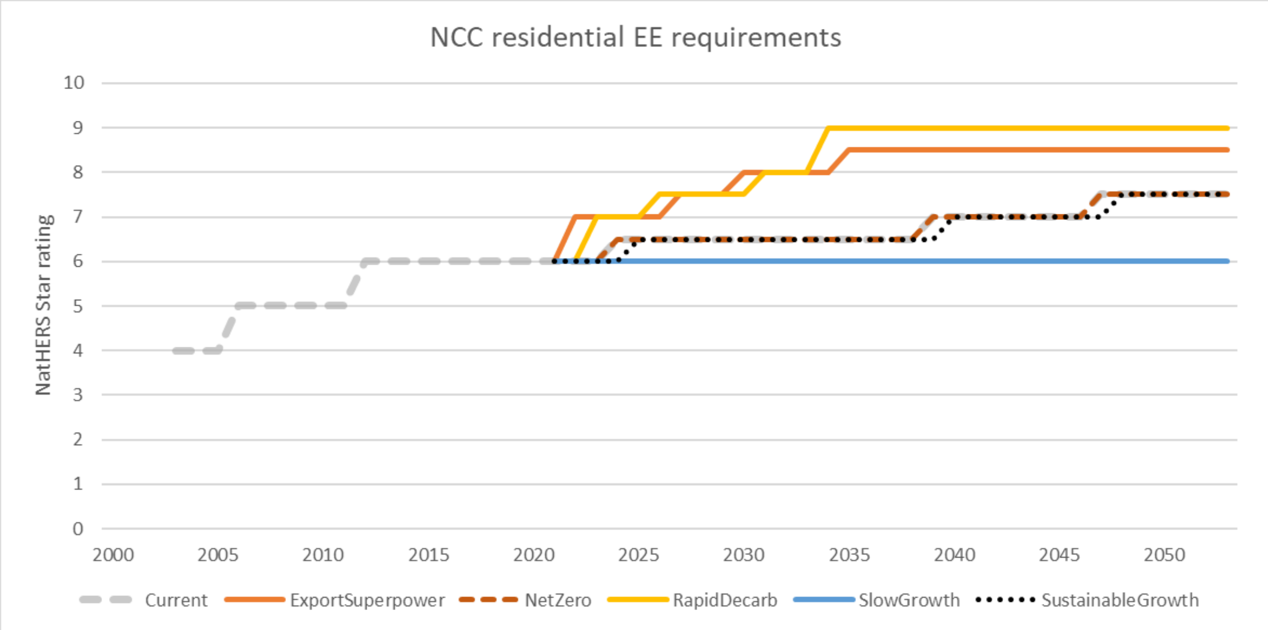
This adjustment factor is also shown in Table D1.

Table D1: Average NatHERS Star ratings at State level, pre-2003 stock characteristics

	WA	NSW	VIC	ACT	QLD	SA	TAS
Avg NatHERS Star rating of dwellings	1.5	1.0	1.5	1.5	1.0	2.0	2.0
Star rating adjustment factor	30%	35%	15%	35%	35%	25%	30%

NCC requirements have increased over time. Currently new Class 1ai, 1aii and Class 2 dwellings must be built to 6 Star energy performance standard or more. Increasing requirements are associated with each of the AEMO scenarios. The historical and future profile of these NCC requirements under each AEMO scenario is shown below.

Figure D1: Scenario depictions of future NCC energy efficiency requirements



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