Energy Efficiency Forecasts 2023 – Final Report

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Executive Summary

This report summarises and provides the background, assumptions and methodology for the 2023 energy efficiency forecasts. The forecasts are presented by sector, region, component type, fuel and end-use in Chapter 5. The study also compares the 2023 electricity savings forecasts to those prepared in 2021.

The report sets out the scope of the work undertaken and provides definitions of key terms and AEMO's market segments. It reviews recent policy changes, including revisions to the Safeguard Mechanism in April 2023 and the recent 2023 Federal Budget, noting that the latter is not directly quantified in these forecasts.

The report also discusses and interprets (from an energy efficiency perspective) each of AEMO's scenarios, which this year are:

- *Progressive Change*
- *Diverse Step Change*
- *Orchestrated Step Change*
- *Green Energy Exports*.

In addition, we undertake a '*Low Energy Efficiency*' or business-as-usual sensitivity analysis based on *Orchestrated Step Change* (only), which essentially projects expected outcomes if *Orchestrated Step Change* economic and activity outcomes occur, but today's policy and program settings are retained. This forecast may provide a useful 'business as usual' baseline against which the incremental effect of new measures or enhanced policy settings may be measured. We also describe how we map a set of policy and market-led efficiency assumptions to each scenario.

Key data sources drawn upon include:

- AEMO for some fuel consumption data and economic/activity forecasts by sector
- Australian Energy Statistics for fuel consumption data
- Direct data/modelling inputs from the Australian, New South Wales and Victorian governments
- Public domain data (eg, on efficiency policy and program impacts)
- The Australian Bureau of Statistics for housing data, and the 2022 Update to the Commercial Building Energy Consumption Baseline study for commercial buildings data.

In addition, discussions were held with a number of Australian Government and state agencies, to ascertain the latest data sources and assumptions. Of course, those agencies are not asked or able to endorse future policy assumptions.

Overall, the projections are reasonably consistent with those from 2021 and past years, noting that:

- The baseline for these projections has been shifted to FY2015, and the NT is included this year (which was not the case in 2021).
- While there have been some policy changes (such as the 2022 version of the National Construction Code, which introduced new residential energy performance requirements), these were partially anticipated in the 2021 forecasts (although the NCC2022 'whole-of-home' provisions were not).
- State energy savings schemes are treated somewhat differently – reflecting discussions with each of NSW, VIC and SA. The NSW Energy Savings Scheme (ESS) is assumed to continue to 2050, reflecting the nature of its underlying legislation, but the VIC Victorian Energy Upgrades (VEU) is here assumed to cease in 2025 – or to at least be reviewed and potentially reframed. This is because we project that continuation of the current emissions-based metric would lead to a rapidly rising requirement for energy savings (VEECs), driven by the falling emissions intensity of electricity in Victoria. The SA Retailer Energy Productivity Scheme (REPS) also has targets announced to 2025 but is currently legislated and assumed to cease in FY2030, subject to future government decisions.
- The Safeguard Mechanism was not modelled in previous years but is now included in all scenarios, following its extensive revision in April 2023. There is, however, considerable uncertainty about this scheme's future impacts, and this will merit careful review in the context of future forecasts.
- Market-led energy efficiency improvement in the commercial sector was not modelled in 2021, but is modelled in 2023, leading to the latter forecasts being larger due to this methodological change.
- Data available in the public domain still does not support quantification of market-led efficiency change in the industrial sector, as was also the case in 2021.

The forecasts note where electrification impacts are expected in association with energy efficiency measures, but it is not within our scope to model all expected electrification. Electrification is expected to be significant in many sectors, and notably with respect to the Safeguard Mechanism, where electrification impacts (not modelled) may exceed energy efficiency impacts (modelled). At the same time, fuel choices and rates of electrification are key differentiators of the expected *market-led* savings under the four scenarios. Broadly, in scenarios where market factors lead consumers to electrify, higher energy efficiency outcomes are expected, due to higher conversion efficiencies.

Finally in Chapter 6 we note a number of limitations to the current analysis, along with a number of important opportunities that would contribute to the outcome of improving confidence in energy efficiency and related forecasting over time.

1. Introduction

1.1 Purpose

The purpose of this Report is to:

1. Set out the historical analysis (from FY2015) and the energy efficiency forecasts (by scenario, sector, fuel, measure, end-use type, load segment and year) to FY2055.
2. Document the energy efficiency forecasting methodology, including:
   - Approaches to estimating market driven (or 'autonomous') energy efficiency improvement
   - Coverage of policy measures
   - Mapping of existing energy efficiency policy settings and potential new measures to AEMO scenarios
   - Discounts or other mechanisms to manage risks such as double-counting of savings, non-compliance, non-additionality and unrealised savings
   - Noting where datasets from external parties have been drawn upon to assist in improving the accuracy of the forecasts and/or the understanding of program impacts.

Chapter 2 analyses which policy measures are included in forecasts, while Chapter 3 presents our mapping of measures by scenario. Chapter 4 summarises our methodology, and the forecasts are presented in Chapter 5. Chapter 6 reflects on limitations in the data and/or analysis and potential opportunities for improvement in future.

1.2 Background

This project is being undertaken for the Australian Energy Market 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) for 2023 and 2024, while the work will also contribute to the 2024 Integrated System Plan. 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 scope of this project includes all NEM regions, together with WA (SWIS) and NT. The ACT is treated as part of the NSW Region, and WA forecasts are limited to the SWIS. By contrast, NT forecasts relate, in principle to the whole of the NT (although off-grid consumption/efficiency is not quantified in this project).

The scope includes electricity and natural gas (and potential renewable gases) in stationary applications except power generation, transmission and distribution. It does not include analysis of peak load impacts associated with energy efficiency policy changes.

Forecasts start from FY2022, as complete historical consumption data is not available for that year for all regions. Values before that year are either actuals (A) or estimated actuals (EA). The base year for analysis is FY2015. As a result, there are no energy efficiency savings recorded for that year, but only for subsequent years, measured relative to FY2015.

The broadest market categories covered are:

- RES (the residential sector)
- BUS (business – which essentially covers all-non-residential consumers). BUS comprises 'business mass market' (BMM) and 'large industrial loads' (LILs).

RES is generally well-identified by networks and meter data service providers, although there may be some cases where larger apartment buildings may be mis-classified as commercial due to the building's load characteristics.

BUS comprises two major sub-categories: COM (commercial) and IND (industry)

- COM is defined in line with 'commercial and services' in Australian Energy Statistics (AES); that is, ANZSIC Divisions F, G, H, J, K, L, M, N, O, P, Q, R and S and I (50 – 53 only (including warehouses)
- IND is defined in this context as ANZSIC Divisions A, B, C, D (other than power generation, transmission and distribution), E.

AEMO also segments BUS by enterprise (energy consumption or demand) size:

- Large Industrial Loads (LILs) have electrical demand > 10MW for more than 10% of the year, and/or gas consumption of at least 500 TJ at one or more sites. These enterprises are primarily found in IND but some also occur in COM (SA only).
- Business Mass Market represents non-residential customers that fall below the LIL thresholds and that do not use demand meters (for electricity). We also refer to this segment as small and medium-sized enterprises (SMEs).

Gas consumers have a different segmentation:

- Residential and small commercial consumers that consume < 10 TJ per year are classified as "TV"
- Medium and large commercial or industrial consumers that consume at least 10 TJ and that have demand meters installed are classified as "TD". TD is further segmented in LILS, with the balance being 'Aggregated'.

These forecasts pre-date the 2023 national Budget, which included some new energy efficiency measures. These are discussed in Section 2.5.

1.3.1 Electrification

The scope includes fuel switching/electrification that is attributable to efficiency policy measures, but not electrification overall. Assumptions regarding the background or market-led rates of electrification are provided by AEMO drawing on work by CSIRO and ClimateWorks in this area. This work does not, however, distinguish between fuel mix choices made by owners of new facilities/buildings/dwellings, as compared to decisions to retrofit existing ones. The context of a new investment provides a low- or no-incremental cost opportunity for electrification (or avoiding costs associated with gas connections and use), making electrification more probable as a market-led outcome. In the existing stock, electrification (of significant end-uses) may only occur at times of major refit or renovation. Overall electrification rates are therefore likely to represent an outcome of these two different components. As discussed in Chapter 4, we make separate assumptions for the fuel mix of new dwellings and buildings by scenario, on the one hand, and the average fuel mix, on the other.

In practice, the distinction between efficiency change and electrification is extremely fine. Most instances of electrification, or fuel switching, will have efficiency implications, and many but not all efficiency policy measures will have at least indirect impacts on fuel choice. The higher the rate of electrification, the faster we would expect energy efficiency to improve, due to the higher coefficient of performance (or specific energy intensity) of most electrical end-uses compared to gas equivalents. 5.2.2

Photovoltaic (PV) output is discussed further in Chapter 4 (Methodology). Change in PV output is not in the scope of this project, but is a necessary input to the analysis as:

1. the mix of consumption that is met from behind the meter generation from sources such as rooftop PV, on the one hand, and from the grid on the other, can change the effective cost of electricity consumption – particularly incremental changes in consumption – with consequences for incentives for energy efficiency improvement; and
2. efficiency policy measures (such as NCC2022, discussed below, but also NCC2019) already impact on the incentives for PV uptake on new buildings. For both residential and commercial buildings, there are some trade-offs allowed between the efficiency of these buildings and PV output. If incremental PV output is more cost-effective at the margin than are improvements in energy efficiency, then we should expect substitution of PV output for energy efficiency improvement (a phenomenon known as solar rebound or take-back).[1]

1.4 Interpretation and Application

These forecasts are best understood as indicators of avoided energy consumption in each year. Avoided consumption is a counter-factual construct that estimates the amount of consumption that would have occurred if not for the (specific type of) energy efficiency improvement quantified. Efficiency improvement is broken down into two effects:

1. Market-led (or autonomous) energy efficiency improvement – due to factors such as changing technologies (cost and performance), consumer preferences and relative energy prices, including electrification, at least to the extent these outcomes are market - rather than policy-driven.
2. Policy-led efficiency improvement – the fraction of total energy efficiency improvement that is attributable to (caused by) specific policy measures and which would not have been expected to occur without that policy measure.

As noted above, FY2015 is given as the base year, which means that all savings are measured relative to FY2015. This is why the forecast savings typically increase over time, although savings that are attributable to individual elements may contract over time, for example if a program is expected to end at a certain date or is scaled back over time.

There are two ways to apply these results. One is to use them as constructed, ie, as absolute savings values (in GWh or PJ) relative to consumption at a fixed point in time, eg, FY2015. If this approach is used, but there is a desire to begin the savings in a future year, say FY2024, then the series could be rebased to the previous year, by deducting the projected FY2023 savings from every forecast year. In this case, the resulting absolute energy savings values could be used for FY2024 and onwards. If this approach is adopted, it is important that the reference projection from which the savings are deducted does not already contain – explicitly or implicitly – *any* expected efficiency change, otherwise savings would be double-counted. We refer to such projections as 'frozen efficiency'. They have the value of illustrating the extent of increase in energy consumption that

[1] See, for example, Y. Qui et al, *Quantifying the rebound effects of residential solar panel adoption*, Journal; of Environmental Economics and Management, Vol. 96, July 2019, pp 310 – 341.

would have occurred if not for energy efficiency improvement over time. As such, they can provide a clear counter-factual reference projection against which efficiency and other changes can be assessed.

A second valid (but more complex) approach is to apply the forecasts with reference to the degree of deviation from the historical trend over time. That is, to what extent is the slope of the energy savings curve increasing, decreasing or remaining constant over time? To illustrate this, Figure 1 below shows a solid line that represents (a hypothetical) historical trend of energy efficiency savings, together with a projection that reflects a continuation of historical trends and policy settings. In this case, the impact of existing efficiency policy measures is likely to be largely or entirely reflected in the projection already – noting that changing economic conditions or demographics implicit in AEMO scenarios can cause the reference projection curve to be non-linear over time. In this case, deducting the absolute value of forecast energy savings, as per the first method above, would double-count the savings. Instead, the relevant observation would be that the slope of the curve is unchanged in the historical and forecast periods; that is, there is no out-of-trend deviation.

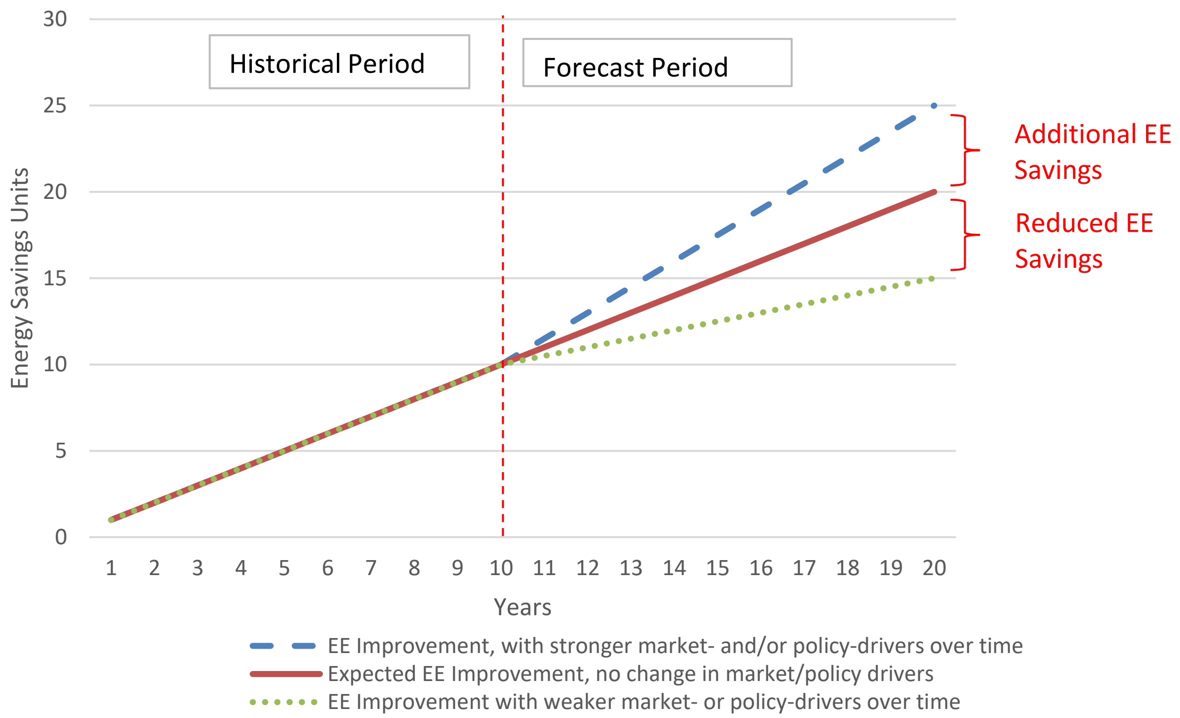

Figure 1: Application of Energy Efficiency Forecasts by degree of deviation from trend over time

If, on the other hand, the slope of the energy savings curve is increasing over time (and even if only for a period of some years, not necessarily for the whole period) – whether due to increased policy stringencies, new measures, or market-led effects including economic conditions, or a combination of all three – then this indicates that savings will be above the previous trend and expected future consumption, as a result, will be lower than previously forecast. The obverse also applies. If policy stringency or scope is declining, programs cease or are scaled back, relative prices or consumer preferences moves in adverse ways, or economic conditions are less favourable, then the rate of increase in efficiency savings over time may decline below trend, indicating that consumption will be higher than forecast.

The first method may guard against double-counting better than the second, as all estimated actual and forecast savings are accounted for and allocated either as a market- or a policy-led effect. If a deviation-from-trend or slope-of-the-curve approach is instead used, caution must be exercised to ensure that energy efficiency changes already implicit in the base or reference projection are not double counted – for example, by only adjusting for out-of-trend movements and not, in this case, deducting absolute savings values. Adjustments can be made year by year and may have different signs in different years – typically where significant policy changes (program closures or new measures commencing) occur.

1.5 Definitions/Glossary

Term	Definition
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'.
AEEI	Autonomous (or market-led) energy efficiency improvement
CBD	Commercial Building Disclosure program
Electrification	Decisions to replace gas or other fuels with electricity.
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.
ESS	NSW Energy Savings Scheme
GEMS/E3	Greenhouse and Energy Minimum Standards/Equipment Energy Efficiency
MEPS	Minimum Energy Performance Standards
NCC	National Construction Code
REPS	SA Retailer Energy Productivity Scheme
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

Term	Definition
	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.
NABERS	National Australian Built Environment Rating Scheme
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.
RES	Residential Efficiency Scorecard
UMD	Universal mandatory disclosure
VEU	VIC Victorian Energy Upgrades program
WOH	Whole-of-home (in the context of residential NCC energy performance requirements and related ratings

2. Policy Review Summary

2.1 Relevant Measures

2.1.1 AEMO Criteria

In assessing which efficiency policies and measures should be included within the forecasts, the following criteria in the National Energy Rules (v196, NER 5.22.3b) apply:

- 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 notes that 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 take 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
- expected degree of additionality to existing policy measures.

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, and the materiality of savings is assessed relative to the combined NSW and ACT consumption.

2.2 Major Measures Included in Analysis

Table 1 sets out the major policy measures that are deemed to conform to the NER criteria above, and which have been modelled in previous years for this reason. Section 2.3 discusses why some measures – including some modelled in past years – are proposed not to be included in the 2023 analysis.

Table 1: Major Existing Measures Included by Sector

Residential	Commercial	Industrial	Comments
National Construction Code Energy Performance Requirements	National Construction Code Energy Performance Requirements		State variations are generally overlooked and/or deemed to be equivalent (eg, BASIX and NCC). Some can be included, such as the delays in application of Section J (commercial building energy performance requirements) by NT; and announced delays in implementation of NCC2022 standards by TAS.
Greenhouse and Energy Minimum Standards (GEMS) and labelling	Greenhouse and Energy Minimum Standards (GEMS) and labelling	Greenhouse and Energy Minimum Standards (GEMS) and labelling	Electricity only
	Commercial Building Disclosure/NABERS Energy for Offices		These are modelled jointly to account for significant non-additionalities.
ESS in NSW, VEU in VIC and REPS in SA	ESS in NSW, VEU in VIC and REPS in SA	ESS in NSW, VEU in VIC and REPS in SA	Collectively referred to as 'state (energy saving) schemes'.

2.3 Existing Measures Not Included

There are many programs, provisions and voluntary initiatives, by businesses and other organisations, that impact on energy efficiency outcomes – both positively and negatively. Many energy businesses offer information, or advisory services, or apps or other tools, that are designed to enable their customers to use energy more efficiently. Some state-owned enterprises are encouraged by their owners to offer interest-free loans for certain efficiency improvements (or solar or batteries). Some of the larger councils also provide similar services that are significant in the context of their regions.

Many state/territory governments undertake significant efficiency programs and initiatives within their own operations, including efficiency upgrades to buildings, minimum standards for office accommodation and many others. Similarly, industry initiatives such as those undertaken by the *Better Buildings Partnership* (BBP), by the *Green Building Council of Australia* (GBCA), by *Climate-Related Financial Disclosures* (CFD) and many, many others, are also very likely to be assisting members and clients to improve their energy efficiency, *inter alia*.

2.3.1 Principles

Drawing a line between these and many similar positive initiatives, on the one hand, and government-leveraged measures and programs, on the other hand, is challenging and contestable. That said, a key principle to be applied is causality. For example, an efficiency program might document an improvement in energy efficiency over time in particular cohort of buildings. However, we need to ask, to what extent did the program *cause* the changes observed, or did other factors cause them, while the program documented the outcomes? We can also ask whether the cohort of buildings represented is typical or representative of a wider class, or are the changes observed largely limited to the actual cohort in question?

Some programs (such as CitySwitch, for example)[2] regularly ask their members not only what they achieved, in terms of outcomes, but how did they do it (eg, what investments did they make or what change projects did they run?) and to what extent would they attribute these actions to the program in question? While such methodologies are far from perfect, they can help to reduce misattribution of outcomes to causes.

A second principle is leverage. If a program or initiative offers encouragement and information, it may help a party that is already inclined to make a change or investment to actually implement the change, or it may draw an efficiency opportunity to their attention that had not previously been considered. Government or industry programs can also reduce the sense of risk that can be perceived by parties engaging with major efficiency investments for the first time, and who are unsure of their ground. A program, support materials, access to other parties who have already made similar investments, encouragement, and sound technical advice, all undoubtedly help to overcome barriers to investment, and could be found to have an incremental impact in terms of causing the outcomes realised. Past programs such as the Greenhouse Challenge and the Energy Efficiency Opportunities programs are both excellent examples, along with CitySwitch, as noted above (albeit on a smaller scale than the other two).

At the same time, voluntary change programs have limited leverage – for example, they do not change the investment economics, they do not (as a rule) realise structural or permanent changes in markets,[3] and they do not mandate outcomes. Those who are not motivated to engage with the

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[2] See https://cityswitch.net.au/, viewed online 26/01/2023.

[3] EEO is arguably an exception to the rule, due to its technical strengths, very significant resourcing, high-profile and effective engagement strategies, and persistence over time. EEO was also backed by Federal legislation and incorporated mandatory elements.

program will not change their behaviours or investment patterns because of it. Regulatory measures – provided they are enforced and complied with – exercise leverage essentially through the force of the law. This is why they are first justified using regulation impact assessment to ensure that the leverage outcomes are beneficial for society as a whole.

A third principle is additionality – although this is linked to causality. Additionality means that the savings in question would not have occurred in the absence of the measure *and* that they are not duplicating those claimed by another measure or effect. Where two measures target the same sector of the economy, for example, and also the same end-uses (say, residential space conditioning), and both have the effect of encouraging similar outcomes (say, upgrade to a heat pump), then it is likely that the sum of the savings claimed by, or expected of, the two measures individually would exceed the actual savings realised, due to a lack of additionality.

The degree of additionality of any two measures, or of a measure relative to market-led or autonomous energy efficiency improvement, can be difficult to establish. However, key indicators are the degree of overlap in sector or market targeted, in the end-use(s) targets, or even policy mechanisms used. A relevant example occurs between the Commercial Building Disclosure (CBD) program – which requires NABERS energy ratings for certain office buildings – and NABERS Energy for Offices, which is a voluntary measure, open to a wider cohort of offices than CBD. For the cohort of buildings covered by CBD, this program completely displaces the savings, for the same cohort, that might otherwise be attributed to NABERS.

Generally, where outcomes targeted by measures or achieved by programs are not greatly different from market-wide outcomes, then it is difficult to conclude that the measures are delivering outcomes that are *additional* to market-led outcomes. Cases such as BPP and GBCA represent best practices within the market and that are clearly well above the average. However, these initiatives do not conform with NER criteria above. They *do* contribute materially to the market-led outcomes we see at the premium end of the property market, however, and are very welcome and valuable in that context.

Our general approach is to estimate *total* change in energy efficiency, to the extent feasible, at the sectoral level, and in the historical period, to ensure that whatever is assumed about market-led and policy-led impacts, when summed together, do not exceed observable total changes.

This approach eliminates the risk of double-counting savings. However, at the same time, it does not eliminate the risk that savings could be misallocated between policy and market drivers. As discussed further in Chapter 5, there are indeed large uncertainties associated with each, primarily attributable to a lack reliable statistic information, data and/or analysis.

This historical analysis also provides at least some indication of the degree to which the total of policy and market effects considered have delivered observable efficiency improvements in the past, and thus helps to shape reasonable expectations about the extent they are likely to do so in future.

In our experience, there is greater risk over-estimating than of under-estimating efficiency savings. The reasons behind this, and our methodological responses to this, are discussed in Chapter 5. In the current context, we note that exhaustively including all potential sources of energy savings would only increase the risk of over-estimating total savings – particularly if we do not equally exhaustively consider all of the counterveiling forces that might offset these savings (new products, changing costs of energy service consumption, etc).

2.3.2 National Measures

In 2021, SPR modelled the efficiency impacts of the Emissions Reduction Fund (ERF) and of the Clean Energy Finance Corporation's (CEFC's) investment activities. At the time we noted an expectation that efficiency savings would be relatively small, as efficiency improvement is not the primary focus of either initiative, and this is evident in the estimates prepared in 2021. We have therefore excluded these measures from the current forecasts.

NABERS voluntary energy ratings, other than for offices – for example, those for shopping centre base buildings, hotels, apartment building common areas and others – are not assessed. The absolute number of buildings rated is relatively low, compared to offices, and even more so as a share of total buildings in each class. In addition, the sample of buildings voluntarily offered for rating is likely to be skewed towards the higher end of the performance spectrum. Finally, the program leverage is low. This is not to say that efficiency improvements are not being realised in these other building classes: the data suggests they are. However, it is difficult to establish (without formal program evaluation) that the outcomes documented are additional to those that would be expected from market forces alone.

Note that we review announcements made in the context of the 2023 Federal Budget in Section 2.5. As noted there, the largest impact is expected to be associated with the expansion of the GEMS program, which is captured in these forecasts. The commitment to develop an in-home version of NatHERS could facilitate universal mandatory disclosure, but would not be expected to induce significant additional savings in the absence of such regulatory leverage.

2.3.3 State and Territory Measures

The ACT operates an Energy Efficiency Improvement Scheme (EEIS) that is significant in the context of that jurisdiction, and doubtless contributes to efficiency outcomes. However, AEMO forecasts are prepared by NEM region, and the ACT is not a NEM region, but forms a relatively small part of the NSW region. For this reason, EEIP and other ACT measures are not included in this project.

In 2021 we included the expected future impact of a number of VIC budget measures announced in that year. We consulted with the relevant VIC government agency (DEECA) and agreed not to retain these impacts in the 2023 forecasts, as they have mostly been completed. This is discussed further in Chapter 3 below.

2.4 Recent/Expected Policy Changes

2.4.1 Residential

The main efficiency policy change in the residential sector since 2021 is NCC2022 – the move to 7-star minimum thermal shell requirements, plus a 'whole of home' energy budget, with the option of offsetting this budget (but not the 7-star requirement) with rooftop PV.[4] We note that the final decision with respect to the whole of home energy budget included higher stringency for Class 1 dwellings (detached houses and semi-detached townhouses), based on Option A in the RIS, requiring the new home to achieve an energy budget that is 70% of a stated benchmark). Class 2 dwellings (apartments) are required to meet a lower-stringency whole-of-home target of 100% of the benchmark (Option B in the RIS). This is understood to reflect the lower probability that a Class 2 dwelling will be able to offset all or part of the energy budget requirement with rooftop PV. Nevertheless, as noted below, we expect that the whole of home requirements will create additional pressure for energy efficiency improvement in regulated energy uses for Class 1s and also a share of Class 1s where solar access may be limited.

The GEMS and 'E3' (Equipment Energy Efficiency) programs, which include mandatory product labelling requirements and/or minimum energy performance standards (MEPS), has implemented few changes to the efficiency policy environment in recent years.[5] A number of exposure draft determinations have been released:

- Dishwashers (2022)
- Lighting (LED and incandescent lamps) (2022)
- Washing machines (2022)
- Rotary clothes dryers (2022)

Comments and inputs are being sought with respect to televisions, computer monitors and digital signage displays. A product profile has been released with respect to residential space heaters.

The only recent residential measures we have been able to identify is that a new standard for smaller air conditioners (below 65 kW) was implemented in 2019. It appears that minimum ratings are between 2.9 and 3.6 for common, non-ducted split systems, which would appear relatively low.[6] A zoned a/c label was also introduced in 2019. The impact of both measures was already estimated in past studies. A new standard for pool pumps appears to have applied from October 2022.

Certain measures are set to expire in 2023,[7] including MEPS with respect to:

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[4] Whole of home, in this context, refers only to 'regulated' energy end-uses including the primary space conditioning equipment, hot water, lighting, pool and spa pumps (where present).
[5] https://www.energyrating.gov.au/consultations, viewed online 26/01/2023.
[6] https://www.energyrating.gov.au/products/space-heating-and-cooling/regulatory-requirements, viewed online 26/01/2023.
[7] The standard practice is that MEPS should not persist without change or review for more than 10 years.

- Transformers and electronic step-down converters for extra low voltage lamps
- Ballasts for fluorescent lamps
- Power (Distribution) transformers
- Set top boxes.

Others are set to expire by 2025:

- Computer monitors - expires 1 October 2024
- External power supplies - 1 April 2025.

Some of the standards in place have been largely or wholly overtaken by technology and market changes. Those relating to fluorescent and some forms of incandescent lighting and set-top boxes (although these are still used, albeit less commonly in an era a ‘smart’ TVs. Past regulation impact statements (RISs) and projections of future savings from such measures are likely to be significantly overstated, simply due to these market and behavioural changes.

An Independent Review of the Greenhouse and Energy Minimum Standards (GEMS) Act 2012 (not program) was released in June 2019.[8] While it found that the legislation is effective, it recommended a range of reforms be implemented in the short, medium and longer terms. We can find no evidence of a government or Energy Ministers response to this report, or that any changes have yet been implemented as a result.

The most recent Prioritisation Plan was released in December 2021[9] and notes the following high priority products and proposed actions/status as at October 2021 – see Table 2 (p.1). It also notes (p. 4) that 23 out of 170 product classes reviewed are currently regulated in Australia and New Zealand, including 10 standards that will sunset by 2025.

We note with gratitude that the Department of Climate Change, Energy, the Environment and Water (DCCEEW), which administers the GEMS/E3 program, shared the results of a new and integrated model that it has commissioned to estimate the impact of GEMS measures. The development of this model is consistent with discussions held at AEMO’s 2021 Energy Efficiency Workshop, where the need for new and integrated/updated impact modelling was recognised. As a result, the expected impact of GEMS has been revised – generally, with a significant reduction in impacts, compared with past estimates, but also with a relative shift of savings towards the residential sector and away from commercial and industrial. These results are reflected in the 2023 energy efficiency forecasts. Also, as noted in Section 2.5, the 2023 Federal Budget included a commitment and funding to expand GEMS.

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[8] The report notes that this work was undertaken by a partner at law firm Allens but it is as an E3 report – see https://www.energyrating.gov.au/document/report-independent-review-gems-act-final-report, viewed online 26/01/2023.

[99] Beletich Associates, *E3 Prioritisation Plan Stage 2 Report*, December 2021.

Table 2: GEMS Priorities and Status, October 2021

High priority product category	Proposed actions	Status at October 2021
Air conditioners	New climate zoned labelling and enhanced MEPS	Included in GEMS determination published in 2019 (in force from April 2020).
Domestic refrigerators and freezers	Enhanced MEPS	Included in GEMS determination published in 2019 (in force from August 2021).
Hot water systems	Under investigation for future opportunities	In 2019, COAG agreed to the introduction of demand response capability requirements for a number of products1 including electric storage water heaters. NZ and NSW progressing work on a water heating strategy.
Industrial products	Under investigation for future opportunities	Technical Discussion Papers on pumps, boilers and compressors released for consultation in Nov 2020. Consultation RIS scheduled to be released in 2021-22. Electric motors issues paper released in Jan 2020, but further work halted in 2021, as not possible to implement via GEMS Act. NZ will go out for consultation. See Section 6 below.
Lighting	Phasing out mains voltage halogen lamps in AUS and introducing MEPS for LED lamps in line with European Union regulations	Ministerial approval achieved (expected in force by 2023).
Non-domestic fans	New regulations	Consultation RIS released May 2017. Work halted during development of Decision RIS, as not possible to implement via GEMS Act. See Section 6 below.
Refrigerated display and storage cabinets	Enhanced MEPS and new regulations	Included in GEMS determination published in 2020 (in force from May 2021)
Swimming pool pumps	New regulations in AUS	Regulations expected to be in force in late 2022.
Televisions	Under investigation for future opportunities including more stringent MEPS	Investigation and consultation underway. Consultation RIS scheduled to be released in 2021-22.

In states and territories, the NSW Energy Savings Scheme (ESS) provides financial incentives to install energy efficient equipment and appliances in NSW households and businesses. It was established in 2009 and since then the scheme claims to have supported projects that will deliver more than 32,500 gigawatt hours (GWh) of energy savings and over $6.1 billion in bill savings by 2029.[10] Scheme rules are updated annually.

In September 2021, the NSW Government announced expansion of the Energy Savings Scheme (ESS) to cover a wider range of fuel switching activities for household and businesses, as well as higher energy savings targets. The program target is set to increase by 0.5% (of eligible state electricity consumption) from 2022, reaching 13% by 2030. Unless the target is further changed (as it has been roughly every 5 years since 2009), it would remain at 13% of (a growing amount) of eligible consumption until 2050. Note that this continuation to 2050 for ESS is different from VEU in VIC and REPS in SA where, as discussed further below, both the latter schemes are scheduled to end in 2030 in the absence of legislative change.

The NSW Office of Energy and Climate Change (OECC) again shared in 2023 its projections for key parameters affecting ESS outcomes, including projected savings by activity to FY2040 and a forecast

[10] https://www.energy.nsw.gov.au/nsw-plans-and-progress/regulation-and-policy/energy-security-safeguard/energy-savings-scheme, viewed online 26/02/2023.

of growth in liable acquisitions, consistent with AEMO's 2022 ESOO Central scenario, and we express our thanks for this contribution.

Discussions were also held with the Department of Energy, Environment and Climate Action (DEECA) in VIC, which develops policy for the Victorian Energy Upgrades program (VEU) and related programs, as noted, and also with the SA Department for Energy and Mining (DEM) which oversees the Retailer Energy Productivity Scheme (REPS).

DEECA noted that its past analysis of VEU impacts, provided in 2021, remains relevant, noting pandemic-related delays in then-expected rates of uptake. Also, future policy settings post-2025 were discussed, and it was agreed that the assumption should be made that the program – as it is currently specified – should not be assumed to continue beyond its current end date of 2030. In practice, it is likely that the program will be reviewed ahead of that date, with outcomes that can't be predicted at this time. We note that the program's use of a carbon emissions target will require increasing quantities of electricity savings as the emissions intensity of electricity consumption in Victoria falls, and/or a shift towards gas savings (which is reflected in both the 2021 and 2023 forecasts), and/or other program changes.

As noted, DEECA also advised that past 'budget measures', modelled in 2021, are now largely complete. Estimates of future impacts associated with rental energy performance standards and social housing upgrades were also provided. The former is included with the minimum energy performance standards (MEPS) measure in the forecasts, while the latter is assessed to fall below AEMO's materiality criteria.

DEM provided direction and guidance to (excellent) program reporting statistics maintained by ESCOSA (the Essential Services Commission of South Australia) with respect to REPS. As with VEU, we also discussed potential post-2025/2030 policy settings. As with VEU, targets are currently set until 2025, and both post-2025 targets, and the future of the scheme beyond 2030, are undefined. We agreed that the working assumption for these forecasts is that the scheme cannot be guaranteed to continue post-2030 and, as a result, it may be noted that savings associated with both REPS and VEU phase out over the 2030 – 2040 period.

2.4.2 Commercial

National

There appears to have been little change in the efficiency policy environment since our 2021 review. The mooted expansion of the CBD program (mooted since at least 2015) has not yet occurred. NCC2022 did not include changes to the minimum energy performance requirements for non-residential buildings – despite the Trajectory for Low Energy Buildings including a commitment to 3-yearly reviews – with the earliest date for such potential changes now put at 2025.

A new GEMS standard for large air conditioners (above 65 kW) was implemented in 2022. The December 2021 Prioritisation Plan noted only one of the priority products had reached the Consultation RIS stage as at that date – for fan units. We have not been able to find evidence that a new standard has been implemented in this area. Standards for commercial chillers were set in 2012 and do not appear to have been updated.

The NABERs program launched a new voluntary rating tool for aged care and retirement living in September 2021, and one for warehouses and coldstores in September 2022. It plans to release new tools for schools and for retail stores over the 2022 – 2024 period.[11] A rating tool for public hospitals has also been developed in recent years, but no detailed data has been published due to confidentiality constraints imposed by data owners. Extending comments in Section 2.3.1 above, it is difficult to quantify the additional impact of these voluntary measures – a dedicated evaluation in collaboration with program managers would be likely to be required for this, including waivers of confidentiality barriers.

State/Territory

At the state/territory level, we note that the NT will implement NCC2019-level energy performance requirements for new non-residential buildings as part of NCC2022, for the first time since 2009.[12] In NSW, ESS has been expanded, as noted in the previous section, and data on expected impacts has been provided by OECC. In addition, we refer to annual reporting by IPART (the Independent Pricing and Regulatory Tribunal of NSW).

Recent changes to VEU include adding activities relating to cold rooms and commercial and industrial air source heat pump water heaters, and revisions to the activity on refrigerated cabinets, voltage reduction units, lighting (mercury vapour, metal halide and high-pressure sodium lamps) and gas boilers and water heaters.[13]

REPS reporting by ESCOSA is broken down by sector and ANZSIC Code.

2.4.3 Industrial

Generally, since the termination of the EEO program in 2014, and apart from coverage of larger, 3-phase electric motors under GEMS/E3, there has been no significant national energy efficiency policy in the industrial sector, despite this sector being Australia's largest energy user. However, a significant change occurred during this project, which was the amendments to the Safeguard Mechanism, which applies to around 215 large industrial facilities in Australia.[14] Strictly this is a greenhouse gas emissions abatement measure, but it is expected to have significant consequences for energy efficiency in the LIL sector. At the same time, modelling prepared by the government was not agreed to be released to the Parliament or public, so we do not have access to detailed assessments of the extent to which the revised Safeguard Mechanism is expected to generate energy efficiency improvements as compared to other responses, such as use of offsets, fuel switching (including electrification, noting that Scope 2 emissions are not included in the scheme's

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[11] https://www.nabers.gov.au/ratings/nabers-accelerate
[12] https://dipl.nt.gov.au/projects/building-energy-efficiency-provisions, viewed online 26/02/2023.
[13] DELWP, Victorian Energy Upgrades, Specifications 2018 – Version 13.0 (applicable from September 2022), 2018.
[14] DCCEEW, *Safeguard Mechanism Reforms: consultation paper*, August 2022.

coverage) and/or changing product mixes and production processes. However, we did discuss the expected impacts of the scheme with relevant areas of DCCEEW, and this confirmed our expectation that significant energy efficiency responses are likely. We note that the general lack of policy focus on this sector in at least the last decade increases the likelihood that there will cost-effective energy efficiency improvement opportunities to realise, that were not previously prioritised. However, the absolute magnitude of these impacts is uncertain, and we recommend that this question be prioritised in future forecasts, by which time the expected/early impacts should be clearer.

In addition, state and territory programs – ESS, VEU and REPS – cover at least parts of the industrial sector and have realised, and are likely to continue to realise, energy savings in this sector, as discussed below.

2.5 2023 Federal Budget Measures

The 2023 Federal Budget was handed down on 9 May. It included significant new funding for energy efficiency measures including:

- $1.3 billion for a Household Upgrades Fund to provide green finance for residential home electrification and energy upgrades, including provision for landlords to support rental housing. This program will be managed by the Clean Energy Finance Corporation (CEFC).
- $300 million in funding to be matched by the states for a total of $600 million to upgrade social housing.
- a Small Business Energy Incentive program (estimated at $314 million of tax expenditure over 4 years), intended to support electrification and energy efficiency.

Importantly, the Government also committed to:

- improve the Nationwide House Energy Rating Scheme and expand it to existing homes
- modernise and expand the Greenhouse and Energy Minimum Standards program to make it easier to choose cheaper-to-run appliances and support emissions reduction.[15]

At this stage, only some details of these measures are available, so the exact scope of measures covered, eligibility requirements and other design aspects is not known. However, the Government expects 110,000 households to benefit from low interest loans under the first measure, while the second is expected to cut energy consumption by 1/3 for 60,000 social housing properties. The CEFC notes,

> "The Fund will provide discounted consumer finance to increase sustainability across the housing sector, including through investment in energy efficiency upgrades, high performing appliances and battery-ready solar PV. The CEFC will work alongside established lenders in

[15] https://budget.gov.au/content/01-col-relief.htm#:~:text=Household%20Energy%20Upgrades%20Fund,housing%20to%20improve%20energy%20performance., viewed online 15/05/2023.

the sector, such as banks, to deliver the program to consumers, similar to the well-established CEFC asset finance programs."[16]

At this stage, we would expect the largest energy savings impacts associated with these announcements to derive not from the tax expenditures, but primarily from the enhancement and expansion of GEMS. As is discussed in Section 4.3.1 below, there is very considerable potential to expand GEMS to achieve additional and cost-effective savings. Funding for this purpose may need to be supported by legislative or regulatory process change for maximum effect.

Secondly, the expansion of NatHERS to existing homes will build on initiatives such as the Residential Efficiency Scorecard (also known as RES) which has been developed in recent years in Victoria and also adopted by a number of other states. However, if this measure remains a purely voluntary ratings tool, additional savings would be likely to be modest (particularly, additional to RES). At the same time, if this development enables and supports measures such as mandatory disclosure and/or minimum standards for existing housing/rentals in future,[17] then its savings impact could be large, as is quantified below.

The tax expenditures noted will be welcomed by those who benefit from them, and they will reinforce moves towards electrification and energy efficiency. At the same time, their additionality in terms of energy savings may be modest, depending in part on final design details.

Media reports indicate that discounted loans under the Household Upgrades Fund will not be income- or means-tested. They are therefore most likely to benefit higher-income households, and these households can already readily access savings or finance for energy efficiency investment.

Full details of how the Small Business Energy Incentive program will work are not yet available, but it will comprise a tax deduction bonus capped at $20,000 on expenditure of up to $100,000 (that is, a 20% bonus) for the FY23-24 year only, and for businesses with annual turnover of less than $50 million. Examples of items covered include:

- electrifying heating and cooling systems
- upgrading to more efficient fridges and induction cooktops
- installing batteries and heat pumps.

Tax incentives are likely to be effective in inducing the targeted investments, but the degree of additionality of energy savings is less clear and will depend in part on the final design of the measure. Installing additional heat pumps or appliances, no matter how energy efficient, still amount to additional energy consumption, unless it is clear that older, less-efficient and/or gas-using equipment is removed (or avoided) at the same time. The primary purpose of batteries is to enable a change in the time of use of energy, rather than to improve energy efficiency. Depending upon the application, they may have an energy savings effect, but they also incur round-trip losses, so net

[16] https://www.cefc.com.au/where-we-invest/special-investment-programs/household-energy-upgrades-fund/, viewed online 15/05/2023.

17 See Section 4.3.1.

consumption savings are not guaranteed. SPR's view is that we have some way to go before the maximum societal as well as private benefit is able to be derived from consumer investment in batteries, such as enabling:

- batteries (individually or collectively) to participate in ancillary services markets
- peak demand reductions to be appropriately rewarded
- Vehicle-To-Grid (VTG) protocols and infrastructure developed for electric vehicles, to avoid duplicating investment in the large batteries these EVs contain.

Social housing upgrades, if well-targeted, could significantly enhance thermal comfort, as well as the health and well-being of occupants of this housing. As a rule, social housing is amongst the least energy efficient of all housing, offering low energy service levels. This has the implication that we should expect significant 'take-back' or rebound effect, as the key benefit pathway may be to lift comfort and well-being, leading to improved health outcome in particular, and potentially other benefits such as enhanced productivity (reduced time off work) and climate resilience. These would represent very important societal benefits and, in addition, some part of the efficiency upgrades are also likely to translate into avoided energy consumption.

While these Budget measures are not quantified here, the GEMS and NatHERS expansions flagged in the Budget do feature in more ambitious scenarios and policy options quantified in these forecasts.

3. Mapping Measures to AEMO Scenarios

3.1 AEMO Scenarios

AEMO scenario narratives and assumptions for 2023 and 2024 are currently under consultation. The following descriptions, taken from the December 2022 *Draft 2023 Inputs, Assumptions and Scenarios Report* (IASR), should therefore be considered as working drafts.

1. **1.5°C Green Energy Exports** – refines the 2021 *Hydrogen Superpower* scenario. This scenario reflects very strong decarbonisation activities domestically and globally to limit temperature increase to 1.5°C, resulting in rapid transformation of Australia's energy sectors, including a strong use of electrification. Higher economic growth internationally (and locally) increases global demand for green energy, enabling greater development of green energy exports domestically (particularly green hydrogen exports via ammonia and other energy intensive manufacturing that utilise hydrogen such as green steel). Compared to the 2021 IASR *Hydrogen Superpower* scenario, NEM-connected hydrogen production is lower, although export demand will still be a significant driver of energy sector investments, and domestic opportunities to utilise green energy sources are high.
2. **1.8°C Orchestrated Step Change** – refines the 2021 *Step Change* scenario. This scenario is centred around achieving a scale of energy transformation that supports Australia's contribution to limiting global temperature rise to below 2°C compared to pre-industrial levels. Like the 2021 *Step Change* scenario, this scenario relies on a very strong contribution from consumers in the transformation, with rapid and significant continued investments in CER which are highly orchestrated through aggregators or other providers with the benefits passed on to consumers. There is also strong transport electrification, as well as opportunities for Australia's larger industries to electrify to reduce emissions. The scenario also reflects growing ambition and interest in developing hydrogen production opportunities to support new domestic loads.
3. **1.8°C Diverse Step Change** – explores key variations on the 2021 *Step Change* scenario. This scenario also targets achieving a scale of transformation to meet Australia's contribution to limit global temperature rise to below 2°C compared to pre-industrial levels. In this scenario, consumers continue to invest in CER including electrified transportation, but hesitate to embrace the technologies and shared control required to orchestrate these assets. With less orchestration occurring, the ability to rely on these investments to operate the power system securely is reduced and the overall scale and contribution of consumers to the energy transformation is therefore lower, requiring greater action and diversified investments from utilities. As such, greater investment in methods to decarbonise the gas sector is deployed, with biomethane blending reducing the emissions intensity of molecular energy use, enabling a greater alternative to electrification for some gas commercial and industrial customers that are best supported by traditional molecular sources of energy.

4. **2.6°C Progressive Change** – explores the challenges of meeting Australia's current Paris Agreement commitment of 43% emissions reduction by 2030 amid economic circumstances that are more challenging. As such, the scenario reflects an extension on the 2021 *Progressive Change* scenario regarding decarbonisation, combined with economic growth fundamentals that are similar to those in the 2021 Slow Change scenario. National and state-based policy commitments necessitate continued energy sector investments, but industrial loads are at greater risk given economic and high energy costs persisting globally. Higher technology costs and supply chain challenges relative to other scenarios slow the pace of change beyond current policies.

Key assumptions and expected outcomes under these four scenarios are shown in Table 3.

Table 3: AEMO Scenario Assumptions

Parameter	*1.5°C Green Energy Exports*	*<2°C Orchestrated Step Change*	*<2°C Diverse Step Change*	*2+°C Progressive Change*
National Decarbonisation target	At least 43% emissions reduction by 2030. Net zero by 2050	At least 43% emissions reduction by 2030. Net zero by 2050	At least 43% emissions reduction by 2030. Net zero by 2050	43% emissions reduction by 2030. Net zero by 2050
Global economic growth and policy coordination	High economic growth, stronger coordinatio n	Moderate economic growth, stronger coordinatio n	Moderate economic growth, moderate coordinati on	Slower economic growth, lesser coordination
Australian economic and demographic drivers	Higher (partly driven by green energy)	Moderate	Moderate	Lower
DER uptake (i.e. batteries, PV and EVs)	Higher	Higher	Moderate	Lower
Consumer engagement e.g. VPP and DSP uptake	Higher	Higher	Moderate	Lower
Energy Efficiency	Higher	Higher	Moderate	Lower
Hydrogen use	Faster cost reduction. High production for domestic and export use	Allowed	Allowed	Allowed
Hydrogen blending in gas network^	Unlimited	Up to 10%	Up to 10%	Up to 10%
Biomethane/ synthetic methane	Allowed, but no specific targets to introduce it	Allowed, but no specific targets to introduce it	7.5% blending target for reticulated gas by 2030 and 10% by 2035	Allowed, but no specific targets to introduce it
Supply Chain barriers	Less challenging	Moderate	Moderate	More challenging
Global/domestic temperature settings and outcomes	Applies RCP 1.9 where relevant (~ 1.5°C)	Applies RCP 2.6 where relevant (~ 1.8°C)	Applies RCP 2.6 where relevant (~ 1.8°C)	Applies RCP 4.5 where relevant (~ 2.6°C)
IEA 2021 World Energy Outlook scenario	NZE	SDS	APS	STEPS

SPR notes that *Green Energy Exports* and *Orchestrated Step Change* are expected to be associated with higher energy efficiency, while *Diverse Step Change* is associated with moderate energy efficiency, and *Progressive Change* lower energy efficiency. As discussed further below in Chapter 5, we expect market-led efficiency to be higher in *Orchestrated Step Change* than in *Green Energy Exports*, as the former has the highest rate of electrification. However, economic drivers and policy ambition are higher in *Green Energy Exports* and, in terms of total energy efficiency change, these two effects tend to offset each other (to differing degrees, depending upon the sector. We interpret these primarily as expected *outcomes*, driven primarily by economic fundamentals, discussed below, but also by different policy settings by scenario. That said, with national decarbonisation targets hardly differentiated by scenario, there is no clear guidance on the extent to which policy ambition might differ between scenarios.

Energy efficiency change over time is primarily driven by the quality and quantity of investment in new technologies, buildings, equipment and processes. Investment tends to be higher when economic growth is more rapid and lower when it is slower. Of course, energy consumption will be higher in the first case and lower in the second, but our task is to forecast efficiency change only.

It is not always the case that higher investment equals higher efficiency outcomes. However, there is a broad tendency towards this, as many technologies have become more energy efficient over time (consider LED versus incandescent lighting). Generally, households and businesses have an incentive to prefer more energy efficient solutions, to avoid unnecessary energy cost. At the same time, energy costs represent a small percentage of most household and business costs, with the exception of large, energy-intensive enterprises. Thus, incentives to prefer energy efficient options exist but, in Australia, are generally not strong. Other factors, such as the utility provided, or perceived to be provided, by new equipment/appliances, and the productivity these may enable in enterprises – along with production output growth opportunities – are likely to be much more important.

Some energy consumers also have very limited control over the efficiency of the buildings they occupy and their fixed appliances, for example where they are renters or low-income households. Indeed, these households account for a significant of share of total occupied dwellings. 2021 Census data show that private rentals (i.e. excluding public housing authority, community housing schemes etc.) amounted to over 27% of occupied dwellings (in NSW), down to 20% (in Tasmania) and, in most states, over half the private rentals were detached houses. These figures imply, on the one hand, that a large number of dwellings are unlikely to have seen significant energy efficiency improvement, but on the one hand, appropriately designed and targeted government energy efficiency schemes could potentially deliver large reductions in residential energy consumption, plus reduced financial stress and improved health outcomes for many low-income households.

As noted above, higher investment and economic growth, and higher household spending, and also technological change, can also create new and additional demands for energy consumption. In such a case, it may be argued that utility has increased, along with energy consumption, with uncertain but not necessarily negative outcomes for energy efficiency. However, since such utility changes are not readily measurable, we find it preferable to represent energy efficiency change by changes in energy *intensity*, such as energy consumption per household or square metre of commercial building space, and these are more objective and readily established with reference to verifiable data.

As noted, the *quality* of investment in energy-consuming activities, services and equipment also matters, and this is where energy efficiency (and technology) policies can make a difference. New houses tend to be more energy efficient (for example, measured by energy consumption per sqm of floor area) than older ones – but they may also be larger and potentially consume more energy per year. Also, changes in housing preferences (eg towards apartments) also have consequences for expected future energy consumption and efficiency.

Applying these perspectives to the scenario narratives above, our scenario interpretations – with respect to energy efficiency – are set out below.

3.1.1 1.5°C Green Energy Exports

Energy efficiency is higher in this scenario primarily because economic growth and investment are higher. That said, much of this extra activity may be concentrated in the export economy, with lesser differences in the domestic economy, say, relative to *Orchestrated Step Change*. Over time, faster economic growth is likely to result in faster population growth, while real household and business income would also be higher, enabling higher investment in energy efficiency, *inter alia*. At the same time, energy consumption will be (much) higher than in other scenarios, particularly in the export economy.

There is an expectation that electrification will be relatively high in this scenario, driven by higher investment in DER and EVs, the availability of Power Purchase Agreements for at least large commercial businesses (enabling them to access the cost advantages of new renewable energy generation). As noted above, electrification itself will increase the efficiency of energy use, as electricity can be used to deliver energy services with many times higher efficiencies than technologies that are based on fuel combustion. Because of this, electrical efficiency is improving globally much faster than the efficiency of gas or liquid fossil fuel use.

The cause or causes of this higher rate of electrification – and the extent to which it is assumed to result from market and/or policy drivers – are not spelled out. However, higher investment in DER and renewable energy (eg, PPAs, but also in the grid) will tend to reduce the real cost of consumption of electricity (particularly behind the meter), and this will encourage electrification. Whether the real prices of fossil fuels rise, relatively to renewable electricity and/or green hydrogen, for example due to carbon constraints or prices, is not clear, but this outcome is at least plausible and would further encourage electrification. Policy settings in future are also very likely to support electrification to a greater degree than at present.

With significant investment in clean energy production and exports, and in ‘green’ products based on this energy, efficiency outcomes in the industrial sector will depend greatly on how these are defined and measured. This is very problematic in the industrial sector, as the 'output' of the sector is a highly diverse set of products and materials. Some studies express energy consumption per unit of value-added by the sector, but such metrics are at least as much influenced by changes in the *prices* of traded goods and commodities, in exchange rates, and in the mix of products produced (which, along with ore grades in the minerals/processing sector, can change from week to week), as they are by quantity of output.

Would energy efficiency policy settings be more ambitious in this scenario? While the assumed national decarbonisation target does not necessitate this, we have also to consider that states and territories are already setting more ambitious emissions targets, and this too will feed into policy settings. Measures such as NCC energy performance targets, MEPS for appliances and equipment, NABERS program developments and others are determined not solely by the Australian Government, but rather by Energy Ministers representing all jurisdictions. We have already seen in Australia at least one important example where efficiency policy settings have been strengthened due to interventions by states and territories.[18] So long as their targets are higher than national ones, we can expect such instances to increase. Of course, the energy efficiency policy ambition of the Australian Government could also increase, as one aspect of seeking to limit emissions in line with an overall 1.5° global climate change goal.

Further, with investment in DER and EVs being key strategies in this scenario, including to shelter consumers and businesses from energy costs, governments may experience greater calls to address the risk of a growing welfare gap between those able to access these technologies and those who are not. Policies could therefore emerge aimed at ensuring building and housing tenants are indeed able to access these technologies on equitable terms.

We therefore assume higher policy ambition in this scenario than in at least *Diverse Step Change* and *Progressive Change*.

3.1.2 1.8°C Orchestrated Step Change

For the domestic economy (at least the residential and commercial sectors, and parts of manufacturing), this scenario may be very similar to *Green Energy Exports*. Subtle differences may arise in the residential and commercial sectors due to different rates of economic and/or population growth. The scenario narrative notes that 'Sustainability has a very strong focus, with consumers, corporations, developers and government, supporting the need to reduce the collective energy footprint by adopting greater energy efficiency measures' (IASR, p. 20). It also notes that electrification is high. While the higher global temperature outcome in this scenario, relative to *Green Energy Exports*, is likely to be attributable primarily to lower global uptake of clean energy products, we also assume that policy settings are somewhat less ambitious than in *Green Energy Exports*.

[18] NCC2022 energy performance requirements for new housing.

3.1.3 1.8°C Diverse Step Change

This scenario is similar to the previous in many ways, with key exceptions including:

- Greater use of biomethane, implying a lesser degree of electrification
- DER uptake is moderate, compared to higher under *Orchestrated Step Change*, with less investment in sharing technologies, including virtual power plants and community batteries
- Instead, network expenditure would be higher.

These factors are consistent with grid-sourced electricity prices being somewhat higher than under *Orchestrated Step Change*, at least relative to gas prices, while biomethane must be more available and also lower priced, to explain its higher usage, although we note that biomethane is assumed to be used only late in the forecast period.

Higher electricity prices might be considered to increase incentives for energy efficiency investment, but these would be moderated, or offset, by the wider use of gaseous fuels, with lower inherent efficiency than electricity. For example, investment in heat-pump- and induction-based technologies would be lower, with relative greater investment in technologies that combust gas, with much lower energy efficiency. Indeed, the primary explanation for lower efficiency outcomes in this scenario would be higher gas consumption.

In addition, given the reduced appetite for co-ordination in this scenario, we assume that policy settings are also not enhanced to the same degree as in previous scenarios. The current trend towards fuel switching and electrification settings in efficiency policies would cease. Overwhelmingly, however, the differences in efficiency outcomes arise due to fuel choice decisions and relative prices, which are, primarily at least, market factors.

3.1.4 2.6°C Progressive Change

In this scenario, economic growth, investment (particularly in DER), and (most likely) population growth are all lower, due primarily to adverse global economic conditions and their feedback effects into the Australian economy. Energy costs are higher. Growth in the export economy, including clean energy exports, is particularly constrained. Supply chain constraints are more severe. At the same time, it is noted that national and state emissions targets and policies continue to apply and to generate reduced emissions.

In such a scenario, the relatively low energy efficiency improvements envisaged would primarily result from relatively low investment, leading to use of older and less-efficient equipment, processes and buildings. Higher energy costs would create greater demand for efficiency improvement, but the supply of cost-effective options, and the appetite (and means) to invest in these, would be less, with higher costs for imported efficiency technologies.

The same national abatement targets are assumed to apply (at least, not lower than the current targets), but with slower economic growth, and less appetite for co-ordinated action, it is likely that efficiency policy settings would be relatively weaker in this scenario than in the others.

Table 4: Mapping of Energy Efficiency Policy Measures/Settings to AEMO Scenarios – Overview

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
Market-led (or autonomous) energy efficiency improvement	Higher, due to primarily to more electrification, but also higher private investment, faster population and housing stock growth/turnover.	High, due to significant electrification, but more moderate economic and demographic drivers, and greater supply chain constraints, than in Green Energy Exports.	Lower, relative to *Orchestrated Step Change*, due to less electrification and more combustion of gaseous fuels. Energy prices may be higher, but this is effect is unlikely to offset lower market-led efficiency improvement in this scenario.	Lower due to less electrification, higher technology costs, lower private investment, slower population and economic growth. Energy prices may be higher, but this effect is likely to be more than offset by the others noted.
National Construction Code energy performance requirements	Energy performance requirements set to highest emissions performance level that is cost-effective from NCC 2025 (non-residential) and NCC2028 (residential) – likely net zero emissions (to also encourage electrification and use of renewable energy). Apartments and others that may face greater challenges are allowed access to offsite renewable energy. Thermal shell/comfort requirements lifted progressively, primarily driven	Similar to 1.5° Green Energy Exports, but lower policy ambition leads to lower stringency in minimum energy performance requirements.	Policy settings as per *Orchestrated Step Change*. Zero net energy not favoured due to concerns regarding 'fuel neutrality'. Residential NCC changes limited to progressive thermal shell (star rating) increases. No significant changes in 'whole of home' energy budgets, as this would constrain gas use.	Delayed implementation of Code changes and lower policy ambition/stringency than Step Change scenarios.

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
	by health and safety considerations, which are explicitly modelled and valued. Trade-offs between use of PV and energy efficiency for non-residential buildings are permitted, as whole buildings will be at zero emissions, provided thermal comfort/performance requirements are also met.			
Appliance and Equipment Standards and Labelling	This program undergoes a major overhaul. Presumption that all major product classes include MEPS and/or labelling, subject only to simplified/ standardised benefit cost analysis, including a significant social cost of carbon. Regulatory and consultation processes radically streamlined, without losing industry and consumer input. The program anticipates, to the extent possible, new product types, and reaches	Similar to *Green Energy Exports*, but with lower policy ambition, leading to lower savings.	Assume same degree of policy ambition as in *Orchestrated Step Change*.	As per 1.8°C Diverse Step Change.

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
	out to manufacturers and importers to 'signal' future regulatory intent. Program is co-ordinated (at least with Code but also industry policy) with the aim of achieving discrete market transformations in key sectors (eg, high performance glazing).			
State/territory energy savings schemes	Continued expansion in state/territory targets, at around historical rates, for states/territories with targets, to the extent currently legislated. Schemes are likely to support electrification as well as efficiency.	Similar to *Green Energy Exports*, but with lower ambition targets.	Same targets assumed as per *Orchestrated Step Change*.	Lowest targets, remaining at currently-announced levels.
Mandatory Disclosure	Universal mandatory disclosure introduced initially for all leased buildings/spaces, with minimum size thresholds for commercial buildings, then progressively expanded to all buildings via a) reduced minimum size thresholds and b) expansion to cover owner-	Lower policy ambition than in *Green Energy Exports* assumed to lead to less floor area impacted by measure and a lower conversion rate (from disclosure event to additional efficiency investment).	As per *Orchestrated Step Change*.	Reduced appetite for policy stringency translates in to reduced participation (relative to *Step Changes*) and a still lower conversion rate.

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
	occupied stock 5 years after leased stock.			
Minimum energy performance standards for existing buildings	Introduced in the short term for tenanted building/spaces, with 5 year implementation period. Energy savings schemes (above) support small-scale investors where justified. Scope of standards includes thermal performance, PV and fixed services – efficiency and electrification. Progressive lifting of minimum requirements over time – assumed to be once per decade.	Lower policy ambition than *Green Energy Exports* leads to reduced floor area impacted, and reduced conversion rate	As per *Orchestrated Step Change*.	Reduced appetite for policy stringency translates in to reduced participation (relative to *Step Changes*) and a still lower conversion rat

3.1.5 Summary

Bearing these analyses in mind, Table 4 provides an overview of our mapping of potential future policy changes to AEMO scenarios. More detailed tables are provided for each sector in Chapter 5.

Discussions were held with program managers of all existing programs modelled, and with those responsible for policy development in all relevant jurisdictions. However, given the forecast horizon to FY2055, program managers were not in a position to endorse SPR assumptions over time.

In addition – and, potentially more importantly – we expect market-led efficiency improvement to vary between scenarios, as noted. This will be driven primarily by differential rates of economic growth, investment/capital formation, building and equipment stock turnover, and population growth. Efficiency outcomes by scenario will therefore reflect different combinations of economic/demographic and policy settings, meaning that efficiency trajectories are expected to be unique for each scenario.

3.2 Orchestrated Step Change – Low Energy Efficiency Sensitivity Analysis

During the project, AEMO requested that a sensitivity analysis be prepared with respect to *Orchestrated Step Change*, which models the outcomes that would be expected to occur with *Orchestrated Step Change* economic and other assumptions, but only *existing* energy efficiency policy measures and settings. This is, in effect, a *business-as-usual* (BAU) version of *Orchestrated Step Change*, and it illustrates outcomes that would be expected (under this scenario) if there were no changes to efficiency policies in future. Such projections provide a baseline against which the incremental impacts of new policy measures, or of changes to existing policy settings, may be assessed. See Chapter 5 for the results of this sensitivity analysis.

4. Methodology and Key Assumptions

4.1 Theoretical Framework

The forecast 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.[19] 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:

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

where

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),

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

Changes in (F)uel mix can be added to this framework, as needed, to create an 'EASIF' identity. However, we apply the EASI framework separately for electricity and gas instead, with the assumption that 'gas' means 'methane'. Note, as discussed in Section 5.2.2, there would be implications for energy efficiency to the extent that blended gaseous fuels were supplied to the market, or to specific market sectors, depending upon the composition of these fuels, the pressure at which they are delivered, and potentially other factors. At this stage, such activities are restricted to small-scale trials. However, if blended fuels became more widespread, or if use of such fuels is assumed to be significant in certain scenarios, then it would be relevant to model this effect on energy efficiency outcomes.

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

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

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 subsectoral (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 approach is stock turnover modelling. Stock growth (eg, numbers of dwellings, floor area of buildings) is a key *Activity* metric in the factorisation methodology. Second, changes in the composition of the dwelling stock (by Class, or the average size of dwellings within a Class) 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, including in the forecast period.

4.2 Overall Approach

Residential/Commercial

For residential and the commercial and services component of Business Mass Market (BMM), there is reasonable statistical information for both the energy consumption and the output of these sectors. As noted below, this is not the case for the industrial sector. Gross floor area is generally used as the output metric for the commercial sector, and either dwelling counts or, more accurately, gross floor area, for the residential sector. Also, it is possible to establish total fuel consumption for both sectors with reasonable (if far from perfect) confidence. This means that it is possible to calculate the *total* change in energy efficiency in the residential and commercial sectors in the historical period (here, FY2015 – FY2022).

We then estimate the impacts of individual (major) energy efficiency policies over the historical period, taking into account non-additionalities between measures and changes in:

- the structure of each sector (eg, the dwelling or building mix by type)
- the fuel mix
- behind-the-meter generation.

We estimate the expected rate of market-led or autonomous energy efficiency improvement over the same period, and check that the sum of market- and policy-led savings equals the measured totals for each jurisdiction. Discounts or other adjustments may be required to either policy-led or market-led impact assumptions, and to ensure that neither element is over-estimated.

For the forecast period, we project rates of market-led energy efficiency improvement that:

a) reflect revealed historical values for each jurisdiction

b) are differentiated for the future consistent with AEMO scenario narratives.

Note that since we explicitly model market-led efficiency improvement, each policy measure's impact must be discounted to the extent that these impacts are understood not to be additional to:

a) saving that would have been expected to occur in any case, due to market-led or autonomous energy efficiency improvement; and/or

b) savings that are also claimed by one or more other policy measures.

As noted above, our scope does not extend to modelling electrification per se, but only electrification impacts associated with energy efficiency measures. However, there are significant risks of double-counting in this area.

Industrial Sector

Stock turnover modelling is feasible for the residential and commercial building sectors since, as noted above, there is high confidence data available with respect to both fuel consumption and gross and net stock formation (ABS Building Activity data) over time, with the latter being used as a proxy for the output of these sectors.

For the industrial sector, however, confidentiality constraints limit the availability of data for both energy consumption and output indicators. Fuel consumption data for industrial ANZSIC sectors is often suppressed, at the state and territory level, due to confidentiality/discoverability concerns, particularly with respect to LILs. In addition, and even for small and medium-sized industrial businesses (SMEs), there are no ready metrics or proxies for output from these sectors that might meaningfully be combined with consumption data as an indicator of change in total energy efficiency. The outputs of industrial enterprises are exceedingly diverse. No doubt for this reason, some analysts use sectoral value-added as a proxy for output but, in our view, such indicators are more likely to respond to changes in the product mix and/or to changes in product prices (and exchange rates, when products are priced in foreign currencies), while saying nothing definitive about changes in the efficiency of energy use. [20]

Therefore, for this study we are constrained to rely on bottom-up estimates of specific program impacts in the industrial sector. To this point, there has been very little policy targeting industrial energy efficiency in any case, but this is expected to change in future due the revisions to the Safeguard Mechanism. In addition, AEMO captures information directly from LILs that helps it to understand future expected gas and electricity demands.

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

4.3 Residential Sector Methodology

The base for projecting energy efficiency change in the residential sector is a model of the housing stock, including stock growth and turnover (additions less removals/conversions), over time. Since the base year for analysis was given as FY2015, we make use of a new data series published by the ABS, which provides an extremely detailed analysis (at the SA2 level) of quarterly stock change (additions, removals, total) by Class from June 2016 to June 2022 (summarised in Table 5).[21] This series combines data from the 2016 and 2021 Censuses together with information (some of which has not previously been published) from the Building Activity series, sourced primarily from local government building approvals. Overall, the data indicates net stock growth averaged just over 1.7% per year (although this slowed to under 1.4% in FY2022), with gross increases of around 1.9% per year offset set by removals averaging 0.2% per year.

Table 5: Summary of End-of-Financial-Year Dwelling Stock Data, Australia

EOFY Stock	Jun-16	Jun-17	Jun-18	Jun-19	Jun-20	Jun-21	Jun-22
Houses	7,184,419	7,279,135	7,371,408	7,472,853	7,556,401	7,639,265	7,729,884
Townhouses	1,230,208	1,261,457	1,293,884	1,325,743	1,352,774	1,379,367	1,401,790
Apartments	1,391,051	1,464,325	1,530,050	1,589,770	1,647,436	1,695,659	1,729,385
Total dwellings	**9,823,477**	**10,022,775**	**10,213,246**	**10,406,408**	**10,574,702**	**10,732,418**	**10,879,349**

For this study, we aggregate this data from the SA2 level up to the state/territory level. For WA, we estimate - drawing on Census and the ABS data above - that some 95.2% of houses, 98.1% of townhouses and 96.9% of apartments in WA were in the SWIS in FY2021.

For future stock growth, we use growth rates from AEMO's Residential Connection Forecast (v2) – see Figure 2 (noting that the two *Step Change* projections are identical and therefore only one is visible in the figure). The projections distinguish houses and attached dwellings, and they are also differentiated by year, region and scenario. NT was not covered in this data and was therefore estimated on the basis of the average ratio of connections to population across other jurisdictions, drawing on AEMO's connection data and ABS 3101.0 National, state and territory population (Table 4) for population data. The connection forecast shows a trend of a rising share of Class 2 apartment dwellings over time, and this is reflected in the stock model.

[21] ABS, *Estimated dwelling stock, additions and removals by SA2 (ASGS2021), June 2016 to June 2022, available from* *https://www.abs.gov.au/statistics/industry/building-and-construction/estimated-dwelling-stock/latest-release#data-downloads*

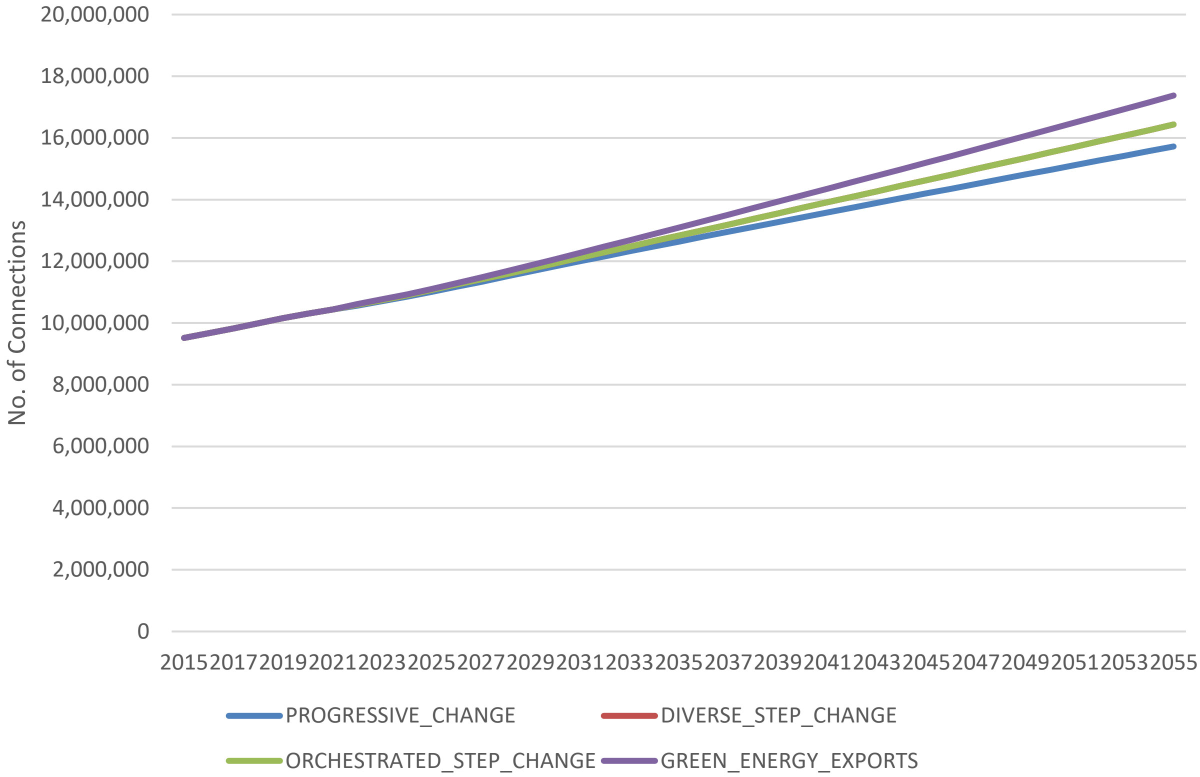

Figure 2: Summary of AEMO Residential Connections by Scenario, Australia

Average dwelling sizes were sourced from (special order) *Building Activity* data for the historical period and projected in the future by state and territory. Broadly they indicate declining average sizes for houses and, to a lesser degree, townhouses; while apartment floor areas remain roughly static – see Figure 3 for an overview. This enabled projections of both dwelling numbers and floor area by Class and scenario (see Figure 4, for example).

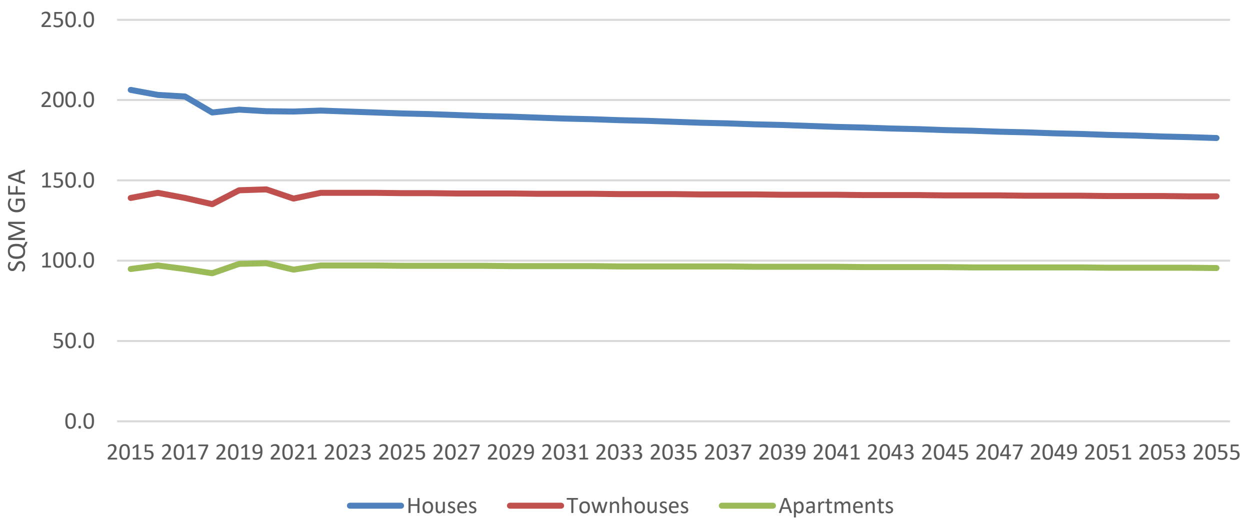

Figure 3: Trend in Average New Dwelling Sizes, Australia

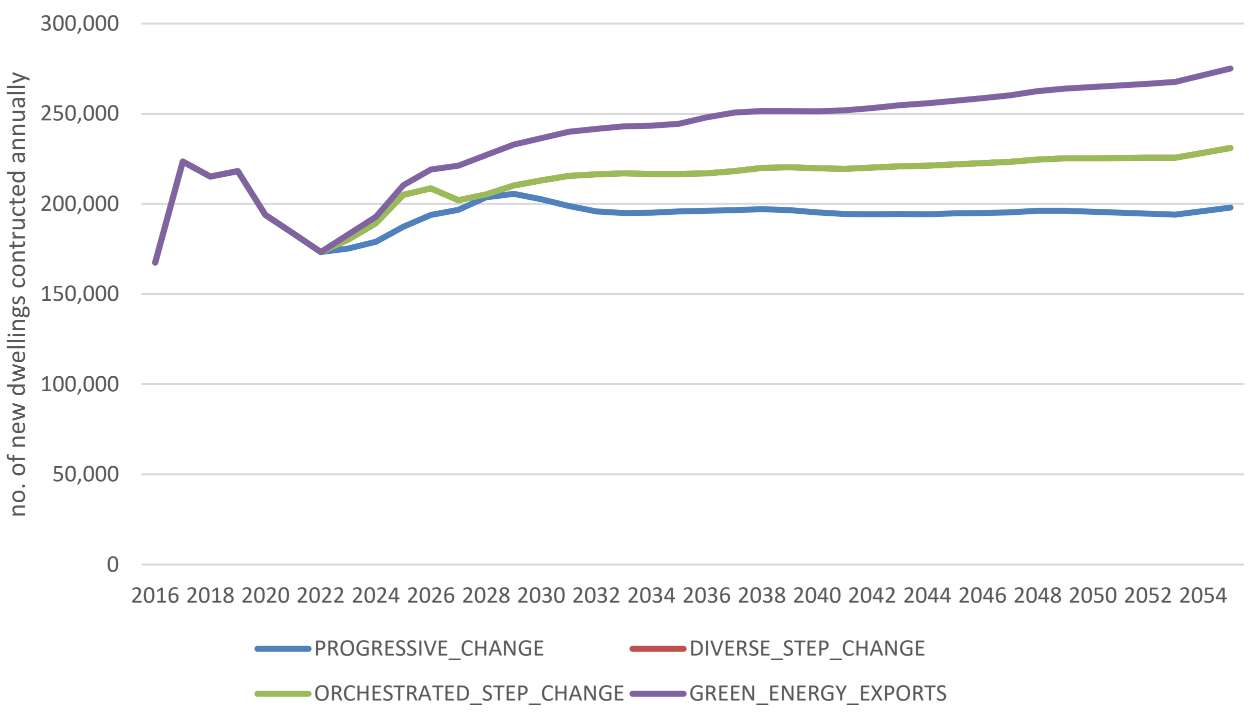

Figure 4: Number of New Dwellings Constructed Annually by Scenario, FY2016 - FY2055, Australia

For modelling of thermal loads and energy consumption, a set of representative NatHERS climate zones was identified, based on the NatHERS climate zone that covers the largest share of SA2 regions in each jurisdiction, as revealed in the ABS data noted above – see Table 6. NatHERS star bands (MJ/sqm.a for each star rating) were sourced from the NatHERS Administrator,[22] while heating and cooling load shares by NatHERS climate zone were sourced from Appendix B of the *Decision Regulation impact Statement, NCC 2019, Energy efficiency for residential buildings, NatHERS heating and cooling load limits*.

Table 6: Representative NatHERS Climate Zones

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Representative climate zone	56	62	9	16	13	26	1	24
Share of all SA2s in this climate zone	39%	39%	26%	60%	33%	38%	76%	98%

[22] https://www.nathers.gov.au/node/517

Table 7: Proposed Energy Efficiency Settings and Measures by Scenario – Residential

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
Market-led (or autonomous) energy efficiency improvement	• Estimated actuals by region for historical period • 0.5%/year for electricity • 0%/year for gas	• Estimated actuals by region for historical period • 0.75%/year for electricity • 0%/year for gas	• Estimated actuals by region for historical period • 0.2%/year for electricity • 0%/year for gas	• Estimated actuals by region for historical period • 0.2%/year for electricity • 0%/year for gas
National Construction Code energy performance requirements	• 7 star takes effect from FY2024 (but FY2027 in TAS) • 8 star from FY2031 • 9 star from FY2041 • WOH provisions move to net zero energy/emissions from NCC2025 (offsite RE allowed where solar access is restricted)	• 7 star takes effect from FY2024 (but FY2027 in TAS) • 8 star from FY2031 • 9 star from FY2041 • WOH provisions move to net zero energy/emissions from NCC2025 (offsite RE allowed where solar access is restricted)	• 7 star takes effect from FY2024 (but FY2027 in TAS) • 8 star from FY2031 • 9 star from FY2041 • WOH provisions move to net zero energy/emissions from NCC2025 (offsite RE allowed where solar access is restricted)	• 7 star takes effect from FY2024 (but FY2027 in TAS) • 7.5 star from FY2031 • 8 star from FY2041 • No change in WOH provisions
Appliance and Equipment Standards and Labelling (GEMS/E3)	• Program targets 10% additional savings by 2030, and 45% by 2055	• Program targets 4% additional savings by 2030, and 18% by 2055	• Program targets 4% additional savings by 2030, and 18% by 2055	• Based on DCCEEW current projections, with no future expansion.
State/territory energy savings schemes	• ESS targets lifted by 0.5% per year, from 13% by FY2030 to 25.5% by 2050 • VEU annual targets lifted from 6.5 million certificates in 2021 to 8.3 million by 2030, but the program is not continued past this date (in practice, it is likely to be reviewed ahead of 2030 may be reframed for the post-2030 period) • REPS targets lifted from 3.75 million GJ in 2025 to 6.75 million GJ by 2030, but the	• ESS targets lifted by 0.25% per year, from 13% by FY2030 to 19.25% by 2050 • VEU annual targets lifted from 6.5 million certificates in 2021 to 7.8 million by 2030, but the program is not continued past this date (in practice, it is likely to be reviewed ahead of 2030 may be reframed for the post-2030 period) • REPS targets lifted from 3.75 million GJ in 2025 to 5.75 million GJ by 2030, but is not	• ESS targets lifted by 0.25% per year, from 13% by FY2030 to 19.25% by 2050 • VEU annual targets lifted from 6.5 million certificates in 2021 to 7.8 million by 2030, but the program is not continued past this date (in practice, it is likely to be reviewed ahead of 2030 may be reframed for the post-2030 period) • REPS targets lifted from 3.75 million GJ in 2025 to 5.75 million GJ by 2030, but is not	• Targets remain at 2025 levels until 2030 for VEU and REPS, then are phased out, but remain at 2025 levels (13%) for ESS until 2050.

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
	program is not continued past this date (in practice, it is likely to be reviewed ahead of 2030 and may be reframed for the post-2030 period)	continued past this date (in practice, the program is likely to be reviewed ahead of 2030 and may be reframed for the post-2030 period)	continued past this date (in practice, the program is likely to be reviewed ahead of 2030 and may be reframed for the post-2030 period)	
Mandatory Disclosure (NEW)	• Universal mandatory disclosure introduced from FY2025, with 10% higher uptake (new upgrades) than for the Step Changes	• Universal mandatory disclosure introduced from FY2025, with an additional 0.05% of the stock electing to undertake upgrades each year as a result.	• Universal mandatory disclosure introduced from FY2025, with an additional 0.05% of the stock electing to undertake upgrades each year as a result.	• Introduction of UMD delayed until 2035.
Minimum energy performance standards for existing buildings (NEW)	• MEPS for rental properties take effect from FY2025. Initial standards require 10% of properties to be upgraded, saving 5% on average of energy consumption. Higher standards apply from FY2035, requiring 10% savings, on average, and again from 2045, requiring an additional 10% savings.	• MEPS for rental properties take effect from FY2025. Initial standards require 10% of properties to be upgraded, saving 5% on average of energy consumption. Higher standards apply from FY2035, requiring 10% savings, on average, and again from 2045, requiring an additional 10% savings.	• MEPS for rental properties take effect from FY2025. Initial standards require 10% of properties to be upgraded, saving 5% on average of energy consumption. Higher standards apply from FY2035, requiring 10% savings, on average, and again from 2045, requiring an additional 10% savings.	• MEPS for rental properties delayed until FY2035 and set at lower levels, requiring only 5% of the stock to be upgraded, and then a further 5% from 2045.

For fuel consumption in the historical period, we review Australian Energy Statistics (AES) data, but were able to use time-series data from AEMO for all jurisdictions (including the SWIS), except NT, where AES was used. AEMO data was separated into delivered, PV generation and underlying consumption, and it was clarified that 'delivered consumption' includes net transfers at the meter. That is, net exports from rooftop PV systems to the grid are already deducted from delivered consumption values, meaning that rooftop PV generation can be added to these values for underlying consumption without double-counting. Forecasts are prepared on the basis of underlying consumption.

4.3.1 Policy and Market-led Efficiency Assumptions

Table 7 indicates our assumptions for policy/program settings or parameters, and for potential new policy measures, aligned with AEMO's four scenario narratives. The rationales for these settings are set out below.

Market-led (or Autonomous) Energy Efficiency Improvement

This study aims to estimate not only the total change in energy efficiency in the historical period (before forecasting this for the future), but also to break the total down into market-led and policy-led components. While it may be argued that it is the total change in energy efficiency that is most important from a forecasting perspective, the methodology of breaking this change down into these two components reflects a number of factors:

- As noted in Section 2.1.1 above, the National Energy Rules require AEMO to assess the impact of major individual policy measures
- Policy settings can be used (*inter alia*) to differentiate scenarios in the forecast period, for example where different emissions targets or degrees of policy ambition are assumed
- Limiting the analysis to policy effects alone would miss efficiency changes that would be likely to occur even in the absence of policies due to technology change, behavioural change, changing relative prices and related factors
- The market-led portion of total energy efficiency change is also likely to be differentiated by scenario narrative, for example due to differences in global abatement ambition/policy co-ordination, and the flow-on consequences of this for the rate of (low/zero emissions) technology development globally, and/or differing degrees of supply-chain constraints.

There is no statistical or other robust data source that indicates even total change in energy efficiency over time at the sectoral level in Australia, let alone the contributions that policy and market effects make to that total. In practice, and for the historical period, we can estimate total change in energy efficiency 'top-down', by combining total fuel consumption and stock turnover data, as discussed further below. Second, we can estimate policy-led energy efficiency change bottom-up, drawing on individual program reporting data. Third, and after applying necessary discounts for non-additionality, we can assume that (any) difference between these two is attributable to market-led change. We present the results of this analysis in Chapter 5 below.

National Construction Code

NCC energy performance requirements were determined by BCA2010 prior to FY2024 (or equivalents such as BASIX in NSW) and will be determined by NCC2022 and future assumptions from FY2024. BCA2010 savings are modelled relative to the previous standard, BCA2009, broadly the difference between 5 and 6 stars under NatHERS. Since NatHERS stars represent annual thermal loads, it is necessary to make assumptions about the space heating technology and fuel types in order to convert these into energy units. We assume average co-efficients of performance (COPs) for gas heating systems of 0.85 and for electricity, values that increase from 3.1 in FY2015 to 7.9 by FY2055.23

Another technical assumption that must be made is referred to as the 'constraint factor', or the extent to which implied energy services levels in NatHERS ratings over-state expected occupancy and usage patterns, and overall energy service levels. These are estimated by jurisdiction and fuel for the base year of FY2015, as part of an overall model balancing exercise. The model replicates total electricity and gas consumption in the residential sector in FY2015 as a function of the stock data (floor area by Class), average star ratings (for the representative climate zones in each region), constraint factors, FY2015 actual gas share of total consumption by region, average COPs, and non-space-conditioning energy consumption (assumptions drawn from the 2021 *Residential Baseline Study* data tables).[24] Constraint factors average 72%, meaning that actual space conditioning energy consumption is assumed to average 28% less than implied by NatHERS without constraints. This difference is explained by a combination of lower occupancy levels, less whole-of-home space conditioning (or greater zoning) and more conservative thermostat settings (trading off less thermal comfort for lower energy bills).

Further, since electrification is also a feature of AEMO scenarios, we make assumptions about the propensity or likelihood that new houses will be either dual fuel or all-electric. These assumptions are differentiated by scenario, jurisdiction and dwelling Class. Overall, however, we assume that most new dwellings do not choose gas after 2030 in *Orchestrated Step Change* and *Green Energy Exports*, and after 2040 for *Progressive Chang*e and *Diverse Step Change*. This effect is assumed to be primarily market-led – that is, driven by consumer preferences, relative prices/utility of fuel/technology combinations – but, as discussed below, it will also be affected by policy settings.

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23 We note that the Beyond Zero Emissions Building Plan (2013) estimates only 70% efficiency (COP 0.7) but for an 'older' gas space heater. 0.85 may be high, particularly for ducted gas systems, where ducting losses apply. For residential air conditioners, historical evidence for COPs is available from E3 (Equipment Energy Efficiency), Decision Regulation Impact Statement: Air conditioners Regulatory reform opportunities and improving energy efficiency outcomes, December 2018, p. 18. Projections for COP are SPR assumptions, informed by discussions with the GEMS program team.

24 https://www.energyrating.gov.au/industry-information/publications/report-2021-residential-baseline-study-australia-and-new-zealand-2000-2040, viewed online 10/4/2023.

The primary market-led effect is expected to be increasingly high levels of rooftop PV uptake (but also encouraged by policy), which significantly reduces both the levelized and opportunity cost of electricity consumption (cf gas but also delivered electricity).

Greenhouse and Energy Minimum Standards/E3 (Equipment Energy Efficiency) Program

Analysis of historical and expected future impacts associated with the GEMS/E3 program (GEMS for short), were initially compiled from:

- Adjustments to 2021 forecasts for actual changes since then, relative to those anticipated, including delays in development/implementation of new measures
- Applying discounts for non-additionality to market-led efficiency change, for example where the impact of measures is likely to have been overtaken by market change (eg, measures relating to fluorescent lighting systems, and measures more than 10 years old).

This led to downwards adjustments in estimated actual and projected savings.

However, during the project, the Department of Climate Change, Energy, the Environment and Water (DCCEEW) agreed to share projections based on new and integrated modelling it had commissioned, covering the expected impact of existing measures only (no future measures). This data showed somewhat lower expected savings than first estimated, with a relative shift towards the residential sector and away from commercial and industrial.

For the final projections, we assume that currently-forecast (by DCCEEW) savings only are realised in Progressive Change but, in line with discussions held with DCCEEW, that higher savings are targeted and realised in other scenarios. We assume that additional energy savings of 4% by 2030 are targeted under *Orchestrated Step Change* or *Diverse Step Change*, and 10% additional energy savings by 2030 under *Green Energy Exports*, reflecting higher policy ambition, with annual increases after 2030 in line with the 2023 – 2030 trend.

We note that higher cost-effective savings would be likely to be available if internal and decision-making barriers were able to be removed, allowing standards to be set at their highest cost-effective levels in all relevant product classes, and particularly if the latter was expanded to include building elements and potentially other energy-using systems. However, this would be likely to require significant change in current legislation, funding and practices.

NSW Energy Savings Scheme (ESS)

The NSW OECC again shared internal modelling in 2023, including expectations with respect to key program drivers such future liable acquisitions and expected savings by sector, activity and fuel. These projections run to 2040 and are based on (2022) ISP Step Change assumptions. For these forecasts, we associate OECC's expected growth in liable acquisitions with *Orchestrated Step Change* and *Diverse Step Change*, extended to 2055 by linear extrapolation, and then assume that growth in liable acquisitions is somewhat slower under *Progressive Change* (3.3% less than in both *Step Change* scenarios by 2055) and somewhat faster under *Green Energy Exports* (3.3% higher than under both *Step Change* scenarios by 2055). However, we assume that the program ends in 2050, in line with current legislation.

For the historical period, we utilise annual reports prepared by IPART for actual historical values for annual targets, certificates registered, estimated annualised savings, sectoral mix of savings and other factors. Helpfully, these reports separately identify the share of certificates generated using the 'NABERS method' (which we discount to avoid double counting – assuming that the effect of this is reduce savings by around 0.3% per year). Since the program commenced in 2009, actual/reported savings are rebased for these projections to 2015 and therefore cannot be directly compared with values published by IPART.

With respect to the fuel mix of savings, annual reports indicate that savings were 100% electricity until 2017 (the program reports in calendar years), but that gas savings reached 5.5% of the total in 2020. We assume the gas share of savings continues to increase over time, reaching 12.5% of savings in 2055. For converting deemed to annualised savings, we assume an average deeming period of 10 years noting that, in reality, this period varies by activity.

The sectoral mix of savings has changed significantly in the historical period, with residential sector savings representing over 50% of the total in 2010. However, by 2020 this had fallen to less than 8%, with the commercial sector at 76%. For the projections, we assume a sectoral mix of savings in line with OECC estimates, which project that the balance of savings will swing back to the residential sector over time.

Victorian Energy Upgrades (VEU)

In a similar manner as with ESS, we base historical savings estimates for VEU on the latest (2021) annual performance report published by the Essential Services Commission. This provides historical values for past certificates created, gas and electricity emissions intensity factors, and the sectoral and fuel mix of savings. With respect to the latter, we note that VEU has (until at least 2021) supported a range of activities that involve replacement of electrical with gas end uses. As a result, gas savings are negative overall, in the historical period, although we assume (in line with advice from DEECA, and also with 2021 forecasts) that gas savings become positive in *Orchestrated Step Change* and *Green Energy Exports*, with expansion of electrification activities.

For the sectoral mix of savings, we assume that the 2021 actual shares (46.8% commercial, 1.6% industrial and 50% residential) are maintained in future. As with ESS and REPS, we assume an average deeming period of 10 years.

DEECA noted that targets are set to reach 7.3 Mt CO2-e by 2025 and are not defined thereafter. Also, the enabling legislation will sunset in 2030 unless legislative action is taken ahead of that time. Initially, we agreed with DEECA to model make assumptions regarding targets in the 2025 – 2030 period by scenario, as set out in Table 7 above, and then assume that no new targets are set thereafter. However, the expectation of falling emissions intensity of electricity consumption in VIC even before 2030 would, on current program settings and metrics, translate into a rapid growth in the demand for energy savings to meet emissions targets over the 2025 – 2030- period. If this occurred, it would be likely to be disruptive for the VEECs market and for retailers. Therefore, and for the purposes of these forecasts only, we bring forward the date of assumed cessation of this program from 2030 to 2025, to avoid this effect. In practice, we would expect DEECA to review the program design ahead of that date, and the program may well be modified rather than simply ceased. However, there is no information with which to base a projection at this time, and thus the working assumption for these forecasts is that the program ceases in 2025 (with a tail of impacts running out to 2034). It may be that this assumption can be updated in the AEMO's next forecasts.

SA Retailer Energy Productivity Scheme (REPS)

REPS is modelled in a similar manner to VEU and ESS, drawing on ESCOSA annual reporting.[25] This includes an associated data sheet which notes targets (to 2025), activity data, and savings by sector, ANZSIC Code and customer size. The only relevant parameter that was not available was the fuel mix of savings, which we assume was 100% electricity in the historical period and for *Progressive Change* and *Diverse Step Change* in the forecast period, but with the gas share of savings rising to 8.5% by 2055 under *Orchestrated Step Change* and 17% under *Green Energy Exports*, in line with higher rates of electrification assumed under these scenarios.

As with VEU, REPS targets are currently set to 2025 but not defined thereafter, and the legislation will expire in 2030, absent prior legislative change. As a result, and again in consultation with the relevant agency (the Department of Energy and Mining), we assume that the program phases out after 2030. In practice, it may also be extended, but that would be dependent upon the decision of a future Parliament. The program's absolute energy savings metric in GJ means that its impact does not vary as a function of economic parameters by AEMO scenario. As with VEU, we assume targets to 2050 by scenario, but no new targets are set thereafter. With an assumed average deeming period of 10 years, savings therefore reach zero by 2040.

Universal Mandatory Disclosure (UMD)

The measures described above are all currently in place. However, given that AEMO's scenarios are narrative-based, rather than based on constructs such as 'business as usual' or 'frozen policy', it is assumed that new policy models could be adopted, as a function of the scenario. Clearly, then, the savings modelled are uncertain to occur. They could be discounted, or delayed, as a function of AEMO's expectations as to the probability that they will occur and in the form modelled.

DCCEEW noted that the Australian Government has consulted widely regarding the potential nature of a future National Energy Performance Strategy (NEPS), but the nature of any resulting policy or program changes is not yet known. We have consulted with DCCEEW regarding all of the policy measures (current and potential future) covered in these forecasts, but the Department is not able to advise whether or not these measures are expected to form part of a future NEPS.

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[25] https://www.escosa.sa.gov.au/industry/reps/annual-report (time series data), viewed online 10/04/2023.

UMD was first canvassed by an Australian Government in 2004 in the *Securing Australia's Energy Future White Paper* which noted (p. 112) that "To complement the existing performance ratings for commercial and residential buildings, the government will work with the states and territories to require landlords and building owners to disclose energy performance information in leases and sales agreements." The 2007 Garnaut Climate Review noted that, "Disclosure schemes, such as energy efficiency ratings, complement an emissions trading scheme as they assist individuals to act on the price signal. Disclosure schemes will be far more effective if they are mandatory, as sellers are only likely to apply voluntary labels to high-performing products, leaving consumers unable to select among average and poorly performing products."[26] However, in 2023, only primary-purpose offices greater than 1,000 sqm are covered by mandatory national disclosure provisions (see Commercial Building Disclosure below). In the ACT, though, it has been mandatory since 2003 for houses that are to be leased or sold to first obtain and then disclose an energy efficiency rating.

UMD could apply only on sale or lease, as per the ACT scheme, or continuously/periodically (annually). We do not here detail the disclosure mechanism, but rather its expected effect. Key assumptions are that, because disclosure is mandatory but there is not *assumed* to be any mandation or financial support for upgrades to occur, then the extent of response to the measures – that is, additional upgrades caused by the measure – is low. In reality, it is likely that this measure could work in synergy with state energy efficiency schemes, which could provide financial support where required for deep retrofits. Also, this measure could proceed in tandem with the MEPS measure below or similar, which would provide a degree of regulatory leverage for the lowest-standard dwellings. However, to isolate the expected impact of UMD alone, we model the measure as applying without such supports.

We assume that the measure would apply to the owner-occupied stock only, to avoid non-additionality to the MEPS measure for rentals, discussed below. In reality, the measure could apply to both owner-occupied and rental sectors, but with limited additionality for the UMD component alone for rental properties (since MEPS would exercise greater leverage for rentals and would, in effect, already require disclosure). For this reason, we assume that only 0.05% of the stock impacted by the measures upgrade each year, with this totalling around 1.7% of the housing stock in FY2055 under *Green Energy Exports*, 1.5% under *Orchestrated* and *Diverse Step Change*, and just over 1% under *Progressive Change*. The latter is lower due to an assumption that implementation of the measure is delayed until 2035 under *Progressive Change*, cf 2025 under other scenarios. 2026 is assumed as a start date for other scenarios in order to allow time for program development and implementation.

The degree of (additional) upgrade that occurs is the other important variable that would determine the impact of UMD. Here we make the assumption that the average upgrade only achieves a 5% reduction in annual energy consumption per house, due to the lack of leverage (regulation or financial incentive) impacting on this parameter. However, this could easily be much higher once

[26] R. Garnaut, *Garnaut Climate Change Review*, 2007, p. 412.

households explore the most cost-effective options. This could be aided by smart program design, such as providing households with ready access to information, calculators and other tools that may encourage them to aim for deeper retrofits.

Minimum energy performance standards (MEPS) for rental properties

The rental property market – at least at the more affordable end of the spectrum – is renowned for poor efficiency standards and inclusions. For this reason, there has been for a number of years now an increasing focus on introducing minimum standards of various types. For example, in Victoria and from March 2023, rental properties must have a fixed heater which achieves specific energy efficiency benchmarks, albeit that these are low.[27] In the ACT, from 1 April 2023 (with a phase-in period to November 2026), rental properties are required to meet (and disclose that they meet) a minimum standard for ceiling insulation (R5, but only if the original insulation level is less than R2). This means that any ceiling insulation over R2 is compliant.[28] In TAS, rental properties must have a fixed heater in the main living area but there are no efficiency or insulation requirements.[29]

We note that these existing standards are low. The ACT notes that it expects over 60% of rental properties to comply with their standards, although this implies that nearly 40% of properties are expected to fail unless upgraded, despite the low minimum standard imposed. Overall, there would appear to be scope for significantly higher standards to apply, and potentially as a national requirement. With an increasing share of households renting,[30] with little incentive for landlords to improve housing in the absence of standards (or other measures), then such a measure could be an effective intervention, leading to additional energy savings amongst other benefits.

4.4 Commercial Sector Methodology

4.4.1 Scope and Structure of Sector

The commercial sector (COM) is a sub-set of business (BUS), that broadly aligns with 'commercial and services' in *Australian Energy Statistics* (ANZSIC divisions F, G, H, J, K, L, M, N, O, P, Q, R and S). Arguably, non-transport energy use in Division I (Transport, postal and warehousing, 50 – 53) should be included in COM, as warehouses are generally treated as a commercial building type, for example under the National Construction Code.

For gas consumption, the commercial mass market sector includes:

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

[27] https://www.consumer.vic.gov.au/housing/renting/repairs-alterations-safety-and-pets/minimum-standards/minimum-standards-for-rental-properties, viewed online 10/4/2023.
[28] https://www.justice.act.gov.au/renting-and-occupancy-laws/energy-efficiency-standards-for-rental-homes, viewed online 10/4/2023.
[29] https://cbos.tas.gov.au/topics/housing/renting/beginning-tenancy/minimum-standards/types, viewed online 10/4/2023.
[30] The national ABS Census Time Series Profile shows that around 59% of apartments, 45% of townhouses and 21% of houses were rented in 2021, with each of these categories having increased since the 2016 Census.

- 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.

4.4.2 Data Sources

Since the 2021 study, a new Commercial Buildings Energy Consumption Baseline Study has been released (December 2022).[31] This 3-year study drew on new satellite and aerial data from Geoscape Buildings,[32] and analysis by CSIRO and SPR, and previously unpublished data from the Australian Bureau of Statistics (ABS). It provides the first comprehensive study of the whole non-residential building stock, and its energy consumption and related greenhouse gas emissions across Australia, resolved at SA4 level and for the ABS Functional Classification of Buildings. This study indicates a significantly larger total non-residential floor area, and a different composition by building type in both the overall stock and in the new stock, than previously understood.

Historical energy consumption by fuel (for electricity and gas) is sourced from Australian Energy Statistics. AEMO data was available for total BUS consumption by year from 2015, but splits by sector were not. Figure 5 below shows the original data (national totals) and also a frozen efficiency projection (that is, FY2015 average fuel intensities applied to actual estimated stock growth). This illustrates that there were significant reductions in both electrical and gas consumption and intensity over this period. Electricity consumption fell, on average, by 2.1% per year, while gas consumption fell on average by just 0.2% per year (implying a relative increase in the gas share of consumption). When net stock growth over this period is taken into account, average electrical intensity (MJ/sqm.a) fell by an average of 3.7% per year, and gas by 1.8% per year.

The importance of taking energy efficiency into account is illustrated by the observation (Figure 5) that over just the 6-year period shown, electricity consumption would have been 15,100 GWh higher and gas consumption 5,600 TJ higher, if not for efficiency improvement over this period. Electrification will also have contributed significantly to the actual historical change. For example, it is likely that only a small proportion of the average 1.8% reduction in average gas intensity per years is attributable to efficiency change, given limited technical and economic potential, and that the majority of this change is attributable to electrification. Note that this implies that the rate of electrical efficiency improvement would have been higher again that the 3.7% per year actual if not for electrification over this period. Our estimate is that electrification accounted for around 0.5% of the change in electrical intensity over this period; that is, that the change in average electrical intensity would have been around 4.2%/year if not for electrification.

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[31] SPR, The Commercial Building Energy Consumption Baseline Study – 2022, December 2022, available from https://www.energy.gov.au/publications/commercial-buildings-energy-consumption-baseline-study-2022, viewed online 27/1/2023.

[32] https://geoscape.com.au/data/buildings/, viewed online 27/01/2023.

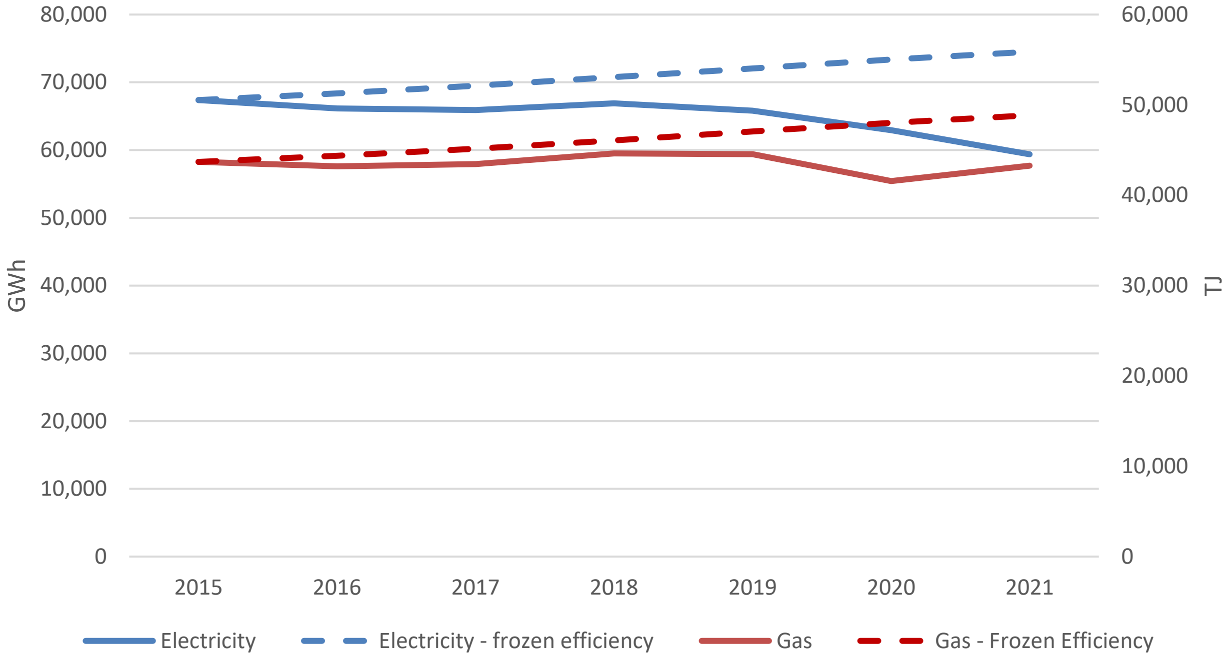

Figure 5: Commercial Sector - Electricity and Gas Consumption Actuals and Frozen Efficiency - NEM, SWIS, NT

As methodological notes, AEMO data is used for end-use shares by region, or the shares of energy savings that are correlated with cooling and/or heating loads, or otherwise baseload. Also, AEMO data is used for the split of SMEs and LILs by region in both the COM and IND (industrial) sectors.

4.4.3 Total Energy Efficiency Change

Total energy efficiency change in the commercial sector in the historical period is estimated top-down by expressing energy consumption by fuel per sqm of non-residential floor space over time. Future stock growth and turnover by scenario is related to AEMO-supplied demand drivers, vis, time-series projections of gross value added – services by scenario. These combine to generate the following projection of net stock growth over time (Figure 6). Note that since the two *Step Change* scenarios have the same change in GVA services, the stock projection is also identical.

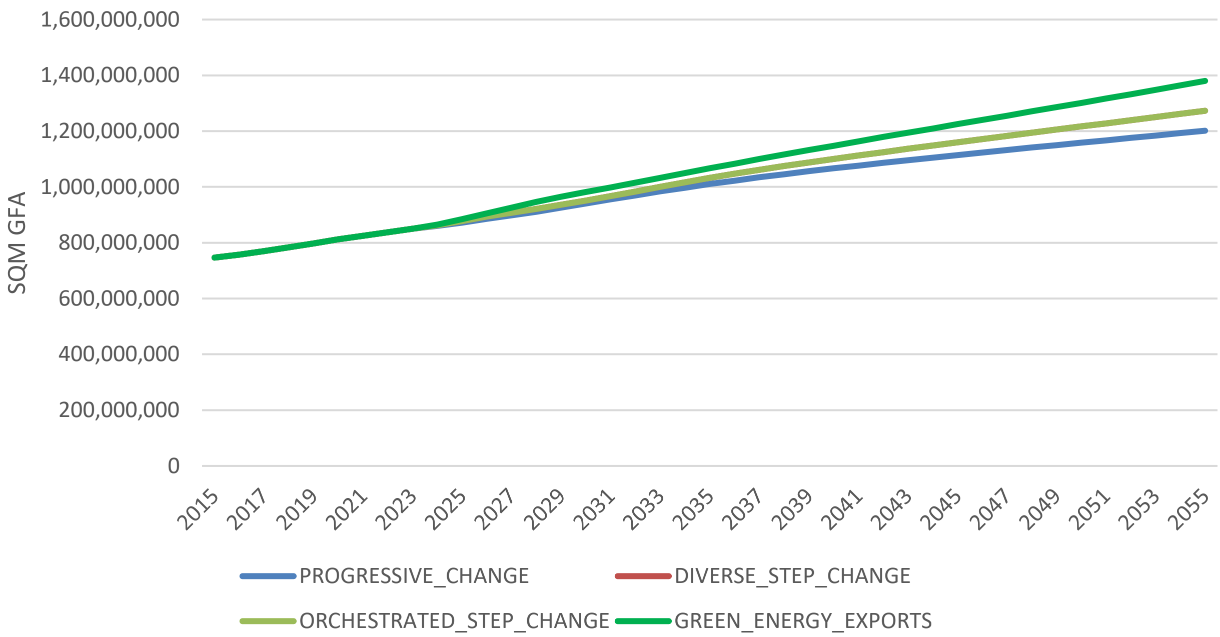

Figure 6: Commercial and Services Gross Floor Area by Scenario, Australia

4.4.4 Market-led Efficiency Change

As in past years, the rate of market-led or autonomous energy efficiency improvement (AEEI) is derived for the historical period. As described for the residential sector, these estimates are made by deducting policy-led savings (discounted for non-additionality to market-led change and/or other policy measures) from total energy efficiency change, as discussed above. This methodology limits potential errors (over- or under-estimation) to the *apportionment* of the total change in efficiency between market and policy effects, rather than in the total itself.

4.4.5 Policy-led Efficiency Change

The historical impact of individual policy measures, as listed in Table 1, is estimated, first from published program data and reports but also additional information provided by program managers. As noted, we apply discounts for non-additionality, which are generally not estimated by program managers. This step is, however, necessitated by requirement that market-led change is estimated as separate from and additional to policy-led change.

For new policy measures, and future policy settings/assumptions, see Table 8. Additional notes on individual measures are as follows.

Table 8: Proposed Energy Efficiency Settings and Measures by Scenario – Commercial

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
Market-led (or autonomous) energy efficiency improvement	• 1.1%/year for electricity • 0.05%/year for gas	• 1%/year for electricity • 0.05%/year for gas	• 0.7%/year for electricity • 0.05%/year for gas	• 0.6%/year for electricity • 0.05%/year for gas
National Construction Code energy performance requirements	• NCC2025 reduces new build average energy intensity by around 29% • Code could specify net zero energy and/or emissions, with offsite renewable energy allowed as part of the building solution, however these impacts would reduce emissions rather than underlying energy consumption • PV/EE trade-off loophole is closed, to ensure that where PV is used, it is additional to energy efficiency requirements • Future Code changes increase thermal comfort/climate resilience requirements, justified primarily on occupant health and safety grounds; a further 20% reduction in average energy intensity is required in NCC2037	• NCC2025 reduces new build average energy intensity by around 21% • Other settings as per *Green Energy Exports*	• NCC2025 reduces new build average energy intensity by around 21% • A further 20% reduction in average energy intensity is required in NCC2037 • Net zero emissions unlikely to be set as target due to use of blended gases	• NCC2025 deferred to 2028 • Other settings as per *Diverse Step Change*

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
Appliance and Equipment Standards and Labelling	• Product classes covered significantly expanded, generating an additional 10% electricity savings by 2030, and continued increases thereafter • Product classes to include industrial equipment, building materials/elements and potentially other more complex energy-using systems • Stringency of standards is increased regularly to the highest level cost-effective at that time	• Product classes covered expanded, generating an additional 4% electricity savings by 2030, and continued increases thereafter	• As per *Orchestrated Step Change*	No expansion of product classes – future savings as per current DCCEEW projections
State/territory energy savings schemes	• ESS targets lifted by 0.5% per year from 13% by FY2030 to 23% by 2050, when scheme is assumed to end • VEU annual targets lifted from 6.5 million certificates in 2021 to 7.3 million by 2025, as currently scheduled, then scheme is here assumed to be reviewed. While the scheme could be altered, for these projections, we assume it ceases from 2026. • REPS targets lifted from 3.75 million GJ in 2025 to 6.75 million GJ by 2030. As current legislation does not extend	• ESS targets lifted by 0.25% per year from 13% by FY2030 to 18% by 2050 • VEU as per *Green Energy Exports* • REPS targets lifted from 3.75 million GJ in 2025 to 5.75 million GJ by 2030. As current legislation does not extend beyond 2030, we assume the scheme ends at that point.	• As per Orchestrated Step Change	• ESS targets remain at 13% until 2050 • VEU as per *Green Energy Exports* • REPS target assumed to remain at 3.75 million GJ until 2030, then cease.

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
	beyond 2030, we assume the scheme ends at that point.			
Mandatory Disclosure (NEW)	• Universal mandatory disclosure introduced initially for commercial building types, around 5.5% of total non-residential floor area. FY2026, rising to 15.4% by FY2055 • Conversion rate (% of buildings disclosed that make additional EE investments in a given year) rises progressively from 1.1% in FY2026 to 5.5% in FY2055 • Higher average savings rate assumed (per additional investment made), averaging 11% TEI reduction • Modelled as additional to CBD and NABERS (but these could also be merged)	• Universal mandatory disclosure introduced initially for commercial building types, around 5% of total non-residential floor area. FY2026, rising to 14% by FY2055 • Conversion rate rises progressively from 1% in FY2026 to 5% in FY2055 • Average savings rate of 10% TEI reduction assumed	• As per *Orchestrated Step Change*	• Universal mandatory disclosure introduced initially for commercial building types, around 4.5% of total non-residential floor area. FY2026, rising to 12.6% by FY2055 • Conversion rate rises progressively from 0.9% in FY2026 to 4.5% in FY2055 • Average savings rate of 9% TEI reduction assumed
Minimum energy performance standards for existing buildings (NEW)	• MEPS assumed to be introduced in FY2026, initially at a low level, to be achieved within 5 years • Standard then applies without change for a further 5 years before being tightened (in 2036 and again in 2046)	• Criteria require 20% of stock to participate • Lower stringency than for *Green Energy Exports* other scenarios such that 10% of the floor area is assumed to require some upgrade, initially, increasing to 20% in second round and 30% in third	• As per *Orchestrated Step Change*	• Criteria require 18% of stock to participate • Lower stringency than for *Step Change* scenarios such that 9% of the floor area is assumed to require some upgrade, initially, increasing to 18% in second round and 27% in third

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
	• Criteria require higher share of stock (22%) than in other scenarios to participate • Higher stringency than for other scenarios such that 11% of the floor area is assumed to require some upgrade, initially, increasing to 22% in second round and 33% in third • Savings rate assumed to be lower, initially on average, than for UMD, due to wider modest stringency settings, at 5.5% (average reduction in TEI), but lifted to 11% in second round and 16.5% in third	• Savings rate assumed to be 5% (average reduction in TEI) for FY2026, lifted to 10% in second round and 15% in third		• Savings rate assumed to be 4.5% (average reduction in TEI) for FY2026, lifted to 9% in second round and 13.5% in third

National Construction Code

NCC energy performance requirements have never been evaluated formally, so far as we can ascertain, nor are annual savings estimates published. We therefore rely on the work undertaken in the context of regulation impact statements (RISs), applied to our stock turnover models. As for the residential sector, BCA2010 applied for the years prior to ~2021, when NCC2019 took effect, and we represent savings in the early years relative to the pre-existing standard, BCA2006.

In 2009 and 2018 RISs, the fuel mix of new buildings was assumed, generally in the underpinning technical analysis, rather than being treated as a variable. However, since we wish to be able to model differing rates of electrification over time as a function of the AEMO scenarios, we constructed a data table estimating three values for each combination of new building class, climate zone, scenario and year:

1. The electrical intensity of new buildings if they are all-electric
2. The electrical intensity of new buildings if they also use gas
3. The gas intensity of new buildings that use gas.

As with residential buildings, this enabled explicit assumptions to be made about the fuel mix of new buildings over time, with these varied by scenario. We make the same assumptions as per residential, that new commercial buildings no longer use gas after FY2040 for *Progressive Change* and *Diverse Step Change*, and after FY2030 for *Orchestrated Step Change* and *Green Energy Exports*. Given that the energy efficiency of new buildings is dependent upon the fuel mix, we model each of the three segments independently and then sum them for the total fuel consumption of new buildings.

In line with past RIS practices, we assume that some portion (here, 10%) of the expected Code savings are not in fact realised. This is a controversial topic, in part because there is little relevant evidence to support any assumptions in this area. For example, no jurisdiction undertakes Code compliance audits for non-residential buildings. Also, the 2009 and 2018 commercial building RISs apply a discount (25%) to the policy case only, and not to the base case, without explaining why the base case would not be similarly affected. The evidence that existed in 2018 was review by The Centre for International Economics (CIE) in Appendix A of the Decision RIS.[33] However, primary issue is a conceptual one. Most literature refers to differences between design and realised energy performance – typically in very high-performance buildings with complex control systems – but the Code is design-based. Strictly, it does not seek to police the energy performance of buildings as-built, but only as-designed.

The requirements for modelling of reference buildings (under JV3, only one verification method) are set out in a prescriptive manner in the Code, and these may bear little relation to the owner's (or

[33] The CIE, *Decision Regulation Impact Statement: energy efficiency of commercial buildings*, November 2018.

eventual occupant's) intended use of the building. For example, the building may operate 24/7 when the reference building modelling assumed 50 hour per week. Clearly, in such as case, the building as-built will use more energy than the reference building, but this may be simply attributed to unrealistic Code assumptions. Importantly, in such a case, energy savings attributable to higher Code standards would be *greater* than expected, not smaller, as is assumed in recent RISs. As a second-round effect (not modelled in the RISs), the return on investment in energy efficiency improvement would be higher than assumed, justifying higher cost-effective standards than would be the case with shorter operating hours.

A study by GBCA provides some insights into the 'performance gap' question, albeit limited to higher-end office base buildings.[34] The gap in question in this study relates to NABERS and Green Star ratings rather than to any difference between reference building simulations and real-world consumption, which is the issue highlighted in The CIE RIS in 2018 and elsewhere. On balance, we continue to apply a 25% discount to expected Code savings, in line with recent RIS practice and our 2021 forecasts, but we note that there is no evidence to support this assumption.

As with other measures, we discount expected savings to represent the effect of the market-led improvement in energy efficiency that might have been expected in the absence of the Code – see Chapter 5 for results.

Greenhouse and Energy Minimum Standards/E3 Program

As discussed above for the residential sector, assessments of historical and expected future GEMS impacts were able to be updated and revised this year, thanks to DCCEEW sharing with AEMO the results of its new and integrated internal modelling. This marks an improvement in confidence of savings estimates compared to 2021, where it was noted that some of the underlying data sources were both dated (eg, early RISs) and prepared using assumptions that were likely inconsistent and superseded. Generally, the effect of this update is to reduce commercial sector GEMS savings to date and expected future based on existing measures (the DCCEEW modelling does not cover potential new measures). The Department's expectations are taken as the Progressive Change case, with differing degrees of program expansion expected under the other scenarios.

Commercial Building Disclosure (CBD) and NABERS

NABERS and CBD are modelled in a parallel manner given that CBD assessments are essentially a (mandatory) subset of NABERS (voluntary) Office Energy ratings. In this regard, CBD and NABERS Office Energy savings are strictly non-additional.

The CBD program publishes very detailed life-of-program statistics, although these are only current to December 2021 (and do not appear to be currently in the public domain – we understand they are being updated for compliance with current Web Content Accessibility Guidelines). This data provides key inputs for the analysis, including total floor area assessed annually under the program,

[34] GBCA, *Energy Performance in Green Star Buildings: closing the performance gap in Australia's commercial office sector*, 2022.

the average energy intensity (not broken down by fuel) of rated (base and whole) buildings over time. Also, the NABERS program segments its overall data in several ways, including separately identifying results for the CBD cohort.

The raw data from these sources implies that the reduction in the rated energy intensity of CBD buildings (primary purpose offices above 2,000 sqm until 30/6/2017, and above 1,000 sqm thereafter) over the 2012 – 2021 period has been very rapid, averaging 4.8%/year for the original CBD cohort, and 7%/year for the 1,000 – 2,000 sqm cohort (over 2017 – 2021). However, 2020 and, even moreso, 2021 results are likely to affected by the COVID pandemic, which led to some office closures, but more often to part-load operation, due to many people working from home. Also, it should be recalled that primary-purpose offices greater than 1,000 sqm are generally premium buildings, located in central business districts, typically owned (and professionally managed) by large property trusts and institutions. Many of the owners will participate in initiatives such as the Green Building Council of Australia, the Better Buildings Partnership, or the Global Real Estate Sustainability Benchmark. It is likely that their progress in efficiency improvement is well above, and not representative of, that of the wider commercial building sector.

Also, it is important to note that the change in the average energy intensity reported under CBD (and also NABERS) will not be entirely caused by these programs, as the nature of metric is that it will reflect all energy intensity changes over time, regardless of their cause. We therefore apply discounts to both CBD and NABERS results, firstly for non-additionality to market-led or autonomous energy efficiency improvement, which we assume to be around 1% per year in this cohort (but which could be higher – there is no directly observable data source that would enable this value to be determined more precisely). Second, we apply specific discounts for non-additionalities between overlapping policy measures. As noted, CBD savings are treated as non-additional to NABERS, by subtracting the CBD-rated floor area from NABERS. CBD is given precedence in this calculation due to its mandatory application. NABERS also reports results attributable to the ESS scheme, which has a 'NABERS method', and these are deducted from ESS (but retained in NABERS), to avoid double-counting. NABERS does not report the fuel mix of savings.

Projecting future savings associated with both CBD and NABERS Office Energy is complicated by an expectation diminishing returns over time. This is due essentially to the pool of in-scope buildings (larger offices) being finite in number, and with at least some of these buildings being rated repeatedly, or even annually, for many years. Neither program requires any energy efficiency improvement. Rather, the mechanism for both is that the act of disclosure (and particularly, as Ross Garnaut noted – cited above – when disclosure is mandatory) enables market forces to work, with both owners and tenants having incentives to upgrade, and select, respectively, higher rated spaces/buildings. For institutional owners, there is likely to be an additional financing incentive, with lower cost finance available from climate bonds contingent upon demonstrated low-carbon performance. However, it should be expected that the most attractive upgrade options are implemented first, with progressively smaller and/or higher-cost savings options remaining over time (even if this effect will be offset by market-led developments, such as improved technology –

eg, LED lighting. The latter effect is not attributable to either program.) This implies that, for a given building, the rate of efficiency improvement – additional to market effects – will tend to decline over time. The decline is also offset by additional recruitment (new buildings), but ultimately the pool of buildings will tend to become exhausted (newly-constructed buildings are less likely to enter either program for a period of time after construction and, when they do, they should already be more efficient on average than older buildings, with fewer cost-effective savings opportunities).

We therefore apply an assumption of diminishing returns when forecasting the impact of both programs to 2055. This saturation effect is stronger in scenarios (such as *Green Energy Exports* and *Orchestrated Step Change*) where demand for ratings is higher, as cost-effective efficiency opportunities would be exhausted sooner. This effect offsets others – like the extent of floor area rated annually – which increase with stronger economic conditions. Electrification impacts are also assumed to occur, with *Orchestrated Step Change* in particular (with the highest electrification) showing diminishing gas savings over time, as the average fuel mix shifts further and further towards electricity.

State Savings Schemes

Data inputs and methodologies for ESS, VEU and REPS are discussed in Section 4.3.1 above.

Universal Mandatory Disclosure

The background to this *potential* new measure is also provided in Section 4.3.1 above. As noted there, there is no guarantee that this measure will be introduced, and estimated savings could be discounted or delayed based on assessments of the probability that it may be introduced.

For commercial buildings, the measure would (at least conceptually) build on the existing CBD measure – although alternative implementation mechanisms could be explored. Previous reviews of CBD have proposed expanding the program to other building sectors, with the sectors generally limited to those for which NABERS ratings tools were then available. NABERS coverage has been expanded over time, and we understand NABERS is also developing a universal ratings tool suitable for use with any non-residential building. We would argue that past limitations to the proposed expansion of CBD should at least be critically reviewed in light of current circumstances.

In any case, UMD is here modelled as applying to all non-residential classes, but excluding share of buildings already rated under NABERS (including CBD), to ensure that the modelled impacts are additional to both. We assume that minimum floor area or other thresholds are used (as per CBD) to at least initially limit the range of buildings covered to the larger end of the spectrum, with these thresholds being progressively reduced over time. We assume that the impact of these thresholds is to initially remove from the scope of the measure 75% of the total non-residential floor area (reflecting an understanding that the floor area size distribution is generally skewed towards smaller buildings, with a smaller number of large floor area buildings.[35] We assume that thresholds are

[35] Unfortunately building size/floor area distributions were not able to be included in the 2022 Update to the Commercial Building Baseline Study, due to data limitations.

reduced such, from FY2031 on, 60% of the total floor area is excluded, and only 45% from 2036 onwards. In reality, the need to exclude floor area based on size is likely to depend upon the cost of disclosure mechanism. If a low-cost approach is used, then the need to exclude smaller buildings (on cost-effectiveness grounds) would be reduced.

As with the residential sector, we assume low/conservative take-up or 'conversion' rates (the percentage of buildings disclosed that go on to make an additional upgrade investment) around 1% of the stock rated in the first instance but reaching around 6% of the rated stock by FY2055, depending upon the scenario (due to varying economic conditions, relative prices, and other factors relevant to upgrade investment decisions). We recall that under UMD, as with CBD and NABERS, neither the uptake rate nor the degree of upgrading would be prescribed. Instead, these would reflect market conditions and the perceived net benefits associated with upgrade opportunities over time. We assume that larger energy savings are cost-effective in scenarios with higher electrification and vice versa.

MEPS for Existing Buildings

This is another *potential* new measure and, as above, there can be no guarantee that the measure will be implemented, including as modelled. AEMO may therefore wish to discount the modelled savings depending upon perceptions of the probability that the savings will be realised.

While conceptually similar to the 'MEPS for rental properties' measures for the residential sector above, it is less clear that its scope would be limited to leased buildings, even if this would be an option. We assume that standards would be applied with the aim of requiring only the least energy efficient buildings in each sector/time period to upgrade,[36] and then gradually raising the standard over time so as to include more buildings/floor area. Specifically, we assume that standards initially have the effect of requiring around 10% of existing floor area to be upgraded (over a 5-year period), with the initial standard requiring on average only a 5% improvement in energy performance. As per Table 8, these values are then differentiated by scenario, primarily to reflect assumed difference in policy ambition.

We assume that standards would be lifted only infrequently – eg, every 10 years – with a further 5-year implementation period allowed for each new standard. However, we assume that the standard is lifted such that 20% of floor area in the second 10-year period, and 30% in the third, would require some upgrading; and we assume that the degree of upgrade would progressively increase from 5% in the first period to 10% in the second and 20% in the third, again with differentiation by scenario.

When compared to UMD, MEPS is a much more highly leveraged measure, with commensurately larger energy savings expected. As per the mandatory minimum insulation requirements noted

[36] By analogy, a similar process was used to determine separate heating and cooling load limits for new dwellings – see tony isaacs consulting and Energy Efficient Strategies, Principles and Methodology for Setting NCC Heating and Cooling Load Intensity Limits and Draft Heating and Cooling Load Intensity Limits for all NatHERS Climate Zones, undated, available from https://abcb.gov.au/sites/default/files/resources/2022/Residential-energy-efficiency-heating-cooling-load-limits-report.pdf

above for rental houses in the ACT, we expect that the primary accommodation of the financial burden for owners would be to allow a period of 5 years for standards to be met. In practice, there could be hardship exemptions and/or alternative compliance pathways offered (such as use of renewable energy), but these are not modelled here. Also, as with residential, state energy savings schemes or other mechanisms could also be provided to assist with implementation.

4.5 Industrial Sector

4.5.1 Scope and Structure of Sector

The industrial sector (IND) for this study is defined as:

- Division A – agriculture
- Division B – mining
- Division C – manufacturing
- Division D – but excluding electricity/gas generation, transmission and distribution (thus retaining water pumping and distribution, for example)
- Division E (construction).

AEMO has provided (confidential) estimates the split of energy consumption between SMEs and LILs by ANZSIC Division, to assist with estimating the sectoral shares of efficiency savings, as well as end-types or base/heat/cool load shares.

4.5.2 Approach

As noted in Section 4.2, it is necessary to adopt a different estimation approach for efficiency change in the industrial sector.[37] This is essentially because there is no visibility – in national data collections or statistics – as to the level or rate of change in energy efficiency in this sector, in the absence of detailed studies. The past Energy Efficiency Opportunities (EEO) program, that was closed in 2014, once provided detailed insights, but these are now dated.

Approximate metrics, such as energy consumption per unit value-added, are sometimes used for want of anything else being readily available, but these are likely to be weakly indicative, at best, of underlying energy efficiency, as discussed above. These metrics are shown in Chapter 5.

The primary estimation approach that is available is bottom-up estimation of individual energy efficiency policy/program impacts, drawing on published program statistics, and generally estimating the share of program savings that are likely to arise in the SME and LIL sectors, based on the character of the end-use or other program-specific factors.

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[37] In principle, the EASIF approach can be applied to the industrial sector, but it must be applied industry-by-industry or product-by-product, and it requires access to confidential enterprise-level data. See for example: https://www.iea.org/reports/tracking-industrial-energy-efficiency-and-co2-emissions, viewed online 31/01/2023.

These factors mean that is has not been possible to derive actual estimates of market-led or autonomous energy efficiency improvement for the industrial sector. Further, since the energy/unit value-added metrics that are available indicate that total electricity and gas intensities have both been *rising in* the industrial sector on average over the 2015 – 2021 period (notably for gas, see Figure 7 below), there is no solid case for assuming a rate of underlying market-led efficiency improvement in this sector.

4.5.3 Policy Measures

As noted in Section 4.2, there are very few energy efficiency measures in the industrial sector at all, and fewer that would be likely to trip the NER criteria noted in Section 2.1.1 above. Prior to the announcement in March 2023 of a revised Safeguard Mechanism, discussed below, relevant measures were confined to:

- GEMS/E3 (industrial chillers and electric motors)
- State energy savings schemes.

For future policy assumptions with respect to these measures, see Table 9.

In the past, we have modelled legacy impacts from the EEO scheme that ran between 2007 and 2014. However, with 2014 forming our base year, the historical impacts of that program will have been present in the 2014 data, and therefore there is no basis for showing incremental impacts for EEO thereafter. Legacy impacts will exist, but the information regarding them is – in principle as least – carried in the base year data.

A more difficult question is to envisage plausible future policy models for the industrial sector. The general challenge is the diverse nature of energy-using processes in the sector. One answer – adopted in the GEMS/E3 program – is to focus on important and common elements of those energy-using processes, such as motors and chillers. The rationale that, in energy-intensive applications, and to varying degrees regardless of the nature of the overall industrial processes, high-efficiency options will be cost-effective, while the elemental approach is relatively simple to administer and simplifies options for suppliers.

At the same time, more complex policy models, that considered whole energy-using systems, rather than only components, would be likely to achieve greater efficiency and/or higher cost-effectiveness. With higher policy ambition, backed by more efficient regulatory processes, the elemental approach could be significantly expanded. There would be synergies, rather than conflict, between this and a more systems-based approach, potentially in other policy interventions, as systems comprised of efficient components will be more efficient than those comprised of inefficient components.

Another approach would be to effectively recreate the EEO program. This combined mandatory application of auditing and opportunity assessment, with voluntary responses to this information by companies, but mandatory reporting – essentially for peer/investor review. In this sense, Climate-related Financial Disclosures adopts a similar approach, albeit without mandation. As in 2021, we therefore propose to again model such a program, which we denote as Industrial Assessments. As with CBD or other disclosure-based schemes, such a measure would not need to require (mandate) any *particular* outcomes in order to encourage efficiency improvements. 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 was the case with EEO.

Another approach is to make use of the price mechanism, or quantitative constraints such as cap and trade. During the project, the Australian Government announced significant revisions to the previously ineffective Safeguard Mechanism. This policy requires facilities that produce at least 100,000 t CO_2-e per year from Scope 1 (direct) emissions to reduce emissions, relative to a determined baseline, by an average of 4.9% per year until 2030. Emissions from offsite electricity are excluded, and carbon offsets can be used to meet the target. Trading of emissions reductions credits is permitted between parties. Baselines are not absolute, but can be adjusted, for example when production volume changes, and new facilities/emissions are permitted, provided an overall cap of 1,233 Mt CO_2-e (cumulative emissions over the period to 2030) is not exceeded. The majority of these facilities are likely to be LILs, but the exclusion of Scope 2 (and 3) emissions focuses on facilities that use gas or liquid fossil fuels, or that produce process emissions, rather those that consume electricity, per se.

Government modelling of the expected impacts of this scheme was not released to Parliament or the public. This, together with the design of the measure – with multiple compliance options, exemptions and contingent factors – means that there is very considerable uncertainty about the extent to which it will drive energy efficiency improvement in these facilities, as compared to many other available response options. The exclusion of Scope 2 emissions is a very strong incentive for electrification, provided that the electricity is not generated on-site from fossil fuels. However, our scope focuses on energy efficiency change rather than electrification. Reliance on offsets will reduce the pressure for on-site emissions reductions, but there is some discouragement of this in the scheme, and offsets add costs to production without producing any co-benefits, at least for the emitter, unlike efficiency improvement which reduces operating costs.

Discussions with DCCEEW confirmed our impression that the scheme is likely to drive material energy efficiency improvements, that would not otherwise have occurred, primarily in the use of gas (or other fossil fuels). An indirect and rather weak incentive only is created for electrical efficiency improvement – where electricity is purchased offsite, replacing fossil fuels that may be extracted on-site and currently consumed with low marginal (but some opportunity) cost, then the electricity is likely to have a higher cost than the fuel it replaces, creating an incentive for efficient use of this energy carrier. In practice, this effect will be extremely difficult to distinguish from electrification, as it is likely that such fuel switching would deliver investment in new and at least relatively efficient electrical plant, including industrial heat pumps, motor drive systems and controls. This effect may be lessened where facilities self-generate electricity from renewables such as solar at very low marginal (and opportunity) cost.

We model the impact of the scheme in fairly simplistic and also conservative manner, noting that more sophisticated modelling would need to represent individual processes and/or facilities and examine the relative attractiveness of the wide range of available response options, as well as considering global market expectations with respect to the highly diverse outputs of these facilities, including any competitiveness impacts. We review the efficiency outcomes that were achieved with the encouragement of the EEO scheme between 2007 and 2014, in terms of the average change in GJ of electricity and gas consumption per $million of gross value added (GVA). It should be noted that this program also realised much larger gas than electricity savings (and also liquid fuels), with cumulative savings estimated to have reached around 52 GJ/$million GVA for gas and only 5 GJ/$million GVA for electricity by 2014. These savings were small in proportionate terms (see Figure 7) but material given the size of this sector.

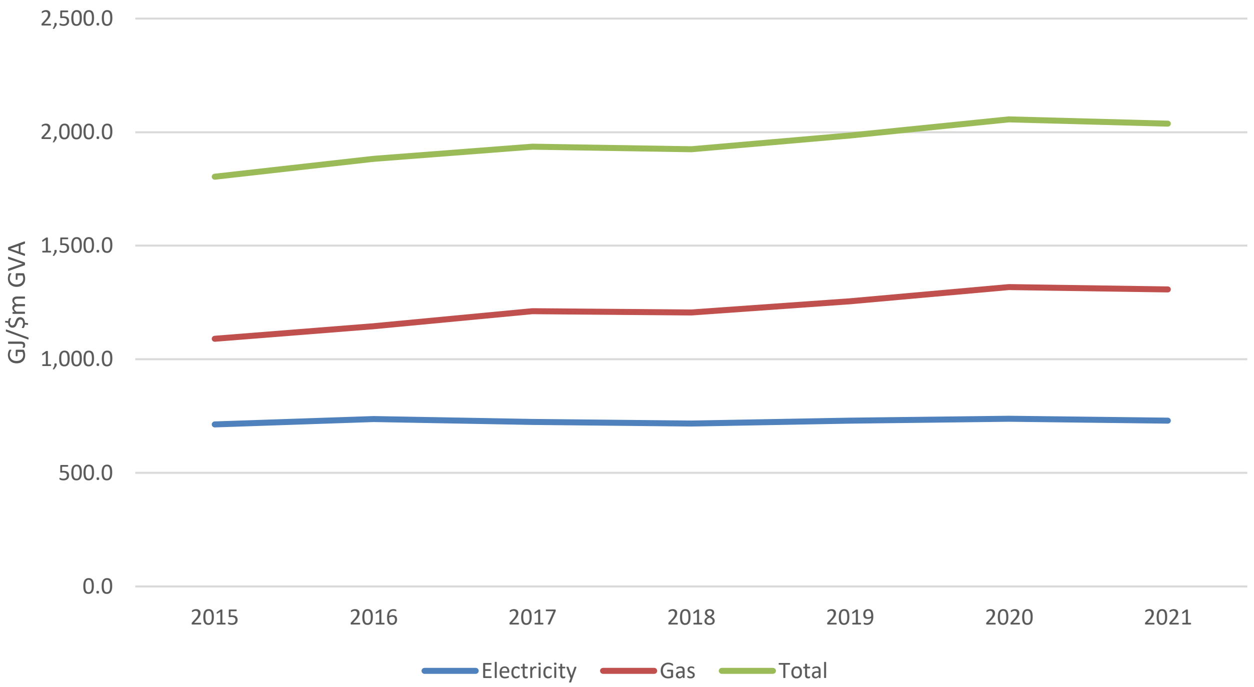


Figure 7: Australian Average Energy Intensity (GJ/$m Gross Value Added) BMM Industrial by Fuel

Noting this, and the uncertainties associated with the scheme's impact, we recommend that AEMO undertakes a more careful analysis of actual and expected impacts ahead of its next energy efficiency forecasting round (eg, in 2025).

Table 9: Industrial SME Policy Settings by Scenario

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
Market-led (or autonomous) energy efficiency improvement	• Not able to be quantified	• Not able to be quantified	• Not able to be quantified	• Not able to be quantified
Appliance and Equipment Standards and Labelling	• Product classes covered significantly expanded, generating an additional 10% electricity savings by 2030, and continued increases thereafter • Product classes to include industrial equipment, building materials/elements and potentially other more complex energy-using systems • Stringency of standards is increased regularly to the highest level cost-effective at that time	• Product classes covered expanded, generating an additional 4% electricity savings by 2030, and continued increases thereafter	• As per *Orchestrated Step Change*	No expansion of product classes – future savings as per current DCCEEW projections
State/territory energy savings schemes	• ESS targets lifted by 0.5% per year from 13% by FY2030 to 23% by 2050, when scheme is assumed to end • VEU annual targets lifted from 6.5 million certificates in 2021 to 7.3 million by 2025, as currently scheduled, then scheme is here assumed to be reviewed. While the scheme could be altered, for these	• ESS targets lifted by 0.25% per year from 13% by FY2030 to 18% by 2050 • VEU as per *Green Energy Exports* REPS targets lifted from 3.75 million GJ in 2025 to 5.75 million GJ by 2030. As current legislation does not extend beyond 2030, we assume the scheme ends at that point.	• As per Orchestrated Step Change	• ESS targets remain at 13% until 2050 • VEU as per *Green Energy Exports* REPS target assumed to remain at 3.75 million GJ until 2030, then cease.

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
	projections, we assume it ceases from 2026. • REPS targets lifted from 3.75 million GJ in 2025 to 6.75 million GJ by 2030. As current legislation does not extend beyond 2030, we assume the scheme ends at that point.			
Safeguard Mechanism	• Revised Safeguard Mechanism assumed to stimulate additional energy efficiency improvement (in addition to other potential responses, not modelled). While the degree of EE improvement induced is uncertain, here we assume that around 10% of the required annual abatement is from this source, with gas savings rate double that of electricity due to electrification incentives.	• As per *Green Energy Exports* but with reduced savings linked to market conditions (somewhat slower growth in industrial sector value added)	• As per *Orchestrated Step Change*, but fewer gas savings due to increased use of blended/green gases	• Lowest EE response due primarily to market conditions assumed in this scenario.
Mandatory Industry Assessments (NEW)	• A new IA program is legislated, to apply from FY2026, initially requiring all industrial enterprises using at least 500 TJ of energy per year to undertake mandatory efficiency and electrification opportunity assessments and report publicly on the findings	• As per *Green Energy Exports*, but more modest efficiency responses expected	• As per *Orchestrated Step Change.*	Assumed to not to apply.

Policy Domain	1.5°C Green Energy Exports	1.8°C Orchestrated Step Change	1.8°C Diverse Step Change	2.6°C Progressive Change
	and any actions taken as a result. • Higher savings outcomes expected reflect market conditions and savings opportunities, rather than program settings			

4.6 Summary of Discounts Applied

'Discounts' in this context cover a number of adjustments that are made to original data inputs, as detailed below.

4.6.1 Residential

For the National Construction Code measure, we apply:

- Unique constraint factors per region, that average 28%, to reduce the energy consumption implied by reference NatHERS star bands (for any given star rating)
- Discounts of 25% for non-realisation of expected thermal shell energy savings
- Discounts for non-additionality to market-led or autonomous energy efficiency improvement (AEEI)
  - These values are derived experimentally for each jurisdiction for the historical period, with unique values for electricity and gas, and are assumed for the forecast period:
    - For electricity, we assume 0.2% reduction in average energy intensity per year for *Progressive Change* and *Diverse Step Change*, 0.75% per year for *Orchestrated Step Change*, and 0.5% per year for *Green Energy Exports*
    - For gas, we assume no AEEI.
- WOH savings are discounted for non-additionality to AEEI.

For GEMS, and as noted above, SPR assumptions for the degree of non-additionality to AEEI for each measure were replaced by DCCEEW model outputs. While the non-additionality assumptions used in this modelling are not known to SPR, DCCEEW's estimated savings are lower than our discounted values.

For UMD and MEPS, and as noted in Section 4.3 above, these as additional to other measures meaning that no discounts for non-additionality are required.

For the state savings schemes (ESS, VEU and REPS) we apply a discount of 25% for non-additionality to AEEI. This reflects the fact that measures such as LED lighting, which feature prominently in jurisdictional savings estimates or reporting, are likely to have occurred over time in any case (it is likely that these schemes will have brought forward savings in time, however).

4.6.2 Commercial Sector

For the National Construction Code measure, we apply:

- Discounts of 25% for non-realisation of expected savings

- Discounts for non-additionality to market-led or autonomous energy efficiency improvement (AEEI)
    - For electricity, we assume 0.6% reduction in average energy intensity per year for *Progressive Change, 0.7%* for *Diverse Step Change*, 1% per year for *Orchestrated Step Change*, and 1.1% per year for *Green Energy Exports*
    - For gas, we assume 0.05% per year.

For GEMS, SPR assumptions for the degree of non-additionality to AEEI for each measure were replaced by DCCEEW model outputs. While the non-additionality assumptions used in this modelling are not known to SPR, we DCCEEW's estimated savings are lower than our discounted values.

For NABERS, we assume non-additionality to market-led efficiency improvement of 1% per year. As discussed in Section 4.4, we assume progressive saturation effects over time due, primarily to the limited market size (for office energy) leading to multiple assessments over time for the same floor area. First, we moderate the expected future growth in floor area assessed, relative to the average historical actual, value by 1.25% per year for *Progressive Change*, 1% for *Diverse Step Change*, 0.25% for *Orchestrated Step Change* and 0% (ie, no discount relative to the historical growth rate) for *Green Energy Exports*. Second, we discount the assumed savings rate for saturation effects by 1.2% per year for *Progressive Change*, 1.1% for *Diverse Step Change*, 1% for *Orchestrated Step Change* and 0.9% for *Green Energy Exports*.

CBD savings are similarly discounted by 1% per year for non-additionality to AEEI. Also, the rate of growth in floor area assessed is assumed to be responsive to AEMO's scenarios, with 1%/year growth in *Progressive Change*, 1.2% in *Diverse Step Change*, 1.5% in *Orchestrated Step Change*, and 1.3% per year in *Green Energy Exports*. Savings by scenario under both NABERS and CBD are more driven by market-led opportunities – and particularly electrification – than by other factors, as the disclosure event (whether voluntary or mandatory) does not in itself determine the degree of *response* in terms of additional efficiency investments – that (if any) is a judgement made by building owner taking market factors into account in each period.

For UMD and MEPS, these as modelled as additional to other measures, meaning that no discounts for non-additionality are required.

For the state savings schemes (ESS, VEU and REPS) we apply a discount of 25% for non-additionality to AEEI. This reflects the fact that measures such as LED lighting, which feature prominently in jurisdictional savings estimates or reporting, are likely to have occurred *over time* in any case (it is likely that these schemes will have brought forward savings in time, however). For the commercial sector, ESS savings are also discounted from non-additionality to NABERS, to the extent of the reported contribution to total savings from this 'activity', which has averaged only 0.3% of historical ESS savings, and this same rate is assumed in future.

4.6.3 Industrial Sector

As noted above, we are not able to establish an evidence-based rate of AEEI for this sector, and therefore policy impacts are not discounted for non-additionality to AEEI.

GEMS and state schemes are discounted as noted in Section 4.6.2 above. Both Industrial Assessments and the Safeguard Mechanism are modelled as additional to other measures, so no further discounts for non-additionality are required.

4.7 Continuity of Policy Impacts over Time

A question that has arisen during this project is whether or not, or to what extent, policy-induced savings may continue on past the cessation of a policy measure (including past the economic life of efficiency investments made during the program or policy window). This is a difficult question to answer. It goes without saying that there have been no post-hoc evaluations of major energy efficiency measures in Australia that have specifically sought to obtain an evidence-based answer to this question.[38] There is an international literature on this topic, which is known as 'market transformation'. However, there is little Australian literature, as this concept appears to be little known, and is certainly little practiced, here.[39]

To estimate the likelihood of such impacts, key questions would be:

1. Did the policy or program have an explicit objective of achieving permanent 'market transformation'?
2. If so, is there evidence that it achieved this outcome? If not, did it happen anyway, as an unintended side-effect of the policy? Or was this outcome instead a market-led effect, not attributable to the program to any significant degree?
3. Is the market, supply-chain, technology, manufacturing practices and/or consumer preferences now so changed by program impacts that reversion to past practices is unlikely?

The classic study in market transformation is the US DOE/US EPA collaboration to commercialise 'sub-compact' fluorescent lamps (generally known as CFLs). This deliberate campaign was a response to the early 'compact' fluorescent lamps being energy efficient and also long-lived, but not, in fact, being very compact (such that they would not fit into conventional light-fittings). These early lamps also had other undesirable characteristics such as flicker, buzz, poor colour rendition, delays to reach full brightness and relatively high cost. In response, these US agencies designed a series of measures that engaged local (and overseas) manufacturers in innovations to address these issues, and to scale up production, essentially by providing a guaranteed market based on *performance-based* specifications, rather than technology types or other criteria. The successful

[38] Although questions of additionality and permanency of energy efficiency program impacts in the industrial sector were investigated in ACIL Allen, *Energy Efficiency Opportunities Program Review*, April 2013, Section 4.2.

[39] See SPR, *Best Practice Policy and Regulation for Low Carbon Outcomes in the Built Environment*, published by the CRC for Low Carbon Living, 2017.

legacy of this program was the sub-compact lamp which, until superceded by LED lamps, overcame all of the limitations noted and became the mainstream lighting solution in many applications around the world.

In Europe, the US, Canada and Japan, at least, similar examples may be found for LED lighting, PV cells, heat-recovery ventilation (HRV) units, high-performance glazing, passivhaus-standard housing, variable speed drive motor systems, and many other product classes. In Australia, the only example that may fit the description of deliberate market transformation is the effective ban on most types of incandescent lamps that was introduced in 2010 (enabled by the US's efforts with sub-compact fluorescent lamps).

None of the energy efficiency measures analysed in this study have an explicit aim of achieving market transformation. Indeed some, such as the NCC, explicitly target the 'minimum necessary' standards of energy performance, although this phrase in not defined. Measures under the GEMS legislation and the wider E3 program around it would have the potential to deliver market transformation outcomes, but we are not aware that any such aspirations are currently held, let alone realised.[40]

State energy savings programs certainly supported and accelerated the rollout of LED lamps, as well as of CFLs before that. However, one of the success criteria for market transformation is that the scale (and nature) of the intervention is sufficiently material, relative to the size of the market and/or innovation investment required, to induce the permanent changes in practices through the entire supply chain. Measures at the scale of individual states and territories can hope to impact local practices, including technology adoption rates, but would not be large enough to induce technology innovation.

To bring this analysis back specifically to AEMO forecasts, the short answer for the majority of cases will be 'no', most programs would not be expected, in themselves, to achieve market transformation, particularly in the absence of any ambition to do so. However, technology innovation goes on, primarily at a global scale, and these changes – eg, from incandescent to fluorescent to compact fluorescent to sub-compact fluorescent to LED lighting – will clearly not be reversed even if support measures are removed. However, if the program did not meet the criteria for market transformation, deliberately or inadvertently, then this efficiency outcome cannot be attributed to the program in question. That is, the lighting efficiency gains will be retained (consumers will not go back to incandescent lamps, in part because they are virtually no longer manufactured), but this outcome is not, or at least not primarily, a policy-led effect. Rather, it is a primarily a market-led effect.

At best, then, we can hope that efficiency outcomes targeted by specific program may pass progressively from a policy-led to a market-led effect and be sustained after the cessation of the program as a market-led efficiency improvement. This is far more likely to occur when and if the programs in question are consciously designed to achieve market transformation. However, and as

[40] Arguably the phase-out of incandescent lighting may be classed as an example of this policy approach.

a general rule, there is little case for attributing ongoing policy-led savings to specific programs after their cessation, unless there is specific evidence of market transformation attributable to that program.[41]

[41] As a case in point, SPR has in past AEMO forecasts attributed savings to the EEO program even after its closure in 2014. This was done specifically because there was evidence – documented in ACIL Allen (2013) above – of at least lasting changes to practices in the affected sectors that were attributed to the program, as well as the long-lived nature of certain investments made under the influence of the program. However, as discussed in Chapter 4, we no longer attribute savings to this measure, 9 years after its closure.

5. Energy Efficiency Forecasts

5.1 Residential - Electricity

5.1.1 Overview by Scenario

Figure 8 provides an overview of the residential electrical energy efficiency forecasts by scenario. This figure includes all efficiency policy measures and market-led efficiency improvement, the total of all load/end-use types (Base, Cool, Heat) and all regions. Overall, *Green Energy Exports* and *Orchestrated Step Change* result in similar totals but, as is broken down below, this is the net effect of two quite different scenario assumptions. Policy ambition and economic drivers are higher for *Green Energy Exports*, but electrification is highest for *Orchestrated Step Change*. This translates into higher *market-led* energy efficiency improvement in *Orchestrated Step Change* (since electrification is primarily treated as a market effect, rather than a policy effect at this time) but less *policy-led* savings, while in *Green Energy Exports*, we see the reverse – smaller market-led savings (due to less electrification and greater hydrogen blending) but higher policy impacts due primarily to greater policy ambition.

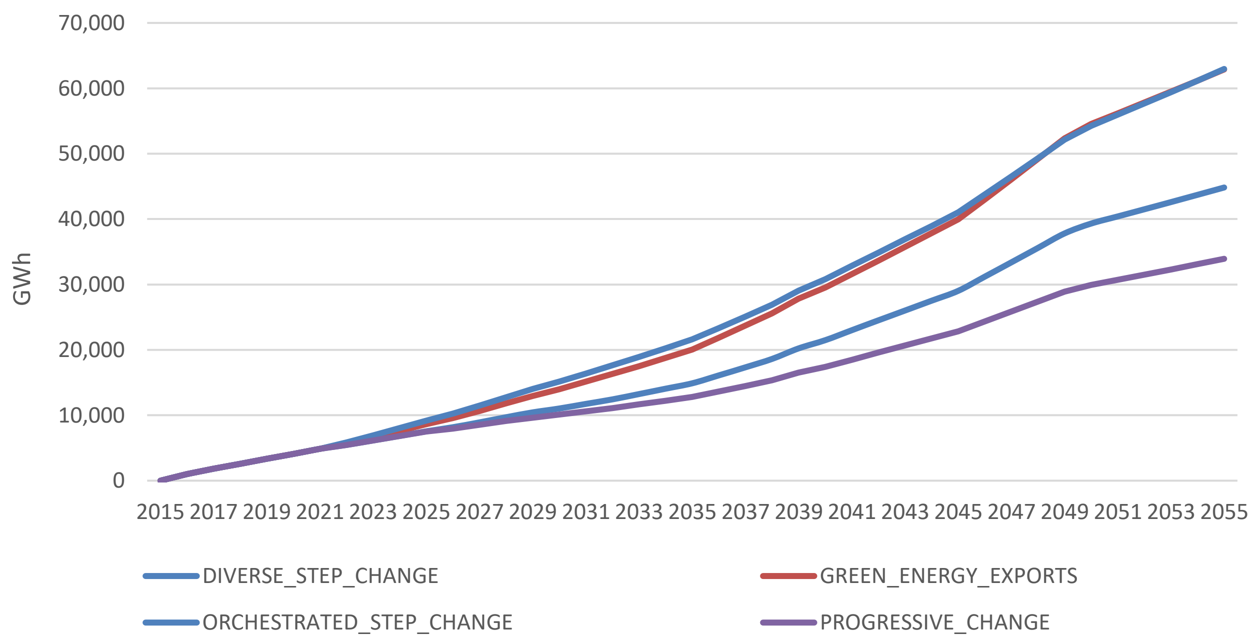


Figure 8: Residential Electricity Energy Efficiency Forecasts by Scenario (all regions, components and end-uses)

It may be noted that savings flatten off through the 2030s in all scenarios. This reflects:

1. The assumed cessation of VEU and REPS in 2030

2. NCC2022 encouraging electrification in 'whole of home' end-uses (and particularly hot water) in cases where PV access is limited, leading to positive gas savings but negative electricity savings.
3. The above effect is assumed to be largely complete within 15 years, or by the late 2030s, with hot water use (at least in new dwellings) largely electrified by that time.

5.1.2 Overview by Measure

Figure 9 overleaf shows the residential electricity forecasts for each scenario by measure. Depending upon the scenario, market-led efficiency improvement is estimated to account up to 32% of total energy savings over the FY2015 - FY2055 period (*Orchestrated Step Change*). However, this falls as low as 14.6% in *Diverse Step Change*, due to this scenario assuming lower electrification and higher use of (renewable) gases.

Generally, the efficiency of overall energy use (in RES and also COM) is inversely related to the share of gas use. This reflects the lower conversion efficiency of gas, particularly in space conditioning, domestic hot water and cooking applications, when compared to heat pumps and induction cooktops. On this basis, market-led efficiency improvement is also assumed to be lower in Diverse Step Change – notably relative to *Orchestrated Step Change*, which has the same policy settings as *Diverse Step Change* – due to lower electrification. *Progressive Change* has the slowest market-led efficiency improvement due to weaker economic conditions, greater supply chain disruption and weaker international co-ordination (likely to slow the rate of commercialisation of low carbon technologies, and also lower policy ambition (reduced co-ordination).

Within the policy measures, energy performance requirements within the National Construction Code account for the highest savings. This reflects its cumulative savings effect with stock growth and turnover, as well as the scope expansion in NCC2022 to include 'whole of home' provisions. As noted, we discount expected savings by 10% to reflect potential non-realisation of expected savings, even though this assumption is not well-supported by evidence. It does have the effect of making the projections more conservative.

The other significant national measure is GEMS, even though, as noted, the savings impact of the measure has been scaled back considerably, drawing on modelling supplied by DCCEEW which manages the program. The Department expects this program will be expanded significantly in coming years, but it has not yet modelled the savings impact of this expected expansion. GEMS impacts are differentiated primarily on the basis of policy ambition, as the program is regulatory in nature and its impacts over time are critically determined by how quickly it is able to respond to market developments (such as technology change), as well as the scope of energy use that it is allowed to reach.

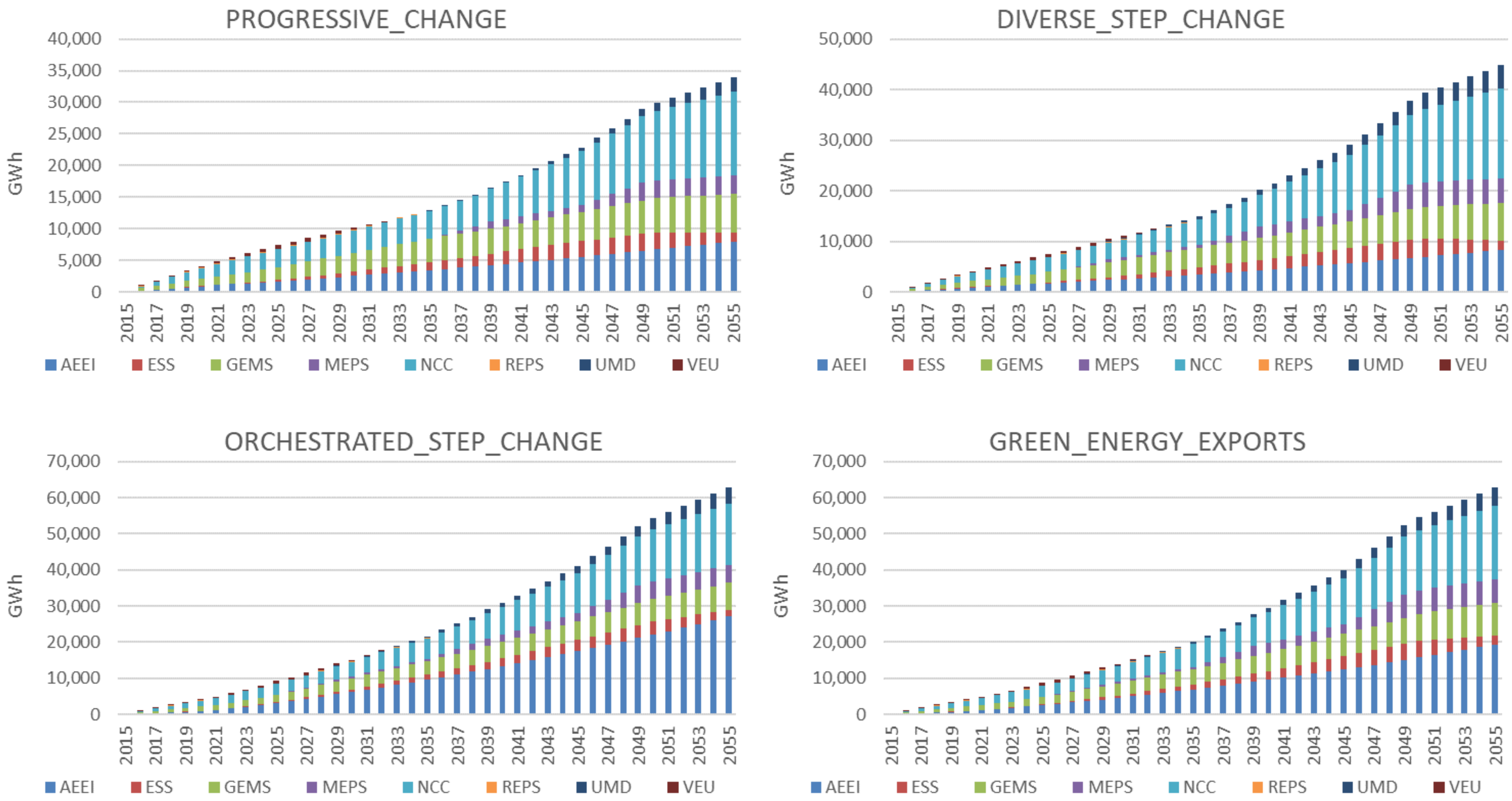


Figure 9: RES Electricity Energy Efficiency Forecasts by Measure and Scenario

Of the state schemes, VEU is larger in scale than the NSW or SA equivalents, generating up to 4.2% of total energy savings over the whole period in some scenarios, despite our assumption that it is phased out over the 2030s. This indicates that the scheme is very significant in the context of the VIC region. ESS accounts for around 1% of total savings over the period, while REPS is around 0.2% of the savings. VEU and REPS impacts vary only modestly by scenario, as their target metrics are expressed in either emissions units (VEU) or absolute GJ (REPS). While both have targets that are differentiated by scenario, both have targets that are set already to 2025 and, as noted, we assume they are phased out after 2030. As a result, there are only a few years in which the differentiated targets have an impact.

The potential new measures – universal mandatory disclosure and minimum energy performance standards for rental properties – are shown to have the potential to contribute material savings over time, assuming they were adopted and implemented nationally. In terms of these forecasts, the savings associated with these potential measures may be discounted for uncertainty. The National Energy Performance Strategy process is expected to lead to some policy changes in the energy efficiency area during 2023, but the nature of these is uncertain at this time.

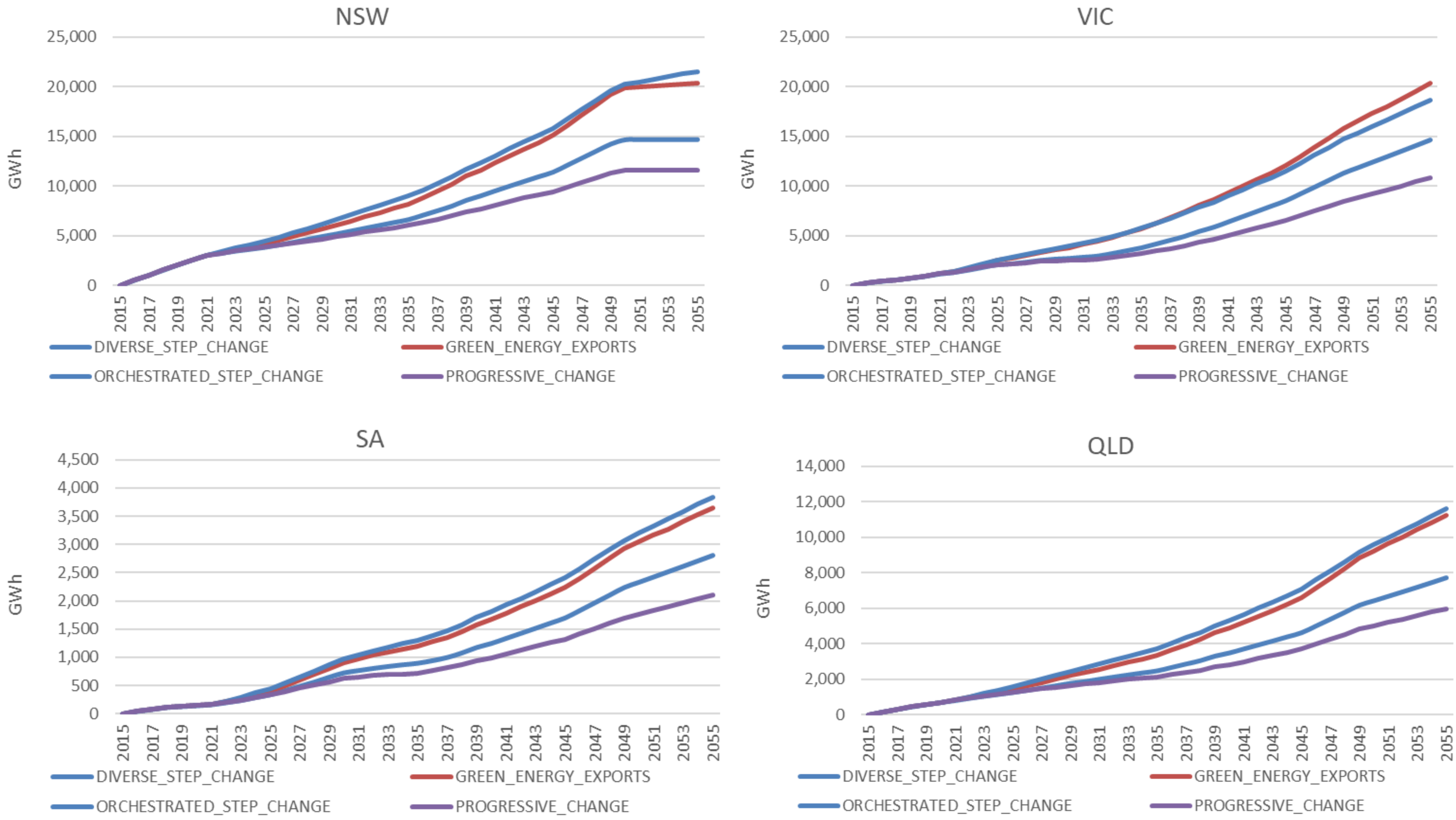
5.1.3 Forecasts by Region

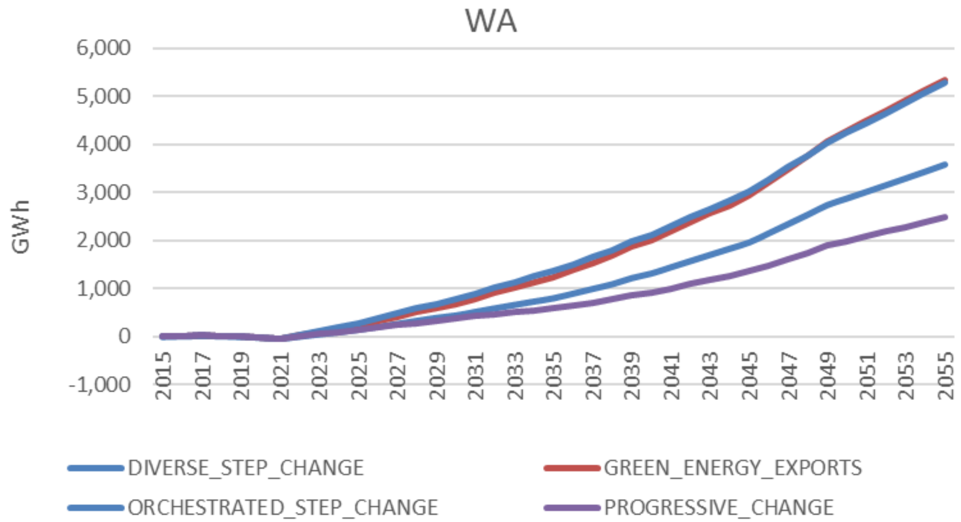
Forecast for RES electricity (total of all end-uses) for each region are shown in the composite Figure 10 overleaf. As noted, most regions are in some degree impacted by electrification of hot water in new housing that leads to negative electricity savings until the late 2030s, matched by higher gas savings. VIC and SA savings are also impacted by the assumed cessation of VEU and REPS from 2030 (with savings rolling off over 10 years). Negative savings are apparent in the historical period for NT, in particular, but also the SWIS, which reflects actual intensification of residential energy use in the historical period. This is assumed to be market-led in both cases.

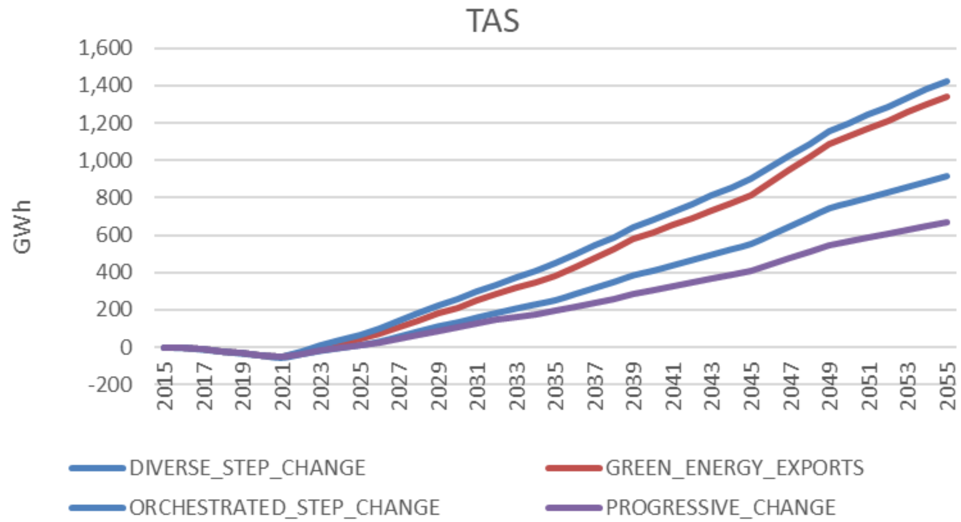
5.1.4 Forecasts by End-Use Type

The expected spilt of total electricity (and gas) savings between baseload, cooling or heating end-uses is estimated using input data from AEMO, which is based on empirical analysis of the degree of change in load as a function of ambient temperature deviations outside a ‘neutral’ band (18 – 21 degrees). This data is summarised in Table 10 below. There may be space conditioning energy consumption within this neutral band, but the AEMO analysis suggests that significant temperature-driven load variations only occur outside this band. As the load splits are not assumed to vary by scenario, we show an indicative Figure for *Orchestrated Step Change* (see Figure 11). We note that, in reality, climate change may be expected to increase cooling loads on houses over time, but this effect is not accounted for here.

Figure 10: Residential Electricity Energy Efficiency Forecasts by Region




WA
GWh
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,000
2015 2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049 2051 2053 2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE


TAS
GWh
1,600
1,400
1,200
1,000
800
600
400
200
0
-200
2015 2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049 2051 2053 2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE

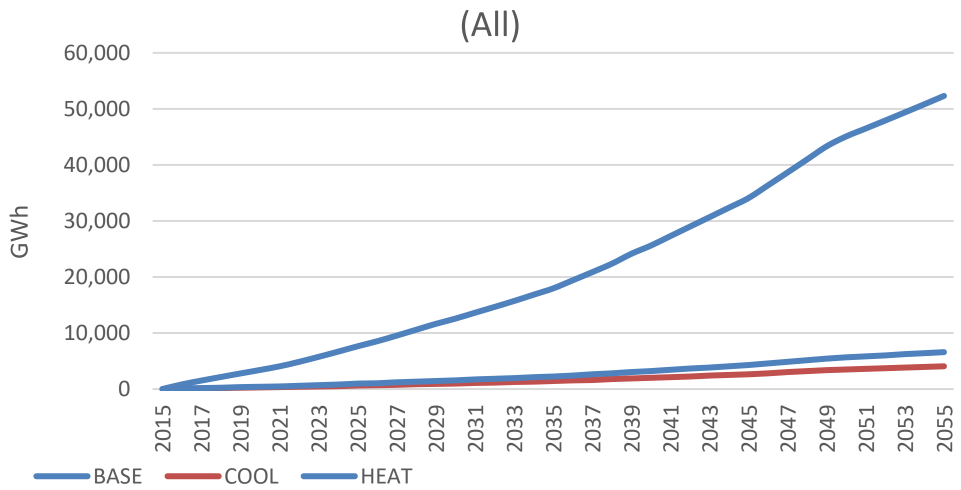

(All)
GWh
60,000
50,000
40,000
30,000
20,000
10,000
0
2015 2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049 2051 2053 2055
BASE
COOL
HEAT

Table 10: Energy Efficiency Savings End-Use Shares by End-Use Type, Fuel and Region

Region	Fuel	Base	Heat	Cool
NSW	Electricity	84.0%	9.3%	6.7%
QLD	Electricity	84.8%	3.6%	11.7%
SA	Electricity	80.4%	12.0%	7.6%
TAS	Electricity	73.9%	26.1%	0.0%
VIC	Electricity	80.4%	16.2%	3.4%
WA	Electricity	89.3%	5.2%	5.6%
NT	Electricity	84.8%	8.6%	6.6%
NSW	Gas	60.0%	40.0%	0.0%
QLD	Gas	90.6%	9.4%	0.0%
SA	Gas	60.1%	39.9%	0.0%
TAS	Gas	65.8%	34.2%	0.0%
VIC	Gas	42.3%	57.7%	0.0%
WA	Gas	74.8%	25.2%	0.0%
NT	Gas	67.5%	32.5%	0.0%

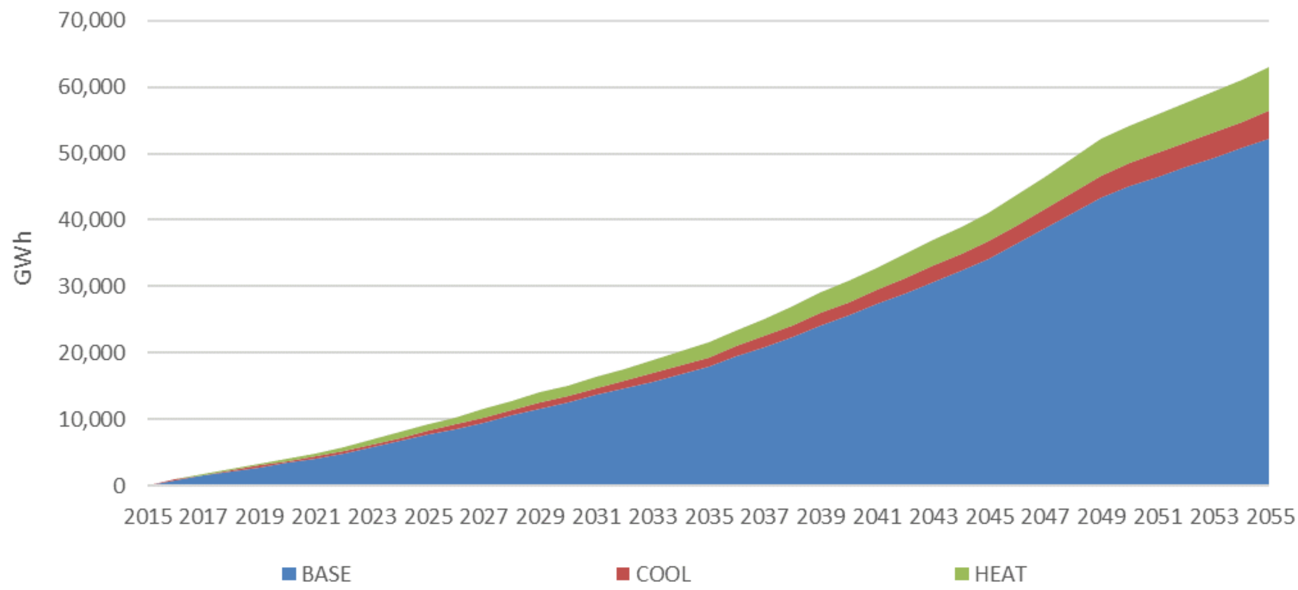


Figure 11: Orchestrated Step Change, RES Energy Efficiency Forecast by End-Use Type (all regions)

5.1.5 Comparison with FY2021 Forecasts

Figure 12 provides a comparison of our RES forecasts for electricity in 2021 and 2023. 2021 forecasts are shown as dashed lines, with colours that match the nearest 2023 scenario (eg, 2023 *Green Energy Exports* can best be compared with 2021 *Export Superpower)*. In 2021, the energy efficiency forecasts had a base year of FY2002, and these have been rebased to FY2015 to match the 2023 approach. It may be noted that there are some differences between the 2021 and 2023 forecasts even in the historical period, which reflects the fact that the 2021 forecasts have not been revised for changes in the historical period, whereas data sources (such as Australian Energy Statistics) have been revised. Also note that the final year is FY2053, so care needs to be exercised when comparing this figure to others in this report that have a final year of FY2055.

Generally, the forecasts are similar through to the mid-2040s, after which assumed new measures (UMD and MEPS, discussed above) contribute to savings. Material changes are:

- NT in included in 2023 but was not in scope in 2021
- Electrification impacts flattening projected electricity savings through the 2030s
- Whole-of-home elements for NCC2022 were not modelled in 2021 (recalling these are expected primarily to drive electrification and hence negative electricity savings)
- In 2021 we modelled extension of ESS-style schemes to other jurisdictions, but this has been replaced with alternative new policy assumptions this time (UMD, MEPS) that are national in scope, as there have been no moves since 2021 for jurisdictions without energy savings targets to introduce them
- VEU and REPS are modelled differently, as noted above, assuming they are discontinued from FY2025 and FY2030 respectively. As discussed, in reality these programs may be extended, potentially with changes to their scope/metrics that are yet to be explored, let alone decided, by the relevant jurisdictions.

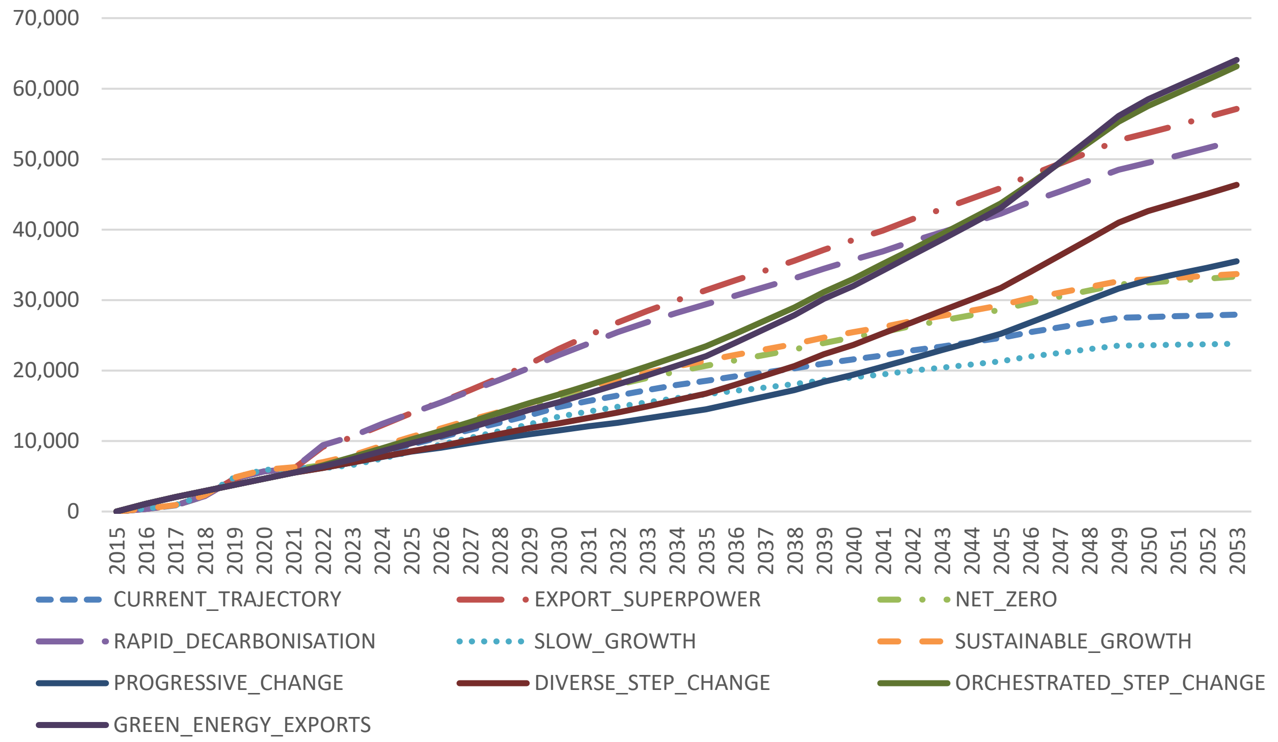


Figure 12: Residential Total Electricity Efficiency Savings by 2021 Scenario (NEM + SWIS) - rebased to 2015

5.2 Residential - Gas

5.2.1 Overview by Scenario

Overall, gas savings due to energy efficiency improvement are much smaller than for electricity, reflecting both the lower gas use overall than electricity in the residential sector and also the lower technical and economic potential for gas savings cf electricity. Efficiency-related gas savings in this sector (that are not electrification) are primarily associated with improved housing envelopes (eg, as induced by the NCC) that require less energy for space heating.

However, the larger effect in most scenarios is electrification, which overall we treat as a form of market-led efficiency improvement (setting aside specific policy impacts on electrification, which are noted). The extent of this market-led efficiency improvement therefore differs significantly between scenarios, primarily as a function of differences in the assumed rate of electrification.

A further overall trend is that gas savings are concentrated in VIC, primarily, and NSW (including ACT), secondly, reflecting higher gas use shares in these regions (Figure 13).

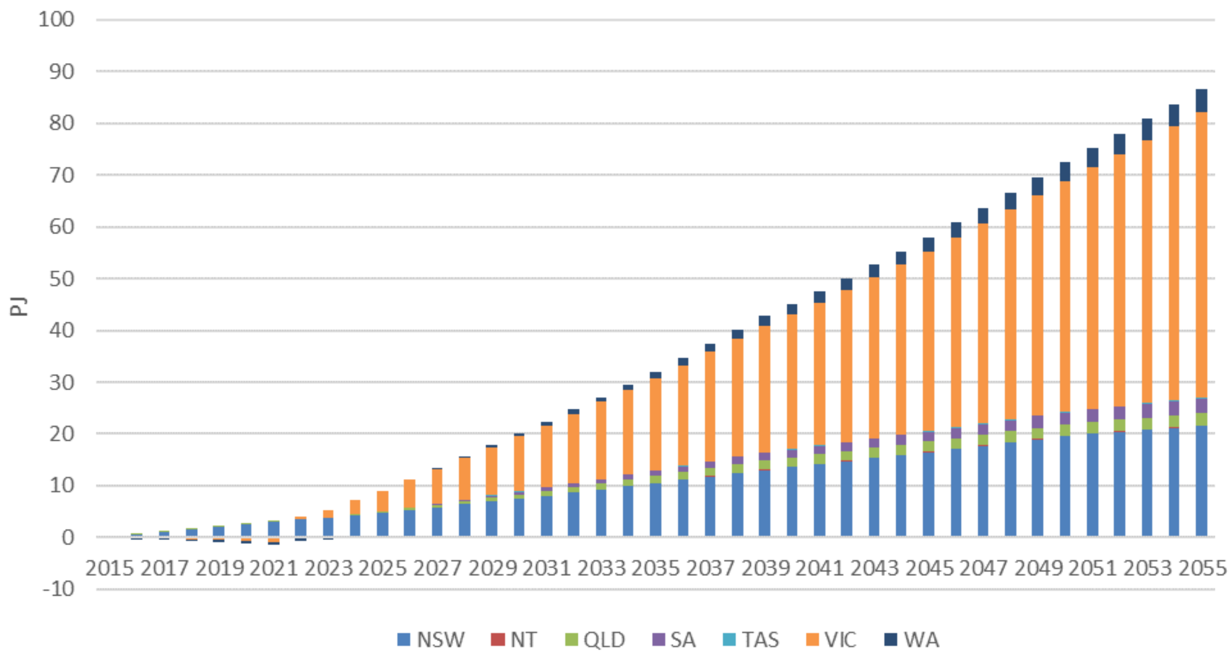


Figure 13: Residential Gas Energy Efficiency Forecasts by Region – Orchestrated Step Change

Overall projections by scenario are shown in Figure 14, with subsequent sections breaking these down by effect ('component type'), region and end-use.

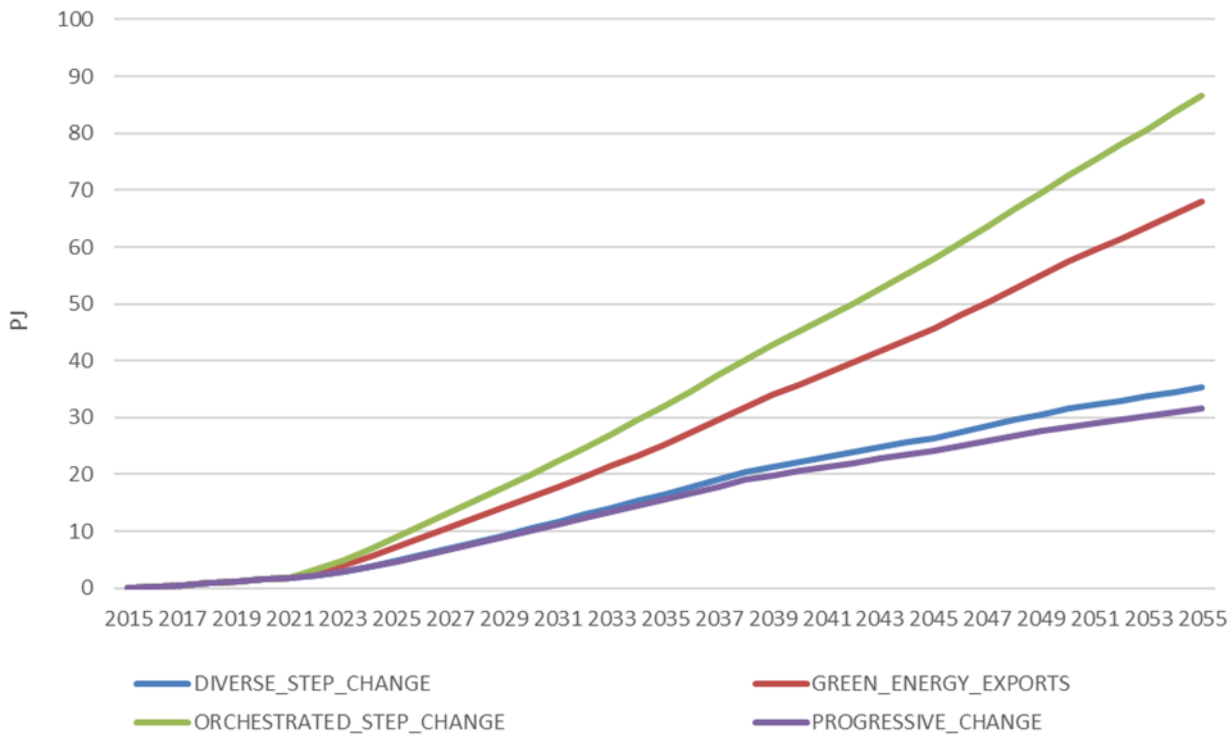
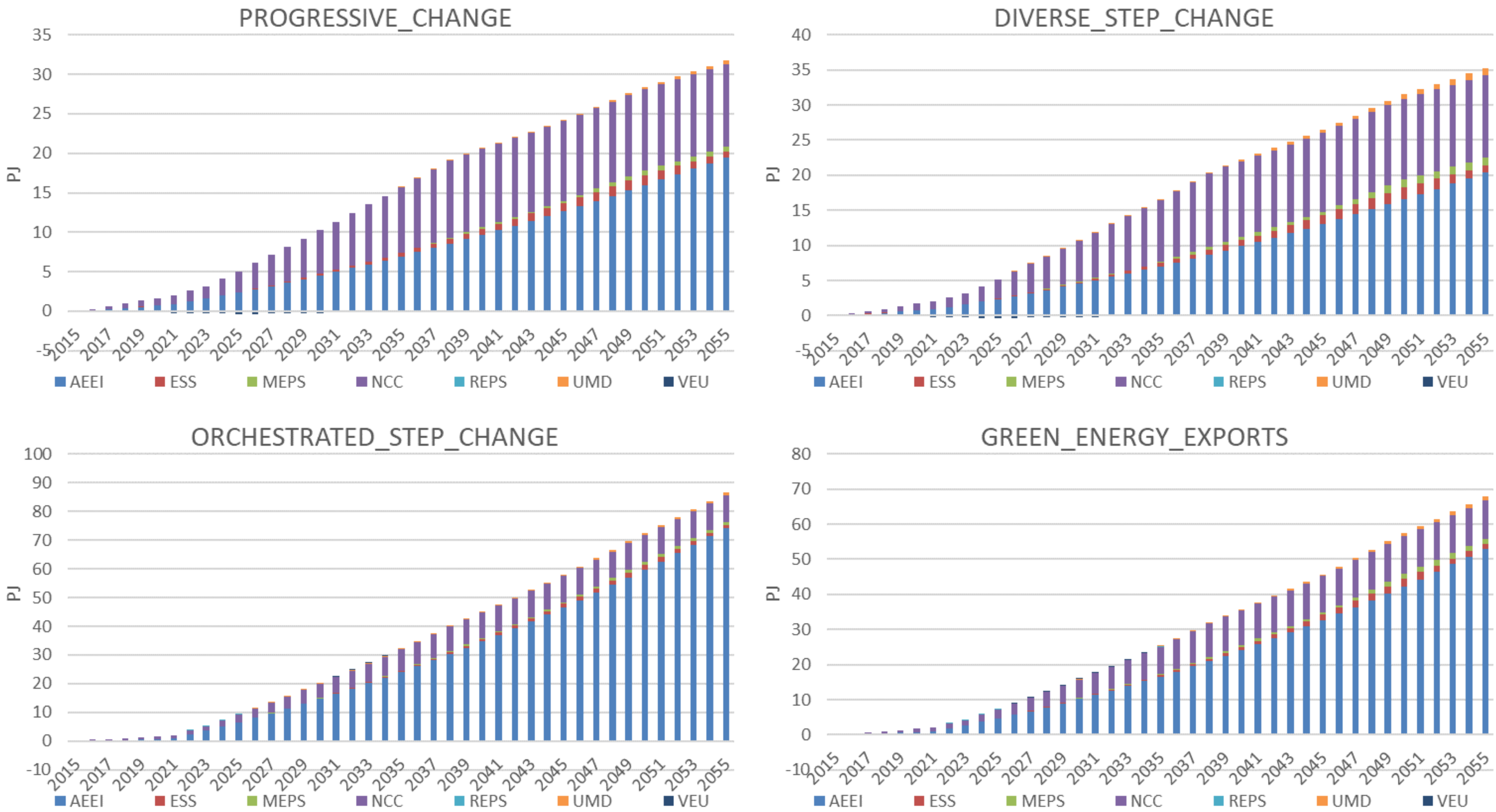


Figure 14: Residential Gas Energy Efficiency Forecasts by Scenario (all Regions and End-Uses)

Figure 15: Residential Gas Energy Efficiency Forecasts by Component Type and Scenario



5.2.2 Overview by Measure

The composite Figure 15 overleaf shows RES gas energy efficiency forecasts by component type for each scenario, for the total of all regions and end-uses.

As also noted in Figure 14, gas savings are highest under *Orchestrated Step Change*, and Figure 15 highlights that this largely due to market-led (or autonomous) energy efficiency improvement (denoted 'AEEI' on the figures). As noted, this largely reflects faster electrification in this scenario, however other aspects of the scenario narrative – such as faster resolution of global supply constraints and greater co-ordination between countries (supporting increased access to low carbon technologies) and higher economic growth – would also contribute this outcome.

The gas energy efficiency forecast for *Green Energy Exports* is lower than for Orchestrated Step Change – despite an assumption of greater policy ambition and greater policy-led savings – due to lower electrification and higher use of hydrogen as a blended fuel with methane. Lower electrification will increase combustion-related losses. In addition, a blended methane/hydrogen fuel would be expected to have lower volumetric energy density (we estimate around 19% lower for a 10% hydrogen blend by energy), and this would further significantly impact on energy efficiency.[42]

As with electricity, *Diverse Step Change* has very similar policy-led savings as *Orchestrated Step Change*, but notably lower market-led efficiency, and therefore shows lower overall efficiency improvement. *Progressive Change* has lower savings again than *Diverse Step Change* due to less electrification, lower policy ambition and weaker economic and supply conditions.

It may be noted that there are negative gas savings shown for some periods for VEU. This is largely a legacy consequence of activities that supported replacement of certain electrical end-uses (eg, hot water and space heating) with gas. DEECA indicated that these activities are likely to be phased out, with additional support for electrification in future. However, given that we model the cessation of this measure in 2030, there is less time for these electrification activities to impact on overall savings outcomes.

5.2.3 Forecasts by Region

The composite Figure 16 overleaf confirms that most gas savings are expected in VIC, followed by NSW, with relatively small values in other regions. As noted, gas savings arise in all regions due to expected electrification of hot water, under the influence of NCC2022, and this is most noticeable in jurisdictions such as QLD, with few other savings measures.

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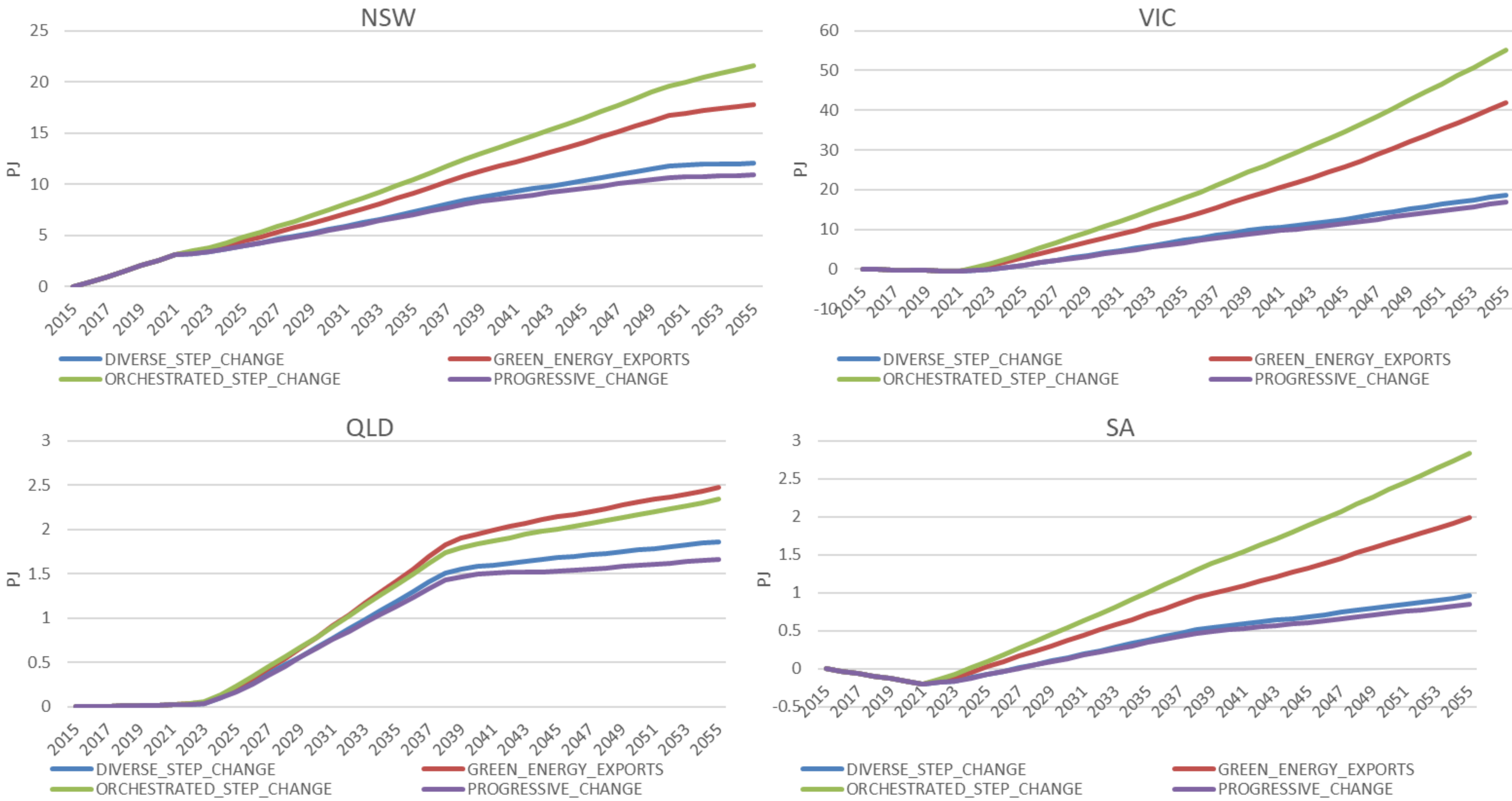
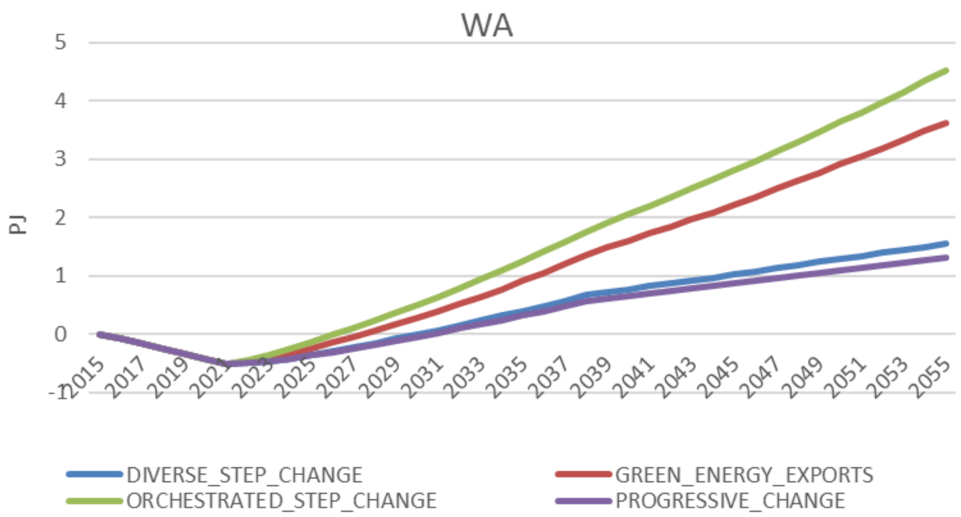
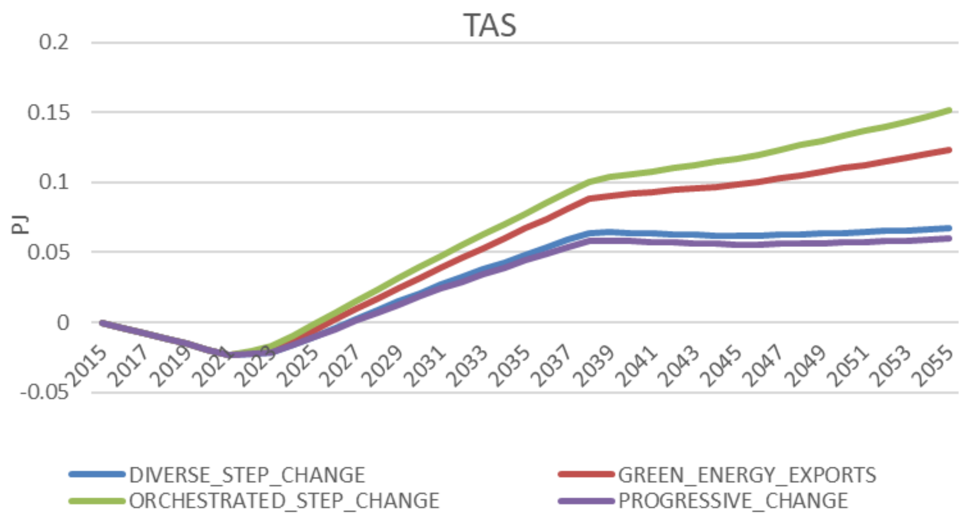
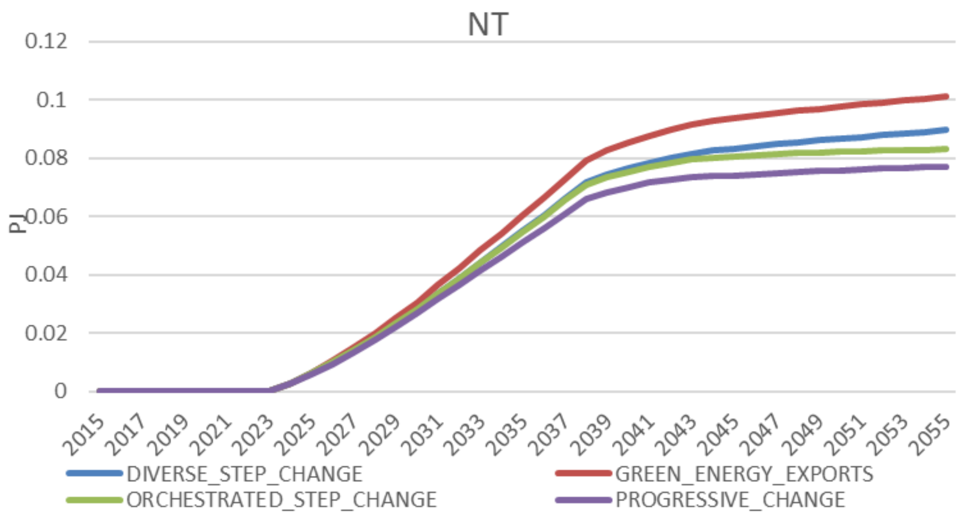
[42] Barring compensating changes such as increased pressure or changed burners – but these may not be practical or cost-effective solutions. Also, a 10% hydrogen blend by energy is equivalent to a 27% blend by volume, and this is higher than the 20% volumetric share that is widely cited as a practical limit for this fuel, due to the consequences for energy density.

Figure 16: Residential Gas Energy Efficiency Forecasts by Region




WA
PJ
5
4
3
2
1
0
-1
2015 2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049 2051 2053 2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE


TAS
PJ
0.2
0.15
0.1
0.05
0
-0.05
2015 2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049 2051 2053 2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE


NT
PJ
0.12
0.1
0.08
0.06
0.04
0.02
0
2015 2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049 2051 2053 2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE

However, this effect is expected to occur in all jurisdictions (that use gas), with the largest absolute impact in VIC. Negative gas savings in the historical period in SA and in the SWIS reflect actual intensification of gas use in these jurisdictions in this period.

5.2.4 Forecasts by End-Use Type

Table 10 above indicated AEMO's estimates of end-use shares, including for gas. These are illustrated in Figure 17 for *Orchestrated Step Change* (noting that end-use shares are not assumed to vary by scenario). Savings are split almost 50/50 between heating and baseload, on average across all regions, but there are significant variations by region due primarily to climatic differences.

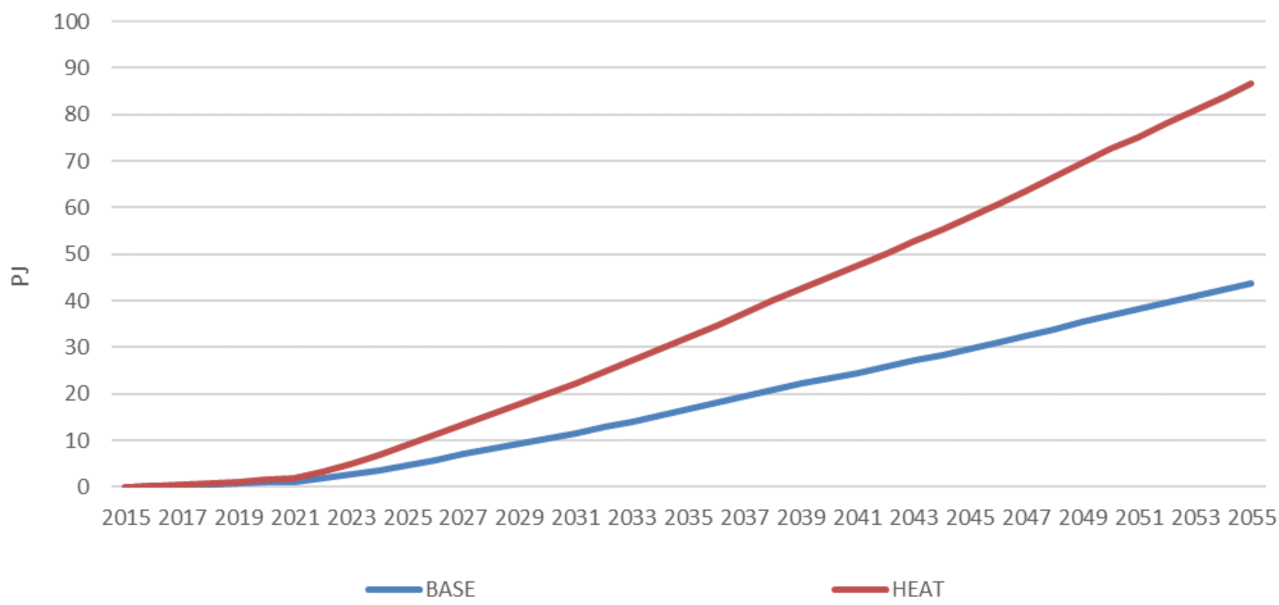


Figure 17: Residential Gas Energy Efficiency Forecast by End-Use Type, all Regions (Orchestrated Step Change)

5.3 Business Sector

The BUS sector comprises Commercial (COM) and Industry (IND), as described in Section 1.3. This section presents an overview for BUS, and then separate forecasts for COM and IND. We note that IND forecasts were altered materially post the late-March Forecasting Reference Group meeting (at which draft forecasts were presented), due to the Government announcing material changes to the Safeguard Mechanism, which are now taken into account in the forecasts. No other significant changes have been made.

5.3.1 Overview by Scenario - Electricity

Market-led electrical energy efficiency savings in BUS range between 42% and 46% of the total saving over the whole period, depending upon the scenario. However, as noted in Chapter 2, we are not able to estimate market-led efficiency change in the IND segment with available data. While this could indicate that market-led (and therefore total) savings could be higher than indicated, we noted in Section 4.5.3 that energy intensity has apparently risen in the IND segment in the historical period, notably for gas but moderately for electricity as well. Thus, it is likely that market-led energy savings in IND were, on average, negative in this period.

The forecasts show that savings are highest in *Green Energy Exports*, due to fastest growth in economic drivers and highest policy ambition, but slowed to a degree by the assumption that more hydrogen is used (notable in IND), with somewhat less electrification than in *Orchestrated Step Change*. Under *Orchestrated Step Change*, market-led efficiency holds the highest share of the total (46.3%), due in part to the high rate of electrification in this scenario, but the absolute value of market-led savings in 2055 is less than under *Green Energy Exports*, due to the latter's faster economic growth. Market-led savings are lower under *Diverse Step Change* due to higher use of gas, and also under *Progressive Change*, reflecting weaker economic conditions.

Policy-led savings are similar under the two *Step Change* scenarios, with these two scenarios being differentiated primarily on their fuel mix and hence market-led efficiency. Policy-led savings are highest under *Green Energy Exports*, and lowest under *Progressive Change*, due to the combination of higher policy ambition and faster stock turnover and growth under the former.

Overall, it may be noted in Figure 18 that electricity savings are slowed during the 2030s by the assumed cessation of VEU and REPS (in all scenarios).

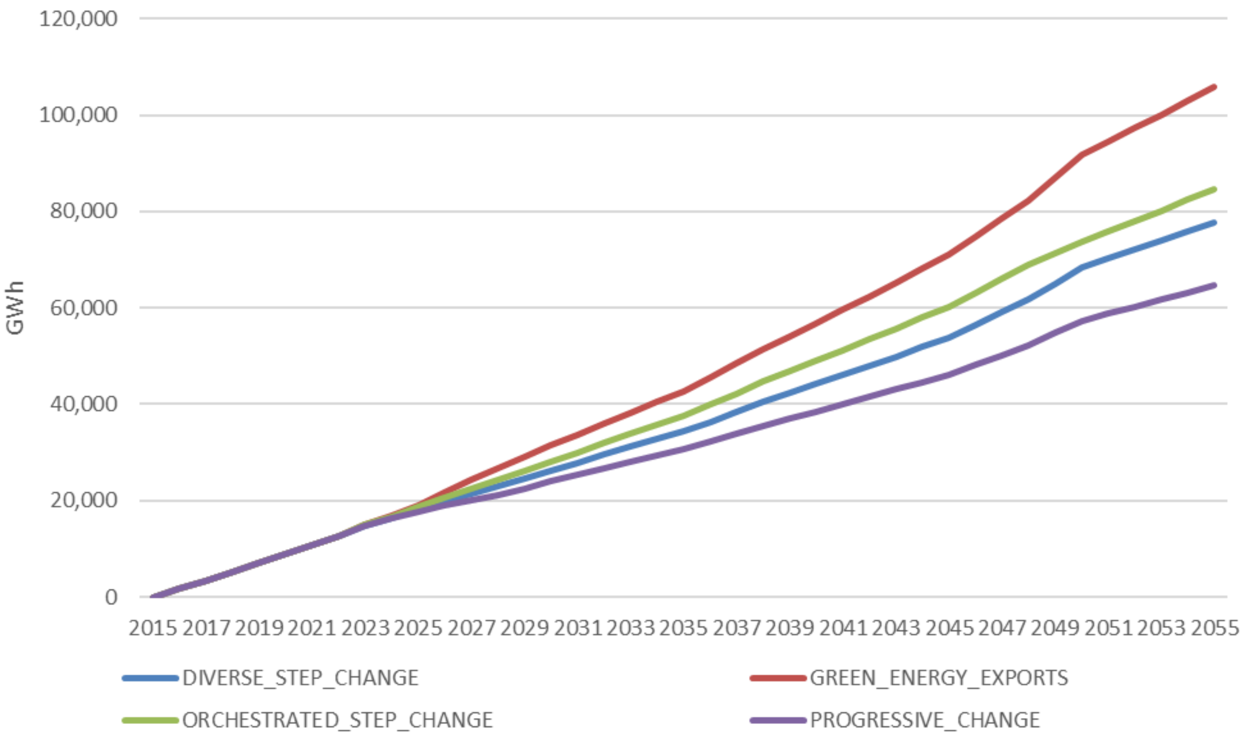
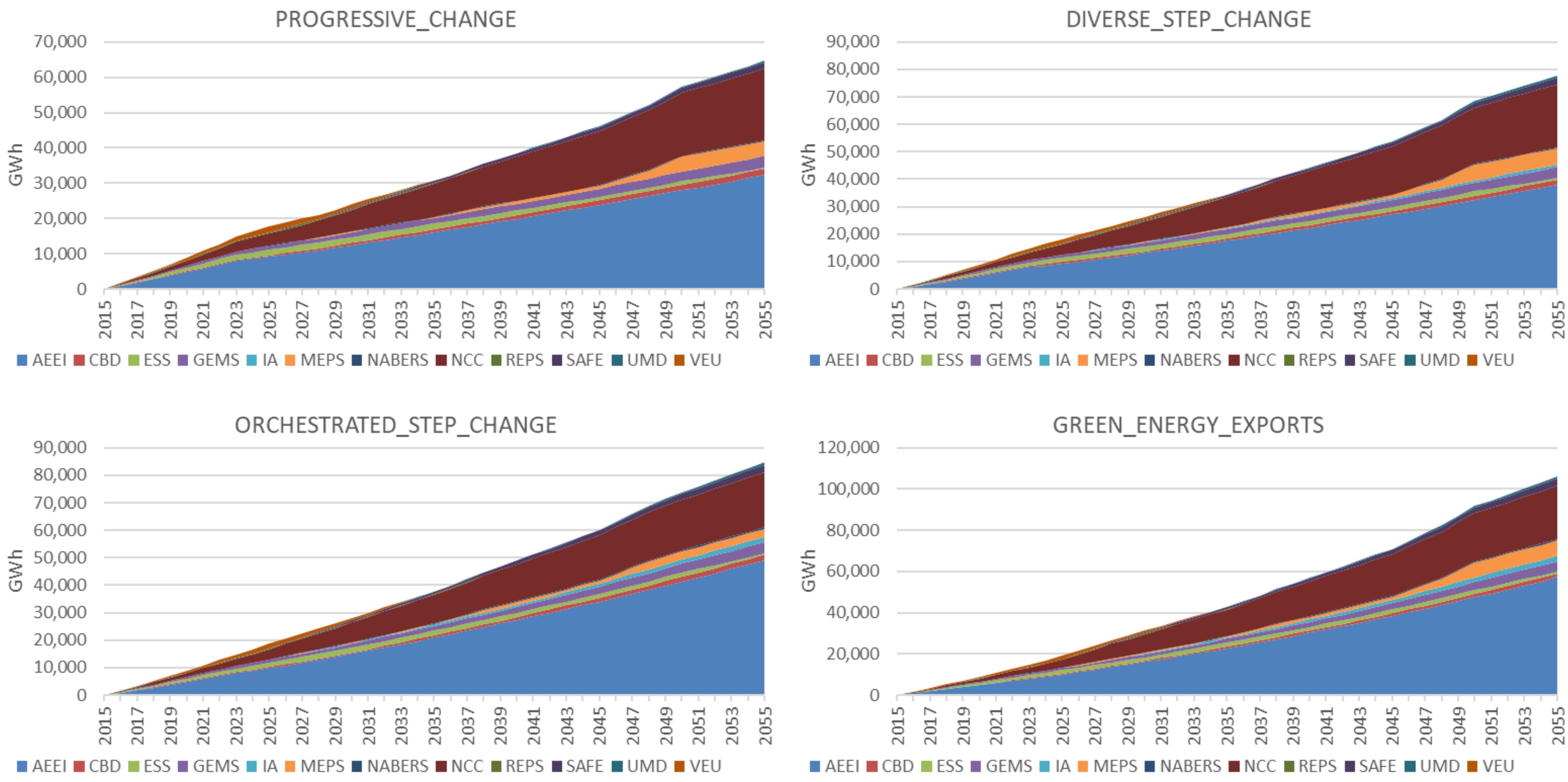


Figure 18: Business Electrical Energy Efficiency Forecast by Scenario, All Regions and End-Uses

5.3.2 Overview by Measure - Electricity

The composite Figure 19 overleaf shows the BUS electrical efficiency forecasts by measure and scenario. It may be noted that commercial sector NCC savings hold the largest share of policy-led savings in all scenarios, with significant contributions from ESS and GEMS.

Figure 19: BUS Electrical Energy Efficiency Forecasts by Scenario, All Regions and End-Uses



5.3.3 Overview by Region - Electricity

The composite Figure 21 overleaf shows the BUS electrical energy efficiency forecasts by region and scenario. NSW, VIC and, to a lesser extent, SA savings are impacted by the cessation of state savings schemes, assumed to take place in 2050 for NSW and 2030 for the other regions.

5.3.4 Comparison with FY2021 Forecasts - Electricity

Figure 20 shows a comparison of 2021 and 2023 BUS electrical energy efficiency forecasts. 2021 forecasts have been rebased to FY2015, and the 2023 projections are cut off in FY2053, for comparability. The 2023 forecasts are in solid lines and 2021 in dashed lines. Note that we have not corrected 2021 forecasts for differences in consumption in the historical period between these two sets of forecasts, hence the divergence in the historical period (attributable to revisions in AES data). If forecasts were rebased to FY2023, the apparent gap between them would be lessened.

However, the key reasons why they differ are:

1. Market-led energy efficiency for the commercial sector was not estimated in 2021, but is included in 2023 and, as noted, this almost doubles the total forecast savings
2. NT was not included in 2021
3. There are some differences in policy settings, including the inclusion of the revised Safeguard Mechanism in 2023.

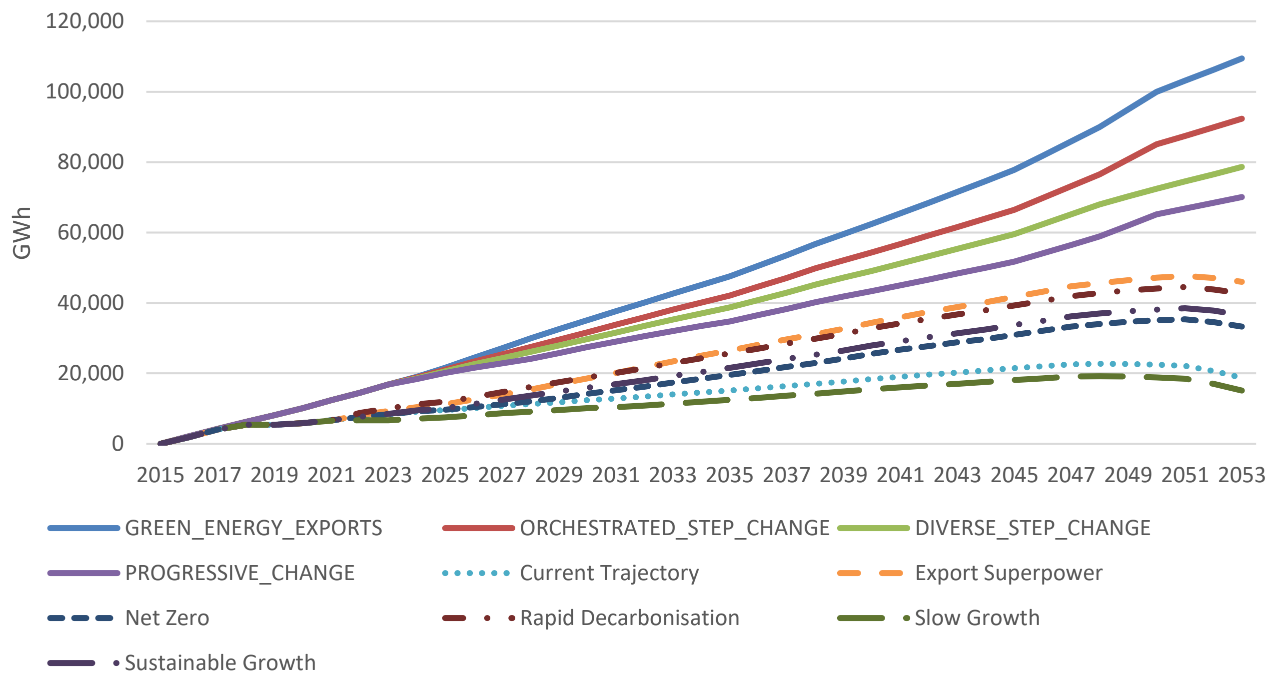
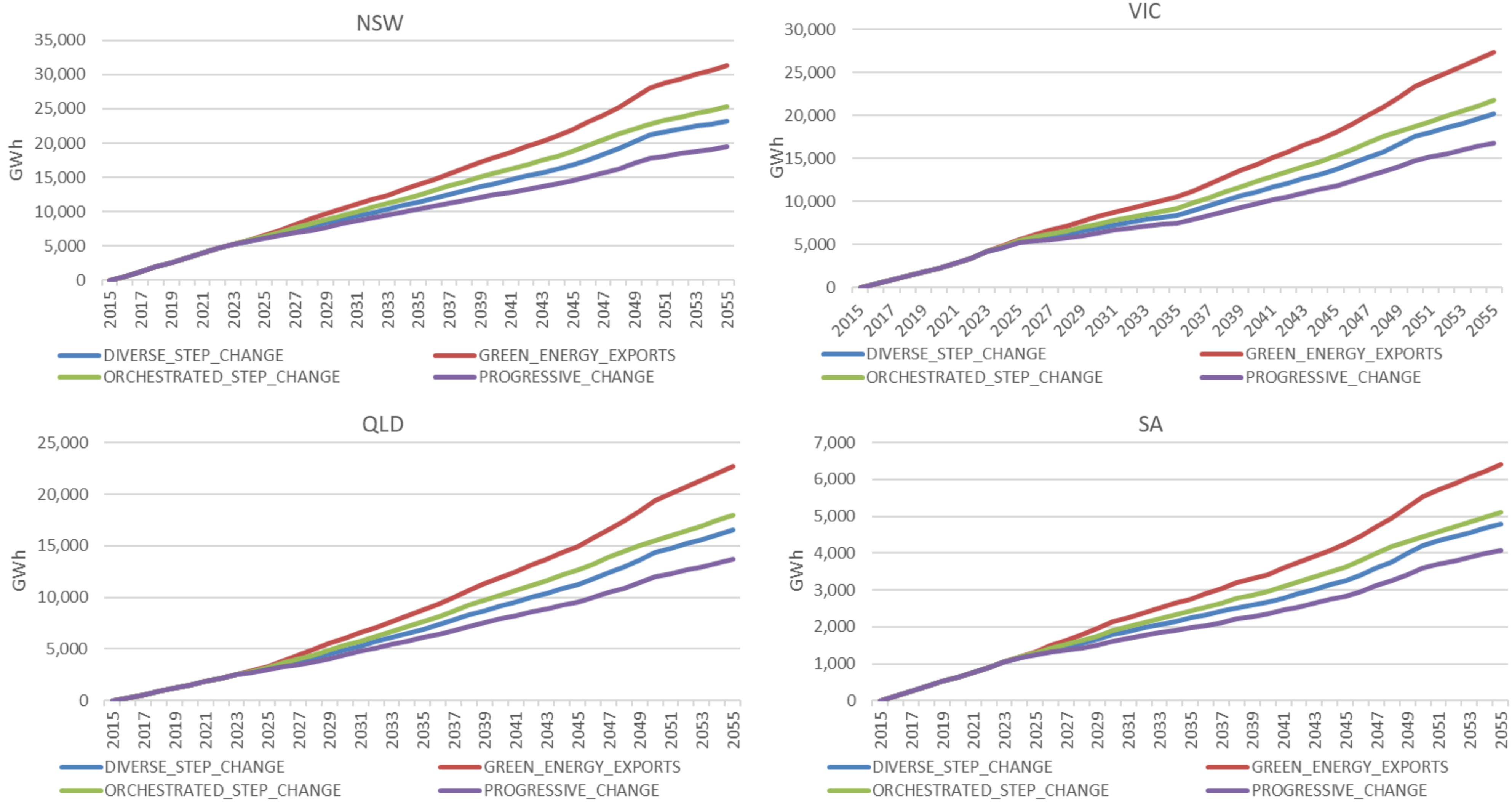
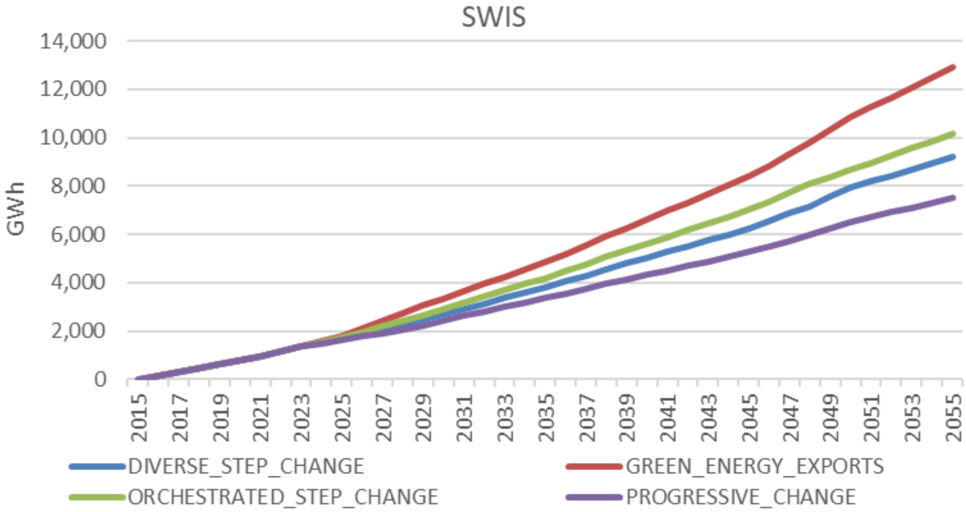


Figure 20: BUS Energy Efficiency Forecasts by Scenario - Electricity, 2023 (NEM, SWIS, NT) vs 2021 (NEM, SWIS - rebased to 2015)

Figure 21: BUS Electrical Energy Efficiency Forecasts by Region and Scenario (all components and end-uses)




SWIS
GWh
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12,000
10,000
8,000
6,000
4,000
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2015
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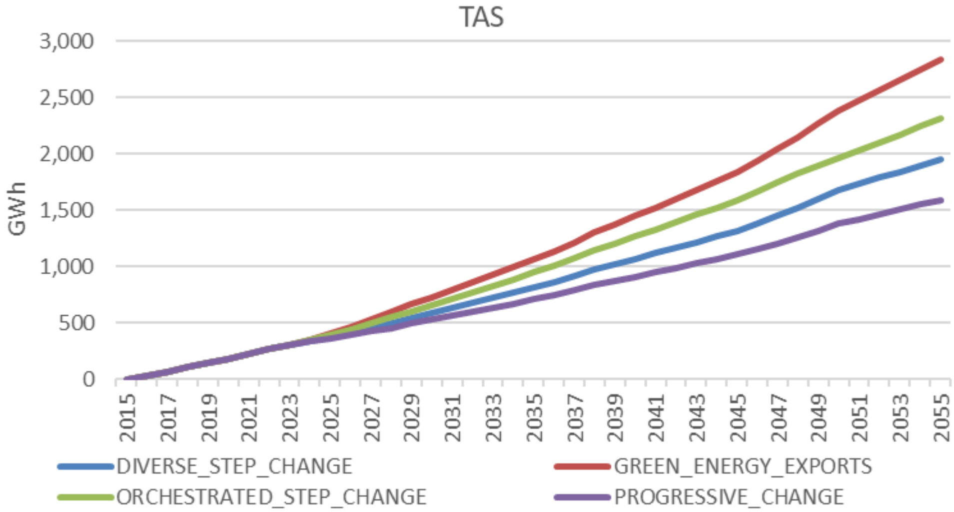
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE


TAS
GWh
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2,000
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2029
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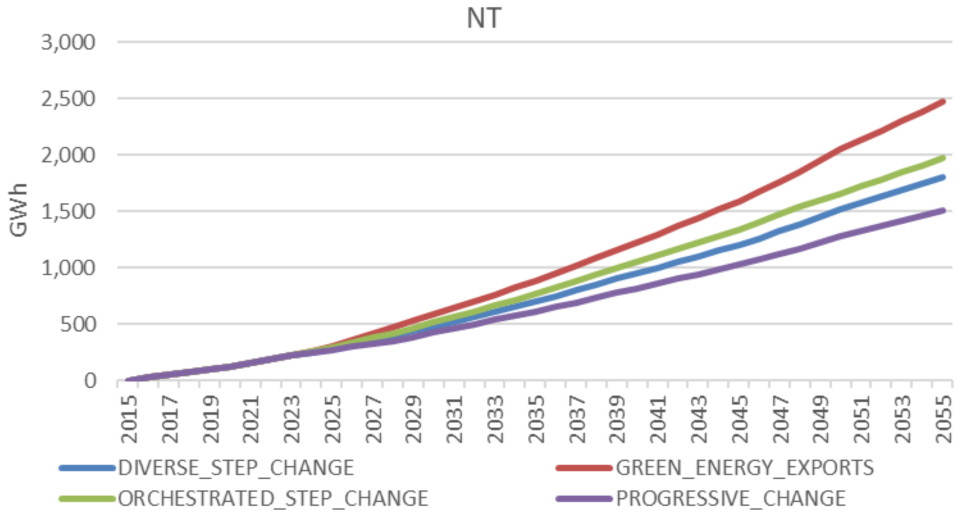
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE


NT
GWh
3,000
2,500
2,000
1,500
1,000
500
0
2015
2017
2019
2021
2023
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2027
2029
2031
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2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE

5.3.5 BUS Sector - Gas

Overview by Scenario - Gas

The combined Figure 22 overleaf shows the BUS gas energy efficiency forecasts by scenario and component type, for all regions and end-uses. It may be noted that the revised Safeguard Mechanism dominates all the scenarios, as discussed in Section 4.5.3, but the *potential* Industrial Assessments measure would also contribute to overall savings, notably in *Orchestrated Step Change* and *Green Energy Exports*. Other measures generate only modest gas savings, and we recall that market-led efficiency improvement is estimated for the commercial sector only.

Overview by Region - Gas

The combined Figure 23 shows the BUS gas energy efficiency forecasts by region and scenario, for all component types and end-uses. We note that the availability of commercial quantities of biomethane varies significantly by scenario and region, and this factor does impact on the overall the fuel mix. In *Progressive Change*, for example, significant quantities are assumed to become available but only from 2048 onwards, in NSW, VIC and SA, and smaller volumes in TAS. In *Green Energy Exports*, biomethane is assumed to be available earlier, from 2026 or 2027, in the same regions. The higher gas savings under *Orchestrated Step Change* than under *Diverse Step Change* reflect higher electrification assumptions, noted earlier, while *Green Energy Exports* shows the highest gas savings as policy ambition is higher, overcoming the somewhat lower level of electrification in this scenario cf *Orchestrated Step Change*.

Figure 22: BUS Gas Forecasts by Scenario and Component Type (all regions and end-uses)

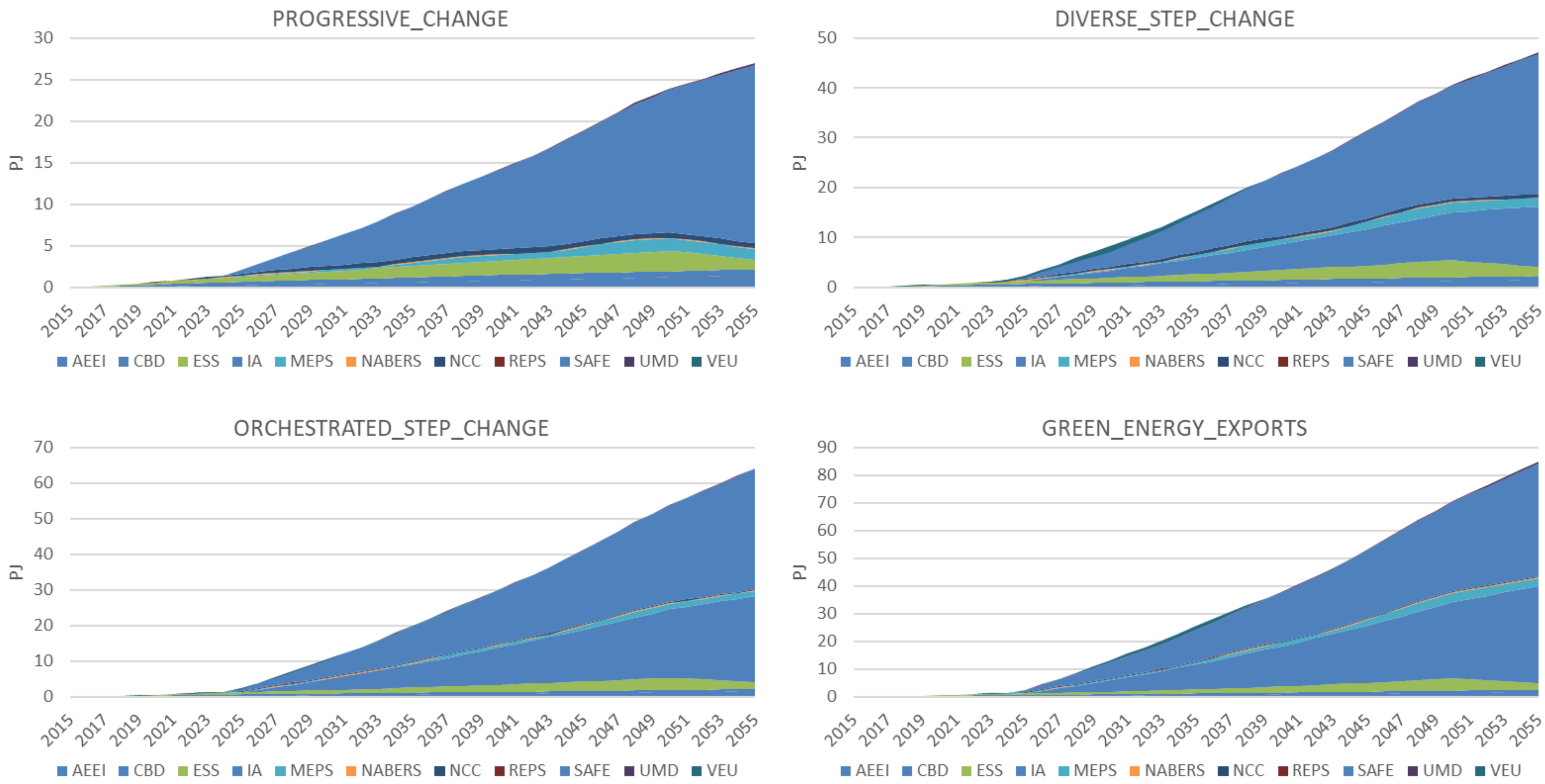
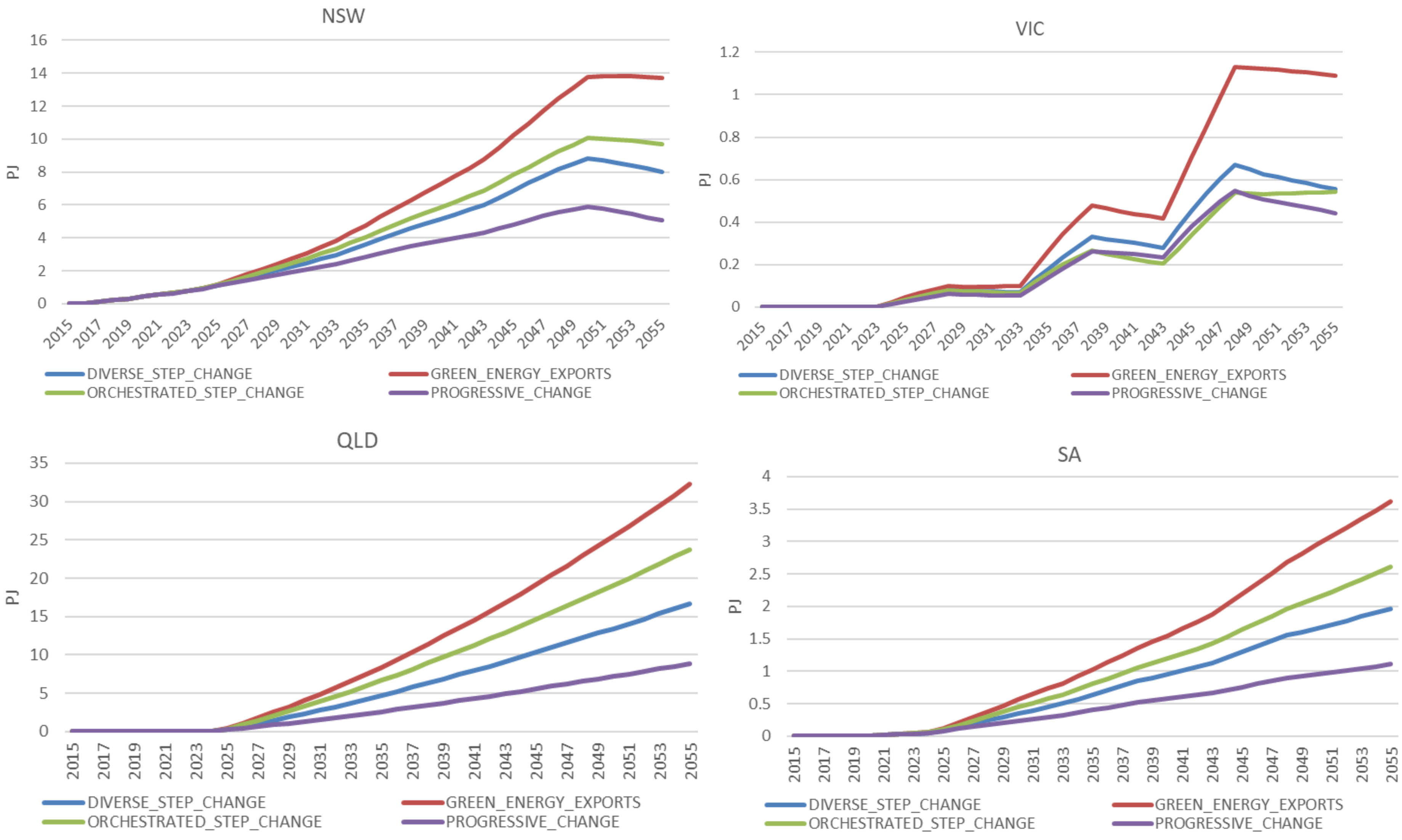
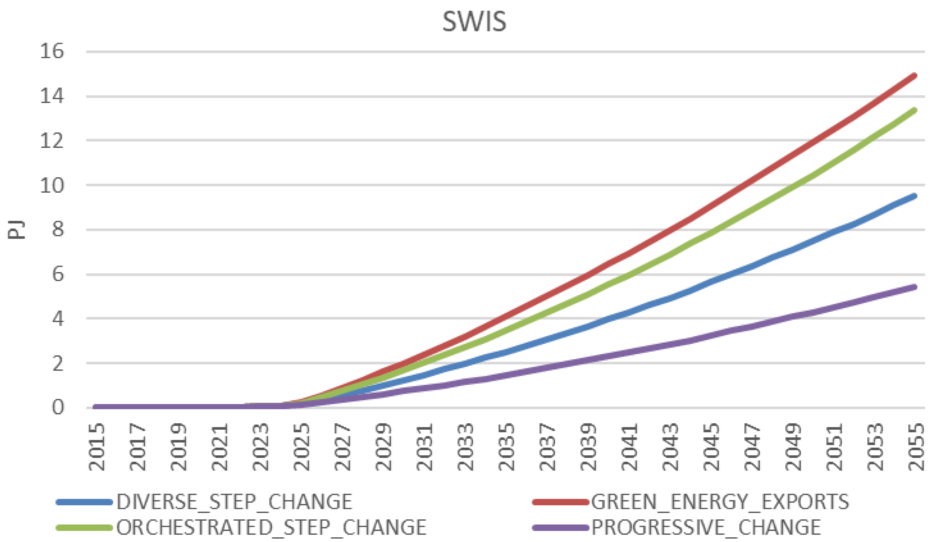
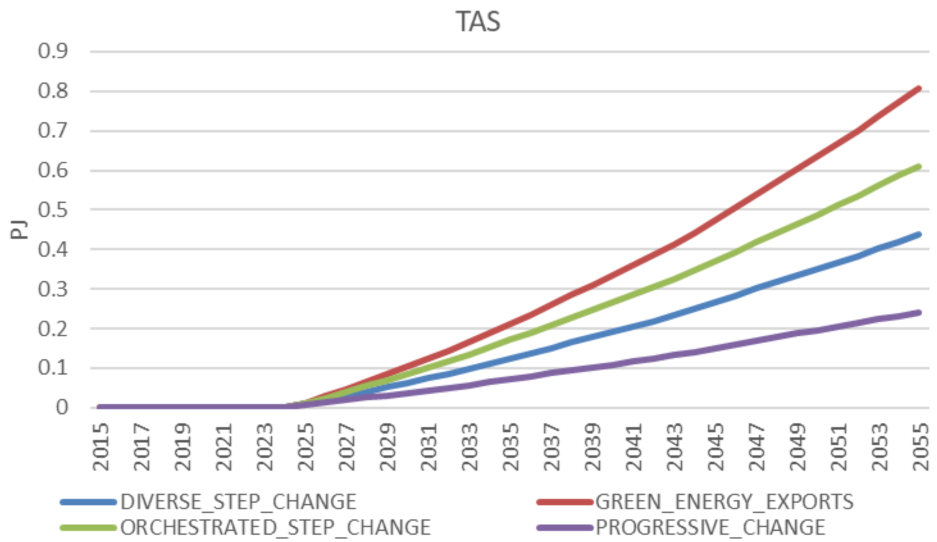


Figure 23: BUS Gas Forecasts by Scenario and Component Type (all regions and end-uses)




SWIS
PJ
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE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PJ
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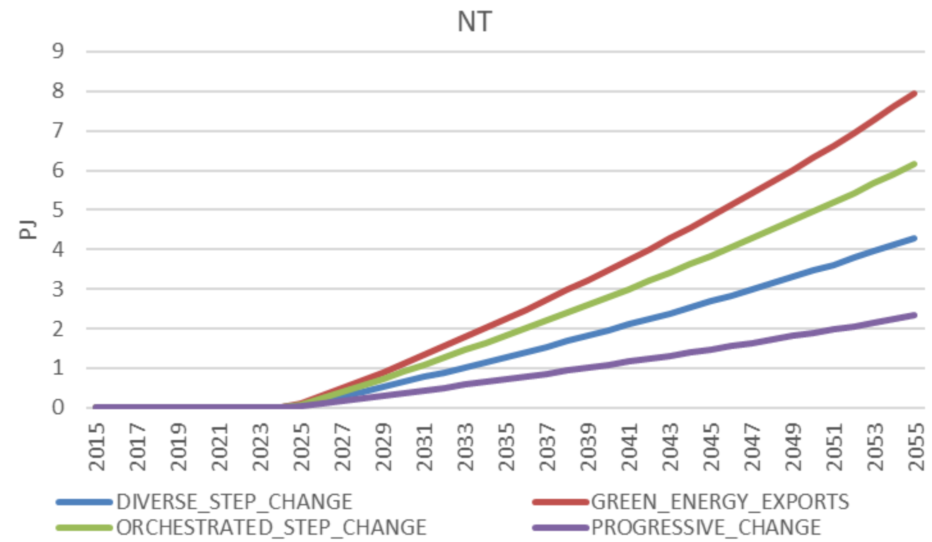
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE


NT
PJ
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE

5.4 Commercial Sector

5.4.1 Overview by Scenario - Electricity

Figure 24 provides an overview of the commercial sector electricity forecasts by scenario.

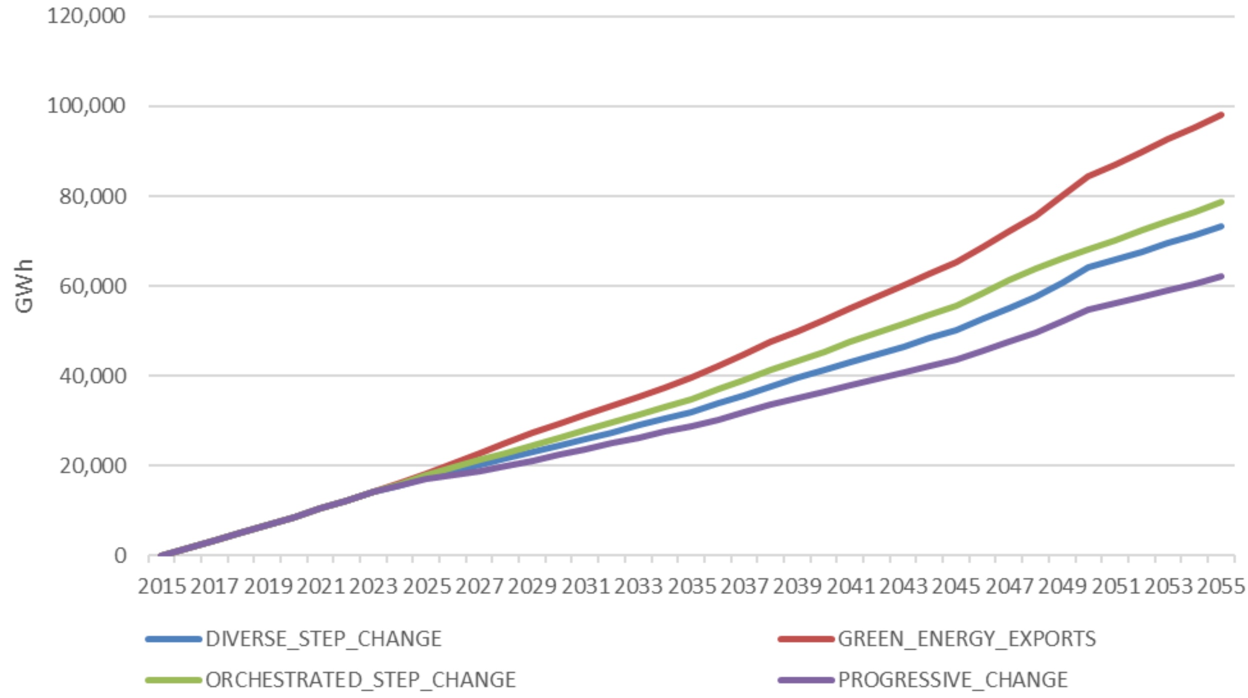


Figure 24: Commercial Sector Electrical Energy Efficiency Forecasts by Scenario (all regions and end-uses)

The general patterns have been noted earlier: a flattening of savings during the 2030s due to the assumed roll-off of VEU and REPS, market-led savings broadly proportional to the degree of electrification vs gas use in the scenarios, and higher policy ambition in Green Energy Exports. Savings later in the forecast period are assumed to be underpinned by *potential* new measures, such as universal mandatory disclosure and minimum energy performance standards for existing buildings, but of course these measures are uncertain at this time. Note that potential NCC impacts on the rate of uptake of behind-the-meter solar are not explored here, as they fall outside our scope.

5.4.2 Overview by Component Type - Electricity

The composite Figure 25 shows the commercial sector electrical energy efficiency forecasts by component type, for each scenario and for all end-uses. Market-led savings hold the highest share of total savings in *Orchestrated Step Change*, but the absolute value of these savings in FY2055 is higher in *Green Energy Exports*, due to faster growth drivers. Policy settings are the same for both *Step Change* scenarios, leading to very similar policy-led savings, but total savings are lower in

Diverse Step Change due to the higher gas consumption in this scenario. Progressive Change combines weaker policy settings, higher gas consumption and weaker economic drivers, and therefore it generates the lowest efficiency savings.

Of the policy measures, the NCC energy performance requirements are easily the most material, accounting for between 40% – 42% of all policy-led total energy savings estimated (electricity and gas combined), including those associated with potential new measures. The NCC share would be higher again without these potential new measures. GEMS offers the second largest policy savings at around 25% of the policy-led total.

5.4.3 Savings by Region - Electricity

Figure 26 shows the electrical energy efficiency forecasts by region and scenario, for all component types and end-uses. The reasons for the differences between regions have been noted above, with assumed roll-off of VEU and REPS from 2030, and ESS from 2050, being the prime examples. Potential new measures, MEPS and UMD, could support savings, particularly from 2040 on (when scope/stringency is assumed to have increased).

5.4.4 Comparison with 2021 Forecasts - Electricity

Figure 27 below compares the 2021 and 2023 commercial sector electricity forecasts by scenario. As noted above in Section 5.3.4, the key difference is the inclusion of market-led efficiency savings in 2023, as well as NT savings, making the two sets difficult to compare directly. We note that, setting aside these two factors, the remaining policy-led forecasts are very similar between the two time periods.

Figure 25: Commercial Electricity Energy Efficiency Forecasts by Region and Component Type (all end-uses)

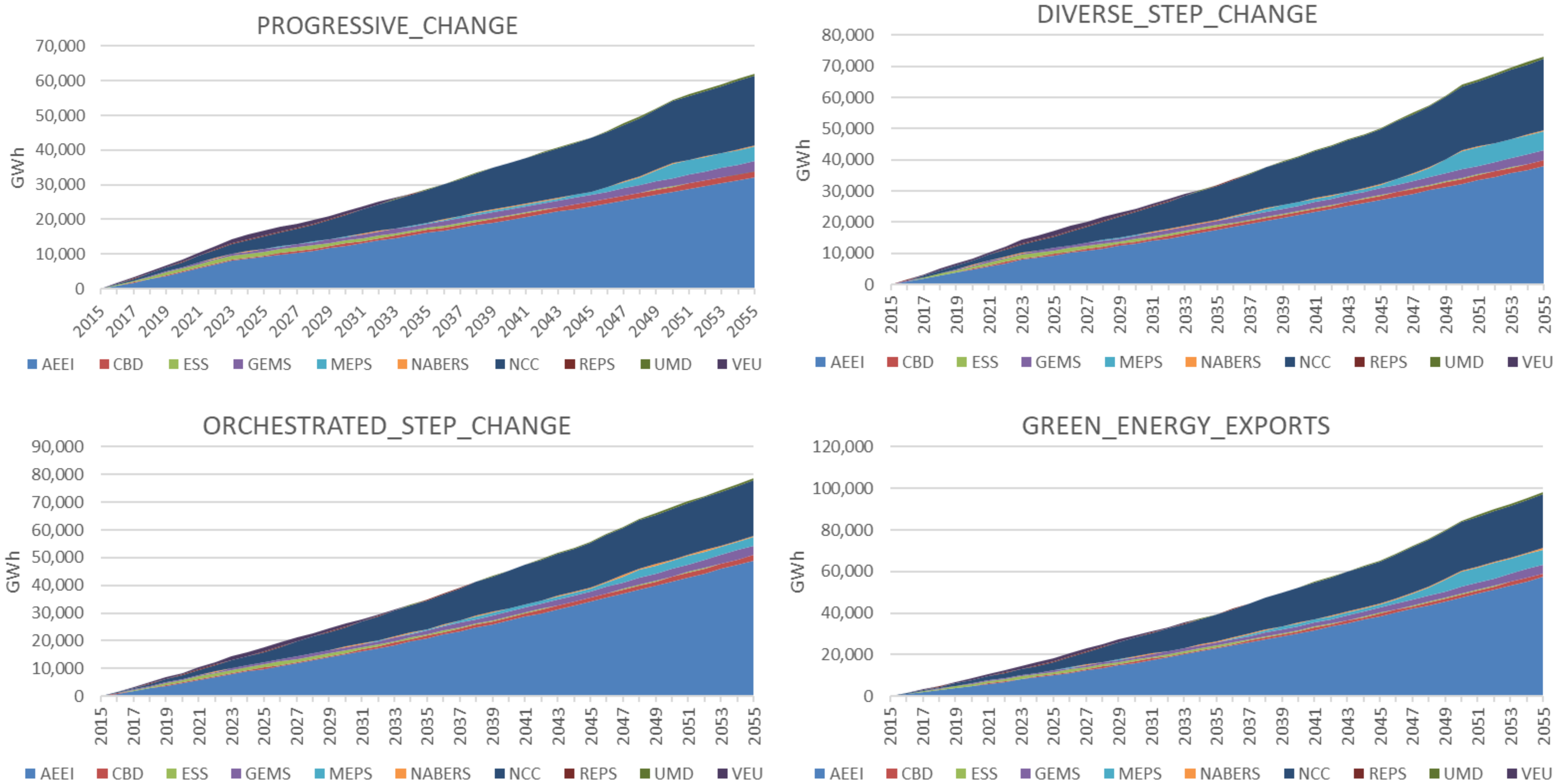
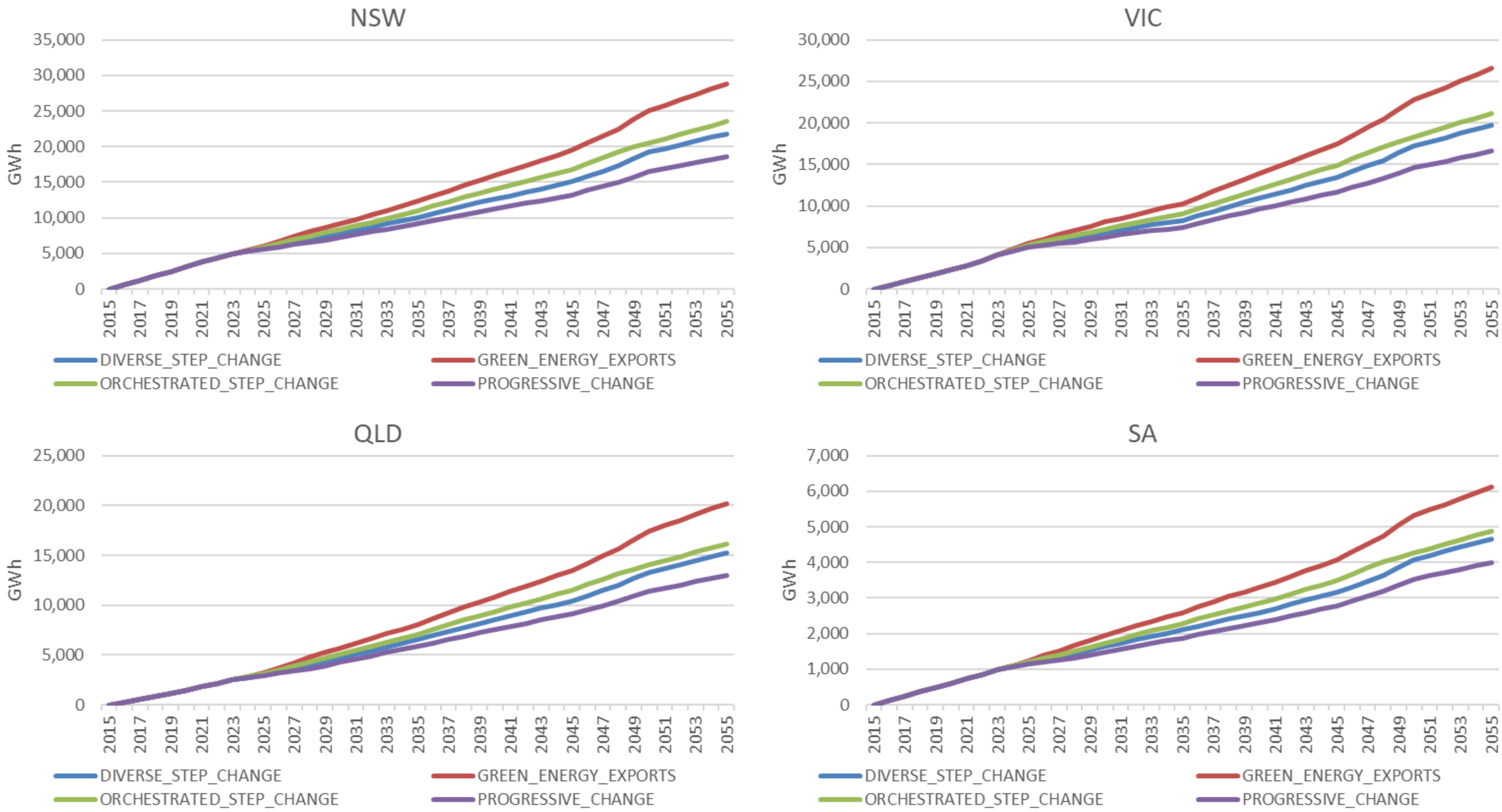
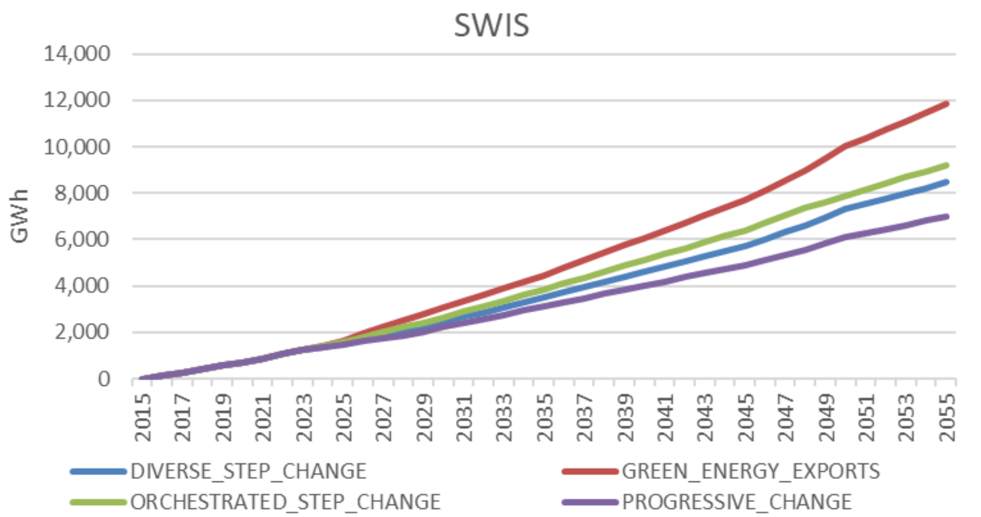
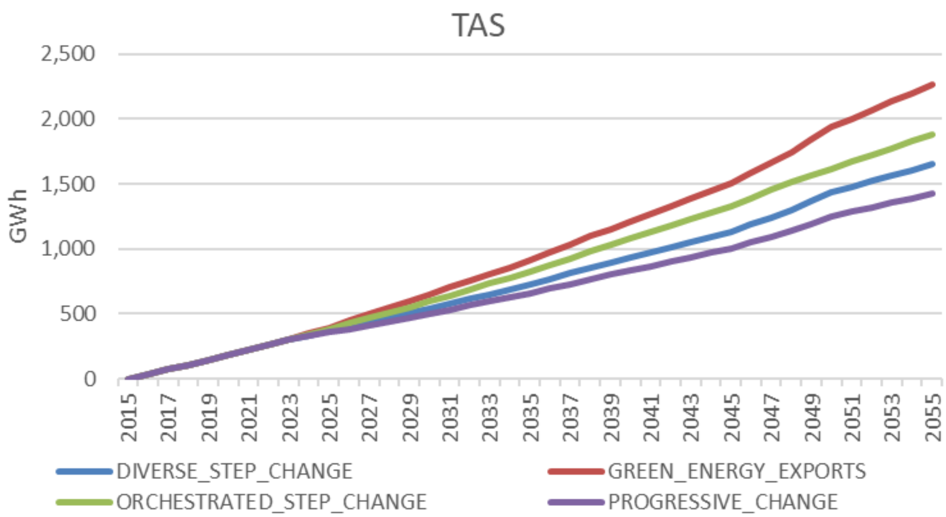


Figure 26: Commercial Sector Electricity Savings by Region (all end-uses and components)




SWIS
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
GWh
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035
2037
2039
2041
2043
2045
2047
2049
2051
2053
2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE


TAS
2,500
2,000
1,500
1,000
500
0
GWh
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035
2037
2039
2041
2043
2045
2047
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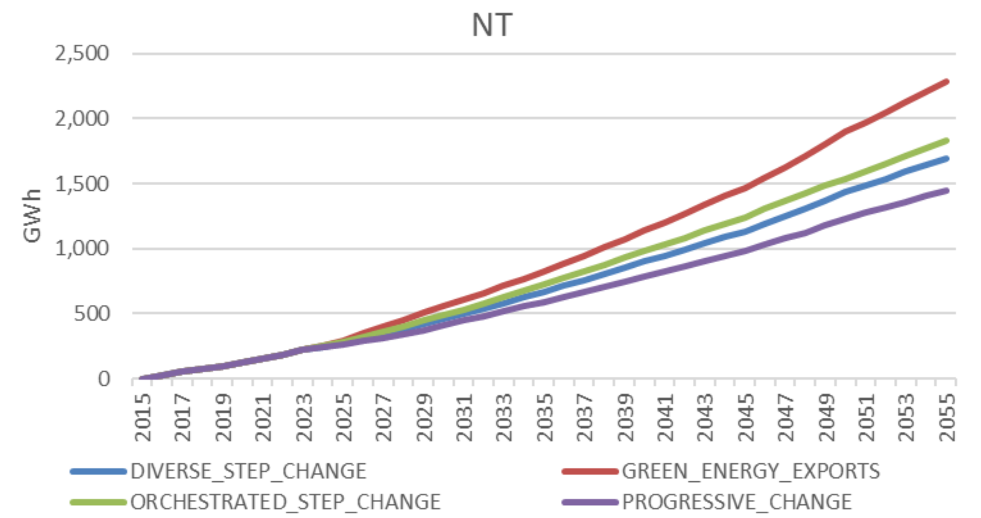
2053
2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE


NT
2,500
2,000
1,500
1,000
500
0
GWh
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035
2037
2039
2041
2043
2045
2047
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2053
2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE

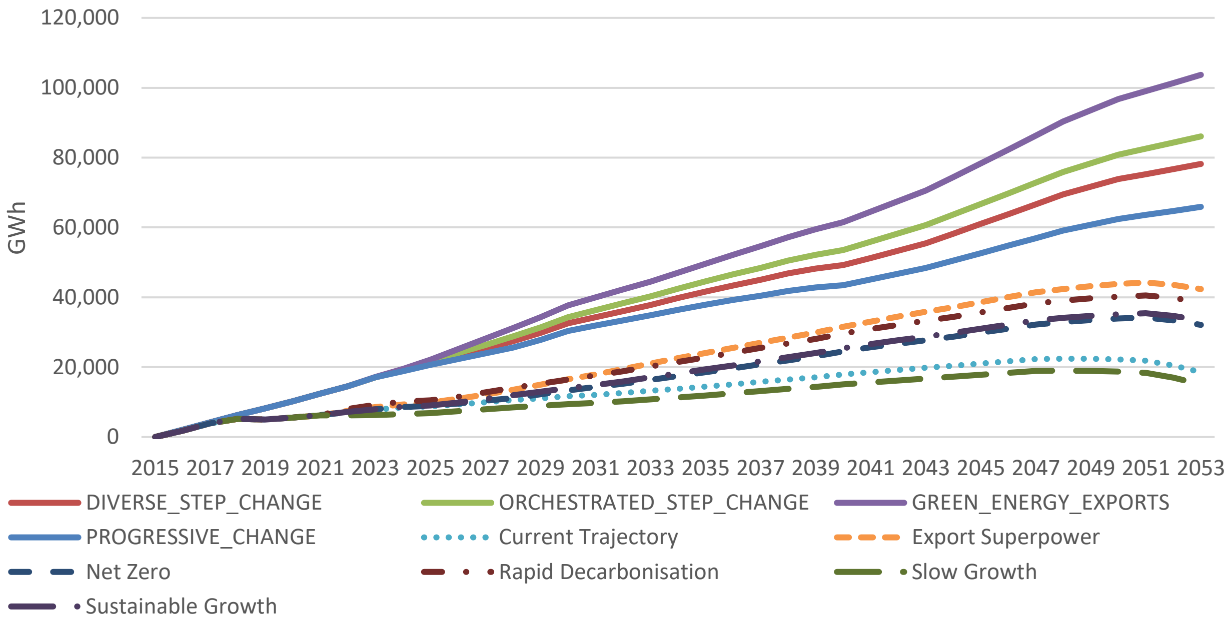


Figure 27: Commercial Sector - Total Electricity Savings by Scenario, 2023 (NEM, SWIS, NT) vs 2021 (NEM, SWIS - rebased to 2015)

5.4.5 Energy Efficiency Forecasts - Gas

Overview by Scenario - Gas

Figure 28 provides an overview of gas savings by scenario in the commercial sector.

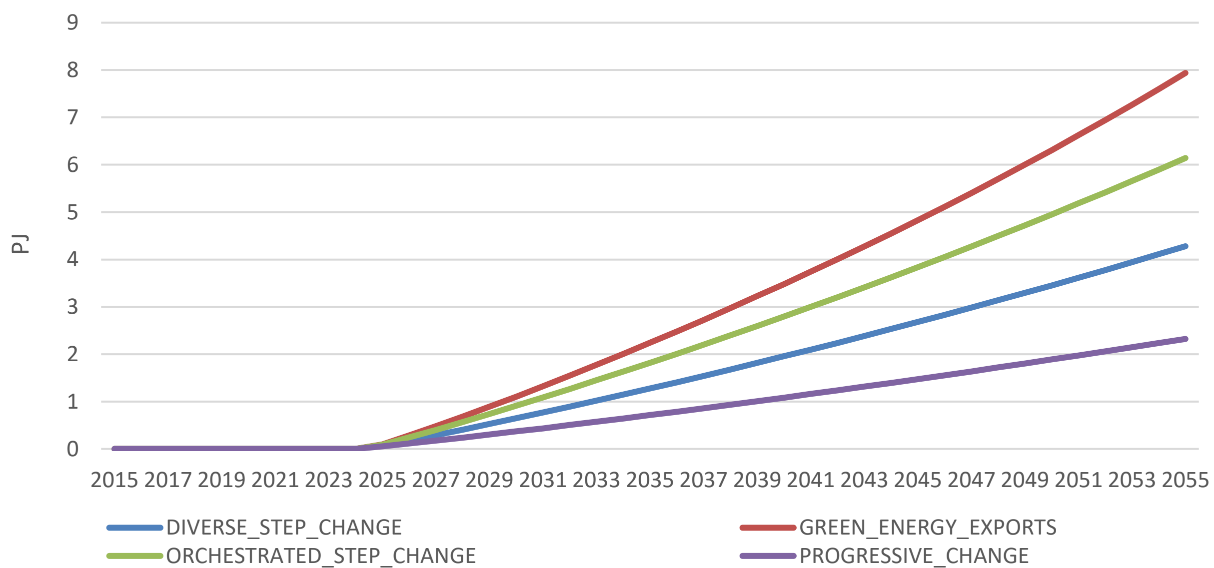


Figure 28: Commercial Sector Gas Energy Efficiency Forecasts by Scenario (all regions, components and end-uses)

Overall savings are very small, compared to electricity, due to gas being a relatively minor fuel in this sector, as well as limited technical and economic opportunities for efficiency improvement. Savings are highest under *Green Energy Exports* due to a combination of highest policy ambition, faster growth drivers and a reasonable amount of electrification. Gas use in this scenario is assumed to be supported by increasing hydrogen consumption, meaning that the gas share of energy use, and savings, is higher than for *Orchestrated Step Change*.

Orchestrated Step Change shows a higher share of market-led savings (19.5% of the total) due primarily to higher electrification, but lower savings overall than *Green Energy Exports* or *Diverse Step Change*. This is because gas use, already low overall, falls most rapidly in this scenario, with less gas use to be saved over time.

Diverse Step Change achieves somewhat higher gas savings that *Orchestrated Step Change*, due to higher gas use. However, the difference is very small (less than 1 PJ difference in 2055). *Progressive Change* again comes in last place due to weaker policy settings and economic drivers.

Overview by Component Type - Gas

Figure 29 provides an overview of the commercial sector gas energy efficiency forecasts by scenario and component type, for all regions and end-uses. In this sector, ESS is one of the largest measures over time, noting that we assume it continues until 2050, unlike VEU and REPS. Market-led efficiency improvement is assumed to be very modest for gas, given limited technical and economic potentials. Gas savings from the NCC, NABERS, CBD and others are projected to be low, primarily due to limited and declining gas use. The potential new measures, UMD and MEPS for existing buildings, are shown the have the potential to realise significant savings (in the context of this sector) later in the forecast period, but whether these measures will eventuate is uncertain at this time.

Overview by Region - Gas

Figure 30 shows commercial sector gas forecasts by region and scenario. While there appears to be significant differences between scenarios in some regions, the absolute magnitude of these differences is very small. First, it was noted above that *Progressive Change* assumes significant quantities of biomethane are used in VIC, NSW and SA from 2049 or 2050, and this skews the fuel mix, and hence the efficiency savings mix, towards gas in these cases. A sawtooth pattern of savings is evident in states that a) use little gas and b) have few policy measures in place that save gas. This pattern is driven by the relatively larger influence of the potential new measures, UMD and MEPS for existing buildings, in those regions, and reflects the gradual ramp up of scope and stringency that is assumed in those two potential future measures.

Figure 29: Commercial Sector Gas Energy Efficiency Forecasts by Component Type and Scenario (all end-uses and regions)

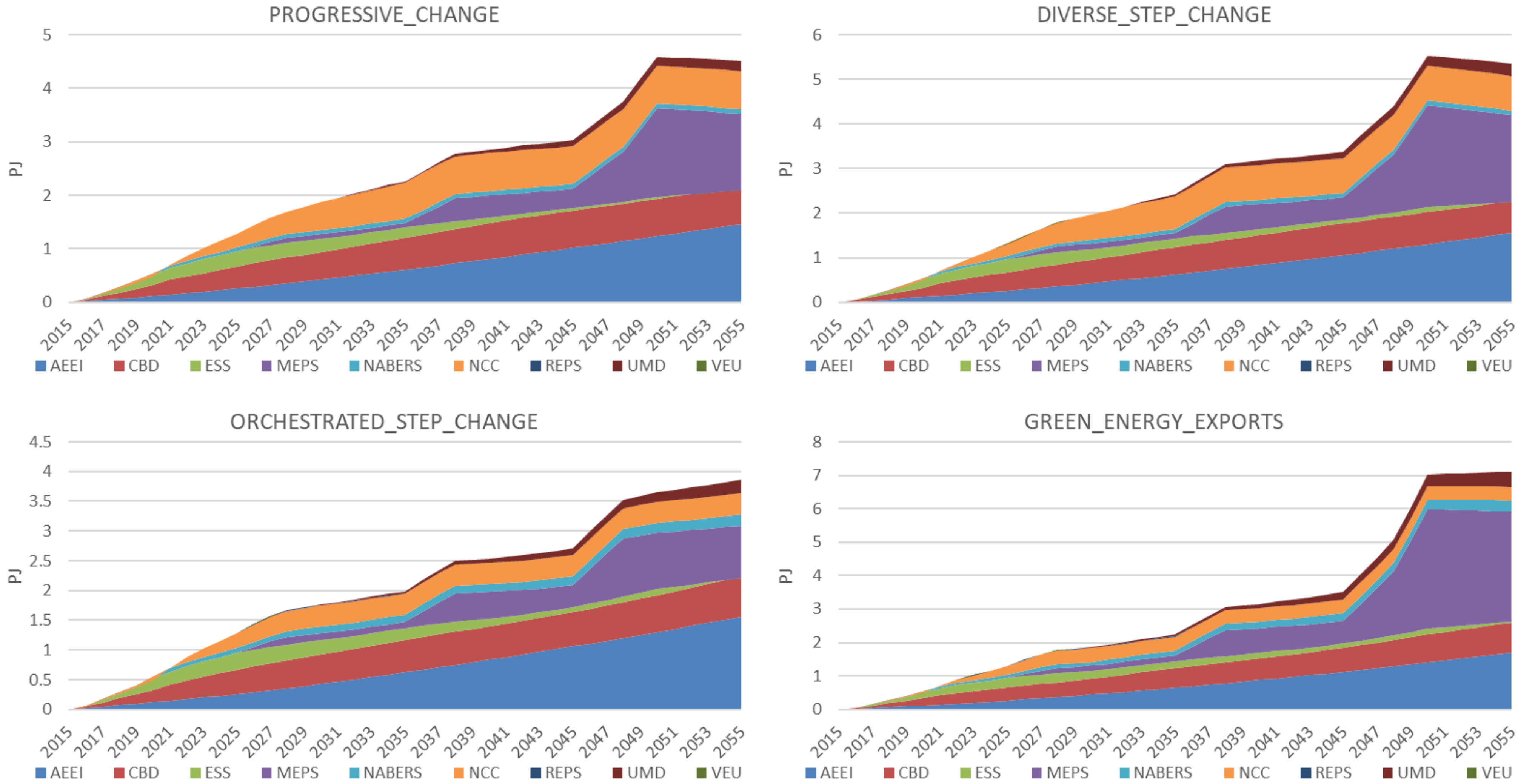
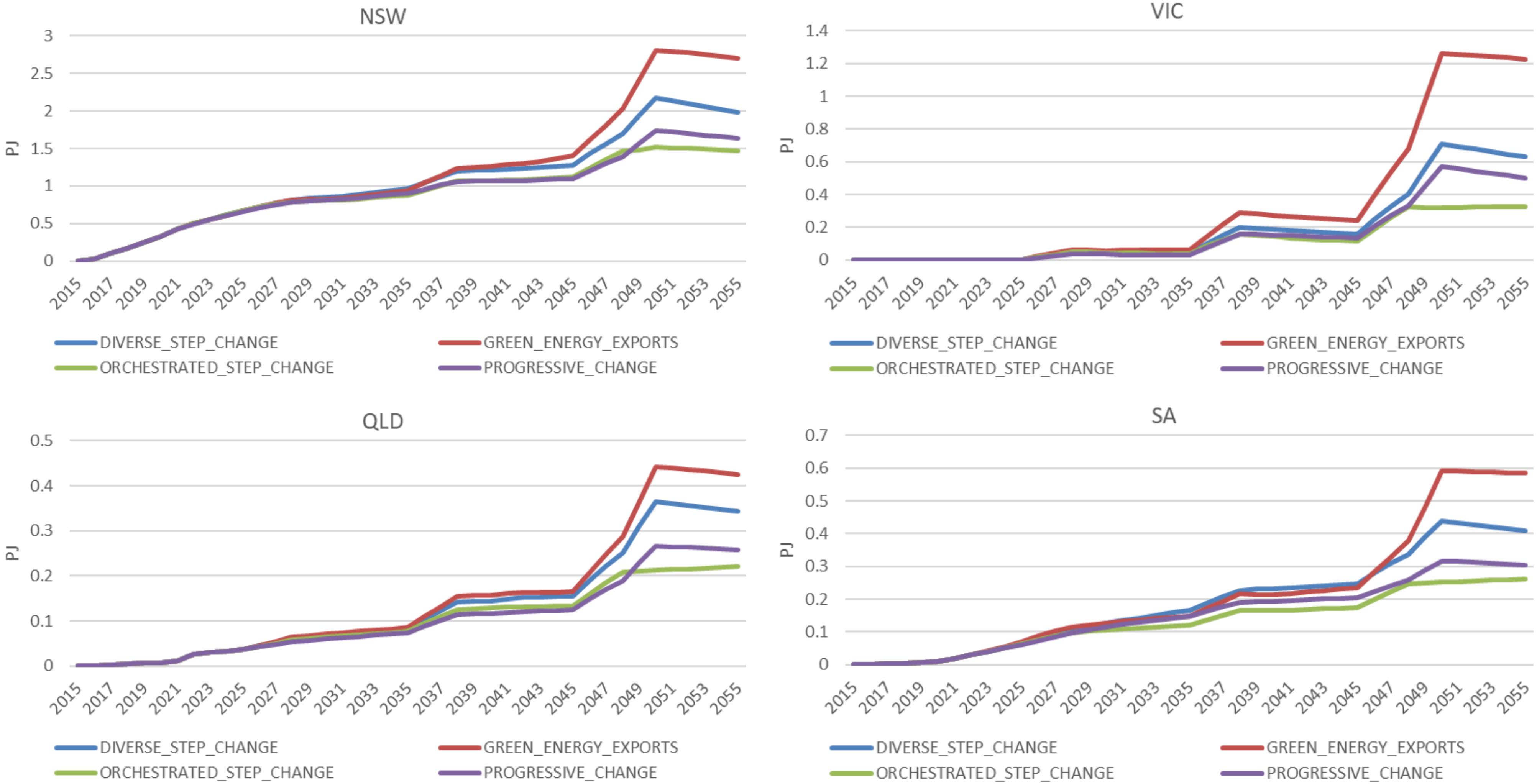
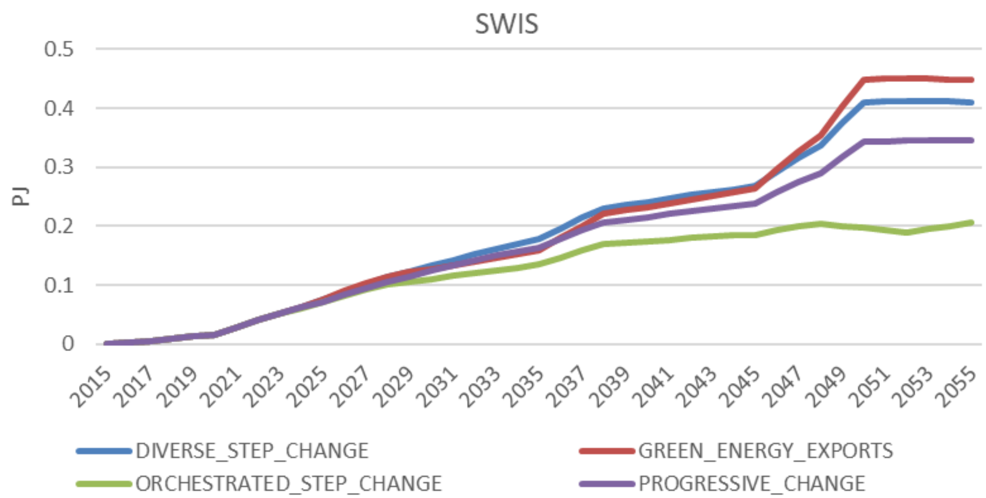


Figure 30: Commercial Sector Gas Energy Efficiency Forecasts by Region and Scenario (all components and end uses)




SWIS
0.5
0.4
0.3
0.2
0.1
0
PJ
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035
2037
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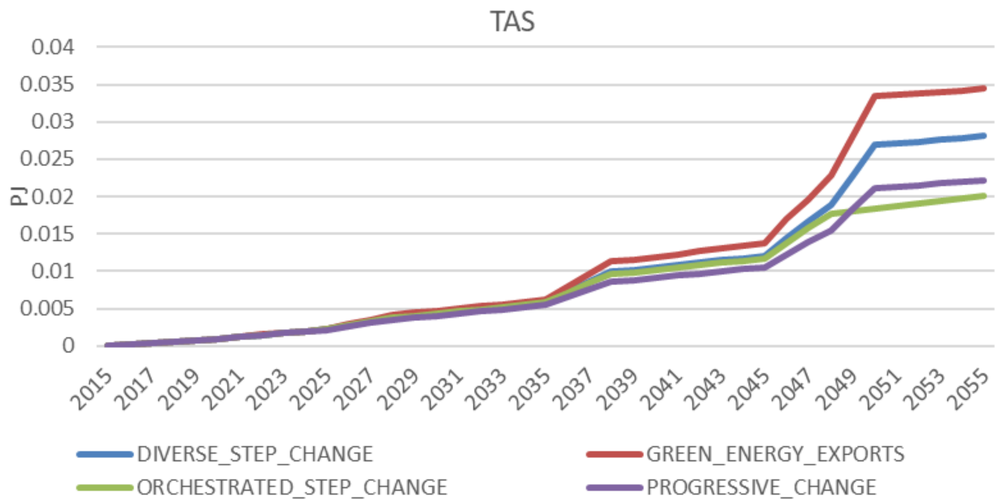
2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE


TAS
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
PJ
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
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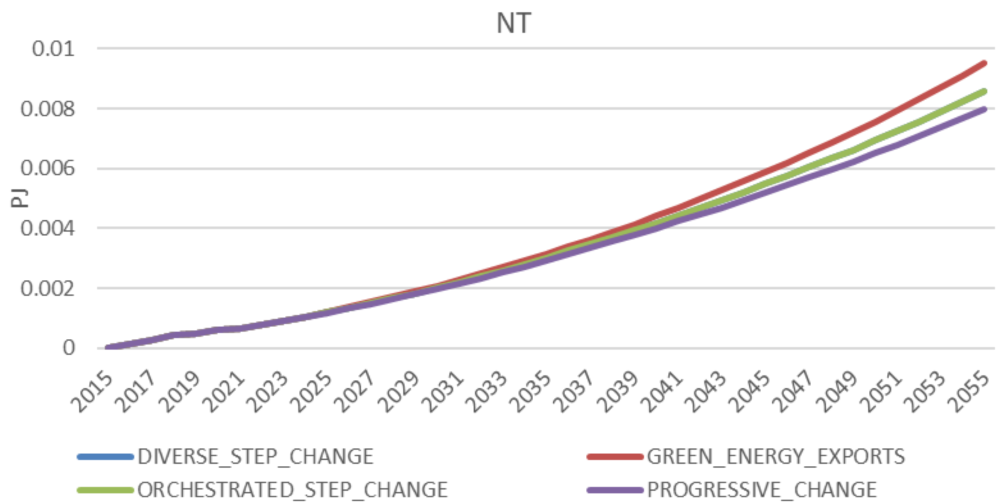
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE


NT
0.01
0.008
0.006
0.004
0.002
0
PJ
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035
2037
2039
2041
2043
2045
2047
2049
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2053
2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE

5.5 Industrial Sector

5.5.1 Overview by Scenario - Electricity

Figure 31 provides an overview of the industrial sector electrical energy efficiency forecasts by sector, summed for all regions, components and end-uses. Generally, the forecasts are strongly differentiated by scenario due to a combination of differences in economic drivers and conditions, policy ambition and electrification/fuel mix change. As noted below, the Safeguard Mechanism is assumed to generate the highest share of electricity savings in all scenarios, even if gas savings from this measure are likely to be much more significant (see below). Also, we do not estimate the electrification (as distinct from efficiency) impact of the Safeguard Measure, but this is expected to be very significant and may well generate negative electricity savings that overwhelm the estimated electrical efficiency savings. This flows from the exclusion of Scope 2 emissions (those from offsite electricity) from the scope of this measure. ESS generally offers the second-highest share of savings, depending upon the scenario. In higher policy-ambition scenarios (*Green Energy Exports*) and those with higher electrification (*Orchestrated Step Change*), the potential Industrial Assessments measure would also contribute significant savings – if indeed such a measure proceeds. In the context of overall industry electrical consumption, all scenarios represent very modest savings.

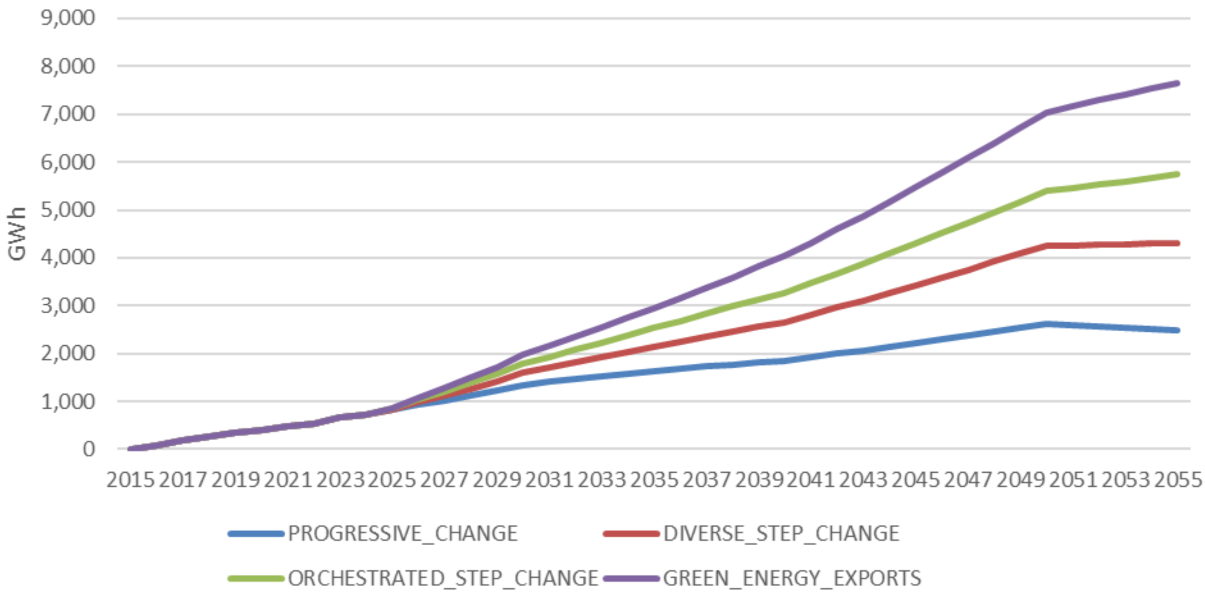
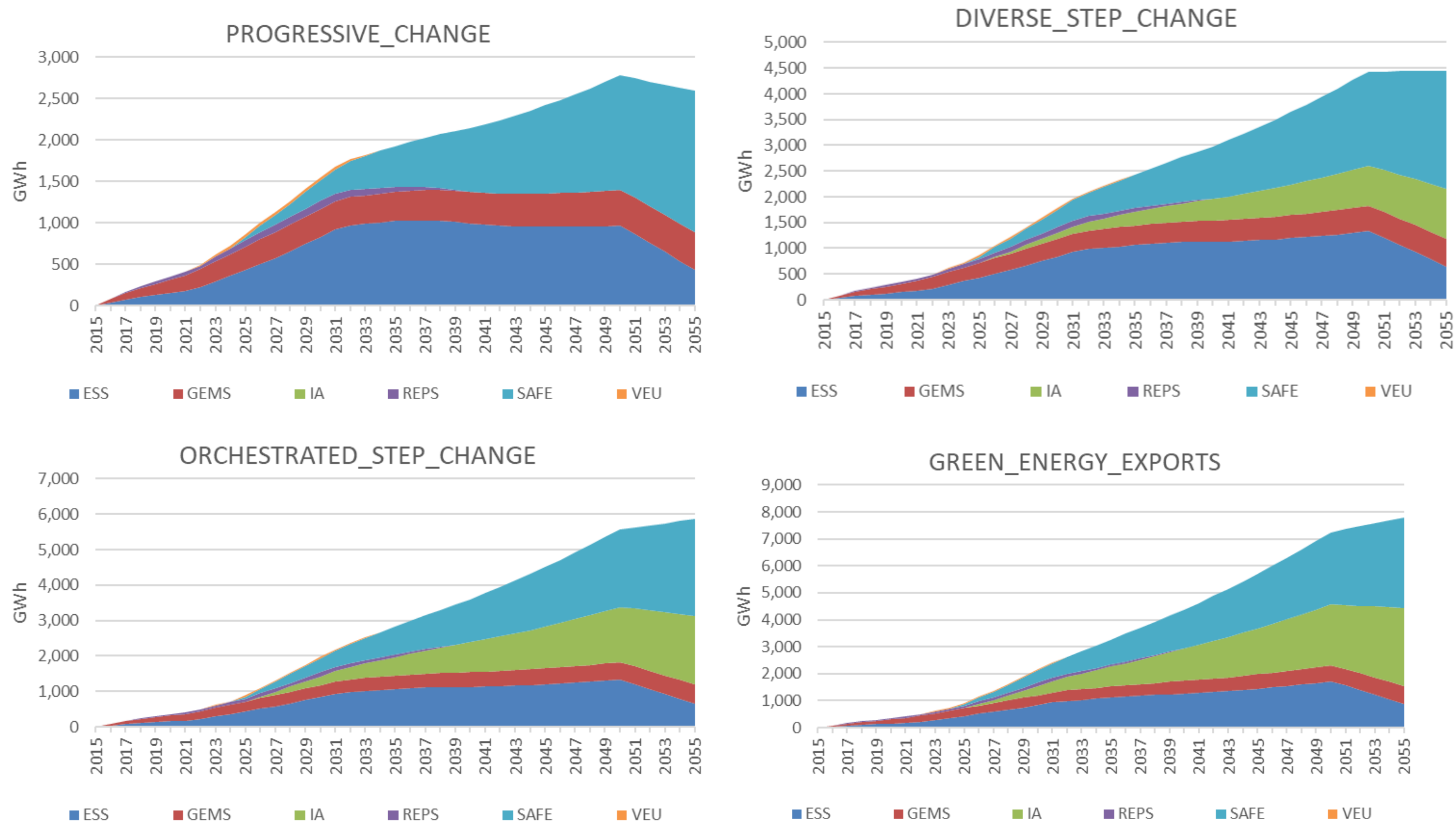


Figure 31: Industrial Sector - Total (Policy-led) Electricity Savings by Scenario (all regions and components)

Recall that market-led efficiency change is not estimated for this sector and also that, for this sector, electricity currently holds a smaller share of the fuel mix than does gas.

Figure 32: Industrial Sector Electrical Energy Efficiency Forecasts by Scenario and Component (all regions and end-uses)



Market-led efficiency trends – or, strictly, *total* energy efficiency trends – we discussed in Section 4.5.2 above and shown in Figure 7. This showed that industrial gas use intensity appears to have increased by an average of 3.1% per year over this period, while average electrical intensity increased by 0.4% per year, leading to a total change in energy intensity of +2.1% per year. Given that there have been some policy measures at work over this period, at least for electricity (GEMS, ESS), achieving some policy-led savings, this implies that market-led changes were, on average, to increase intensity by even more than the above-cited values, which were then offset to a modest degree by the measured policy impacts, leading the total intensity change averages noted. It is not *necessarily* the case that this increase in energy intensity indicates declining energy efficiency; however, it certainly casts doubt on whether there was, at least on average, any market-led efficiency improvement, at least over this period.

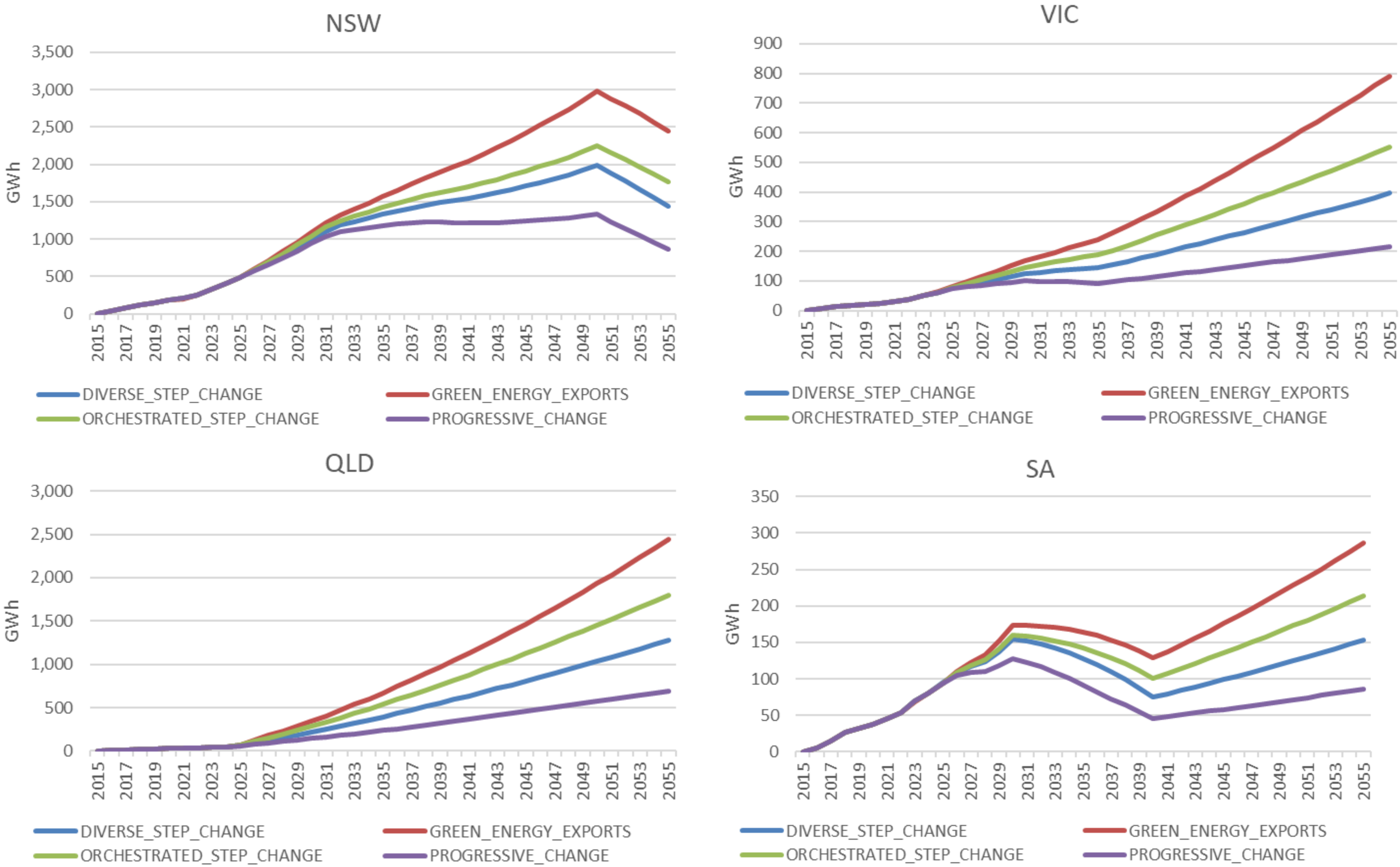
5.5.2 Overview by Measure - Electricity

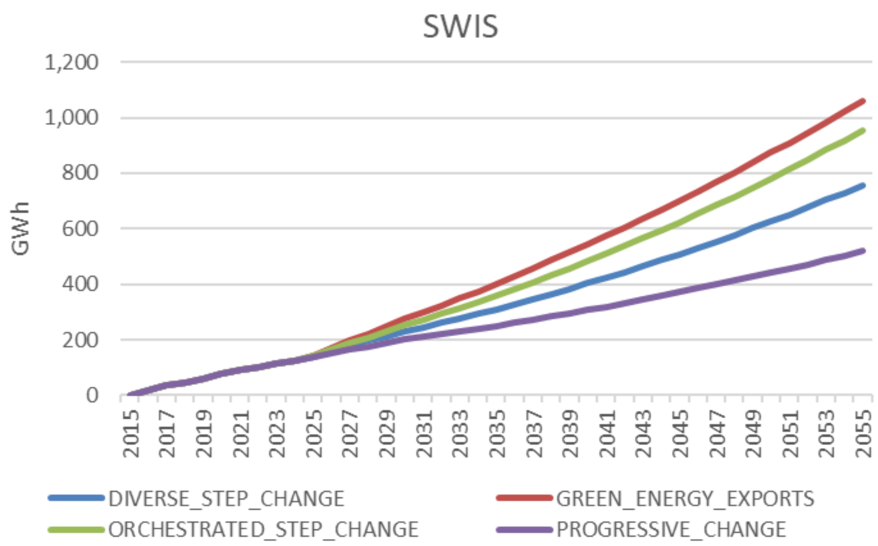
The relative importance of the Safeguard Mechanism ("SAFE"), ESS and, in *Orchestrated Step Change* and *Green Energy Exports*, of the potential Industrial Assessments measure, can be seen in Figure 32 above. ESS savings taper off after the assumed cessation of this program in 2050. VIC and SA programs make a relatively small contribution, as these measures both (at present) have less focus on the industrial sector than does ESS, and because these measures are assumed to be phased out from 2030.

5.5.3 Forecasts by Region – Electricity

Figure 33 provides the industrial sector electrical energy efficiency forecasts by region and scenario, for all components and end-uses. Savings in NSW, VIC and SA are noticeably impacted by the assumed cessation of state energy savings schemes, as discussed above.

Figure 33: Industrial Sector Electrical Energy Efficiency Forecasts by Region and Scenario (all components and end-uses)




SWIS
GWh
1,200
1,000
800
600
400
200
0
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
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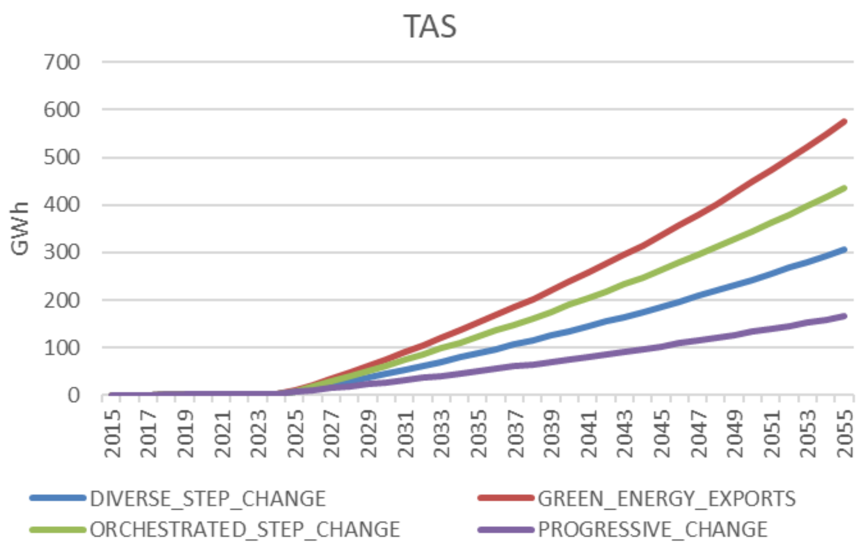
2053
2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE


TAS
GWh
700
600
500
400
300
200
100
0
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035
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2039
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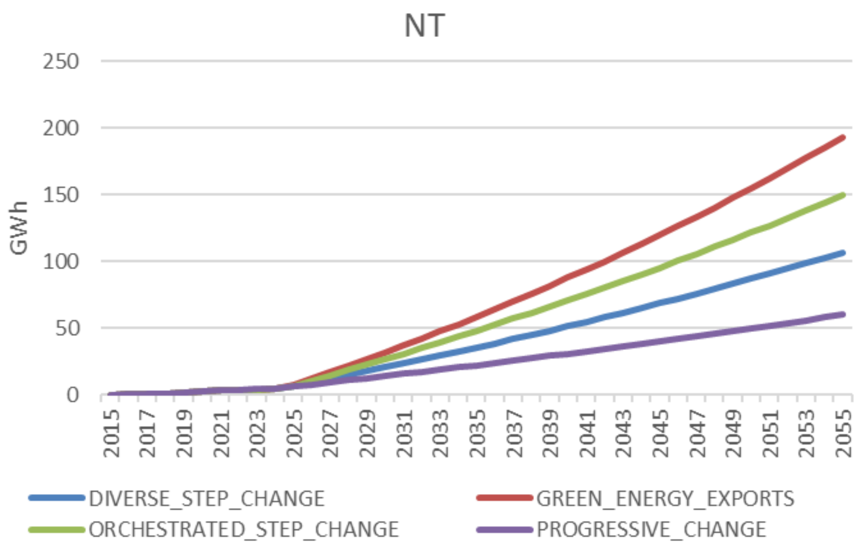
2055
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE


NT
GWh
250
200
150
100
50
0
2015
2017
2019
2021
2023
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DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE

5.5.4 Comparison to 2021 Forecasts - Electricity

Figure 34 shows the comparison of 2021 and 2023 industrial electricity efficiency forecasts, with dotted/dashed curves for 2021 and solid ones for 2023. As noted, NT was not included in 2021 forecasts. However, the larger effect is the inclusion of the Safeguard Mechanism in 2023. As noted, this measure accounts for more savings that other measures, even if savings are skewed in favour of gas, as discussed below. By contrast, GEMS savings are assumed to be smaller in 2023 than they were in 2021, due to downward revisions of impacts in new DCCEEW modelling.

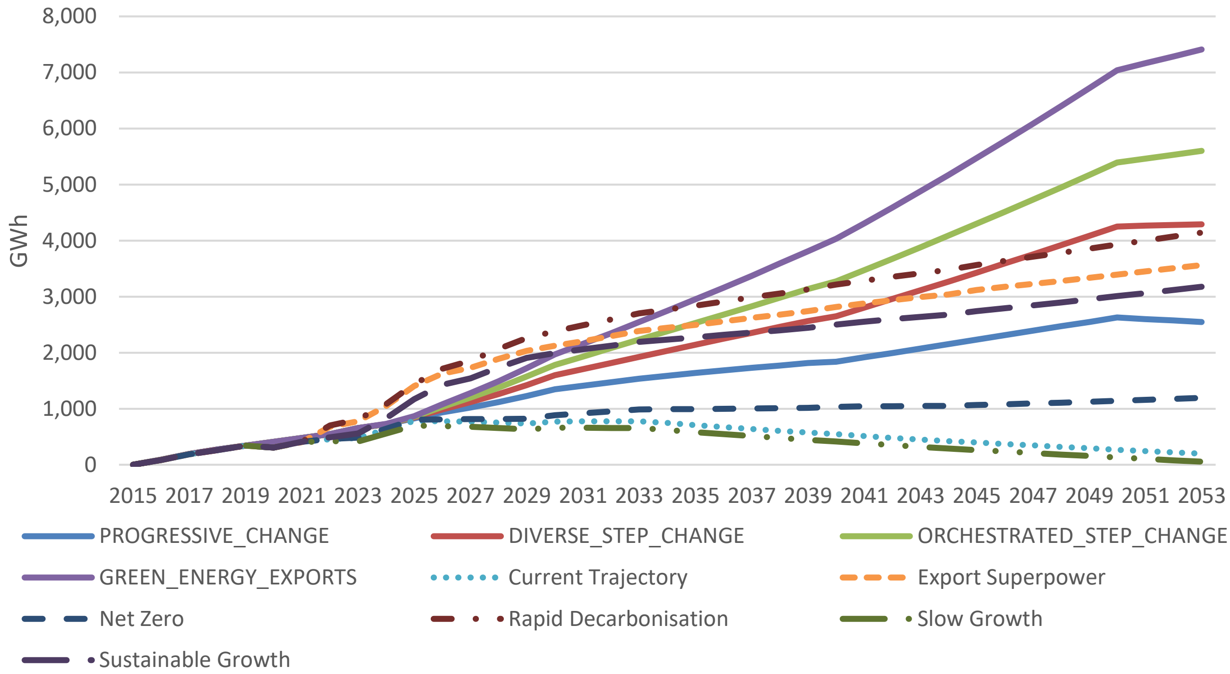


Figure 34: Industrial Sector - Total (Policy-led) Electricity Savings by Scenario (2023, NEM, SWIS, NT) vs 2021 (NEM, SWIS, rebased to 2015)

5.5.5 Overview by Scenario – Gas

Figure 35 gives an overview of the projected gas efficiency forecasts by scenario for the industrial sector (SMEs and LILs), for all component types and regions. Note that there are very few (policy-led) savings in the historical period. This reflects factors such as GEMS not covering any gas using products/equipment in this sector, ESS being primarily focused (at least to date) on electricity savings in this sector, and the absence of past measures such as EEO. Also as noted, we do not estimate market-led gas efficiency savings, but the limited evidence available suggests that industrial gas intensity has been increasing, on average, since FY2015 – see Section 5.5.1. Scenarios are therefore mainly differentiated by policy ambition or stringency, but also by the degree of electrification and/or use of blended methane/hydrogen fuels. However, in this sector, it is more likely that pure hydrogen will be used, avoided the efficiency penalties noted above that apply to blended fuels. Again it may be noted that even though the two *Step Change* scenarios have the same policy assumptions, the higher degree of electrification leads to higher efficiency outcomes under *Orchestrated Step Change*.

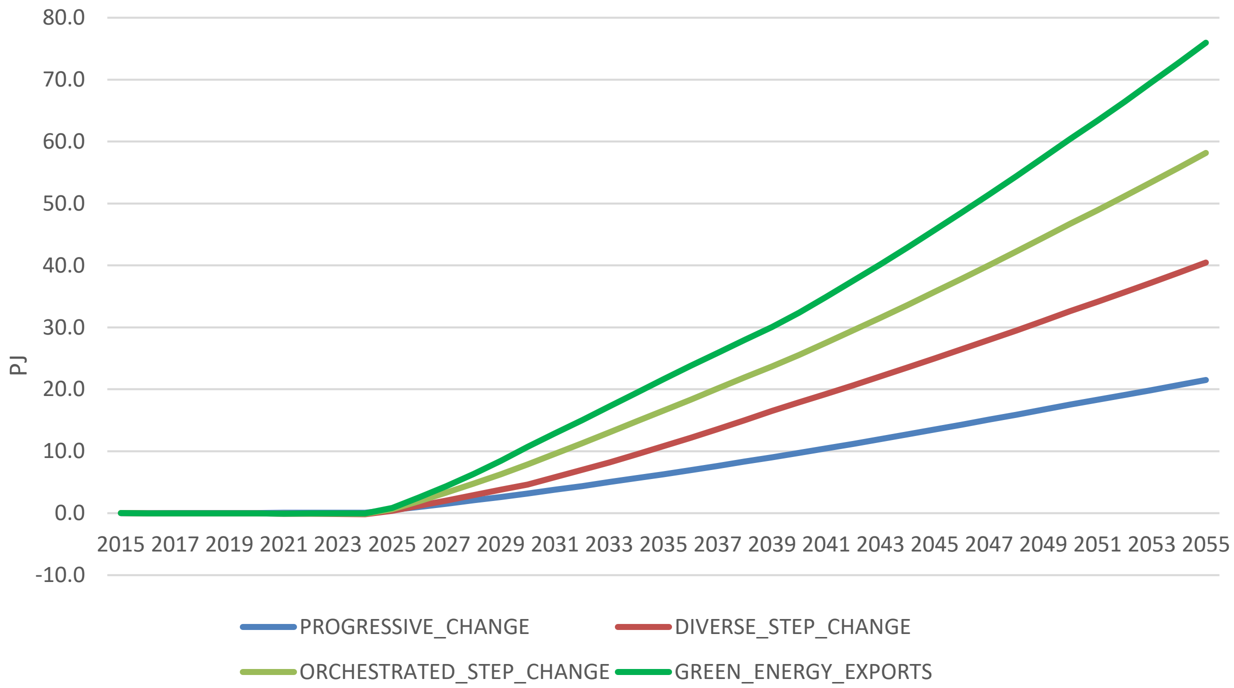


Figure 35: Industrial Sector - Total (Policy-led) Gas Savings by Scenario

5.5.6 Overview by Measure – Gas

Figure 36 highlights that the Safeguard Mechanism is expected to be the major driver of gas efficiency savings in the industrial sector (mainly LILs) even though, as noted, we do not estimate here the expected significant electrification effect of that measure, but only efficiency impacts. If an Industrial Assessments program were also introduced, it would also deliver significant savings.

Figure 36: Industrial Gas Energy Efficiency Forecasts by Scenario and Component (all regions and end-uses)

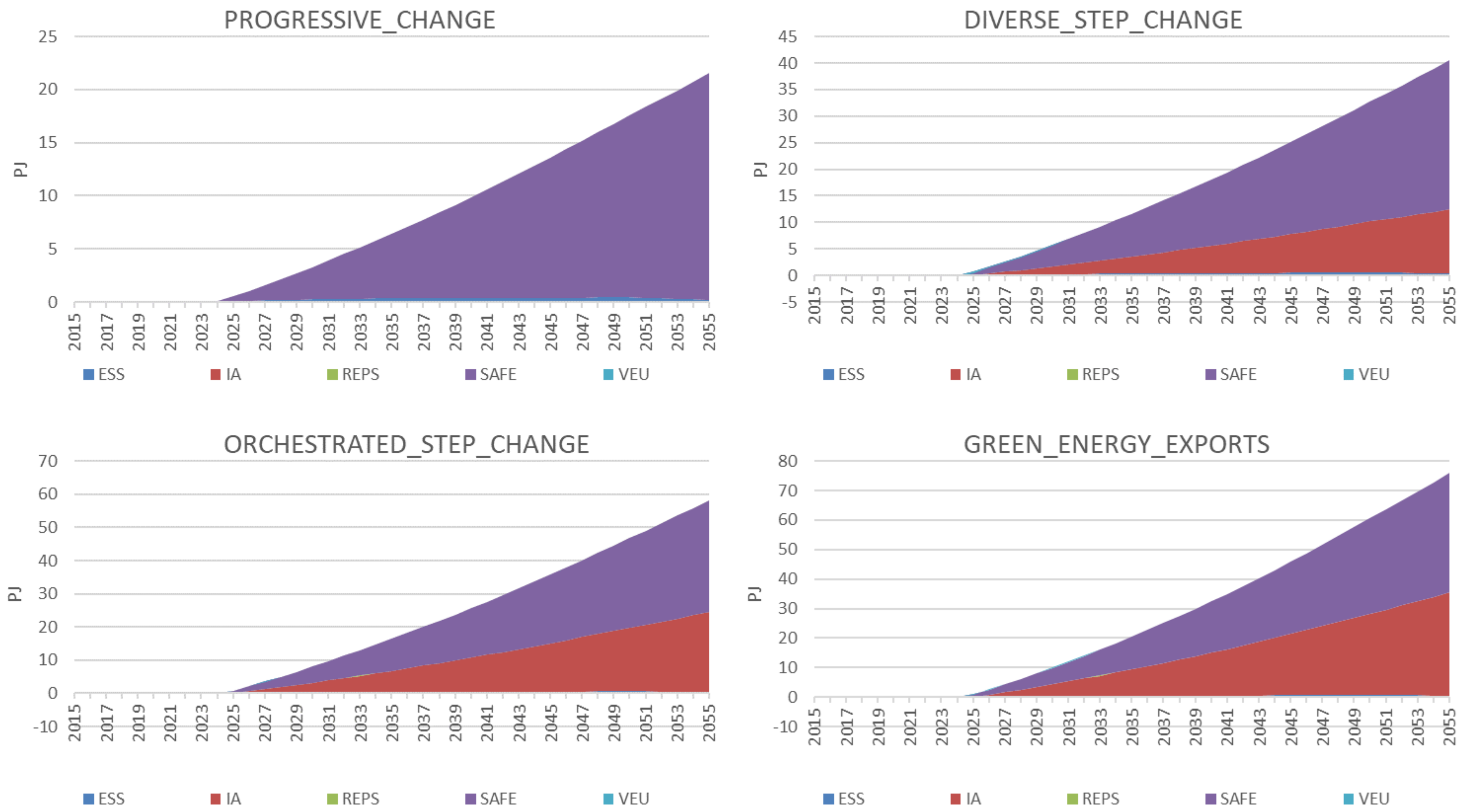
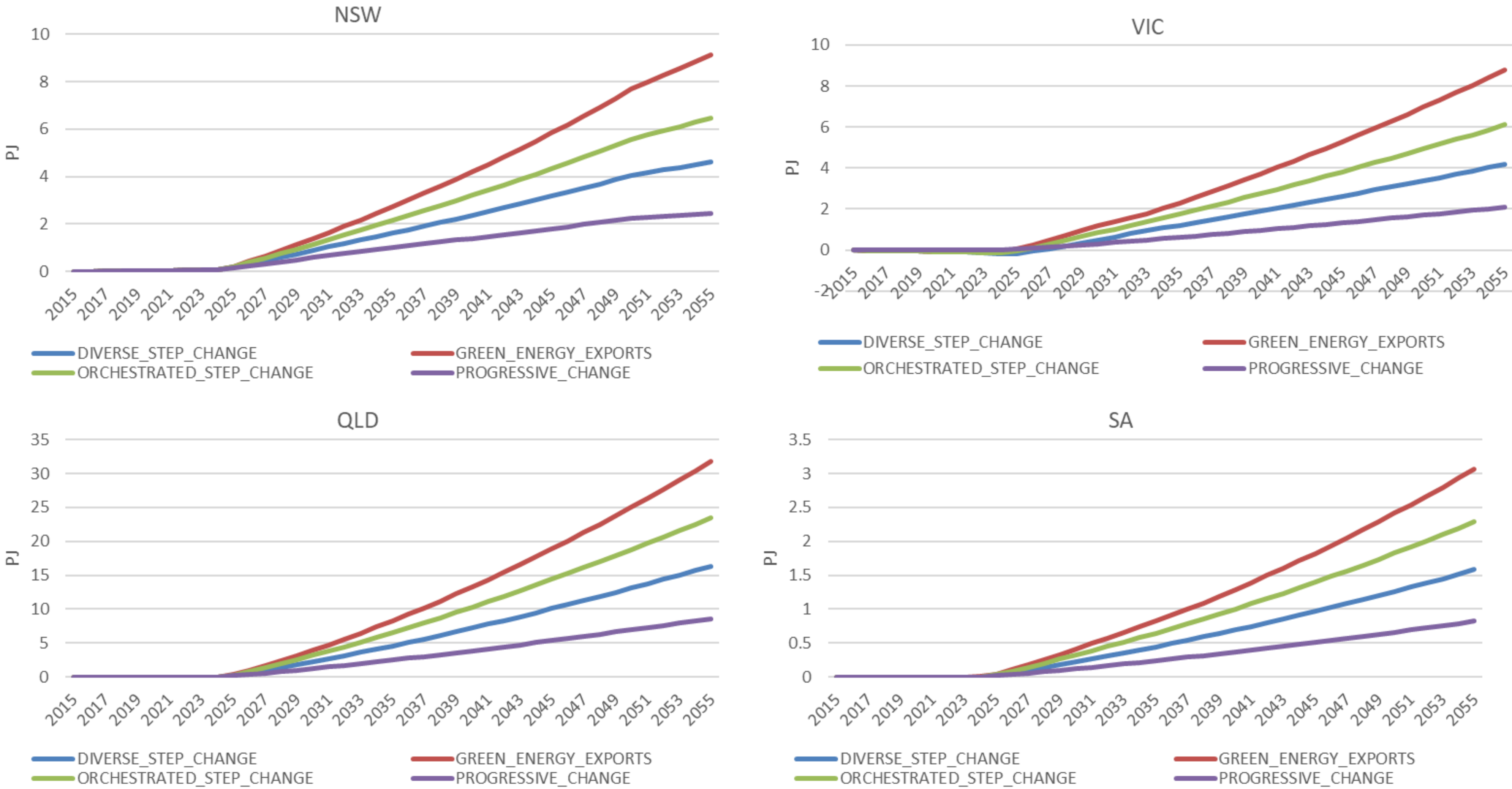
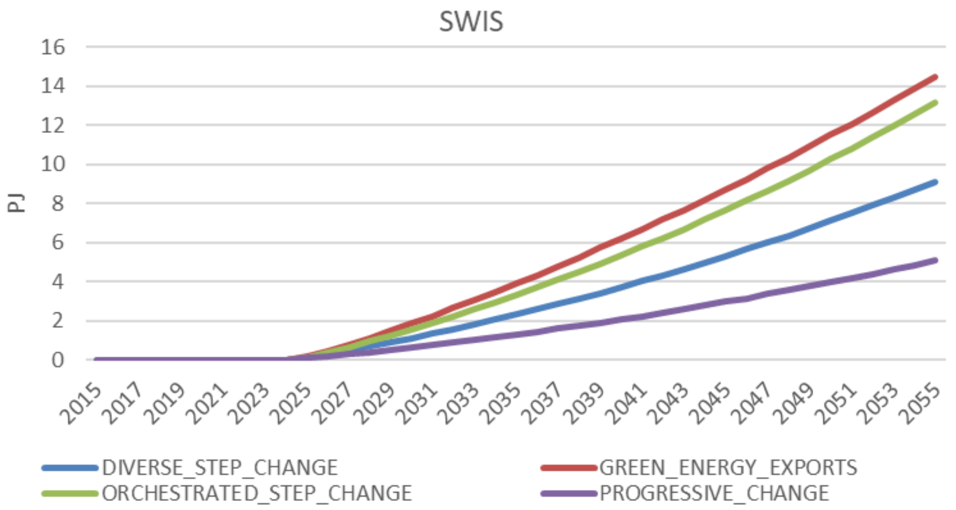
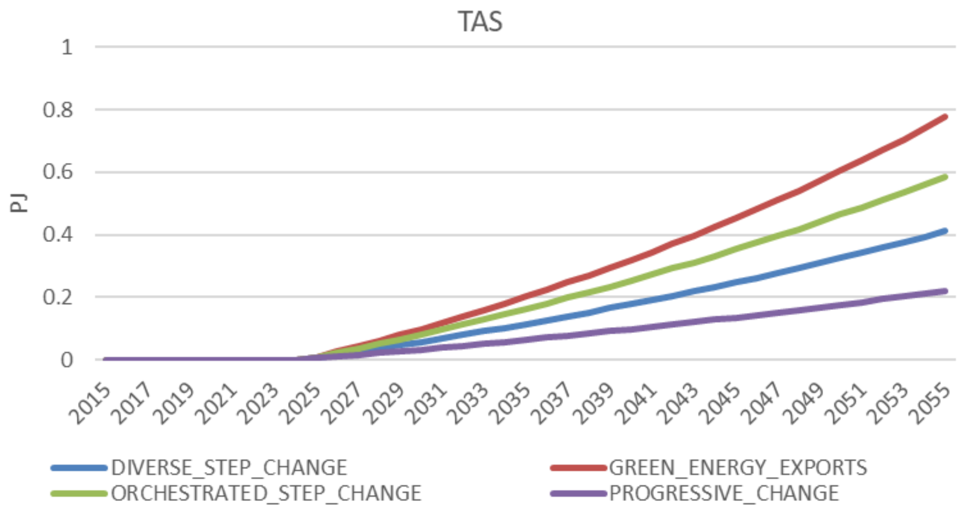


Figure 37: Industrial Sector Gas Energy Efficiency Forecasts by Region and Scenario (all components and end-uses)

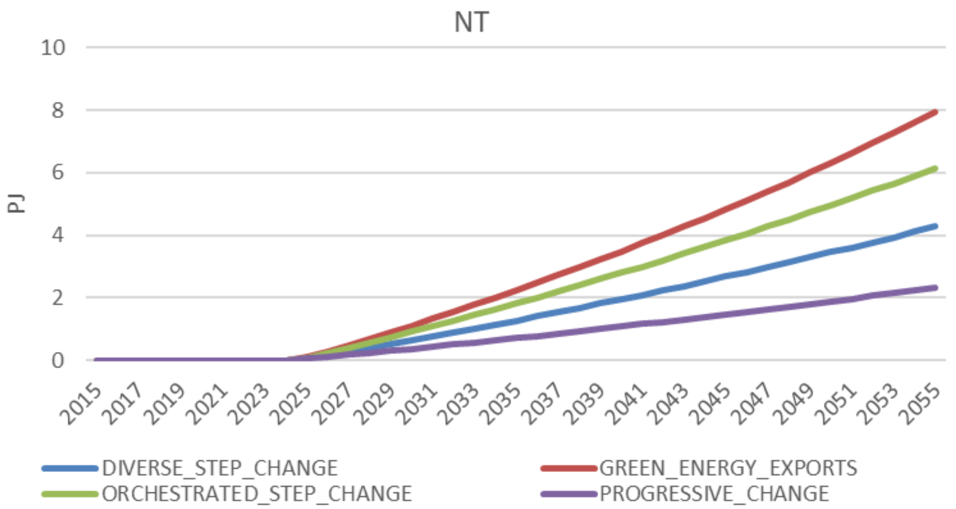




SWIS
PJ
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE



TAS
PJ
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE



NT
PJ
DIVERSE_STEP_CHANGE
GREEN_ENERGY_EXPORTS
ORCHESTRATED_STEP_CHANGE
PROGRESSIVE_CHANGE

5.5.7 Forecasts by Region - Gas

Figure 37 above shows the industrial sector gas energy efficiency forecasts by region and scenario, for all component types and end-uses. In *Diverse Step Change*, there is expected to be more gas used and, as noted, some activities encourage fuel switching towards gas (ie, negative gas savings), which is more pronounced in this scenario. In *Green Energy Exports*, there are higher policy targets and more electrification than in *Diverse Step Change*, and somewhat larger gas savings as a result, but all of these effects small, peaking at around 1 – 1.5 PJ in either direction. VEU savings are assumed to roll-off by 2035, hence VIC's gas savings patterns return to a pattern more similar to that of other states thereafter, with savings primarily driven by the Safeguard Mechanism and, potentially, Industrial Assessments.

5.6 Orchestrated Step Change – Low Efficiency Sensitivity Analysis

As discussed in Section 3.2, we have also explored what amounts to a BAU version of *Orchestrated Step Change* – that is, with *Orchestrated Step Change* economic and market-led efficiency assumptions, but with policy settings that remain at currently-announced/legislated levels. This provides an indication of outcomes that would be expected if *Orchestrated Step Change* were considered the 'most likely' scenario, but without strengthened policy settings. Summary findings for this sensitivity analysis are set out below.

5.6.1 Residential Sector

An overview of electrical energy efficiency forecasts under the *Low EE Scenari*o is shown in Figure 38, with the total of the original Orchestrated Step Change forecast shown as a dashed curve in red. The total in this BAU case is 31,350 GWh short of the original *Orchestrated Step Change* by FY2055, or 38%. There is no contribution to savings from potential new measures such as UMD and MEPS for rental properties, which contributed significantly to savings in the later period under *Orchestrated Step Change*. Lower savings also arise in NCC, GEMS and ESS.

In the case of gas, the BAU total is only 4.3 PJ, or 5%, less than the original *Orchestrated Step Change* by FY2055. This is because the majority of gas savings are assumed to derive from market-led forces, primarily electrification, and this is assumed to be the same under the original and the *Low-EE* cases (which differ in policy settings only).

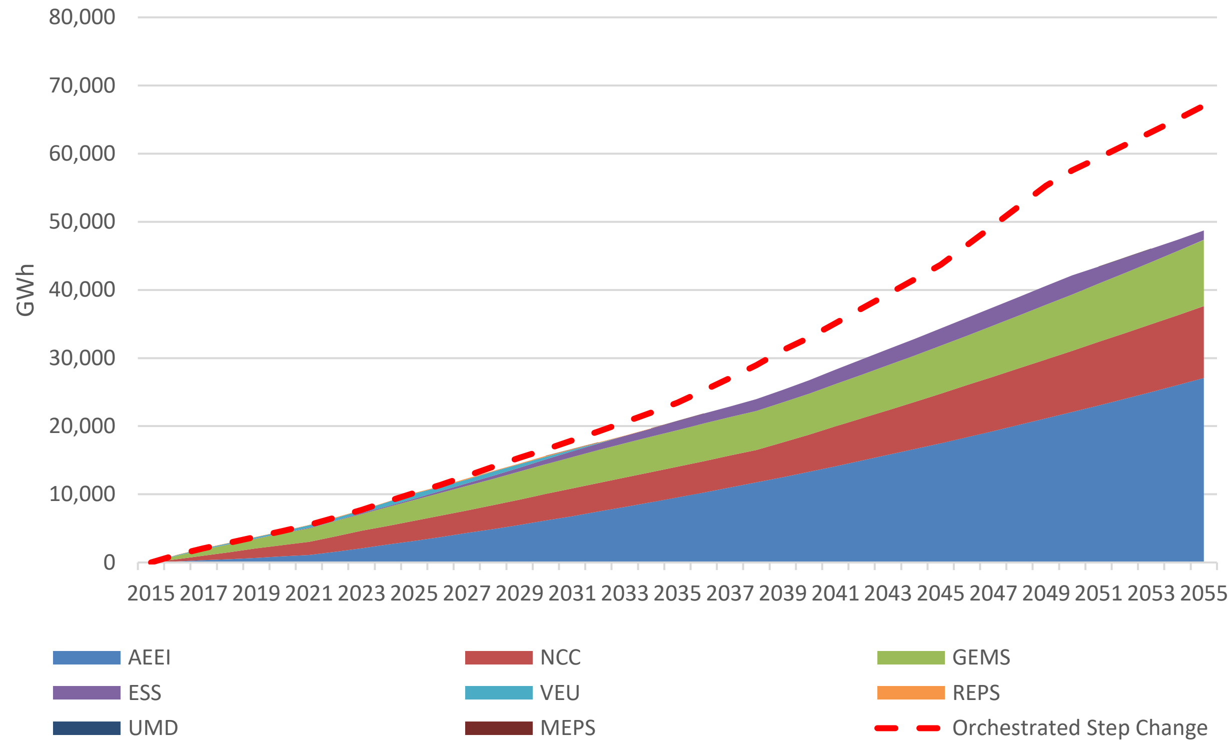


Figure 38: Residential Sector, Electrical Energy Efficiency Forecast, Orchestrated Step Change Low EE Sensitivity by Component Type (all regions and end-uses)

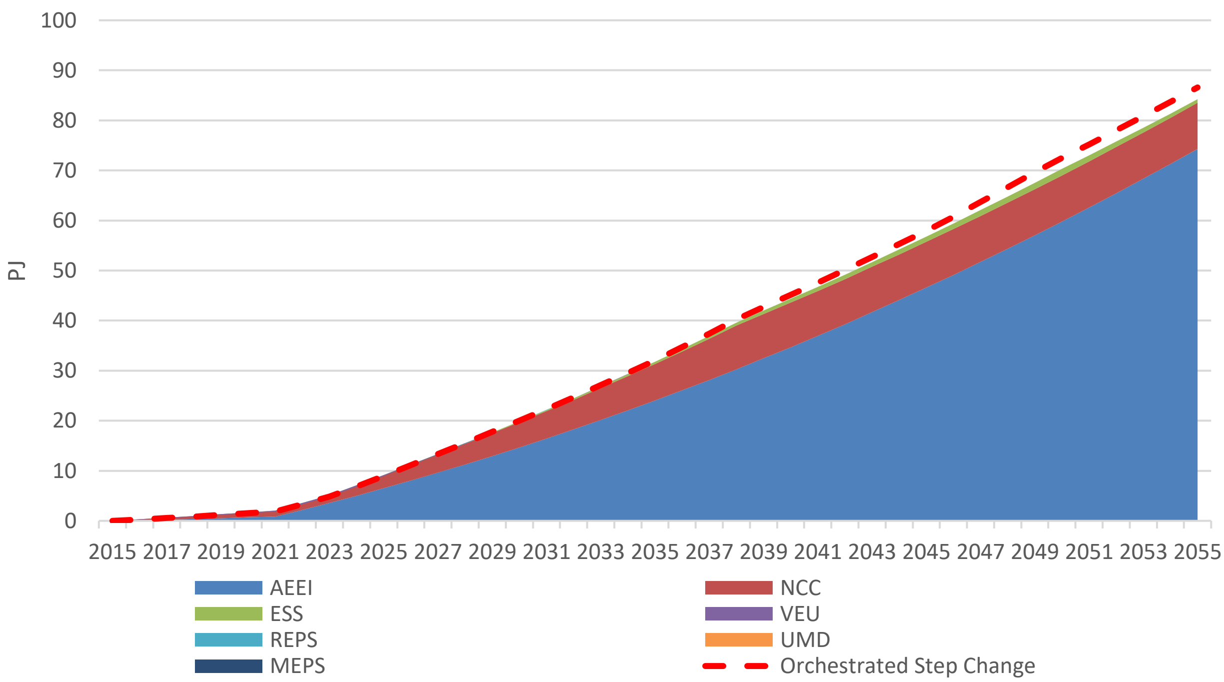


Figure 39: Residential Sector, Gas Energy Efficiency Forecast, Orchestrated Step Change Low EE Sensitivity by Component Type (all regions and end-uses)

5.6.2 Commercial Sector

Figure 40 provides an overview of the *Low-EE* sensitivity analysis for the commercial sector by component type, for all regions and end-uses. While the reduction cf the original *Orchestrated Step Change* is significant, at 19,000 GWh or 21% by FY2055, it may be noted that a significant share of the total savings in this scenario is expected to be market-led savings. With electricity already the dominant fuel in this sector, and expected to be even more so in this scenario, both market and policy energy efficiency savings are shifted towards electricity. There are no savings assumed in this scenario for UMD or MEPS for existing buildings.

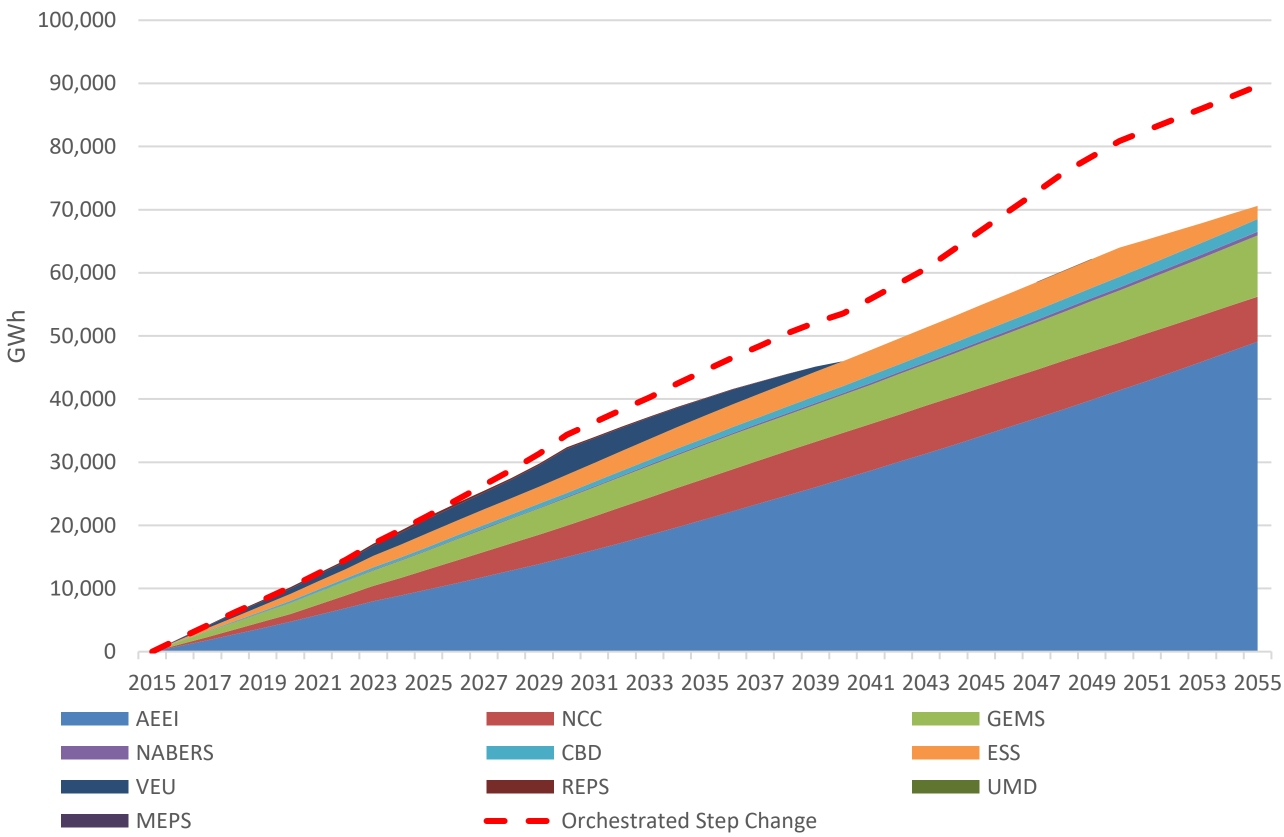


Figure 40: Commercial Sector, Electrical Energy Efficiency Forecast, Orchestrated Step Change Low EE Sensitivity by Component Type (all regions and end-uses)

Figure 41 below shows the equivalent chart for commercial gas efficiency savings in the *Low-EE* sensitivity. While the reduction from the original *Orchestrated Step Change* is significant in proportionate terms, at 37% by FY2055, the overall reduction in savings is only 2.2 PJ, due to the low use of gas in this sector and scenario. This scenario also features the most electrification.

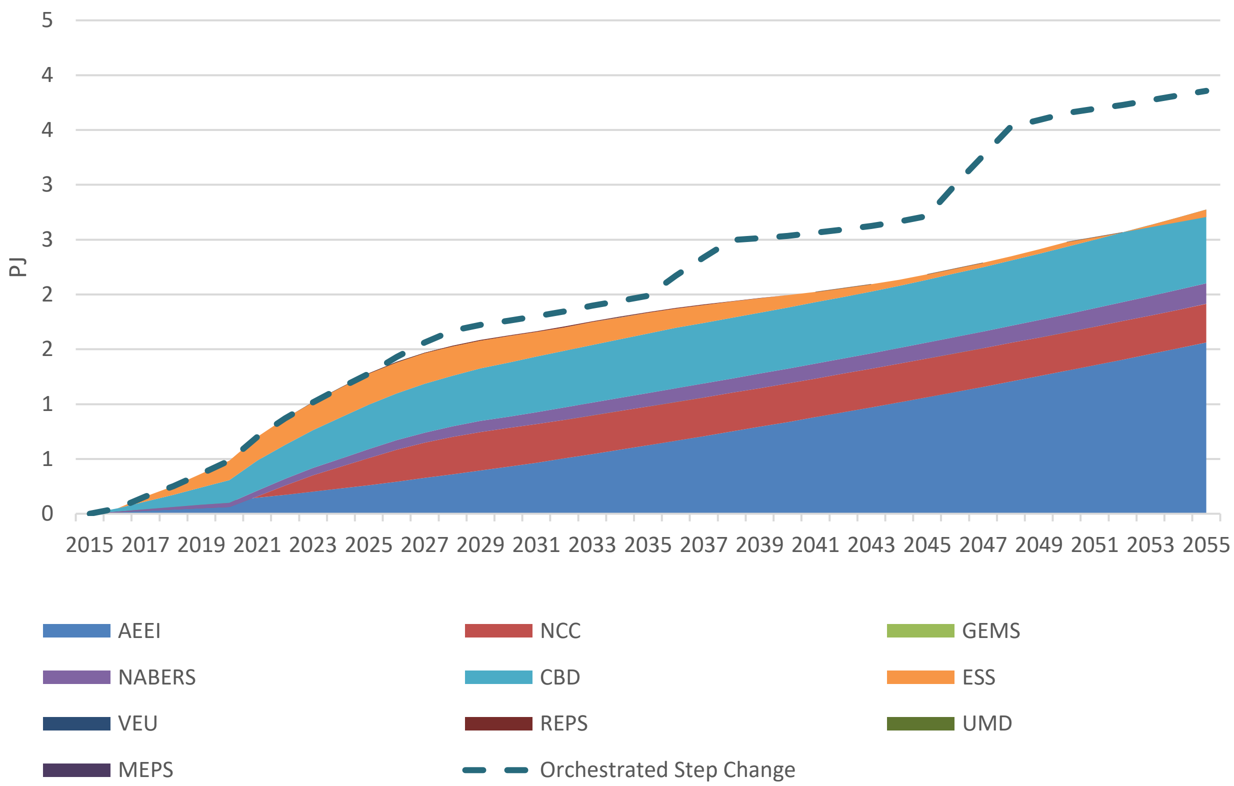


Figure 41: Commercial Sector, Gas Energy Efficiency Forecast, Orchestrated Step Change Low EE Sensitivity by Component Type (all regions and end-uses)

5.6.3 Industrial Sector

In the industrial sector, electrical energy efficiency savings in the *Low-EE* sensitivity are proportionately lower than sectors, in part due to market-led savings not being modelled and therefore failing to act as a buffer against the weaker policy settings (Figure 42). Total savings in FY2055 are some 5,750 GWh or 39% lower than in the original *Orchestrated Step Change*. No savings are assumed from Industrial Assessments in the sensitivity case, but the Safeguard Mechanism is retained, as it is treated as existing policy.

In the case of gas, savings are again proportionately higher than in other sectors, with a 42% reduction, or 24.4 PJ, by FY2055. This again reflects the absence of the market-led savings buffer, and gas consumption is proportionately higher than electricity in this sector. In this Low-EE sensitivity, almost all of the gas savings in FY2055 would be attributed to the Safeguard Mechanism, with a small contribution from ESS (which is assume ceases in FY2050).

Overall, the *Low-EE* sensitivity falls 52,500 GWh short of the electrical energy efficiency savings expected to be realised in FY2055 under *Orchestrated Step Change*, in total across the RES and BUS sectors, and almost 31 PJ short of *Orchestrated Step Change* gas savings in the same year.

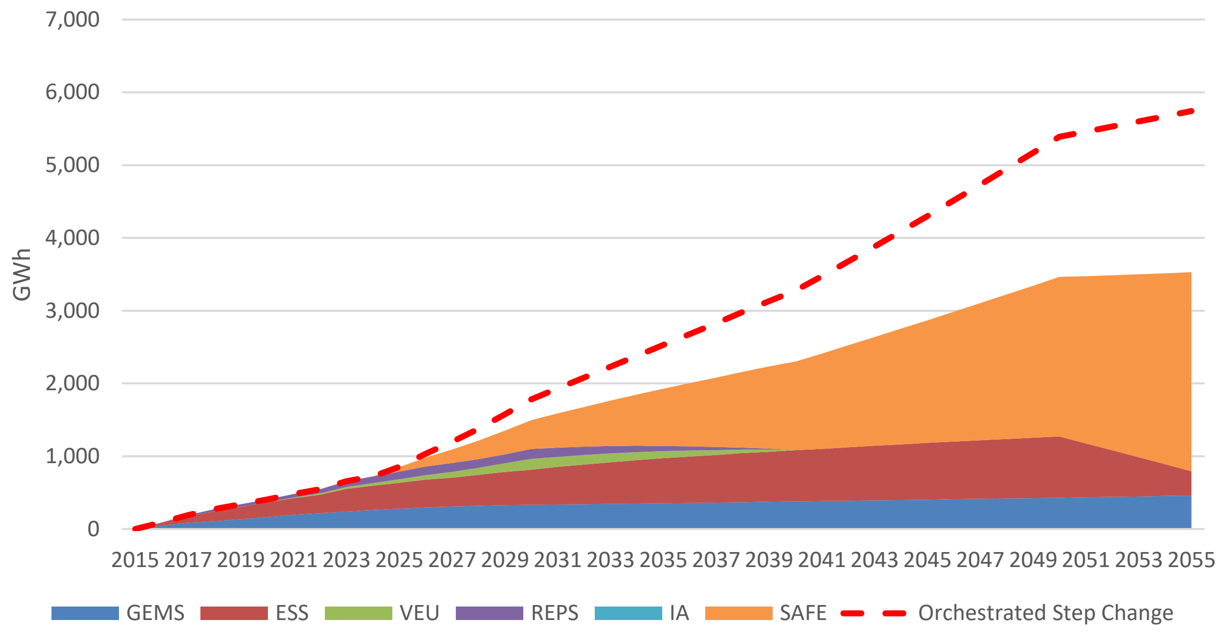


Figure 42: Industrial Sector, Electrical Energy Efficiency Forecast, Orchestrated Step Change Low EE Sensitivity by Component Type (all regions and end-uses)

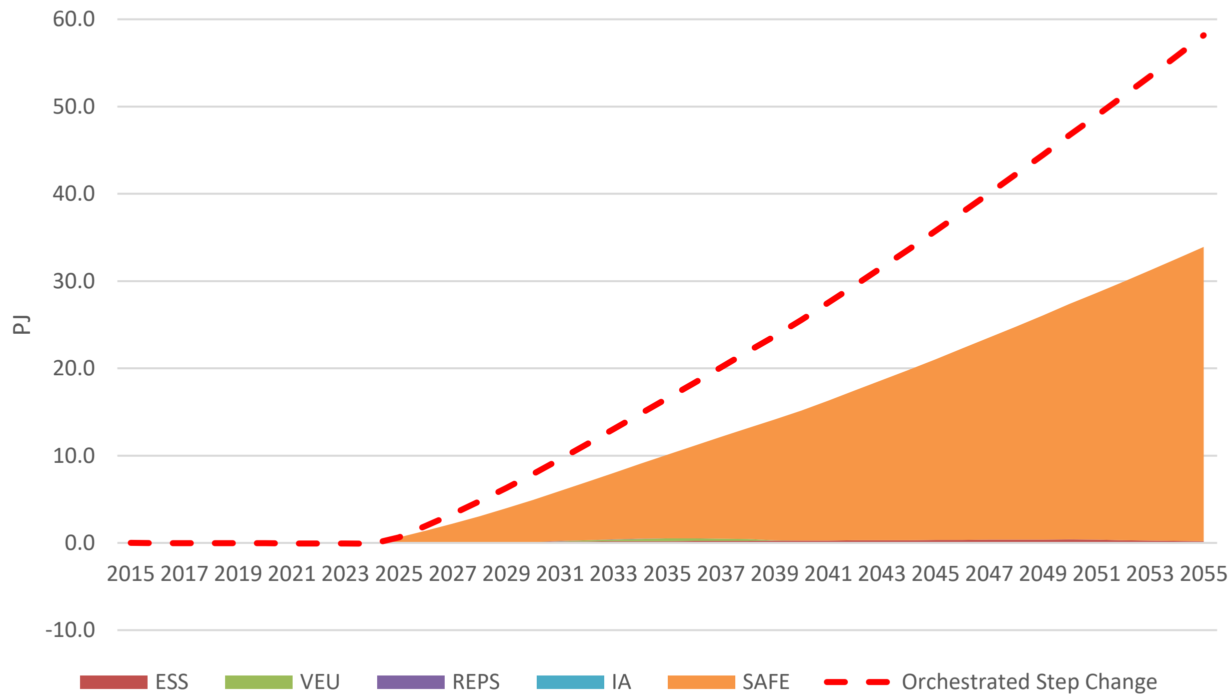


Figure 43: Industrial Sector, Gas Energy Efficiency Forecast, Orchestrated Step Change Low EE Sensitivity by Component Type (all regions and end-uses)

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

6.1 Quality Assurance Processes

The forecasts were reviewed internally by Dr Hugh Saddler and by Brett Janissen, both SPR Associates. Draft forecasts have also been reviewed by AEMO staff on multiple occasions and were presented to a meeting of AEMO's Forecasting Reference Group on 29 March 2023.

6.2 Validation Opportunities

Validation opportunities for avoided energy consumption are rare. Only policy/program evaluations that are independent, professional and which explicitly examine non-additionalities, are likely to be relevant. Such evaluations are undertaken very infrequently in Australia, and generally only for regulatory measures, but occasionally for other policy designs including financial incentives.[43] There have been formal evaluations for the CBD program, for example;[44] for GEMS (but not at a detailed, measure-by-measure level for some time);[45] 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 than applied in BCA2009.[46] As discussed further below, there are currently no validation opportunities available with respect to market-led efficiency improvement. However, this situation could be improved over time.

The primary constraint on the accuracy of energy efficiency forecasts in Australia is the lack of access to authoritative data. Broadly this reflects:

- a long history of inadequate investment in public good data systems, including those relating to energy consumption and use, and in related statistical collections
- increasing privatisation of data collection, notably following the establishment of the National Energy Market, not accompanied by adequate public-good data access or publication requirements
- a decline in investment in the maintenance of existing and important data collections, such as Australian Energy Statistics, but also private collections such as GfK's data on equipment

[43] 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.
[44] 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.
[45] 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, rather than by Allens..
[46] CSIRO (M. Ambrose et al), *Evaluation of the 5-Star Energy Efficiency Standard for Residential Buildings – Report*, December 2013.

- and appliance sales, and the former Electricity Supply Association of Australia energy price data series.
- infrequent and inadequate surveys by the Australian Bureau of Statistics and related entities
  - For example, the last ABS survey of Household Energy Consumption was undertaken in 2012, while the last Fuel and Electricity Survey is understood to have been undertaken by ABARE in 2009, but we can find no clear reference to support this[47]
  - No similar surveys have ever been published with respect to non-residential energy consumption or use, so far as we can ascertain.

All aspects of energy efficiency data have significant limitations. For example:

- energy consumption information, as reflected in Australian Energy Statistics, is largely modelled rather than sourced in a statistically-valid manner, is subject to major revisions, and now features multiple discontinuities that prevent meaningful time-series analysis
- while AER and AEMO collect certain information from market participants, neither institution aims to collate or publish this information in a statistically meaningful way
  - AER does have a requirement to publish basic consumption data, but this too highly aggregated to be useful for analytical purposes
  - Data from sources such as Regulation Information Notices (RIN data) is incomplete in terms of coverage of all regions – particularly for gas – and features significant discontinuities even with the short time-series available
  - It is also published on a network-by-network basis, with limited information as to which sectors of the economy are using this energy, and no information on what the energy is being used for.
- energy pricing is considered an important driver of energy efficiency investment, but only very limited statistical information exists in this key area in Australia. The AEMC publishes limited information only on residential electricity pricing, and only every second year, while occasional insights are available from the ACCC (with notable improvement in 2022)[48]
- there is no evidence regarding actual historical rates of autonomous or market-led efficiency change in Australia for any sector in Australia – as noted in Chapter 2, this can only be estimated by subtracting policy-led change (which itself must be estimated) from total efficiency change (which can be estimated for commercial and residential but not industrial)
- for policy-led savings, and as noted above, independent program evaluations, particularly for non-regulatory measures, but also for some major regulatory measures such as the National Construction Code, are extremely rare, and those that are undertaken do not

[47] ABS, 4670.0 - Household Energy Consumption Survey, Australia: Summary of Results, 2012.
[48] ACCC, Inquiry into the National Electricity Market – May 2022 Report, May 2022.

always include explicit consideration of non-additionality to market-led and other policy-induced efficiency effects

- physical output data for key industrial sectors (matched by energy consumption data at the same level of disaggregation) is not published, most likely due to this information being considered confidential.

That said, we note in Chapter 4 that there have also been a number of relevant data improvements:

- The 2022 Update to the 2012 Commercial Building Baseline Study was published in December 2022
- The ABS now publishes quarterly stock totals for additions and removals of each of houses, townhouses and apartments (2016 – 2022 only), drawing on 2016 and 2021 Census data *inter alia*
- Australia Energy Statistics (AES) Table F has undergone some review and revisions since 2021, which we understand led to revisions of at least residential and commercial and services electricity and gas consumption totals from FY2015 onwards. These revisions unfortunately introduce a new discontinuity between FY2014 and FY2015, and we hope that further improvements can be made to this important data source.

6.3 Future Improvement of Forecasts

As implied above, primary opportunities to improve energy efficiency forecasts in Australia would include:

1. Energy consumption
    - Ensuring that AEMO and its service providers have access to definitive and authoritative information on historical actual energy consumption in all regions of Australia, for all sectors (at least resolved to ANZSIC Divisions), and for at least electricity and relevant gases, including consistent historical time-series back to at least FY2015.
    - Ideally, since AEMO has access to metered consumption data on a highly spatially disaggregated basis, while this is not available from any other source,[49] this data would be compiled and published, or at least made available for research purposes, on a spatially disaggregated basis, as SA1 or SA2.
    - Note that this must include all components of energy consumption including self-consumption of behind-the-meter generation, as well as net transfers through meters, such that underlying demand can be quantified.
2. Activity

[49] AER RIN data is also discussed in this report.

- Dwelling/building counts and floor area by type and Class represent adequate proxies for the physical output of the residential and commercial sectors respectively. However, no such proxy exists for the industrial sector. It is likely that indices of the physical output of sub-sectors would need to be compiled and maintained over time to act as output series, so that the energy efficiency of the industrial sectors could be assessed in future. Such a task might be undertaken by the ABS or other parties.

3. End use

   - For estimating the impacts of policies and programs (as well as for many other purposes such as load and time of use studies), it is necessary to understand the structure and efficiency of end-use in each sector, for each fuel and in association with the economic structure (Divisions and sub-divisions) noted above. Infrequent collections by the ABS for the residential sector only are not fit for purpose. Efficient and statistically representative ways of collecting and publishing such information could be designed, including by agencies such as ABS or CSIRO.

4. Market-led energy efficiency

   - While total energy efficiency change over time should be the most important focus for these forecasts, there are additional insights available from separately considering the market- and policy-led components of change. However, this is only true if each component can be established with confidence. The policy-led components are discussed below. However, apart from the methodology used in this study, there are no independent and evidence-based opportunities to establish market-led efficiency change. The first step is to ensure that it is possible to establish both total and policy-led change over time as accurately as possible as, in principle, the difference is market-led change. However, other countries adopt different approaches to this challenge – such as the techno-economic analysis used by the US, Japan, Korea and EU countries. This approach track sales and the energy performance of a wide range of products sold, by sector and geospatial unit, and considers R&D effort, future cost and performance trends, and current and expected future market take-up. This approach could in principle be used to directly estimate market-led efficiency change, and could also be reconciled with policy-led and total energy efficiency change estimates.

5. Policy and program impacts

   - For some time now, policy and program impacts have been affected by an apparent need to report as large an impact as possible, rather than an accurate assessment of incremental impact. At the same time, independent policy and program evaluations, that were once considering essential 'program hygiene', have been become extremely rare. It is likely that these factors are related. At the same time, tax expenditures have never been subject to the same impact assessment and reporting requirements as other policy models, making it practically impossible to assess their impact, let alone their cost-effectiveness, even after the fact.

- Overcoming these barriers would require promotion of a culture and a practice in government that all interventions – whether involving tax expenditure or regulation – would be subject to a routine, uniform and independently-reviewed regime of impact assessment, performance monitoring, public reporting, and evaluation.

6. Explanatory data

    - To interpret the above data, and to make plausible future scenarios, a wide range of additional data sets are required. Most important is energy price information, as discussed above. We note that the ACCC has in recent years compelled retailers (of electricity only) to provide information that can be used to derive actual estimates of average prices paid for electricity in certain sectors and regions. Of course, this is limited to NEM states and to one energy carrier, but could represent a model upon which to build up to a minimum-necessary data set for analytical and related purposes.

We acknowledge that not all of the above is within AEMO's gift or mandate. However, AEMO exists within the wider system of energy market governance and administration, with up- and down-stream linkages that may present opportunities for influence and/or investment, including in partnership with others, to progressively address these improvement opportunities over time.

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