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Energy Efficiency Impacts on Electricity and Gas Demand to 2037-38: Final Report

Prepared for:	**Australian Energy Markets Operator**
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Executive Summary

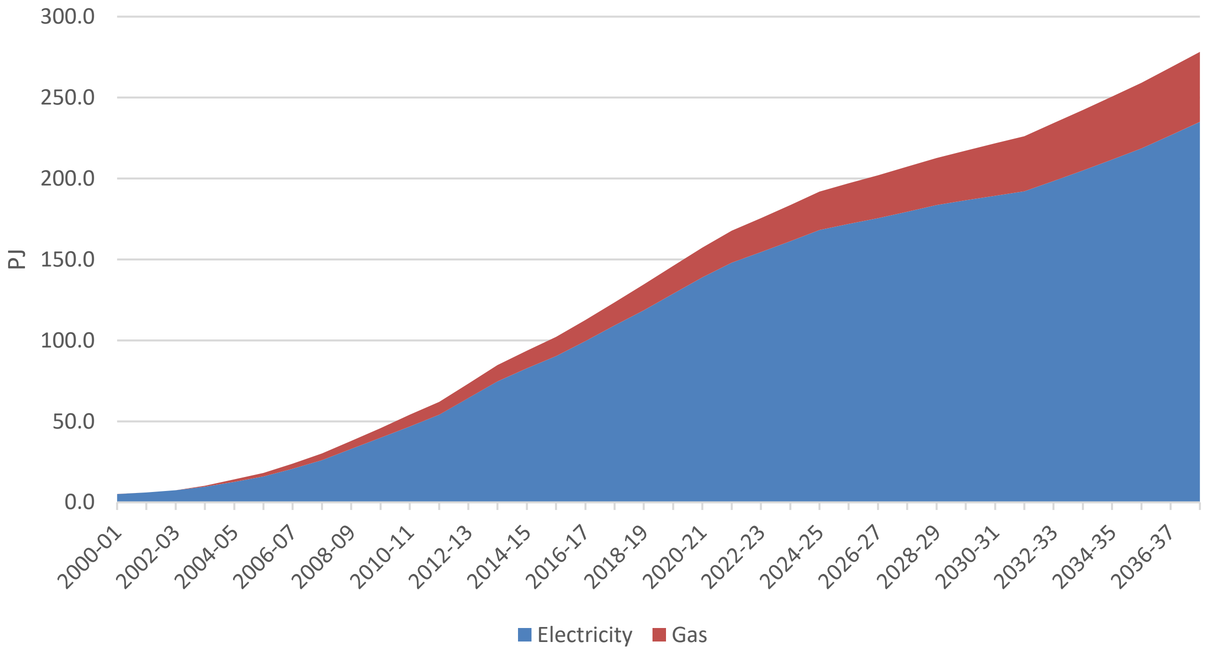
We estimate that the impact of major energy efficiency policy measures in Australia has been to reduce annual energy (electricity and gas) consumption in the residential and commercial sectors by 127 PJ in FY2018 relative to a FY2000 'frozen' efficiency' baseline. That is, energy consumption would have been 127 PJ higher in FY2018 if not for the savings attributable to major energy efficiency policies, including:

- Energy performance requirements in the National Construction Code
- Ratings and disclosure schemes such as NABERS and Commercial Building Disclosure (CBD)
- The Equipment Energy Efficiency (E3) program of mandatory energy performance standards and/or labelling for 55 classes of appliances and equipment
- State-based energy savings targets and related schemes in NSW, VIC and SA
- Smaller measures such as the Australian Government's Energy Efficiency in Government (EEGO) Operations program.

In FY2015 (the latest year for which *Australia Energy Statistics* data are available), estimated total savings (96 PJ in that year) were equivalent to 10.6% of total electricity and gas consumption in the residential and commercial and services sectors. That is, the measures avoided 10.6% of the consumption that would otherwise have occurred in FY2015.

By FY2038, we project total energy savings – again relative to a FY2000 base year – will reach 278 PJ in the moderate scenario. Savings are heavily weighted towards electricity, as most efficiency measures actually in place avoid electricity rather than gas consumption – see Figure 1 below.

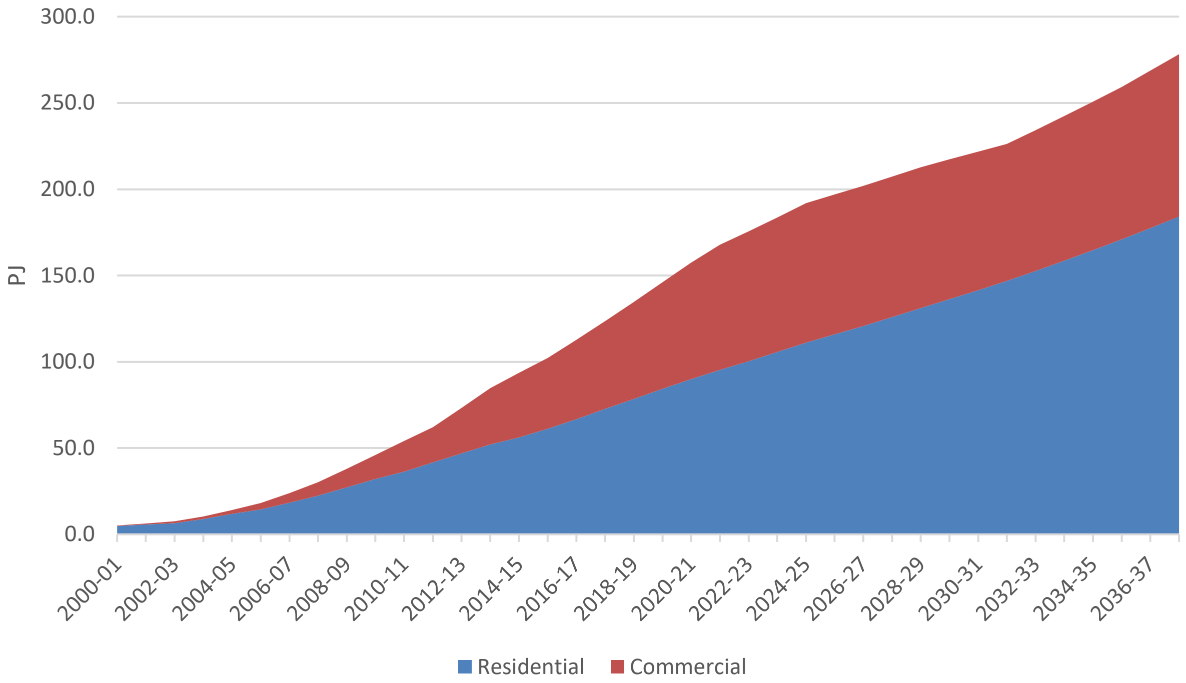
Figure 1: Historical and Projected Future Energy Savings, All Efficiency Measures, by Fuel – Moderate Scenario



In this study we do not attempt to determine what portion of these savings may have occurred in absence of the policy measures, for example due to changing technology, consumer and producer behaviour, and relative prices. It should also be noted that the estimates of historical energy savings are already present in actual consumption data.

Figure 2 below indicates that the residential has to date made up the majority of energy savings, and this is expected to continue in future. However, the residential sector's share of total savings falls from 94% in FY2001 to a projected 66% by FY2038. This reflects a shift in state-based savings schemes towards the commercial sector (notably commercial lighting), together with the anticipated effect of National Construction Code energy performance requirements, including a proposed update in 2019, whereas no lift in residential energy performance standards is currently expected or modelled.

Figure 2: Historical and Projected Future Energy Savings, All Efficiency Measures, by Sector – Moderate Scenario



In terms of avoided summer peak load, the energy savings measures are also contributing significant savings, expected to total just under 7,400 MW for residential (Figure 3) and just over 7,000 MW for commercial (Figure 4) sectors by FY2038. This reflects the net outcome of a) higher residential energy consumption savings than for commercial, b) lower conservation load factors for residential (that is, a more 'peaky' profile), and c) a higher share of cooling consumption savings in the commercial sector than in the residential sector.

Figure 3: Residential Avoided Peak Load, Australia, Moderate Scenario

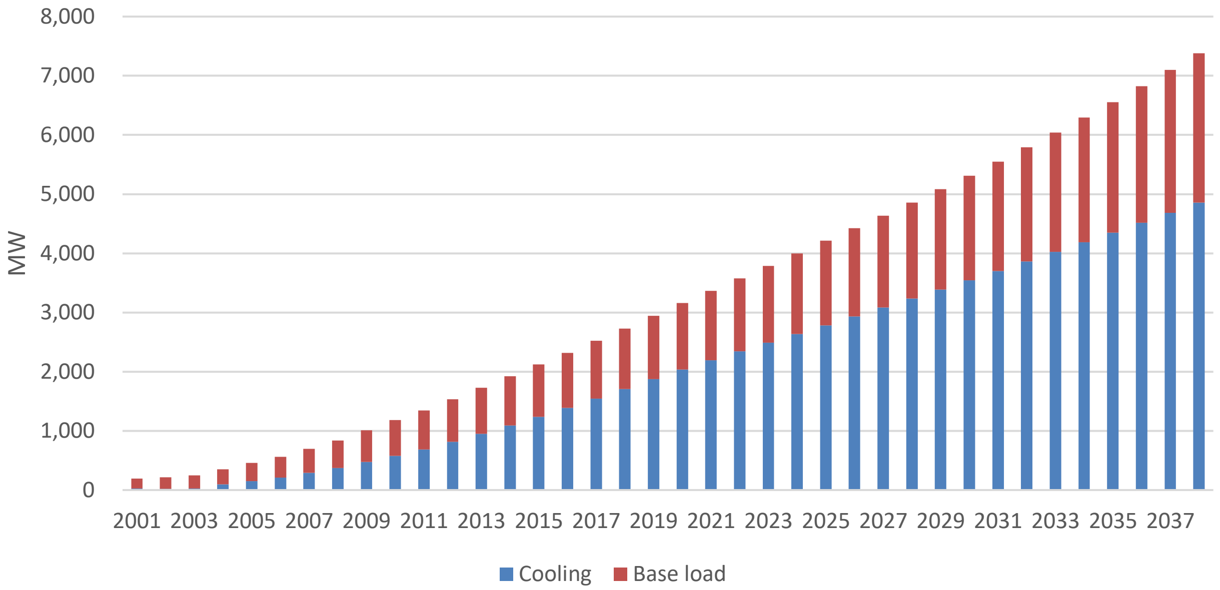
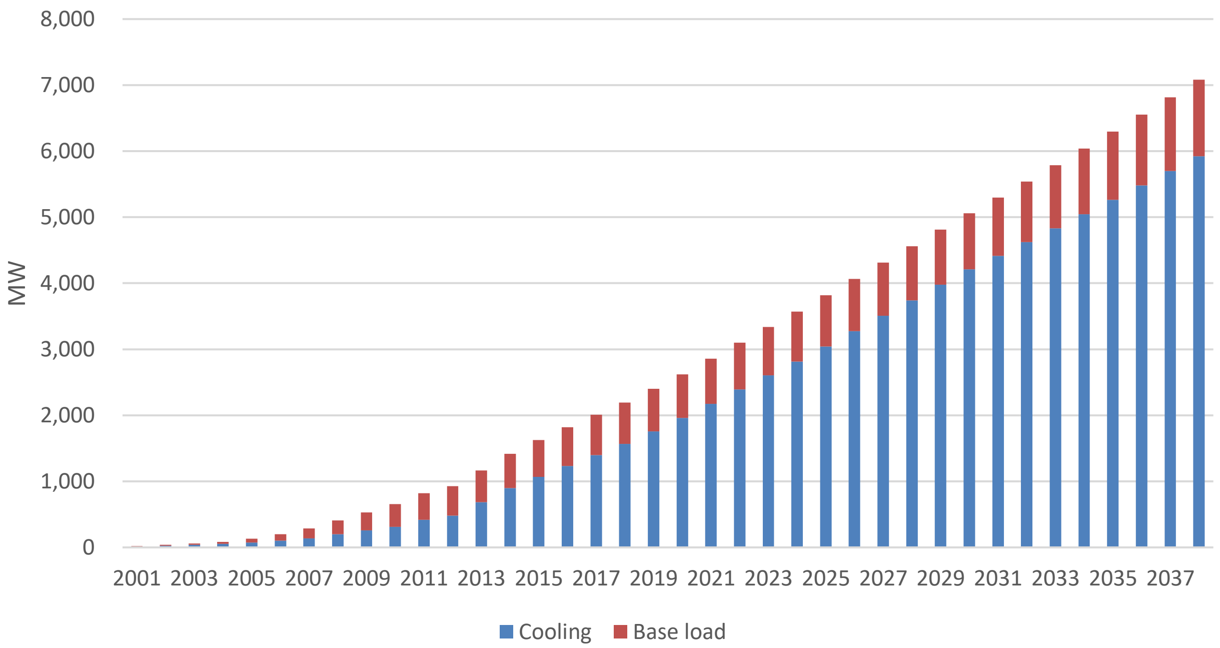


Figure 4: Commercial Avoided Peak Load, Australia, Moderate Scenario



1. Background

1.1 Background

The Australian Energy Market Operator Limited (AEMO) is an independent organisation responsible for operating eastern, south-eastern and western energy markets and systems in accordance with the National Electricity Rules and National Gas Rules. Its functions include:

- market and system operator of the National Electricity Market;
- market operator 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, and operator of the Wallumbilla gas supply hub (wholesale);
- market operator of a number of retail gas markets in eastern and southern Australia;
- national transmission planning for electricity transmission networks.

AEMO's objectives are to promote efficient investment in and operation of Australia's electricity and gas services for the long-term interests of consumers with respect to price, quality, safety, reliability and security of energy supply.

1.2 Purpose

A key role played by AEMO is the preparation of annual energy forecasts on a regional basis, for both electricity and gas. This information is an important indicator to market participants regarding the likely future demand for energy (electricity and gas), which helps shape expectations regarding the expected return on investment for both supply and demand-side offerings. This in turn helps contribute to maintaining an appropriate supply and demand balance in the NEM, thus helping to ensure efficient price outcomes for consumers.

In this context, AEMO has commissioned *Strategy. Policy. Research.* to prepare estimates of the historical and projected future effect of (major) energy efficiency policy measures in reducing the demand for and consumption of electricity and gas, by state and territory. This report effectively updates a similar one by pitt&sherry that AEMO commissioned in 2016, *Estimating the Effects of Energy Efficiency Policies and Programs on Usage of Electricity and Gas*, June 2016. Compared to that report, the scope of the current work extends to Western Australia and the Northern Territory – or, strictly, to the South Western Integrated System (SWIS) in WA and to the Darwin Katherine Integrated System (DKIS) in NT.

1.3 Context

The apparent demand for gas and electricity in recent years has slowed, reflecting a complex mix of factors, including electricity and gas prices that have risen sharply over the last ten years – although this effect has largely levelled off in the last year or two. While Australia's population and economy have continued to grow relatively strongly in recent years, household consumption (included of energy) has been constrained by modest growth in real wages.[1] The growth of embedded solar energy systems, for residential and increasing for commercial customers, continues apace, reducing the demand for grid-based energy. Certain technology changes, most notably LED lighting, but also more efficient heat pumps, have also been contributing to reducing demand for electricity.

A further factor influencing the demand for energy – and electricity in particular – is government energy efficiency policies and measures. While some jurisdictions began to implement efficiency measures in the 1990s or even earlier, key measures – such as minimum energy performance standards (MEPS) and labelling, and building code energy performance standards – were mostly introduced and then expanded or updated through the 2000s.

The progressive build-up of the stock of more efficient appliances, equipment and buildings over time tends to offset the factors that support demand growth – such as rising populations and economic activity. Some measures have also been introduced to encourage more efficient use of gas, but comparatively little when compared to electricity. However, building energy performance standards have tended to slow the growth in demand for space conditioning, including space heating by gas.

State energy efficiency targets and measures have grown incrementally over time. The *Commercial Building Disclosure* scheme has been expanded from FY2017, by reducing the eligibility threshold to 1,000 sqm. There is a regulatory proposal in development for higher energy performance standards for non-residential buildings from 2019, which is likely to proceed, but no similar proposal for residential buildings. Greenhouse and energy minimum standards (GEMS) and labelling programs have stalled for at least the last 5 years, with no new standards or labels being introduced over this period. However, a number of new proposals are now in various stages of development. Some measures that were contributing to energy efficiency improvement, including carbon pricing and the Energy Efficiency Opportunities program, have ceased operation in recent years.

There has also been a significant slowing in government investment in energy efficiency research in recent years. As a result, the evidence base with which to trace the unfolding impact of historical energy efficiency measures, or to assess the case for new ones, is far from ideal. The Australian Bureau of Statistics has discontinued its series last published as *Environmental Issues: Energy Use and Conservation* in March 2014.[2] This publication and its predecessors provided important, if infrequent, insights into the stock of certain energy using equipment, and certain energy use

[1] http://www.tai.org.au/content/power-down; http://www.tai.org.au/content/power-down-ii-australia%E2%80%99s-electricity-demand

[2] Australian Bureau of Statistics Catalogue No. 4602.0.55.001

behaviours in the residential sector, such as fuel switching for space conditioning and/or water heating. The *Commercial Building Baseline Study* has not been updated since 2012. As discussed further below, there remain very significant uncertainties associated with the stock and energy use, and therefore greenhouse gas emissions, associated with non-residential buildings in Australia. No national statistics are collected in these areas.[3] The total impact of the appliances and equipment minimum energy performance standards and labelling program has not been reported upon in detail since 2014, but is updated in this study.[4]

2. Methodology

2.1 Overview

Our methodology closely follows that used in the 2016 study referenced above, but updated and expanded to the extent feasible. Key enhancements include:

- Inclusion of Western Australia's SWIS and NT's DKIS
- Aligning our model of the dwelling stock to the latest 2016 Census data, in addition to current building completions data
- Including estimates for energy savings expected to be realised by proposed changes to the energy performance standards for non-residential buildings in the 2019 version of the National Construction Code (NCC2019)
- Updating estimates for all state-based energy efficiency targets measures
- Adding estimates for the Victorian Energy Efficiency Target (not included in 2016).

Broadly, our methodology estimates the annual energy (electricity and gas) and peak demand savings in all states and territories that are attributable to the major energy efficiency measures in Australia including:

- The Greenhouse and Energy Mandatory Standards (GEMS) program (minimum energy performance standards and labelling for certain appliances and equipment)
- Energy performance requirements within the National Construction Code (NCC, for 'the Code', previously referred to as the Building Code of Australia, or BCA)
- Building ratings and disclosure schemes including NABERS and Commercial Building Disclosure (NatHERS is included as a Code requirement)

[3] Australian Energy Statistics is organised by ANZSIC codes and does not resolve the energy consumption attributable to non-residential buildings, and at the date of publication, was current only until 2015-16. The ABS publishes the value of work done in non-residential construction, but no indicators of the *volume* of work done – for example net floor area constructed – either in total or by building class or type.

[4] The 2015 Review of the Greenhouse and Energy Minimum Standards (GEMS) program, by Databuild, drew on unpublished estimates of savings that were attributed to the then Department of Industry and Science (see, for example, p. 29).

- State-based energy savings targets and programs in NSW, Vic and SA.

Energy savings are separated into baseload, heating load and cooling load components, to facilitate analysis of the impacts on measures on summer peak load, in addition to impacts on energy consumption.

In line with AEMO's requirements, we select a FY2000 base year, as this year predates most if not all of the energy efficiency measures analysed. Energy savings are estimated for the FY2001 – FY2017 historical period, and projected for the FY 2018 – FY2038 period, relative to the FY2000 'frozen efficiency' baseline. We do not here attempt to estimate the extent of 'business as usual' or autonomous energy efficiency improvement that may have occurred over the period since 2000 in the absence of these policy measures. Similarly, we do not here account for changes in the apparent demand for electricity attributable to behind-the-meter solar PV, or to price changes, or to technology changes unrelated to specific energy efficiency policy measures. AEMO has other work in train to examine these factors, and SPR personnel have previously examined these questions in other studies.[5]

The savings estimates can best be interpreted as indicating the extent to which energy demand (and consumption) would have been higher, in each of the historical and projection years, if not for the presence of the policy measures analysed.

Three scenarios are examined, aligned to the 'strong', 'central' and 'weak' scenario assumptions employed by AEMO. In this study, the weak scenario is based on an assumption of no new (unannounced) policy measures – although we include NCC2019 in this scenario as the regulatory proposal is at an advanced stage, including with industry consultation largely completed, and we consider the measure is likely to proceed. The central scenario assumes that the NEPP measures not separately modelled contribute the equivalent of a further 10% in energy savings over the projection period, while the strong scenario lifts that to 20%. In effect, the scenarios align to differing degrees of policy ambition and implementation by current and future governments. They should not be interpreted as representing lower or feasible upper bound outcomes: even the weak scenarios assume that current (major) policy measures remain in place until their currently scheduled end dates, while the even the strong scenario is not modelled to represent the maximum cost-effective potential for energy efficiency improvement in Australia.

The analysis accounts for at least major risks of double counting of energy savings. Key examples include:

- National Construction Code provisions relating to hot water and lighting, where MEPS and labelling programs also exist
- Different increments to energy efficiency performance standards (appliances, equipment, buildings) over time

[5] See, for example, pitt&sherry, *Quantitative Assessment of Energy Savings from Building Energy Efficiency Measures*, March 2013.

- Specific areas of duplication, such as between NABERS, CBD (which uses NABERS ratings), the NSW Energy Savings Scheme (ESS) (which allows savings to be counted for NABERS upgrades) and the Emissions Reduction Fund (ERF) (which similarly credits (at least 1 star) NABERS upgrades), subject to also meeting other requirements.

To estimate savings we employ bottom-up, evidence-based modelling techniques that resolve key features of energy-using sectors such as the extent and composition of the physical stock of energy use equipment (including buildings); the turnover of that stock (new sales or construction, less stock retirements at end-of-economic-life); and changes in the specific energy intensity of cohorts of equipment and buildings, as influenced by efficiency measures. This approach is based on the EASI ('easy') identity pioneered by the International Energy Agency:[6]

$$\triangle E \sim \triangle A * \triangle S * \triangle I$$

where $\triangle$E is change in *energy* consumption; $\triangle$A is change in *activity* levels (eg, the number of appliances or houses); $\triangle$S is change in the *structure* of end-use (eg, change in types of appliances or houses); and $\triangle$I is change in the energy *intensity* of each unit of activity and structure.

Fuel mix considerations can be added to this identity (known as EASIF, or 'easy if') or, alternatively, fuel mix can be considered as an element of the structure of energy consumption.

Further details of the methodology are provided below.

2.2 Residential Sector

2.2.1 Stock and Stock Turnover

For this project, we developed a new residential model to align with new data available from the 2016 Census, in addition to the most recent building completions data. The model is based on housing stock by location, separated into the three main stock types – Classes 1a)i) (detached), 1a)ii) (semi-detached) and 2 (apartments) – as reported by the 2016 Census. For each of the five states plus ACT in the NEM, separate data was extracted down to the level of urban centres with populations of 20,000 or more (10,000 in SA), so as to allocate stock to Climate Zones within each state. In NSW, where Greater Sydney is split between two Climate Zones, data was accessed at the geographical level below Greater Sydney, so as to obtain an accurate separation between East and West Sydney. ACT data were added to NSW Climate Zone 7 numbers.

The next step towards constructing a complete dwelling distribution for 2016 was, for each state, to sum the separate Climate Zone numbers extracted in this way. In each case, the sums were, of course, less than the state totals. The final step to construct a complete allocation of dwellings for 2016 was to allocate the differences in each state to each of the relevant Climate Zones and each of

[6] See, for example, IEA, *Energy Efficiency Indicators: essentials for policy making*, 2014, pp. 129 – 133.

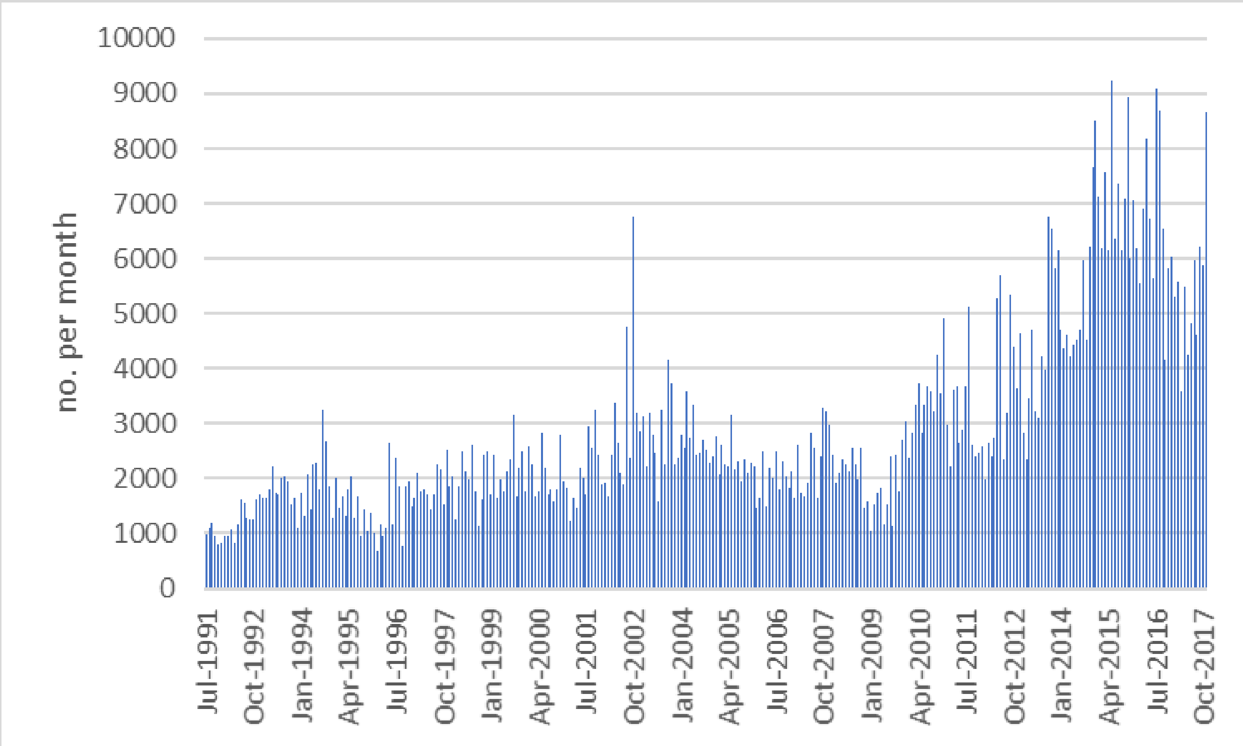
the dwelling types, using expert judgment. Note that a complete allocation of the Census data, without the need for these judgments, would in principle be completely feasible, but would be time consuming, because of the large number of small population geographical areas for which data would have to be extracted.

In order to understand trends in both total numbers within each climate zone and the changing mix of dwelling types, more limited data sets (omitting some of the smaller geographical areas) were extracted from the results of the 2011, 2006, and 2001 Census. The result was a set of "snapshots", at five-year intervals, of housing stock within each of the five NEM regions, allocated by Climate Zone and by dwelling type. These "snapshots" were then linked by linear interpolation for the years between each Census.

To convert this year-by-year picture of the dwelling stock to a dynamic stock model, it was next necessary to add estimates of stock turnover. For this purpose, quarterly ABS dwelling completion data (Cat. No. 8752.0) was extracted and summed for financial years. When annual completion numbers were placed alongside year on year stock changes (mostly increases), it was found that for Class 1A1 dwellings the number of completions was consistently much higher than the net stock increase in almost every year in every Climate Zone region in every state. The difference was assumed to be stock removals (ie, demolitions), thus making it possible to construct a complete dynamic stock model, including stock turnover, over the past fifteen years. For Class 1A2 and Class 2 dwellings, which are reported as combined totals in the dwelling completion statistics, it was found that completions were seldom much more numerous than the net stock increase in each year. For simplicity, therefore, stock removals were assumed to be zero throughout.

The next task was to project stock numbers forward from 2016 to 2038. The driver of stock numbers was assumed to be residential connection numbers by state, as provided for this study by AEMO. The year on year rate of growth of housing stock in each state was assumed to equal the corresponding rate of growth in residential connection numbers. The total state stock of each of the three dwelling categories was projected year by year by first assuming that additions and removals were the same in 2017 as in 2016. Each of the four figures (Class 1A1 additions and removals, Class 1A2 additions, Class 2 additions) was then slightly adjusted up or down to give a total stock figure which reconciled with the projected total stock for the year. This process was repeated for each subsequent year to 2038. The overall outcome of this process is that numbers of Class 1A2 and Class 2 dwellings grow significantly faster that numbers of Class 1A1 dwellings, so that shares of each in the total stock change gradually and steadily over the projection period, although detached houses (Class 1A1) still account for the majority of dwellings in each state by 2038. This trend is already well-established in the historical data, for Class 2 dwelling in particular, as shown in Figure 5 below. Most analysts expect the trend towards apartment style living to continue, at least in major urban centres in Australia.

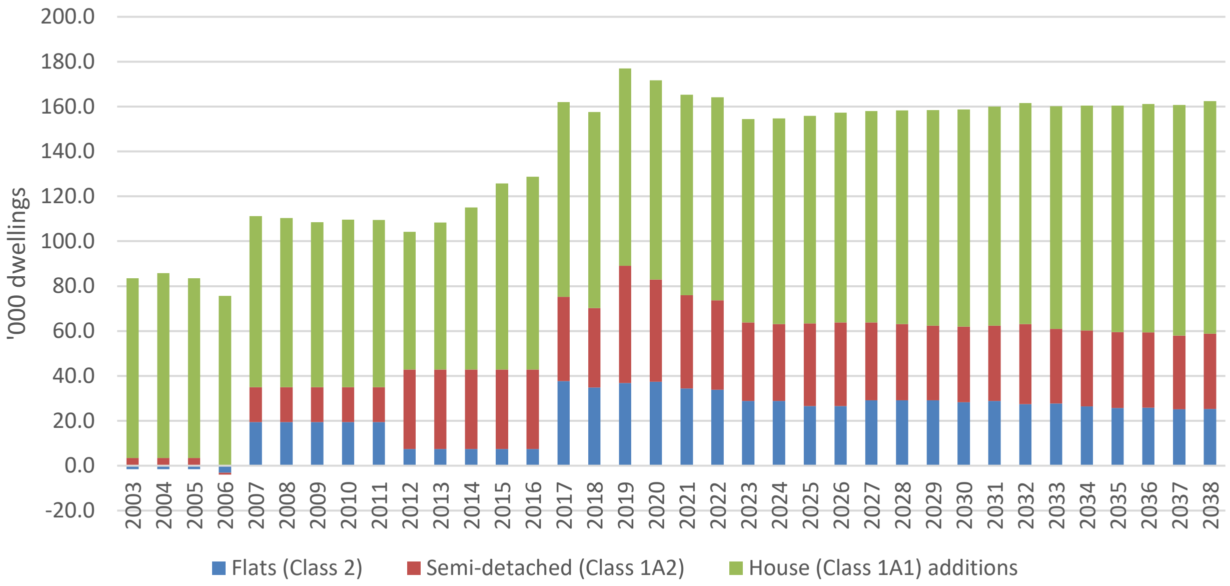
Figure 5: New Apartment Dwelling Units Approvals by Month, 1991 – 2017, Australia



Source: Australian Bureau of Statistics, *8731.0 Building Approvals Australia, Table 20. Number of Dwelling Units Approved in New Residential Buildings, Original – Australia*, Commonwealth of Australia, 2017

Finally, it was assumed that numbers of each dwelling type grow at the same rate, year by year, in each Climate Zone as they do in the state as a whole. Shares do, however, vary markedly between Climate Zones, as they do today, with more rural Climate Zones, e.g. Zone 4 in all states, having a significantly higher share of detached houses than, say, Zones 5 or 6. Figure 6 below provides an overview of the modelled stock growth by dwelling type from FY2003 to FY2038.

Figure 6: Residential Stock Growth by Dwelling Type, Australia, FY2003 – FY2038



The results of this model provide key inputs to the estimation of energy efficiency savings, in the form of, firstly, total numbers of dwellings in each state in each year and, secondly, numbers of new dwellings in each dwelling class in each Climate Zone in each state, and the total number of dwellings in each year in each state. These are discussed in turn.

Total numbers of dwellings are used to calculate electricity savings from the various residential appliance and equipment measures. The approach used was identical to that used in the 2016 Report referenced above, except that dwelling numbers, rather than population, are used to allocate savings to states. It could be argued that dwelling numbers are in fact preferable to population for this purpose, but in practice the difference is not great because of the similarity in average persons per dwelling mentioned above. The various climate and fuel mix/technology weightings used to allocate national savings from air conditioner and water heating efficiency were reviewed but remain essentially unchanged from 2016.

Numbers of new dwellings by climate zone and state are used to calculate savings from the various National Construction Code measures, including minimum star rating and lighting. It was assumed throughout that, from a 2001 base year, the average business as usual energy efficiency rating is 2-star. Hence, energy efficiency savings are the differences between heating and cooling energy consumption in a 2-star house and the heating and cooling energy use in a house of the minimum star rating in force in the year concerned. It is assumed that the average conditioned floor area of Class 1A1 dwellings is 200 m2 in all Zones in all states and the corresponding conditioned floor are for Class 1A2 and Class 2 dwellings is 130 m2.

Space conditioning energy consumption for each of the selected climate zones is drawn from the National House Energy Rating Scheme (NatHERS) star bands, which show the allowed annual thermal load limits, in MJ/sqm.a, for each climate zone. Note that these limits are assumed to be the same for all dwelling types. To convert these thermal load limits into expected energy consumption, a series of steps is required. First, the nature of space conditioning task – by fuel and technology – has to be established. This has been done with reference to the actual residential fuel mix by state as revealed by Australian Energy Statistics, and expert judgement with respect to the incidence and mix of space heating and cooling by climate zone and state/territory. Co-efficients of performance are projected for heat pumps, assuming a COP of 2 for the (year 2000) base case, improving to 4 for 6 star housing. Gas space conditioning COP is assumed to be fixed at 0.85. Where heat-pump or gas ducted heating systems are assumed, a loss factor of 15% is applied.

A strong shift towards use of reverse cycle air conditioners (RCAC) in new dwellings choosing to use electric heating was assumed over the period from 2001 to 2017, especially in Climate Zones 6 and 7. Note that the modelling of fuel and equipment type mix has been handicapped by the fact that the ABS discontinued its triennial household energy use surveys (Cat. No. 4602.0) after 2014.

It is important to note that use of the new housing stock model has increased the estimate of energy savings from MEPS measures, when compared to 2016 results, and all else being equal, because of its use of gross numbers of new detached dwellings, rather than the net increase in total numbers. In all past years, removals have equalled roughly half of completions, meaning that the gross number of new dwellings is about twice the net increase. This means that the average energy efficiency of the housing stock is improving twice as fast as might be expected from the net increase in new dwellings alone.

We note that we have not modelled fuel switching that may well be occurring in the existing housing stock – due to a lack of evidence in this area. Colloquially, however, we understand that there is a significant shift away of gas-based space heating (in places where there has been prevalent, eg, ACT, NSW, SA and to a lesser extent VIC) due primarily to the significant increase in retail gas prices, but also due to an increase demand for cooling, where highly efficient and relatively low-cost split system RCACs are able to provide space cooling *and* heating services. This means that we may be under-estimating energy savings in the existing housing stock.

On the other hand, we have made no allowance for the fact that many old dwellings being replaced are likely to have had smaller conditioned area, particularly in milder Climate Zones. Hence, use of gross, rather than net, increase in detached dwellings may tend to over-estimate savings per house.

2.2.2 National Construction Code Savings

Heating and cooling savings (by fuel) associated with progressive increases in National Construction Code (NCC) energy performance standards are modelled, as broadly described above. Generally, we assume a base case energy efficiency of 2-star, lifted to 4-star in 2003-04 for Class 1 dwellings only; to 5-star and including for Class 2 dwellings from 2006 (first full year of savings 2006-07); and to 6-star from 2010 (first full year of savings 2011-12). For NSW (and ACT, by implication) we assume energy performance standards lag around 1-star behind the national averages, given evidence that this has occurred to date due to the BASIX Code variation. This is significant nationally, as NSW is the largest residential market in Australia. Similarly, we model the fact that the 6-star standard was only adopted in TAS in 2014, while NT standards are assumed to remain at 5-star, where they are now.

Heating and cooling energy shares are allocated by climate zone, with heating shares for example ranging from 0% in Climate Zone 1 (northern Australia) to 90% in Climate Zone 7 (Tas, ACT, parts of NSW). The separation of heating and cooling load in this way facilitates an examination of the expected impact of these Code changes on peak demand by climate zone/state/territory (see Section 2.2.6 below).

The National Construction Code since 2010 contains energy performance requirements for elements other than space conditioning – such as for hot water, lighting and pool and spa pumps. Lighting savings are estimated by state and territory based on data from CIE, *Final Regulation Impact Statement for residential buildings (Class 1, 2, 4 and 10 buildings): Proposal to revise energy efficiency requirements of the Building Code of Australia for residential buildings*, 2009. Note that Code lighting savings are treated as additional to GEMS, as the Code imposes an 'installed lighting energy density' limit in W/sqm, while GEMS measures are based on minimum lumens/Watt requirements for lamps. The GEMS program in itself provides no discipline on the amount of lighting that can be installed (wired-in) to houses and – at one point, at least – large numbers of halogen lamps were being installed in both new and existing housing: the Code provision at least limits this outcome for new housing.

Hot water savings provisions in BCA2010 were generally not additional to savings measures already in place at state level but, as modelled in George Wilkenfeld and Associates, *Regulation Impact Statement: for Decision Specifying the Performance of Water Heaters for new Class 1 Buildings in the Building Code of Australia,* 2009, additional savings are estimated for Victoria. Pool and spa pumps are considered a minor savings measure.

We model no future residential Code performance standards, as we understand there is no prospect of a national increase in stringency in 2019. It is possible that some states/territories may nevertheless lift standards in their own jurisdictions. Further progress with residential standards nationally will await future reviews, and would not be expected before 2022 at the earliest (as the current practice is for 3-yearly Code energy performance reviews).

A 10% non-compliance factor for Code energy savings is assumed, given qualitative evidence that under-compliance with Code energy performance requirements is widespread.[7] We note, however, that no quantitative analyses have been undertaken to verify this parameter.

2.2.3 State Energy Savings Schemes

We model savings associated with the three larger state-based energy savings targets and schemes, in NSW (Energy Savings Scheme or ESS), VIC (Victorian Energy Efficiency Target or VEET) and SA

[7] pitt&sherry and Swinburne University of Technology, *National Energy Efficient Buildings Project, Stage 1 Report*, December 2014.

(Retailer Energy Efficiency Scheme or REES). Generally, our methodology is to work from published annual reports and other performance reporting for these schemes, but then to make allowances for the fact that reported savings for a given year are generally 'deemed' savings, which anticipate a flow of savings over time. Therefore, we spread these deemed savings out over a period of 7 years, as a typical deeming period (in fact these vary by savings type and may be shorter or longer). The split of savings between electricity and gas, and between the residential and commercial sectors, also reflects program-specific data. For future expected savings, we assume that currently-announced targets and timelines will be met, and programs will cease as currently provided for (where that is clear).

In the case of ESS, a nominal target of 8.5% of electricity sales has been announced for 2019, equivalent to 7.5% after deductions for the energy-intensive, trade-exposed sector. In the absence of additional information, we assume this target level is maintained to 2038. In reality, it is likely that the target could be lifted further in future, but this is not modelled. ESS publishes estimates of GWh savings for the 2009 – 2015 period, on an 'actual' rather than deemed basis, and these are taken at face value. For the future periods, we model savings in GWh by applying the annual deemed savings implied by the announced target (after deductions) assuming an average 7 year deeming life. The current scheme legislation assumes the scheme will cease from 2025. Therefore, only the 'tail' of savings measures already implemented in earlier years is modelled from that point on, which means that savings reduce to zero by 2032. We assume that the historical split of savings by sector over the life of the scheme to date (around 91% commercial, 9% residential) continues, and likewise we assume that 100% of savings are electricity – even though gas savings are (now) eligible, reporting to date shows no gas savings have been claimed. The key data source for our analysis is IPART's *NSW Energy Savings Scheme – Compliance and Operation in 2015 – Annual Report to the Minister*, which appears to be the most recent report published. We estimate that up to 25% of ESS Certificates may be attributable to savings in the industrial/manufacturing, rather than commercial/residential, sectors.

For REES, we assume that (currently unstated) targets for 2019 and 2020 rise in the same proportion to rises in recent years. The scheme is currently scheduled to terminate in 2020. Our savings estimates and projections are based primarily on Essential Services Commission of South Australia, *Retailer Energy Efficiency Scheme Annual Report 2016*, July 2017. Note that in its first phase, this was the 'residential' EES, with eligible savings confined to that sector, but was expanded to cover the commercial sector in Phase 2. We note that, like other similar schemes, commercial savings now dominated at a reported 72% of total savings in 2016 (Table 5.2 in the cited report). The fuel mix of savings is taken from the same table, and is predominantly electricity (71% of residential and 98% of commercial savings).

VEET was not modelled in 2016, we understand due to concerns regarding the extent of additionality. Many energy savings schemes in their early years were primarily characterized by 'give-aways' of compact fluorescent lamps, and then standby power controllers. Particularly following the mandatory phase-out of incandescent general service lamps, there were considerable concerns that genuine and additional savings could be very low. ESS first, but then other schemes, expanded their coverage to the commercial sector, and modified deemed savings calculations, to at least improve additionality. We include VEET here for completeness, noting that this introduces a discontinuity with the 2016 Report. Key information sources include Essential Services Commission, *VEET Performance Report 2016*, August 2017, along with various 'explanatory notes' published by ESC.

VEET is modelled on the basis that it is expected to continue to 2030, but targets are only announced currently to 2020. Therefore, we assume that the 2020 target of 6,500,000 VEECs continues unchanged through to 2030. We then assume the scheme terminates in FY2030 (but we model the tail of deemed savings measures already implemented). As the target is specified in carbon units, it is necessary to project carbon-to-energy conversion factors. We use factors drawn from the *National Greenhouse Accounts Factors Workbook* (2017), with future electricity factors projected to fall at the same rate into the future as in the historical period (from 2009). Annual deemed CO_2-e targets (to 2030) are thus converted into annualised energy savings, again assuming an average 7 year deeming period. Savings are split by sector and fuel using data from Appendix B of the ESC Report above. This data suggests that gas savings to date have been negative (ie, an increase in gas consumption), and this is projected to continue. Savings to date are around 86% residential and 14% commercial, and again these shares are projected into the future (noting that the experience of other schemes is that commercial savings tend to dominate over time). Our savings estimates are not discounted for additionality, although this may be appropriate, particularly for earlier 'give-away' savings. However, this would require a level of information and modelling that is outside the scope and timeline of this project.

2.2.4 Greenhouse and Energy Minimum Standards (GEMS) and Labelling

Energy savings associated with the GEMS program have been updated by George Wilkenfeld and Associates (GW), a specialist with a long association as an independent analyst for the program. GWA prepared the most recent (E3 2014) projection of E3 measure impacts used in the 2016 analysis referred to above. For this study, GWA:

- Updated the E3 energy (GWh) estimates for the historical period, and projections to 2038, for each of the 55 measures (see Table 1 below)
- Reclassifed E3 programs according to the latest E3 work program and priorities, into the following groups:
    - Already implemented
    - On track to implementation
    - Possible implementation in the near future
    - Suspended (i.e. they were in the 2014 calculations but are not supported under current policy settings sufficiently to progress further).

Table 1: GEMS Measures by Stage of Implementation

Sector	Phase	Program #	End-Use	Program Description
R	A	1	Refrigeration	Household Refrigerators & Freezers - Labelling 1986 to MEPS 2005
HW	A	2A	Water heating	Large electric water heaters
HW	A	2B	Water heating	Small electric storage water heaters
R	A	3	Washers/ Dryers	Clothes washers, dishwashers, clothes dryers (Plug loads only)
C	A	4	Heating/ Cooling	Close Control ACs - MEPS 2009
C	A	5	Heating/ Cooling	AC Chillers - MEPS 2009
R	A	6	Lifestyle/ Electronics	Televisions - labelling & MEPS
R	A	7	Lifestyle/ Electronics	Set Top Boxes - MEPS
R	A	8A	Lifestyle/ Electronics	External Power Supplies MEPS (Residential)
C	A	8B	Lifestyle/ Electronics	External Power Supplies MEPS (Non-Res)
C	A	9	Refrigeration	Refrigerated Dispaly Cabinets MEPS
R	A	10A	Lighting	Lamp efficacy, (Res use)
C	A	10B	Lighting	Lamp efficacy, (Comm use)
R	A	11A	Lighting	Ballast MEPS (Res use)
C	A	11B	Lighting	Ballast MEPS (Comm use)
C	A	12	Lighting	Tri-Phosphor Lamps (Comm use)
I	A	13	Motors/ Pumps	Motors - MEPS 2001, 2006
T	A	14	Transformers	Distribution Transformers (2004 MEPS)
HW	HW	15	Water heating	WELS Impacts
C	A	15	Water heating	WELS Impacts
I	A	15	Water heating	WELS Impacts
HW	D	22	Water heating	Heat Pump Water Heaters
HW	D	22	Water heating	Electric, solar & other electric storage water heaters - heat loss MEPS
HW	D	23	Water heating	Solar-electric water heaters - all measures other than heat loss
R	A	24	Heating/ Cooling	Air conditioners - Res MEPS 2004-2010
R	A	24A	Heating/ Cooling	Air conditioners - Res MEPS 2011
C	A	25	Heating/ Cooling	Air conditioners - Non-Res MEPS 2001-2007
C	A	25A	Heating/ Cooling	Air conditioners - Non-Res MEPS 2011
T	EF	26	Transformers	Distribution Transformers (2017 MEPS)
R	EF	27	Lifestyle/ Electronics	Standby - range of products
R	C	30	Motors/ Pumps	Swimming pool pump-units labelling+MEPS
C	A	33A	Lifestyle/ Electronics	PCs and Monitors (Business Use)
R	A	33B	Lifestyle/ Electronics	PCs and Monitors (Residential Use)
C	C	34	Heating/ Cooling	AC Chillers - MEPS 2017
R	C	35A	Heating/ Cooling	Air conditioners (Residential - fixed) - MEPS 2017
R	EF	35B	Lifestyle/ Electronics	Battery Chargers (Small consumer)
C	A	35C	Heating/ Cooling	Air conditioners (Non-residential) - MEPS 2017
R	C	36	Lighting	LED MEPS - Res
C	C	37	Lighting	LED MEPS - Comm
I	EF	38	Motors	Motors - MEPS 2017
R	C	39	Refrigeration	Household Refrigerators & Freezers - MEPS 2017
R	A	40	Lifestyle/ Electronics	Televisions - labelling upgrade & MEPS - 2013
C	C	42	Refrigeration	Commercial refrigeration - MEPS 2015
R	C	47	Heating/ Cooling	Portable air conditioners (Now included in 35A)
C	EF	42A	Refrigeration	Commercial Refrigeration (Compressor MEPS)
C	EF	42B	Refrigeration	Self-contained food-service
C	EF	47-55	Refrigeration	Commercial Refigeration (Quantified)
C	C	56-59	Other	Process & Industrial Equipment (Quantified) - Fan-units
C	EF	63-65	Refrigeration	Commercial Catering (Quantified) - ELEC
R	D	63-65	Lighting	Halogens phaseout
				Totals (Implemented - Code A)
				Totals (On track - Code C)
				Totals (Possilbe - Code D)
				Totals (Suspended - Code EF)

- Estimated latest national impact estimates to 2038, broken down by:
    - energy end use (water heating, lighting, refrigeration HVAC etc)
    - target sector (residential/commercial).

The impacts of some measures already implemented (before 2014) were modified based on subsequent research. The implementation of some measures has been delayed, and/or the impact projections have been revised as the design and scope of the measures has been refined in Regulation Impact Statements. Some measures included in the 2014 projections have been abandoned, and some new measures have been proposed. The full list of measures is at Table 1.

The above data is reported as national totals only, meaning that procedures have to be developed for allocating shares of each savings measure to individual states, including an allowance for savings occurring in WA and the NT.

For residential appliances and equipment, three separate allocation approaches were used:

- For reverse cycle air conditioners, savings were allocated to both cooling and heating on the basis of a composite index constructed from population, ownership levels (based on data in ABS Cat. No. 4602.0.55.001 and prior issues of this series), heating degree days, cooling degree days, and the relative fuel to thermal energy efficiency of different types of heating (reverse cycle, electric resistance, gas).
- For simple air conditioners the same index, except without heating degree days, was used.
- For water heaters, savings were allocated using an index constructed from population, average ownership levels (from ABS) and pitt&sherry modelling data on average water heating loads by state.
- For all other types of appliances and equipment, savings were allocated on the basis of population. Note that this simple approach implicitly assumes that ownership levels are uniform across states. This is a not unreasonable assumption, given that there are no gas or solar options for these; electricity is the only energy option (with the exception of cooking, which however has no efficiency measures modelled).

For commercial equipment, two allocation approaches were used:

- For air conditioning equipment, savings were allocated between cooling and heating, and between states, using an indicator constructed from population, cooling degree days, heating degree days, and an adjustment for estimated gas share in heating. Compared with residential consumers, heating degree days were considerably smaller and cooling degree days considerably larger, reflecting the greater importance of internal heat sources in commercial buildings.
- For all other equipment, savings were allocated on the basis of population.

The GWA revealed that the additional energy consumption savings for residential MEPS, comparing 'possible' and 'on track' with 'implemented', amounted to 3% for on-track and 16% for possible. These correspond well with our assumptions, for the moderate and strong scenarios relative to the weak, of 10% and 20% additional savings respectively. For commercial, the analysis shows that that potential savings for on-track and possible measures are much higher (a 52% and 108% respectively). However, given the uncertainty associated with these measures at the current time (there have been no COAG decisions or other government commitments), we retain the more conservative assumptions of 10% and 20%. It should be noted, however, that there is some 'upside' risk of additional commercial savings should these GEMS measures come to realisation.

2.2.5 Other National Energy Productivity Plan Measures

In December 2015 all Australian governments, though the COAG Energy Council, adopted the *National Energy Productivity Plan*. The Plan contains a long list of proposed measures to assist in achieving the goal of improving Australia's energy productivity, measured as GDP per PJ of national primary energy consumption, by 40% between 2015 and 2030.

As noted earlier, there is a considerable body of research and analysis in train regarding many if not all of these measures. For those that focus on energy efficiency, the only measure close to realisation is the proposed change to Section J minimum energy performance requirements for non-residential buildings, which is discussed further below. Given the ongoing uncertainties as to the final design of measures, their stringency/additionality, and timing of realisation, we have again followed the 2016 methodology of making a general allowance for additional savings, attributable to as yet unrealised NEPP measures, starting in 2018-19 and increasing linearly each year to reach 10% by 2037-38 for the moderate scenario. In other words, total savings, as modelled, of electricity and gas used for heating, cooling and base load in each state are increased by 0.5% in 2018-19, 1.0% in 2019-20 and so on up to 10% in 2037-38. For the strong scenario the 2037-38 increase is set at 20%, so the annual increment is 1%, rather than 0.5%. For the weak scenario, no additional savings are assumed from NEPP.

2.2.6 Peak Demand Analysis

The energy consumption savings modelled from the above measures are separated into baseload (eg, Code hot water and lighting measures, state-based energy savings schemes[8]); and heating and cooling (from the Code space conditioning analysis in Section 2.2.2 above). The share of new dwellings with RCAC installed is assumed to be high (85% or more) in all climate zones apart from CZ7, even in 2003 (when 4-star was introduced). Even in climate zone 7, we assume that the incidence of RCAC in new dwellings is rising through time, and generally 90% or more across new housing in Australia. Conversely, we assume the share of dwellings using gas heating is a) confined to certain states and climate zones (Vic, SA, parts of NSW) in 2003, and b) falling over time. From

[8] Assigned to baseload due to the high share of lighting in energy savings.

BCA2010 on, we assume 15% of new dwellings in Eastern Sydney and 10% of dwellings in Victoria are installed with gas ducted heating.

The energy savings associated with the GEMS program are separated into those relating to building heating and cooling, on the one hand, and other appliances, equipment and water heating, on the other hand. For residential air conditioners, state-specific shares for use of heating and cooling equipment were taken from the last (unfortunately 2014) edition of ABS, *Environmental Issues: Energy Use and Conservation*, March 2015 (Cat. 4602.0.55.001). This indicates that only some 3.7% of NT households used no air conditioning at that time, rising to 48.4% of TAS households. Cooling and heating use assumptions (by households with air conditioners) are based on heating degree day (HDD) and cooling degree day (CDD) data by state and territory, sourced from AEMO. Energy savings associated with space conditioning equipment are then shared between heating and cooling load using unique factors developed for each state and territory, as noted, taking into account heating and cooling degree days. For other MEPS and labelling (for example covering lighting, refrigeration, electric motors, external power supplies, PCs and monitors, water heating, etc), we assign these to baseload, with shares of national savings assigned to states and territories on the basis of population shares.

In line with AEMO's brief, we then calculate avoided summer peak demand (not winter) associated with the above energy savings. For this analysis we employ the conservation load factor (CLF) methodology, as developed in Australia by the Institute for Sustainable Futures and Energetics, and documented in a report prepared for the Department of Climate Change and Energy Efficiency.[9] Input values including the CLF were informed by two additional references by Oakley Greenwood/Marchment Hill[10] and SKM MMA.[11] The reduction in peak demand that is attributable to avoided electricity consumption is calculated using the following formula:

$$\text{Peak demand reduction}^{i}_{\text{Summer, Winter}} = \frac{\dfrac{\text{Annual energy usage reduction}^{i}_{\text{jurisdiction}}}{8{,}760\text{ h}}}{\text{CLF}^{i}_{\text{Summer, Winter}}}$$

Rearranging the formula, the CLF for a specific energy saving technology is defined as "…its average reduction in load divided by its peak reduction in load (annual energy savings in MWh divided by number of hours per year divided by system co-incident peak reduction (in MW)".[12] The CLF for residential air conditioning used in this study is 0.15, similar that that indicated in Oakley Greenwood et al (pp. 71-72). This enables an estimate at the reduction in peak demand (in MW) associated with the modelled energy savings (in GWh).

[9] Institute for Sustainable Future and Energetics, *Building our savings: Reduced infrastructure costs from improving building energy efficiency*, report prepared for the Department of Climate Change and Energy Efficiency, July 2010.
[10] Oakley Greenwood/Marchment Hill, *Stocktake and Assessment of Energy Efficiency Policies and Programs that Impact or Seek to Integrate with the NEM: Stage 2 Report*, August 2012.
[11] SKM/MMA, *Energy Market Modelling of National Energy Savings Initiative Scheme – Assumptions Report*, December 2011.
[12] Oakley Greenwood/Marchment Hill (2012), p. 41.

In line with the overall weak, moderate and strong scenarios, we also produce three sets of avoided peak summer demand, reflecting:

- No additional energy savings from NEPP (weak)
- 10% additional energy savings from NEPP (moderate)
- 20% additional energy savings from NEPP (strong).

To estimate the avoided summer peak demand associated with appliance and equipment energy efficiency improvements (the GEMS program), specific conservation load factors were developed for each equipment class, drawing on a range of sources, as presented in ISF/Energetics (2010) – see Table 2 below. It may be noticed that most are above 1, indicating that energy savings are either 'flat' (invariant by day) or shifted towards off-peak times (eg, lighting).

Table 2: Residential Appliance Conservation Load Factors (Summer)

Product Class	CLF
Televisions - labelling & MEPS	1.5
Set Top Boxes - MEPS	1
PCs and Monitors (Residential Use)	1.5
Lamp efficacy, (Res use)	3
Ballast MEPS (Res use)	3
External Power Supplies MEPS (Residential)	1
Household Refrigerators & Freezers - Labelling 1986 to MEPS 2005	0.7
Clothes washers, dishwashers, clothes dryers (Plug loads only)	1.5
WELS Impacts	2
All electric water heaters	2

2.3 Commercial Sector

2.3.1 Stock and Stock Turnover

There is very considerable uncertainty about the total size, composition and rate of turnover of the non-residential building stock in Australia. The Australian Bureau of Statistics captures and publishes data on the number of new residential dwellings completed each quarter (and captures but does not publish data on the average size of these new dwellings), while further insights are available from Census data and other collections, for example those covering family and household composition, building tenure and others. However, no similar data is captured or published for non-residential buildings. For these, only the 'value of construction work done' in $million per quarter is published. We have no insight into how this value of work done decomposes into:

- Price and quantity effects – eg, is a change in the value due to an increase in building activity, or an increase in the value of the same volume of building activity, or some combination of the two?

- Demolitions, alterations/refurbishment and new building construction
- Work in different non-residential building sectors (schools, hospitals, offices, etc)
- Square meters of new buildings constructed by type.

The lack of transparency as to the productivity of the construction sector – ie, how much physical building work is done in a period, and at what unit cost – is all the more remarkable given the importance of this sector in the national economy. For example, in the last 12 months, the value of non-residential construction work done was $39.6 billion.[13] Despite this, we have no authoritative and national picture of what physical outcomes resulted from this significant expenditure. Instead, to model the size and turnover of the non-residential building stock, we have to rely on a composite of many partial sources including:

- The 2013 Commercial Building Baseline Study (COAG, *Baseline Energy Consumption and Greenhouse Gas Emissions in Commercial Buildings in Australia,* November 2012) – this study does not cover all non-residential building types and the data is current only to 2011
- NEXIS (Geoscience Australia's *National Exposure Information System* - a database that "…compiles publicly-available information, statistics, spatial and survey data to model exposure information about residential, commercial and industrial buildings, institutions (public), infrastructure assets and agricultural commodities".[14] While NEXIS "…aims to capture all Residential, Commercial or Industrial buildings across Australia",[15] it should be noted that this source excludes all 'institutional' buildings such as hospitals and healthcare; schools, universities and the like; and museums and galleries
- State-based data, such as that available (for a fee) from Valuer-Generals' offices. In some cases, dedicated studies have been undertaken, such as the *Next Wave Refresh* project recently undertaken in Victoria[16]
- Local government level data, such as the City of Sydney's highly detailed Floorspace and Employment Survey
- Commercial/industry sources, including the Property Council of Australia's offices database, and other data providers such as Jones Lang Lasalle and others
- Research sources, including Beyond Zero Emissions' *Buildings Plan* 2014.

Each of these sources has its own strengths and shortcomings, and none offer a high-confidence, national description of the entire non-residential stock or of its annual turnover/net growth over time.

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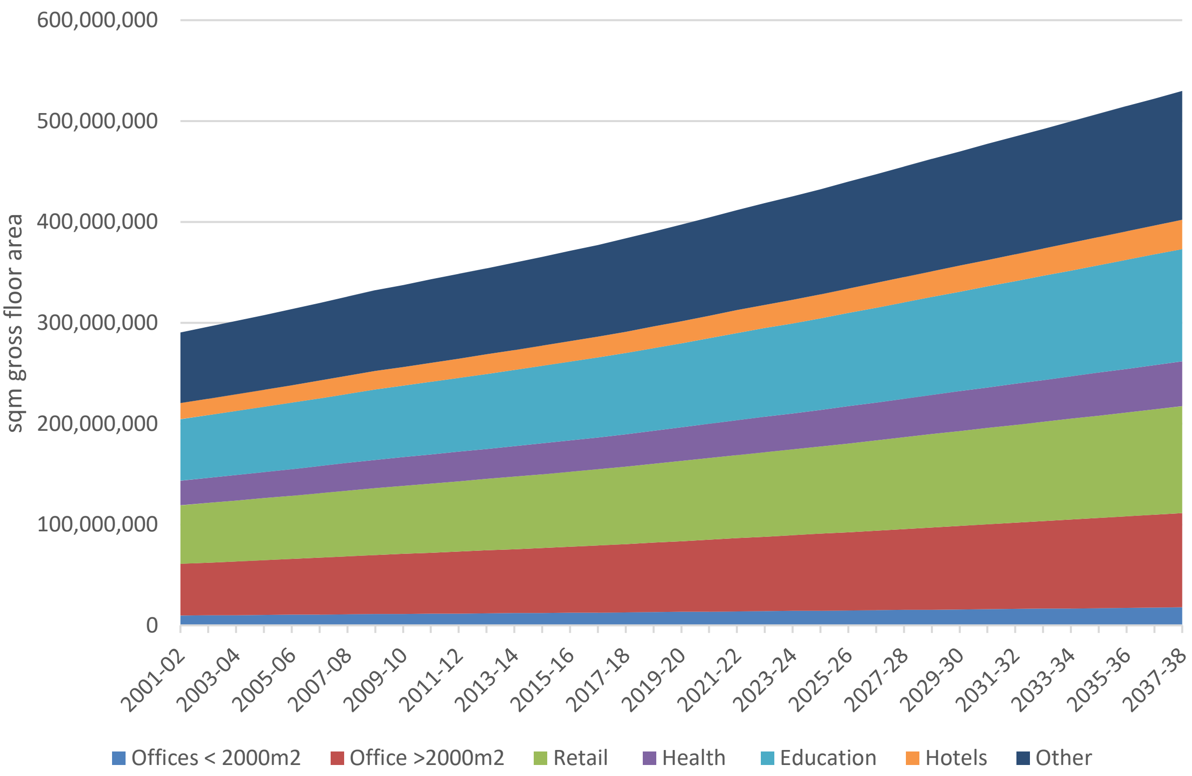
[13] ABS, 8752.0 Building Activity, Australia, Table 01, Value of Building Work Done by Sector, Australia.
[14] http://www.ga.gov.au/scientific-topics/hazards/risk-impact/nexis
[15] Geoscience Australia, *National Exposure Information System (NEXIS) Building Exposure: Local Governments Areas (LGAS) Aggregated Metadata*, Version 7, 2016, second page (pages are not numbered).
[16] AECOM, *The Next Wave Refresh: retrofitting Victoria's commercial buildings*, 2018, published by Sustainability Victoria.

For this project, we employ a non-residential building stock model that identifies the net stock (in sqm) for offices, retail, health, education, hotels and other, by state and territory, from 2000-01 to 2037-38. This model draws most heavily on the Commercial Building Baseline Study, referenced above. In line with that source, historical growth in the net stock is assumed to have been 1.9% annually on average over the 2001-01 to 2008-09 period, and 1.6% annually over the 2009-10 to 2016-17 period. For the projection period, we assume that net stock growth annually is equivalent to around 60% of the projected GSP growth by state, with the latter provided by AEMO, with different assumptions for weak, neutral and strong scenarios. The 60% figure represents an average ratio of stock growth to GDP growth observed during the historical period (FY2000 – FY2017) – recalling that the stock growth number has low confidence. Nevertheless, the stock model may be toggled to indicate the effect of lower or higher economic growth on lower or higher growth in the net stock of non-residential buildings in the projections period. In line with the Commercial Building Baseline Study, we assume that 1% of the stock is demolished each year, which means that the gross floor area built to Code each year is somewhat greater than the net change in stock from year to year. An overview of the historical and projected commercial stock is shown in Figure 7 below.

Figure 7: Commercial Building Stock by Type, FY2001 – FY2038 (Neutral Scenario)



2.3.2 National Construction Code

We model three Code iterations – BCA2006 (the initial energy performance requirements); BCA2010 (which continue to apply today); and NCC2019, whose provisions expected to take effect from May 2019. The primary data sources for each are the relevant RISs, for unit energy savings by fuel, building type and climate zone/state/territory (where resolved), matched to the above-described stock model. Generally, the Consultation RIS documents have become more sophisticated and complete over time.

Energy savings associated with BCA2006, for example, were only resolved by state/territory (and climate zone), but not by fuel or building type.[17] Indeed, the RIS only indicates 'cumulative area 2007 – 2010' (that is expected to be impacted by the measure) and total energy savings (in TJ) over this period. This enables us to calculate a 'specific energy saving' in MJ/m_2.a for each state and territory. We assume that savings are distributed by fuel in line with (the average of the) fuel mix data in the Commercial Buildings Baseline Study; that is, 84% electricity and 16% gas. For the current context, the split of savings by building type is not material. Savings from this first Code iteration were relatively modest, in the order of 30 – 60 MJ/m_2.a, on average, across the states and territories. At the same time, the RIS suggest that savings varied significantly by climate zone (eg, up to 312 MJ/m_2.a in Climate Zone 1, and just 17 MJ/ m_2.a in Climate Zone 3).

For BCA2010, which took effect from mid-2011, the relevant RIS provided savings estimates by fuel and for basic building types, in addition to climate zone/state/territory.[18] While this RIS was prepared externally, by the Centre for International Economics, the building simulation modelling appears to be have been undertaken internally by the ABCB Secretariat. By comparison with BCA2006, specific energy savings are generally much larger, with typical savings for offices over 150 MJ/m_2.a; for retail buildings, hotels and other commercial, at least 300 MJ/m_2.a; and for health buildings, generally more than 400 MJ/m_2.a. This translates into large savings in total for the commercial sector. Note that the above savings estimates are modelled as additional to those associated with BCA2006, which represented the 'BAU' at the time BCA2010 was being contemplated.

Finally, for NCC2019, this is currently a well-advanced, but not yet agreed, regulatory proposal that is expected to take effect in May 2019.[19] The Consultation RIS, which has again been prepared by the Centre for International Economics, is currently out for formal consultation. However, the proposal has effectively been in a consultation phase since the second half of 2017, and it appears to be generally supported by industry. Therefore, it is likely that the proposal as currently framed will be approved by COAG later this year. The RIS contains three main scenarios that essentially

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[17] Australian Building Codes Board, *Regulation Impact Statement: Proposal to Amend the Building Code of Australia to include Energy Efficiency Requirements for Class 5 to 9 Buildings*, March 2006.

[18] Australian Building Codes Board, *Final Regulation Impact Statement for Decision (RIS 2009-07): Proposal to revise the energy efficiency requirements in the building code of australia for commercial buildings – classes 3 and 5 to 9*, December 2009.

[19] Australian Building Codes Board, *NCC2019 Consultation Regulation Impact Statement: energy efficiency of commercial buildings*, March 2018.

relate to differing degrees of compliance, or the extent of the ‘performance gap’ between modelled and actual energy consumption. Our estimates are based on the ‘medium realisation scenario’, which assumes that 75% of the modelled energy savings are realised in practice (pp 58 – 60).

When compared with BCA2010 in particular, the proposed NCC2019 savings are modest. Hotels, in this scenario, are assumed to realise savings, on average, of 73 MJ/m_2.a for electricity and 4.6 MJ/m_2.a; while the equivalent numbers for offices are 12.7 and -2.4 MJ/m_2.a. Not surprisingly, this scenario is modelled to deliver a national benefit cost ratio of 9.3, indicative of low stringency (but high cost effectiveness) (p. 69). Again, the above figures are modelled as additional to BCA2010.

2.3.3 NABERS and Commercial Building Disclosure (CBD)

These measures are initially modelled jointly, as the reported savings for NABERS include those attributable to CBD. CBD uses Building Energy Efficiency Certificates (BEECs) for disclosure of energy performance, and BEECs are based on whole building or base building ratings. Indeed, modelling the savings impact of NABERS (and CBD) is complicated by the fact that, as an outcomes-based rating, reflecting actual in-service energy consumption, ratings trends over time include all efficiency gains, regardless of their cause. Second, NABERS ratings upgrades (of at least 1 star) are eligible for support under the NSW Energy Savings Scheme (ESS) and also the Australian Government’s Emissions Reduction Fund (ERF), creating a further double-counting risk. For this reason, the ‘headline’ results published by the NSW Office of Environment & Heritage cannot be relied upon to indicate the unique savings attributable to the scheme only, and the separate contributions of other measures must be disaggregated from the NABERS results.

In fact, we can find no evidence that any support has been provided for this purpose under ERF, while the (excellent) NABERS online Annual Report indicates that a peak of some 73,000 ESCs (equivalent to deemed MWhs in the ESS) was reached in 2013-14, but that only some 20,000 were issued in 2016-17.[20] The ERF result is consistent with the statutory review of this ERF methodology that was carried out by SPR personnel, which concluded that while the method was valid, it was unlikely to attract commercial interest.

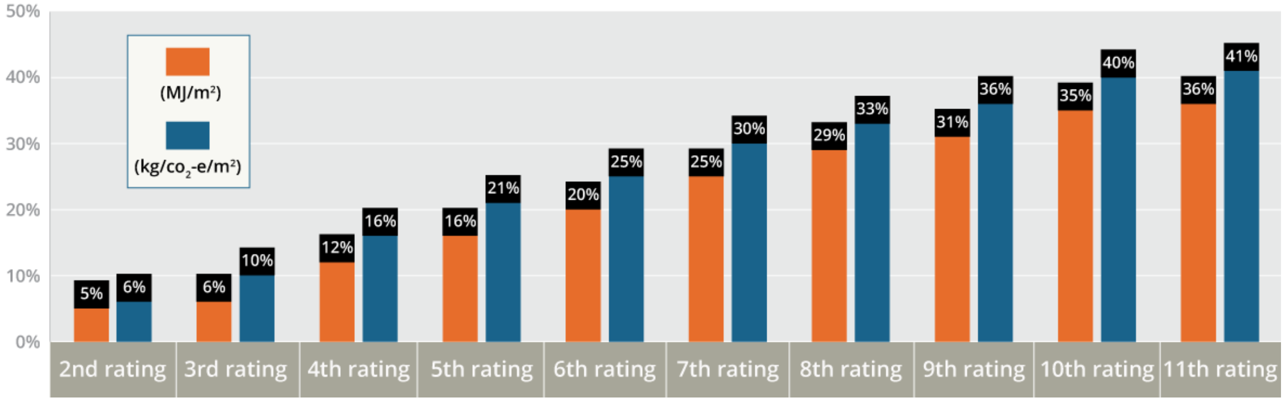
The NABERS Annual Report 2016-17 indicates that the take-up or use of NABERS energy ratings has reached a high share of the national office market – with 81% of the national stock rated at least once by FY2017. We assume that the take-up rate reaches 90% by around 2026 and then plateaus, due to CBD covering only office spaces of 1,000 sqm or more (from 2017-18). Uptake in other sectors (hotels, shopping centres, data centres) is considerably lower. It is important to note that larger property trust and institutions, that own a high share of at least central business district offices in Australia, choose to rate their offices annually – even though this is not required by the CBD scheme. This reflects market demand for ‘continuous disclosure’, not only to attract tenants,

[20] https://nabers.gov.au/AnnualReport/2016-2017/

but also to demonstrate performance credentials that are known to enhance portfolio capital values and yields.[21]

Second, the average reduction in energy use for offices (base and whole buildings) rated multiple times is very significant – on average, a 36% reduction in energy intensity is recorded for offices rated 11 times (most likely, over at least 11 years) – noting again that this includes savings from all sources.

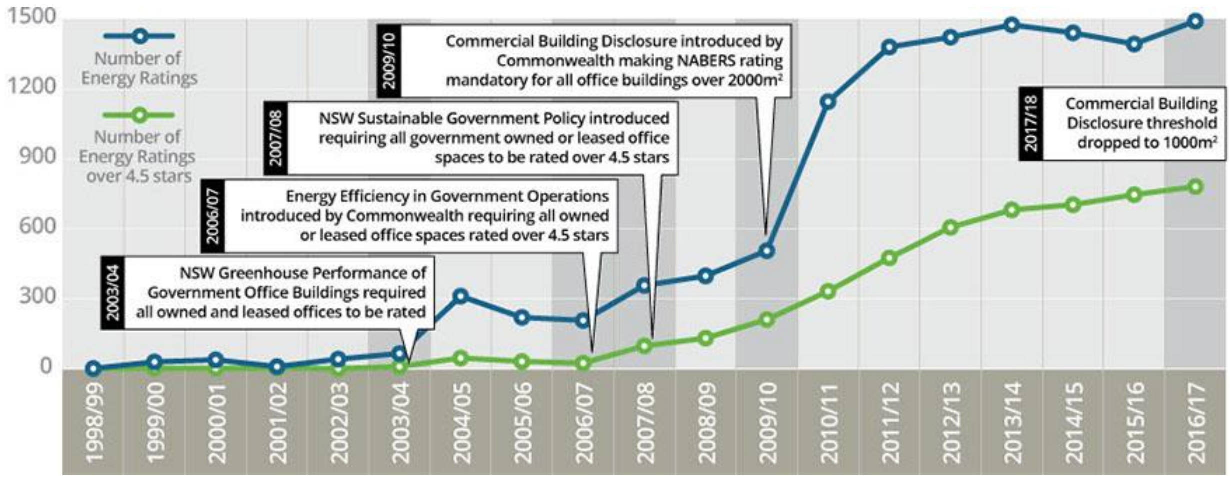
Figure 8: Average Reduction in Energy Use After Multiple NABERS Ratings



Source: https://nabers.gov.au/AnnualReport/2016-2017/life-of-program-statistics.html

A third important note is that the take-up of NABERS office energy ratings at least doubled following the introduction of CBD – clear evidence of the impact of that scheme.

Figure 9: NABERS Office Energy Ratings and Government Policy



Source: https://nabers.gov.au/AnnualReport/2016-2017/life-of-program-statistics.html

[21] Australian Property Institute and Property Funds Association, *Building Better Returns: a study of the financial performance of green office buildings in Australia*, 2011.

To estimate the separate impacts of NABERS and CBD requires several steps. First, we capture the national office market penetration data, and also the average energy savings realised by offices rated multiple times. Data is not published on the share of offices rated in a given year by the number of times rated – however, only a share of all offices rated will have been rated up to the maximum 11 times shown in the above figure. Therefore, we estimate the share of offices rated each year that achieve the average energy savings noted – with the share increasing from very little in 2001 to 70% in 2011, then falling to 30% in 2012, due to the significant increase in offices required to be rated for the first time due to CBD, before increasing steadily again over the balance of the projection period (again reflecting both CBD and market preferences for continuous disclosure).

We then model a (modest) saturation effect. There is already some evidence in Figure 8 above that the rate of increase in savings may be beginning to diminish in recent years, even if total savings are still rising. This is consistent with a saturation effect attributable to owners implementing the largest and most cost-effective savings measures first, and then finding steadily fewer cost-effective efficiency opportunities to implement over time – even if this effect will be offset by new opportunities arising, for example, by technology change (eg, LED lighting) or by rising energy costs (or declining technology costs) that improve investment returns.[22] We assume a progressive reduction of savings of 2% per year from 2012 – 2038. The combination of the above factors generates an overall annual savings value for each year (still for the combined effect of all measures captured in NABERS ratings) that is considerably lower than the headline rates, but still significant peaking at about 26% in 2030.

The next step is to isolate the savings attributable to CBD. As CBD is a mandatory scheme, while NABERS is voluntary, we assume that the area rated annually for CBD is attributable to CBD only. In the absence of CBD, of course, some of this floor area may have been rated voluntarily. The floor area rated annually for CBD is detailed in CBD Annual Reports and reached 13.5 million sqm in 2015-16. We assume that this will increase by some 30% from 2017-18, due to expansion of the scheme to include spaces above 1,000 sqm (in buildings for which the primary purpose is 'office'), and then grow at 2% annually thereafter. The share of CBD floor area relative to NABERS floor area defines the share of savings that we attribute to each – which implicitly assumes that energy savings per sqm under both schemes are comparable, which we believe is a reasonable assumption, as their 'mechanics' are the same (information disclosure).

However, we first adjust the joint savings by deducting those that are attributable to the National Construction Code, as described above. The savings net of NCC are then distributed between CBD and NABERS according to their respective floor area coverage. For both schemes, the fuel mix of savings is taken from the 'large office' data in the Commercial Building Baseline Study; that is, 89% electricity and 11% gas.

[22] It should be noted that the period covered by the NABERS data and figures was a period of very rapid energy price rises, and price effects will also be captured in this data.

2.3.4 Energy Efficiency in Government Operations (EEGO)

This Australian Government scheme commenced in 2001. Key elements were a tenant light and power target of 7500 MJ/person.a by 2011 and a base building target of 400 MJ/m2.a by 2011. We can find no evidence that these targets have ever been lifted. The Australian Government also has a target for (newly) tenanted buildings that they will achieve a 4.5 NABERS rating. The NABERS Annual Report cited above indicates that the average of all office energy ratings in 2016-17 was 4.4. Therefore, the additionality of this measure (and similar measures at state level) is now limited. A further new element was in the introduction of a requirement to insert Green Lease clauses in (new) Australian Government tenancies. However, a recent report noted that the purpose of these clauses is "…to ensure a commercial building meets and maintains a 4.5 NABERS Energy rating".[23] Therefore there would be no additional energy savings to those already modelled for this measure attributable to the Green Lease clauses – assuming the EEGO policy is enforced. Overall, savings attributable to this scheme are small.

2.3.5 State Energy Savings Schemes

The methodology used to estimate savings from these schemes is described in Section 2.2.3 above. As noted there, commercial sector savings are estimated to be 91% of all savings under NSW ESS, 72% of savings under SA REES, and 14% of VIC VEET.

2.3.6 Greenhouse and Energy Minimum Standards (GEMS)

The state and territory shares of national MEPS and labelling schemes under GEMS that focus on commercial energy use were estimated as described in Section 2.2.4 above. Commercial/industrial MEPS in temperature-sensitive end-uses include close-control air conditioners, chillers, non-residential air conditioners, while those covering baseload include PCs and monitors, certain lamps, ballasts, refrigerated display cabinets, external power supplied (non-residential) and electric motors.

2.3.7 Peak Load Analysis

In a similar manner to residential energy savings, commercial energy savings attributable to the above energy savings measures are allocated to baseload (temperature insensitive) and heating and cooling categories. The building-related heating and cooling shares are again based on weighting factors that reflect building stock shares by state/territory; heating and cooling degree days by state/territory; and state-specific values for the gas share of space heating, in line with the Commercial Building Baseline Study. The cooling share is assumed to be 100% in NT and QLD, and as low as 27% in TAS. MEPS and labelling for commercial end-uses are again separated into temperature-sensitive and baseload end-uses as noted in Section 2.3.6 above.

[23] Grosvenor Management Consulting, *An Analysis of the Use and Effectiveness of the Australian Government's Green Lease Schedules*, August 2017.

Then, as with residential cooling energy savings, a conservation load factor (0.4 for commercial buildings) is applied to estimate the MW of summer peak demand reduction associated with the avoided (cooling) energy consumption. Winter heating peak savings are not examined in this study, but could be relevant for at least TAS. These savings are again associated with AEMO's weak, moderate/neutral and strong scenarios by assuming that the moderate and strong scenarios are characterised by 10% and 20% additional energy savings from NEPP measures not already characterised in this study.

As with the residential sector, CLFs were also compiled for the specific end-uses covered by the commercial GEMS measures, sourced also from ISF/Energetics (2010) – see Table 3 below.

Table 3: Commercial End-Use Conservation Load Factors (Summer)

Equipment Class	CLF
Close Control ACs - MEPS 2009	1
AC Chillers - MEPS 2009	0.4
Air conditioners - Non-Res MEPS 2001-2007	0.4
Air conditioners - Non-Res MEPS 2011	0.4
PCs and Monitors (Business Use)	0.5
Lamp efficacy, (Comm use)	0.5
Ballast MEPS (Comm use)	0.5
Tri-Phosphor Lamps (Comm use)	0.5
Linear fluorescent lamps - MEPS 2013 (BUS)	0.5
Refrigerated Display Cabinets MEPS	0.5
External Power Supplies MEPS (Non-residential)	1
Motors - MEPS 2001, 2006	0.7

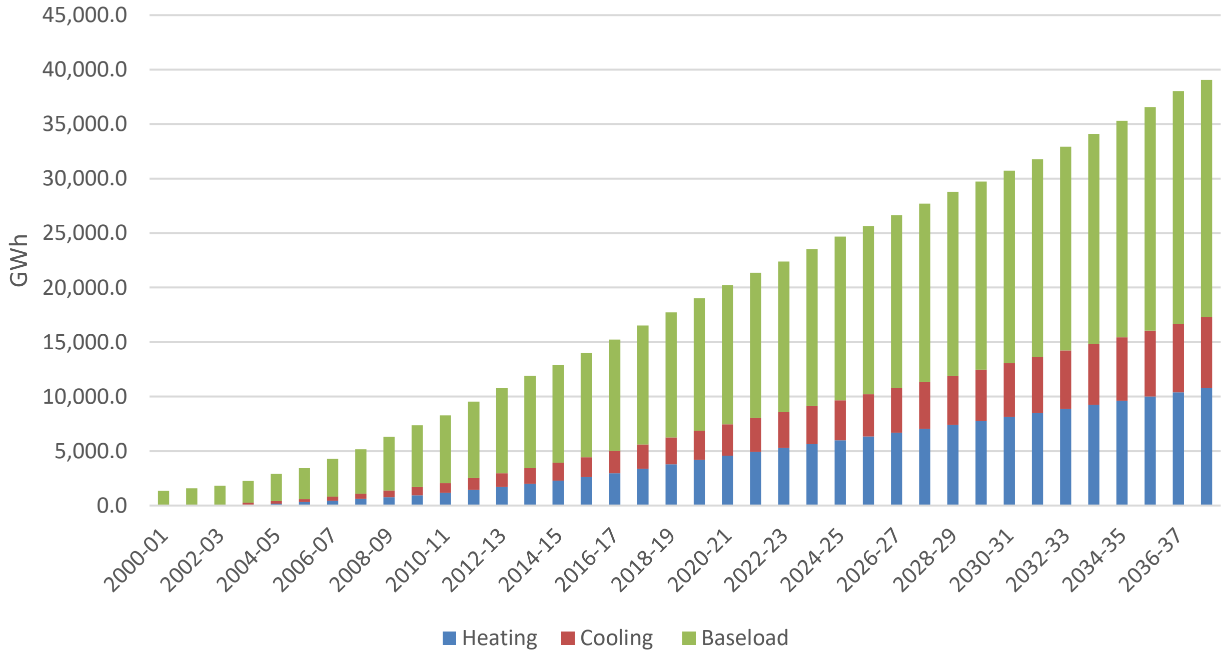
3. Results

3.1 Residential Sector

3.1.1 Overview

Figure 10 summarises the electricity savings associated with the energy efficiency measures noted above, including their distribution by load type. By FY2038, savings are expected to have reached about 39,000 GWh. While this is a large number, it must recalled that this is a counter-factual scenario relative to FY2000 frozen efficiency. In other words, the historical savings shown are already present in actual consumption data. As noted earlier, the values shown below can perhaps best be interpreted as the additional consumption that would have occurred (or would be projected to occur) in the absence of the policy measures modelled.

Figure 10: Residential Energy Efficiency Electricity Savings by Load Type, Australia, FY2001 - FY2038, Moderate Scenario

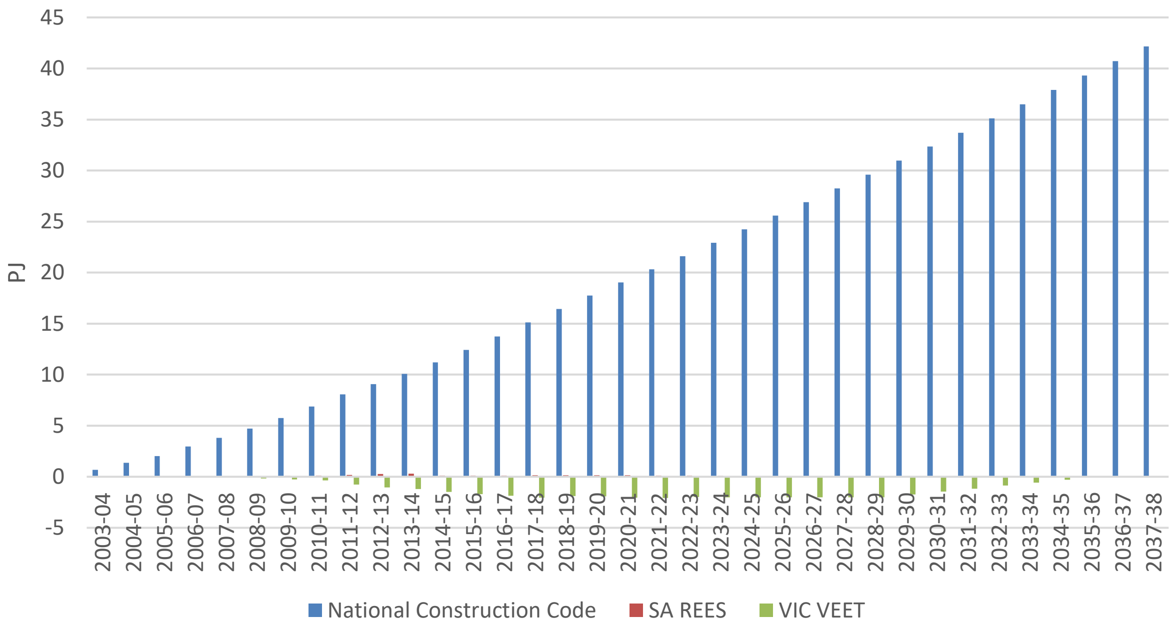


We can compare the above savings with total residential electricity consumption as revealed in Australian Energy Statistics, Table F. This indicates total residential consumption in FY2001 was 110.6 TWh, rising to 126.7 TWh by FY2015 (the last year for which AES data is available). The above savings are equivalent to 10.2% of FY2015 consumption, indicating that consumption would have been about 10% higher without these measures. This represents cumulative annual growth in savings, attributable to these measures, over just over 0.5% per year in the historical period.

It may be noted from Figure 10 that the growth in policy-induced energy efficiency savings is projected to decline slightly after about FY2021, at least on current policy settings. Unless policy stringencies or efficiency standards are lifted over time, market-driven changes tend to reduce the additionality of measures over time. That is, the gap between a (fixed) policy-induced efficiency requirement and the (moving) default market outcome will tend to close over time. This can also be thought of as a saturation effect: once 100% of the stock of a certain appliance class reaches the mandatory minimum level, for example, then all future replacements of that appliance type would achieve no additional energy savings, unless the stringency of the standard were lifted.

By contrast with electricity savings, gas savings attributable to the measures modelled are minor, and very largely attributable to National Construction Code energy performance standards. The savings commence in FY2004 following the introduction of the initial housing efficiency standards in 2003. As is discussed further below, VEET induces additional gas consumption, hence the negative savings shown in Figure 11 below.

Figure 11: Residential Gas Savings, FY2003 – FY2038, Moderate Scenario

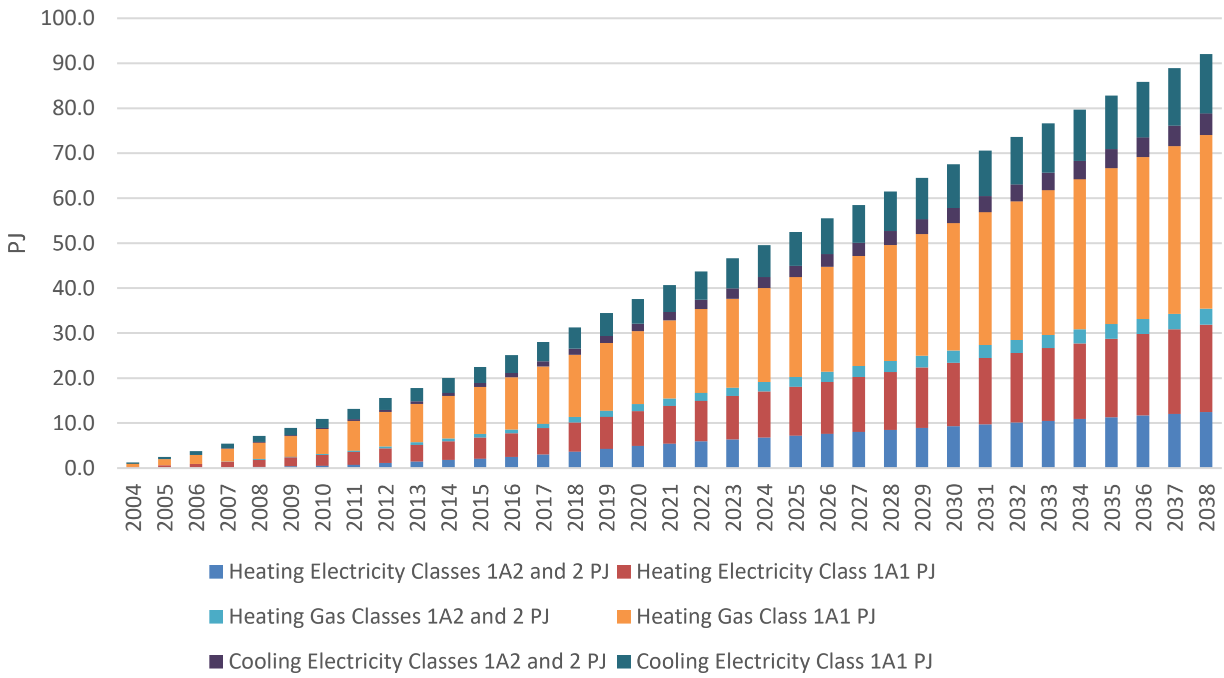


3.1.2 National Construction Code Savings

As noted in Chapter 2, we estimate NCC induced savings separately by dwelling type, fuel, state and territory, and heating and cooling end-uses. Figure 12 below shows the national savings in PJ, to facilitate like-for-like comparison of fuels. It sums the impact of 4-, 5- and 6-star housing requirements that have been introduced in 2003, 2006 and 2010 respectively (with some variation by state/territory and dwelling type).

Total savings are expected to reach 92 PJ by 2038, relative to the FY2000 base year. Savings commence in FY2004, following the introduction of housing standards for Class 1 dwellings in 2003 (Class 2 dwellings were not covered until FY2006). The savings grow by around 3 PJ per year from 2017 onwards.

Figure 12: Residential Heating and Cooling Savings by Dwelling Type and Fuel, FY2004 - FY2038, Moderate Scenario



It is noticeable that the savings are weighted towards heating energy savings, rather than cooling, and also towards gas rather than electricity. This reflects a complex interaction heating and cooling shares by state, the distribution of dwellings by state/territory (and climate zone), the fuel mix by state/territory, and the differential co-efficients of performance for gas and electrical space conditioning equipment. Considering heating load only, more gas than electricity is saved when residential standards are lifted because:

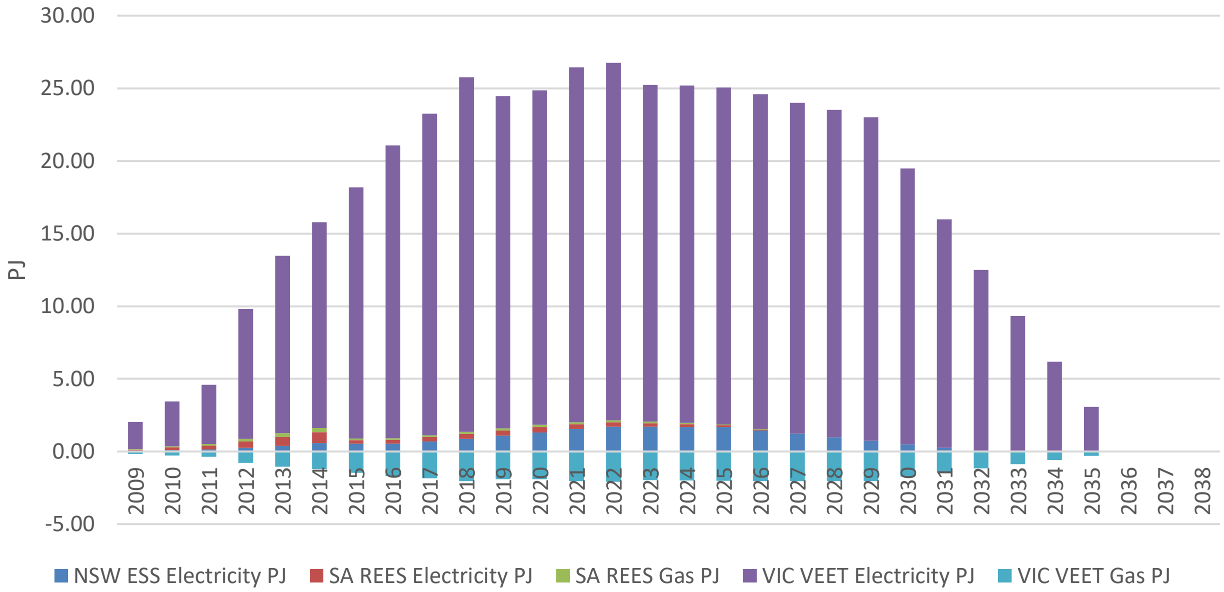
- a significant portion of the stock (and stock growth) is in cooler climate zones, most of which use gas for space heating (only Tas has limited gas availability)
- NatHERS star bands allow more $MJ/m^2.a$ in cooler climate zones, so a given star rating change equates to more MJ of savings in these zones
- space heating by gas is far more energy-intensive than space heating by RCAC (COP ~ .85 for gas compared to COP 4.0 or more for RCAC).

We note that consideration is being given to modifying NatHERS and related Code requirements in future to add separate heating and cooling load caps, in addition to an annual thermal load cap. This would be intended to force more consideration of the summer performance of the housing stock by designers.

3.1.3 State Energy Savings Schemes

Figure 13 shows our estimates of savings attributable to the state-based schemes ESS, REES and VEET. Total savings peak at about 24 PJ (net) through the 2020s, and this appears to be dominated by VEET (electricity). The likely explanation for this is that, unless for the other schemes, VEET targets are denominated in t CO_2-e, which convert into relatively higher targets in energy units. Also, VEET savings to date at least are skewed towards the residential sector, whereas the other schemes favour the commercial sector.

Figure 13: Energy Savings from State-Based Schemes by Fuel, FY2009 – FY2038, Moderate Scenario



3.1.4 GEMS and Labelling

Residential energy consumption savings derived from GWA's updated analysis are set out in Figure 14 group by end-use sector. Appliances and equipment dominate due primarily to the longevity of standards for whitegoods such as refrigerators and clothes washers (the first refrigerator standard was introduced in 1986); the fact that standards for these products have been lifted several times; and also because of their ubiquity in Australian households.

Figure 14: Residential GEMS Savings by End-Use Type, Moderate Scenario

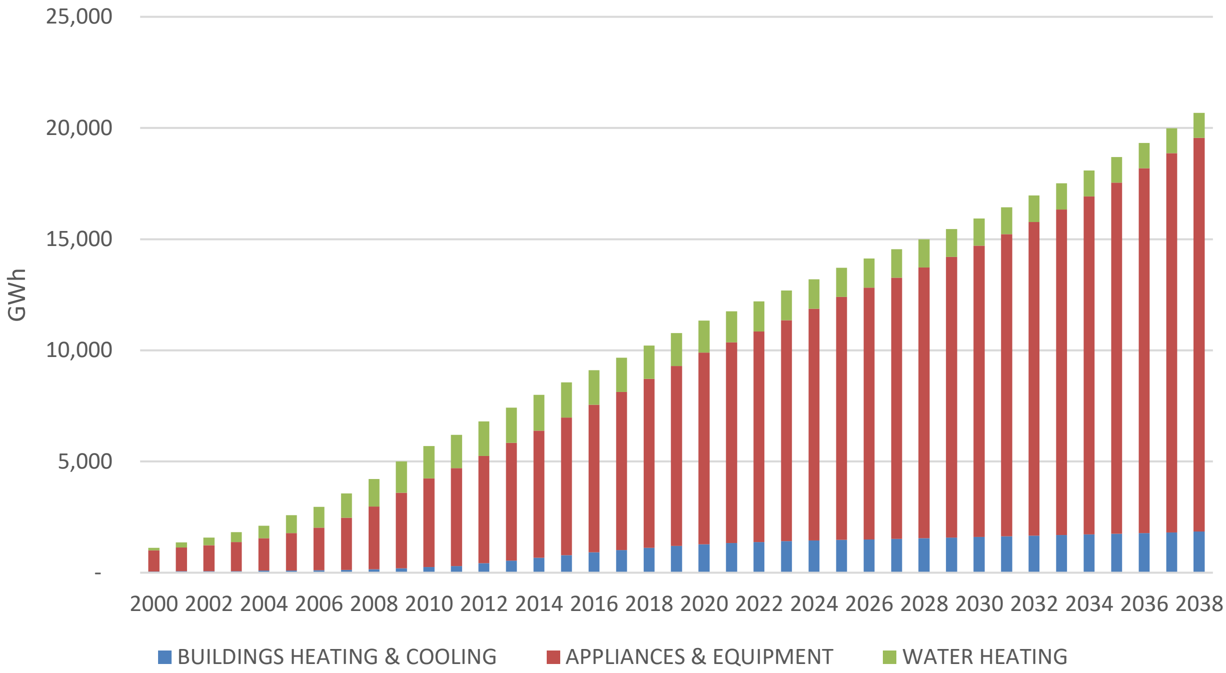
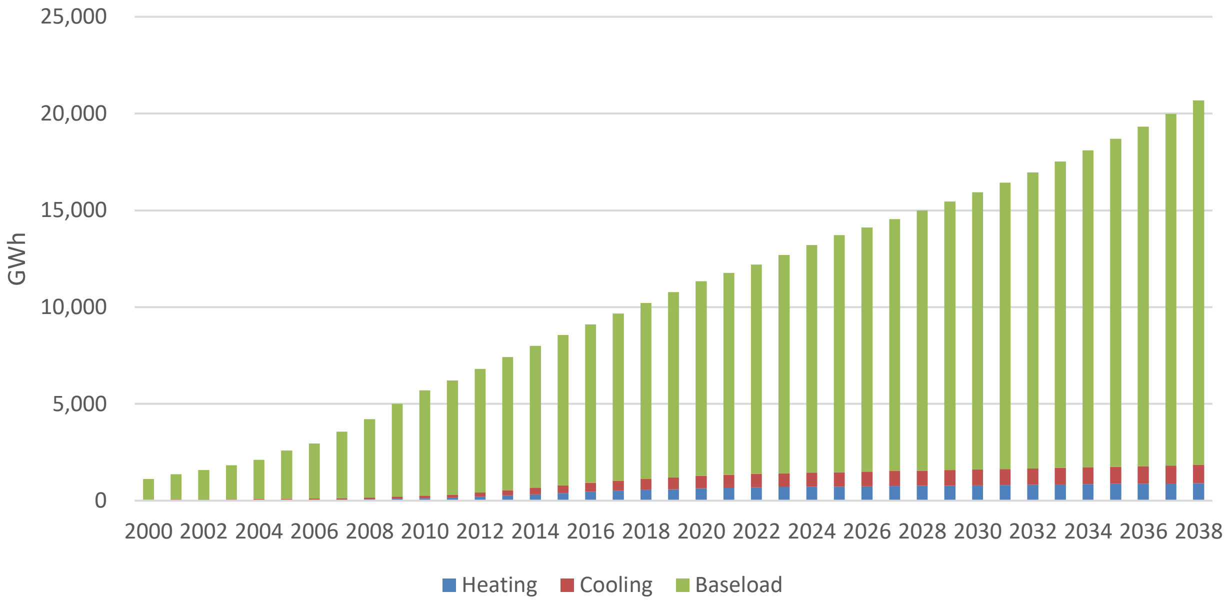


Figure 15 presents the same savings data but split into heating, cooling and baseload consumption savings estimates. Space-conditioning measures, such as reverse cycle air-conditioning (RCAC) MEPS and labelling, are separated into heating and cooling energy savings using the factors noted above, that take into account heating and cooling degree day differences between states and territories, in addition to ABS data on the uptake of RCAC by state and territory. Other measures – including those affecting lighting, hot water, home entertainment, etc – are allocated to baseload.

Figure 15: Residential GEMS Savings by Demand Type, Moderate Scenario



3.1.5 Summer Peak Demand Savings

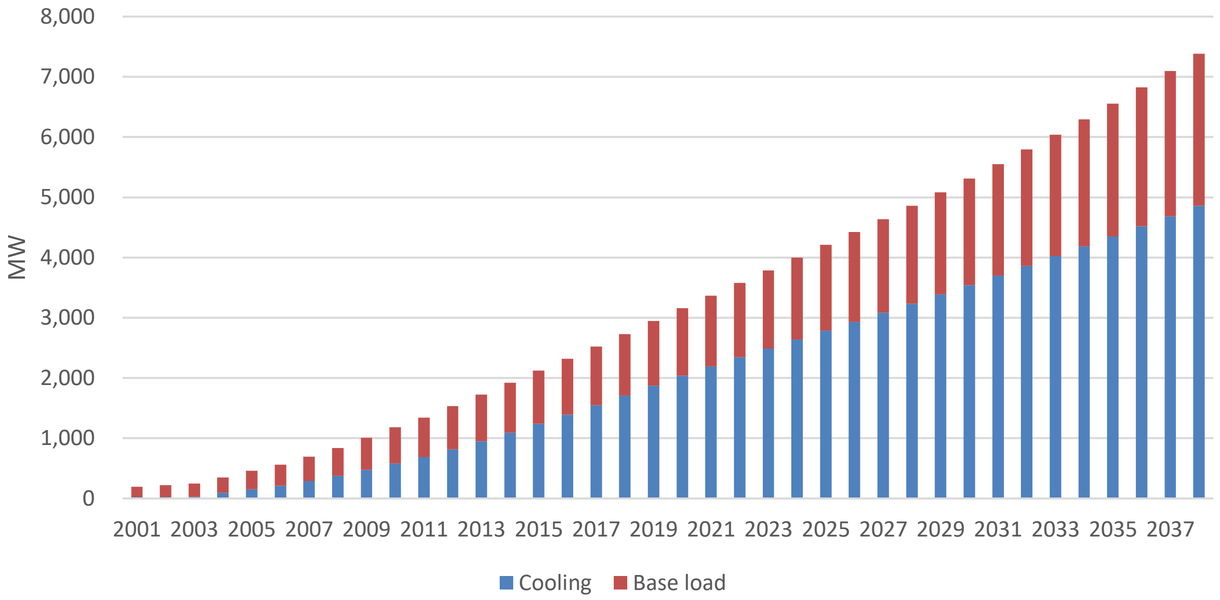
Avoided summer peak loads have been calculated for each of the weak, moderate and strong savings scenarios, using conservation load factors as described in Section 2.2.6 above. It is important to recall that, as with the energy consumption savings, the values noted below cannot simply be deducted from current or future capacity, as the historical impact of measures is already present in and affecting the current demand for network capacity. Thus, the estimates are again best interpreted as the additional capacity requirements that would have been required if it were not for the energy savings measures modelled.

Figure 16 below shows the avoided peak demand associated with the moderate scenario residential energy savings measures, for the whole of Australia (data is also available by state/territory). The savings are separated into cooling and baseload savings, as described in Section 2.2.6, with cooling load savings unsurprisingly dominating the summer peak analysis. These results are primarily driven by savings in the energy consumption of air conditioners, which in residential premises are known to be highly coincident with peak system demands - see ISF/Energetics (2010), for example. In total, the measures are estimated to avoid just under 7,400 MW by 2038, relative to the FY2000 baseline.

If the avoided loads are compared between the residential and commercial sectors, it can be noted that they are each around the 7,000 MW mark by 2030, despite the fact that a) residential energy consumption savings are some 25% higher than those for commercial, and b) summer CLFs are lower (meaning more ‘peaky’) for residential than for commercial. Thus, we might expect to see more avoided peak load in residential than in commercial. The reason that this does not occur is because the residential cooling savings are the smallest share of total residential savings (see Figure

10), while commercial cooling savings dominate total commercial savings (see Figure 17). This effect more than offsets the higher (less peaky) CLFs in the commercial sector.

Figure 16: Avoided Peak Load, Residential Sector, Moderate Scenario



3.2 Commercial Sector

3.2.1 Overview

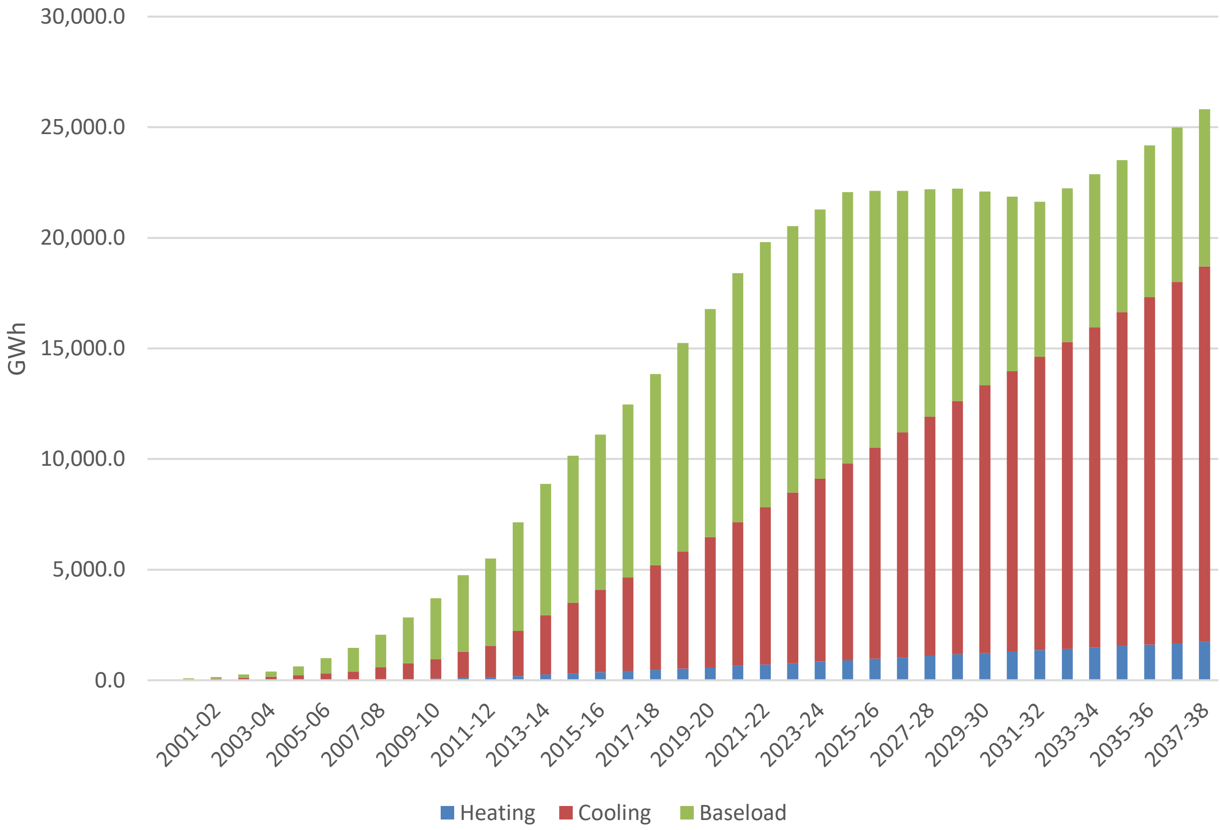
Figure 17 below provides an overview of the electrical energy savings attributed to the policy measures included in this analysis, by load type. Total electricity savings are projected to reach just under 26,000 GWh by 2038, which about 25% less than the residential sector savings.[24] Using the Australian Energy Statistics 'commercial and services' sector (which may not be a perfect fit for AEMO's commercial sector), total electricity use in this sector rose from 41.3 TWh in FY2001 to 64.3 TWh in FY2015. On this basis, the energy efficiency measures avoided a similar proportion to their impact in the residential sector, equivalent to 15.8% of actual electricity consumption in FY2015.

The plateauing of total savings in the period between about 2025 and 2032 represents the impact of the (assumed) phasing out of state-based energy savings schemes. As discussed in Section 2.2.3, this reflects a combination of legislated timelines (but noting that legislation can be amended) and the fact that targets are only set for a limited number of years in advance. It is quite possible that these state-based schemes will continue to exist, and to target higher savings year-on-year, in which case the curve will appear more linear. We note that the return to growing savings after 2032

[24] Note that this is not an accurate reflection of the potential for energy efficiency improvement in the two sectors: rather, it indicates that energy efficiency policy measures are skewed towards the residential sector.

reflects the continuing growth of savings, year-on-year, from the National Construction Code in particular.

Figure 17: Commercial Energy Efficiency Electricity Savings by Load Type, Australia, FY2001 - FY2038

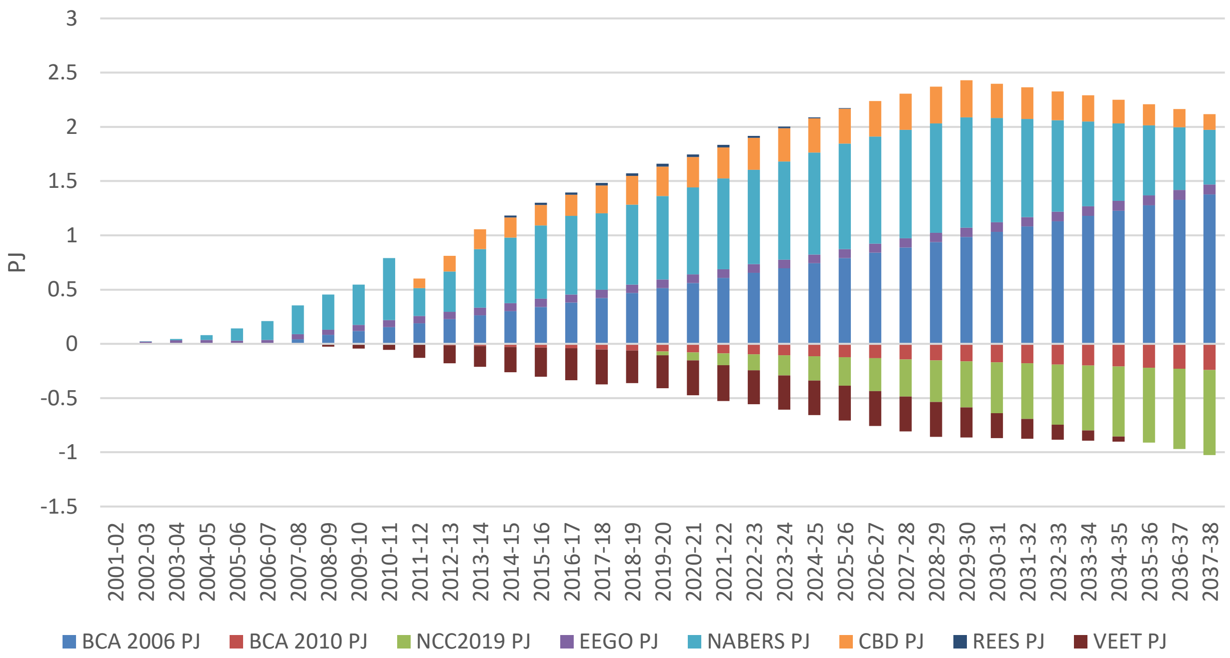


It may be noted that the savings are increasingly skewed towards cooling demand savings, while heating demand savings play a minor role, and baseload savings increase until the mid-2020s before declining. The cooling/heating split reflects the different load mix of commercial, as compared to residential, buildings, where cooling energy use is significant, even in cooler climates, as commercial HVAC systems must extract considerable internal heat loads generated by lighting, equipment and people, in addition to solar gains, and thus are often cooling buildings even in periods of mild temperatures. The reduction in baseload savings in the later years reflects the modelling assumptions noted above for state-based schemes, most of which are assumed to a) generate baseload savings (particularly lighting) and b) cease generating savings before 2038. These schemes may, of course, be extended in time and/or have higher energy savings targets set in future.

We note that our methodology for estimating cooling and heating load savings, as described above, may differ from AEMO's, which examines the change in energy use above and below 18° C. This may be a subject for further research in future.

Gas savings from commercial energy efficiency measures are negligible, peaking at a net 1.6 PJ of savings in FY2030. Some measures – BCA2010, NCC2019 and VEET – are modelled to increase gas consumption (while saving electricity consumption). Figure 18 shows the contribution to overall commercial gas savings of all measures modelled.

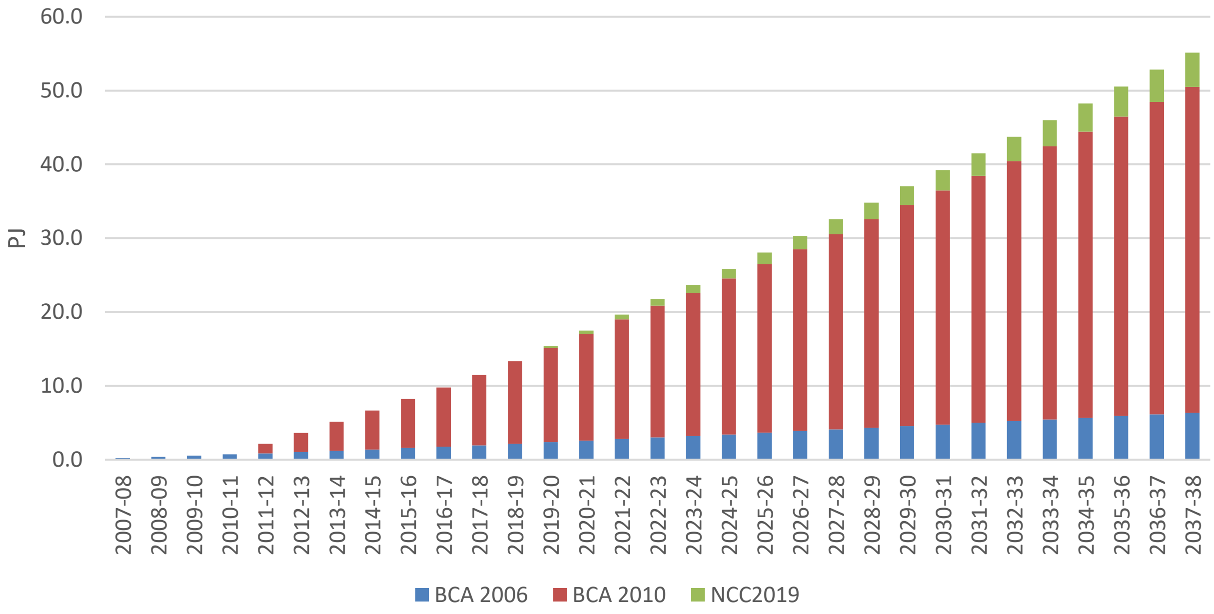
Figure 18: Commercial Gas Savings, FY2001 - FY2038



3.2.2 National Construction Code Savings

Figure 19 below shows the historical and projected future electricity savings for non-residential buildings (strictly, Classes 3, 5 – 9 and Class 2 common areas). It may be noted that BCA2010 dominates the savings, as the stringency of this Code change was higher than either the 2006 or proposed 2019 changes, relative to the previous provisions. We note that there is considerably greater potential for higher commercial building standards to be cost effective, as indicated by the very high benefit cost ratio for NCC2019. The high BCR (12) implies that considerably more cost could be expended in upgrading energy performance before the incremental benefits of doing so fell to a point where it would no longer be cost effective to further increase standards. It may be reasonable, therefore, to factor in to longer term outlooks the opportunity for further lifting of standards in 2022, 2025 and 2028. Indeed, we note that the Australian Government has just released a request for quote to map out a trajectory to zero energy or emissions non-residential buildings, with 2028 the latest date mapped in scenarios.

Figure 19: National Construction Code Commercial Building Electricity Savings, FY2008 - FY2038

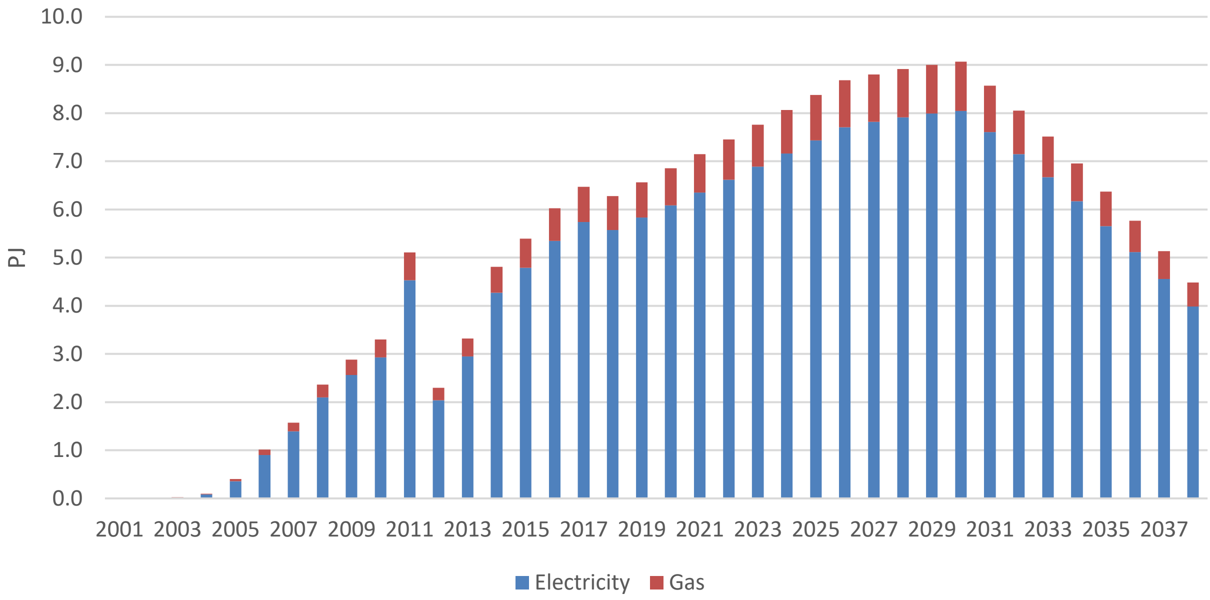


3.2.3 NABERS

As described in Section 2.3.3, estimating the energy savings that are attributable to NABERS only is complicated by many competing policy measures. Elements of the analysis could therefore be contested. In some ways, it is the joint effect or trend that is most important – and it confirms that offices in particular are becoming more energy efficient in Australia. The challenge and potential for controversy is in the allocation of cause and effect, and attributing degrees of additionality to different programs.

That said, using the methodology described, we estimate that there are significant energy savings attributable to NABERS, that are projected to peak at about 9 PJ in FY2030 (assuming the measure is maintained for that long). As may be noted from Figure 20, the savings are heavily weighted towards electricity. The significant dip in savings after 2011 is due to the impact of the Commercial Building Disclosure scheme (see below). The tailing off of savings in later years is attributable to our modelling a saturation effect. The policy rationale of NABERS is that by informing both owners and tenants about the absolute, and perhaps more importantly, relative, efficiency of a given office building or space, a market-driven incentive to upgrade that space is created. However, the more this strategy succeeds, the more the potential for further efficiency upgrades is exhausted. This should be be expected to translate into diminishing returns over time – even if this effect will be offset by the emergence of new savings opportunities over time due to technology change or changes in relative prices.

Figure 20: NABERS Energy Savings by Fuel



We note that we have not quantified the energy savings associated with NABERS hotels, data centres or shopping centre tools, due to their much lower take-up of these, and also because there is less detailed quantitative reporting of program results for non-office buildings. The NABERS online report shows that around 6 million sqm of shopping centres were rated in each of FY2016 and FY2017, or around 130 buildings each year. The average energy intensity of buildings rated in FY2017 was slightly higher than in FY2016, but – given the low number of ratings – this could be due to a changing cohort of rated buildings. Only four hotels were rated in FY2017 and six in FY2016, while the same numbers for data centres were 12 and 11. Little results data is presented, presumably for confidentiality reasons, but the average star rating was a little (4.3%) higher in FY2017. Again, this could be due to a changing reporting cohort.

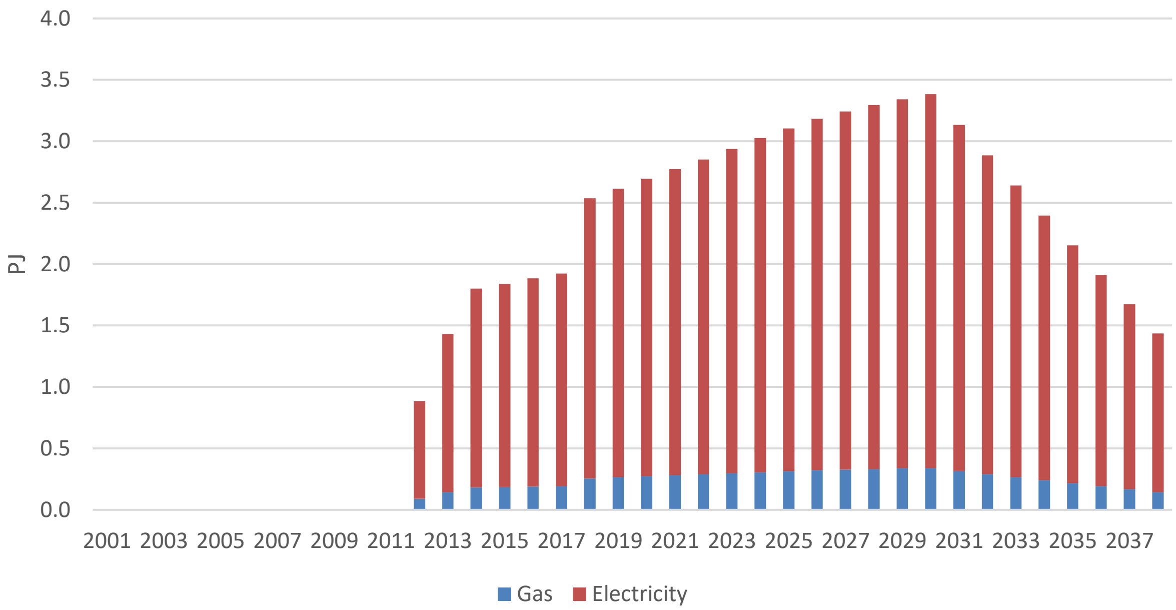
3.2.4 Commercial Building Disclosure

As also described in Section 2.3.3, this measure is in many ways a counterpart to NABERS. Since it is mandatory, however, we assume that savings attributable to it essentially displace those that might otherwise be attributable to NABERS. CBD commenced in late 2011, covering office spaces of 2,000 sqm or above, and this threshold was dropped to 1,000 sqm from FY2018. This latter effect accounts for the expected step-up in savings from FY2018. It should be noted that the scope of the measure is limited not only by the minimum floor area thresholds, but also by the fact that it only applies to offices in buildings for which the primary purpose is 'office' (broadly, at least 50% of the net lettable area is for office use). The Commercial Building Baseline Study indicated that around 36% of office floor area is located in mixed use buildings, and this is likely to be weighted towards smaller office areas.[25] Overall, we expect CBD savings to be less than half of those attributable to

[25] COAG National Strategy on Energy Efficiency, *Baseline Energy Consumption and Greenhouse Gas Emissions in Commercial Buildings in Australia: Part 1 Report*, November 2012, pp 33 - 35.

NABERS, peaking at around 3.6 PJ in FY2030, and heavily weighted towards electricity. We understand there is some investigating underway of the potential to expand the scope of the scheme to other building types. This, and/or further expanding the scope of office spaces covered, would see a higher savings impact for this measure.

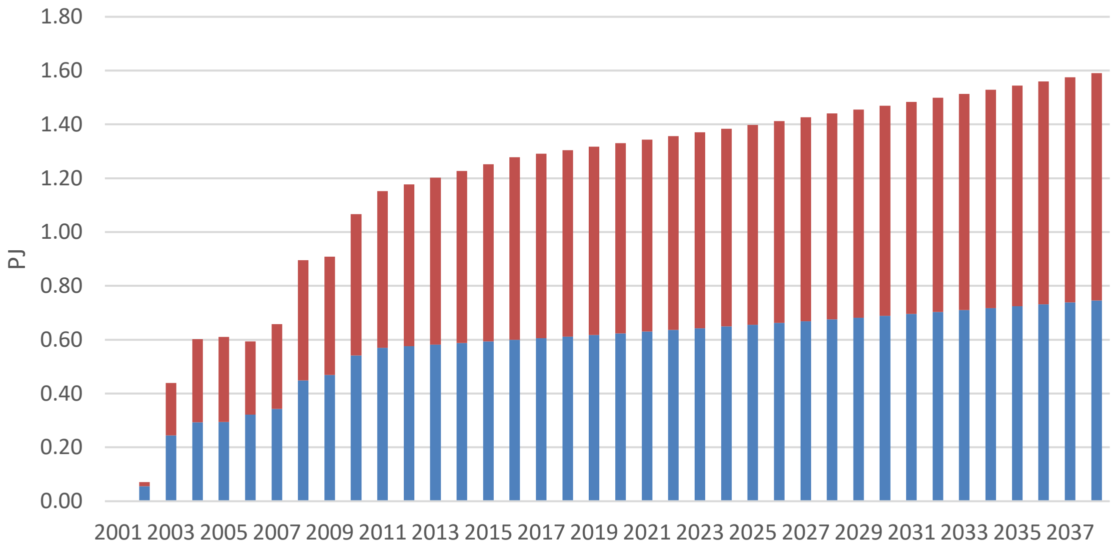
Figure 21: Commercial Building Disclosure Energy Savings by Fuel



3.2.5 Energy Efficiency in Government Operations (EEGO)

As described in Section 2.3.4, there are two main elements to EEGO, a tenant light and power target and a base building target. There has been no change in targets since they were announced in 2006, and not annual reporting since 2011-12, although individual agencies may report to their own Ministers. Savings estimated are small and rapidly diminishing in additionality. Savings are mostly of electricity.

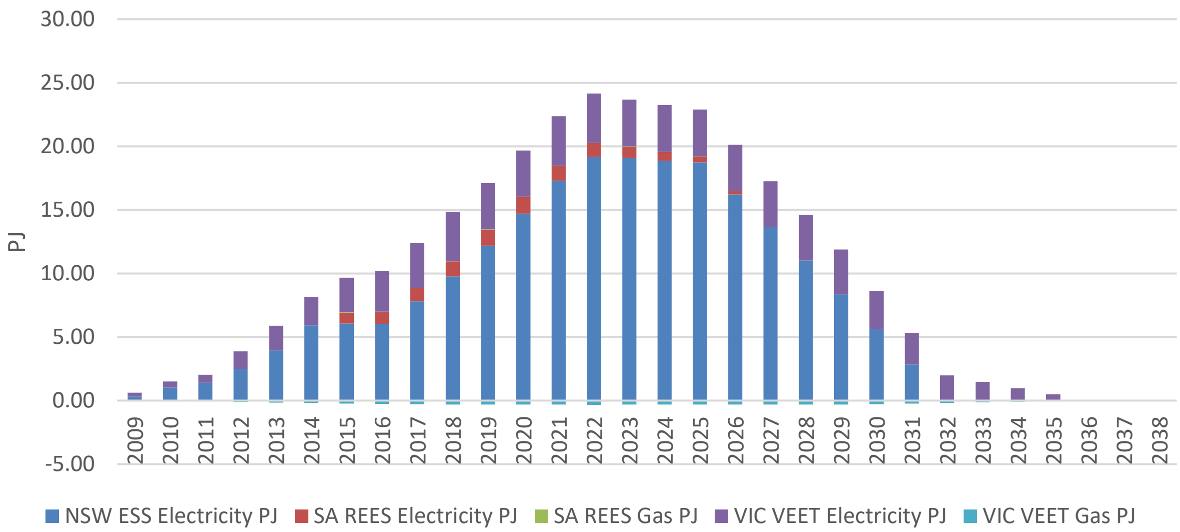
Figure 22: Energy Efficiency in Government Operations Energy Savings



3.2.6 State-Based Energy Savings Schemes

Figure 23 below shows our estimates of the energy savings attributable to NSW ESS, SA REES and VIC VEET by fuel over the FY2009 to FY2038 period. In total, savings are expected to peak in FY2022 at just under 24 PJ, at least on currently-announced targets and settings. The majority of the savings are for electricity, and dominated by those projected for ESS in NSW. As was noted in Chapter 2, 91% of savings (to date) under this scheme are electricity.

Figure 23: Commercial Energy Savings from State-Based Energy Savings Schemes by Fuel

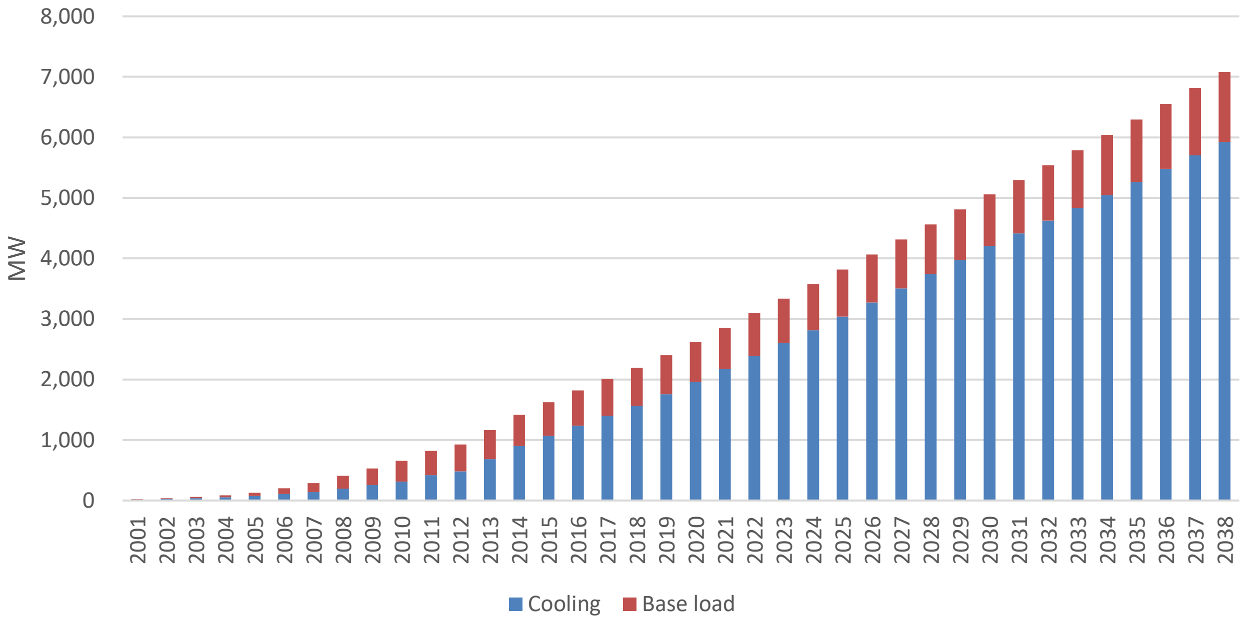


3.2.7 Summer Peak Demand Savings

The methodology for estimating reductions in summer peak load as a consequence of commercial sector energy savings is described in Section 2.3.7 above. Again, we stress that these are a counter-factual observation of the capacity avoided, at least in the historical period, due to the presence of the policy measures analysed.

Figure 24 shows that the avoided peak load in the commercial sector is significant, projected to exceed 7,000 MW by 2038. This represents an incremental avoided demand over the 2018 – 2038 period of around 4,900 MW. As noted in Section 3.1.5, the avoided peak demand in the commercial sector is similar to that in the residential sector, despite lower energy savings and higher CLFs, due to the much higher weighting (and total size) of cooling savings in commercial when compared to residential, as shown below.

Figure 24: Commercial Sector Avoided Peak Load, Moderate Scenario, Australia



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