ENERGY EFFICIENCY EMPLOYMENT IN AUSTRALIA

An analysis of the current and potential jobs created by saving energy in Australia

Report by:
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Commissioned by:
energy efficiency COUNCIL
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1 Summary of results

Energy efficiency has played a key role in improving Australians' wealth, health and wellbeing. More efficient businesses are more productive, and more efficient homes are warmer in winter, cooler in summer and cheaper to run. Improving the energy efficiency of Australian homes and businesses is the largest opportunity we have to reduce households' energy bills. However, to date very little effort has been made to estimate the number of people employed in energy efficiency.

This report attempts to provide an upper and lower bound estimate of the number of people currently working in energy efficiency activities in Australia. The estimates of current employment figures are based on a range of existing sources of information.

This report also seeks to provide an estimate of the additional employment that could be created in coming years by government policies to drive the adoption of a range of what could be considered energy efficiency's 'low-hanging fruit'. The 'low-hanging fruit' is a series of upgrades to homes and businesses that are technologically mature, relatively straight-forward to implement and deliver significant returns on investment.

The report finds that:

- Energy efficiency is already a major employer in Australia. A minimum of around 59,000 people work in roles that affect homes' and businesses' energy efficiency. However, it is likely that a much larger number of people are involved in roles that involve some level of energy management – potentially 236,000 workers. This means that, at a minimum, more people are employed in roles that involve energy efficiency than any other part of the energy sector, including coal mining and electricity networks.
- A program to implement a series of basic energy efficiency improvements to Australian homes and businesses would create an extra 120,411 job years of work. That is 120,411 full-time jobs for one year if all of those upgrades are completed within 12 months. Market-based energy efficiency schemes, like the NSW Energy Savings Scheme, could conservatively generate 43,000 (about one-third) of those job years of employment.

These figures might seem remarkable at first glance, but they make intuitive sense. Australia has tens of millions of buildings and pieces of energy-using equipment, and a large workforce is required to build, use and maintain these assets. It also makes sense that, if Australian governments were to adopt policies aimed as accelerating energy efficiency improvement of this large number of assets, it would generate significant levels of employment.

Australia's energy efficiency workforce has been hiding in plain sight. This report shines a light into a major part of our economy that is worthy of far more attention.

1.1. Current employment

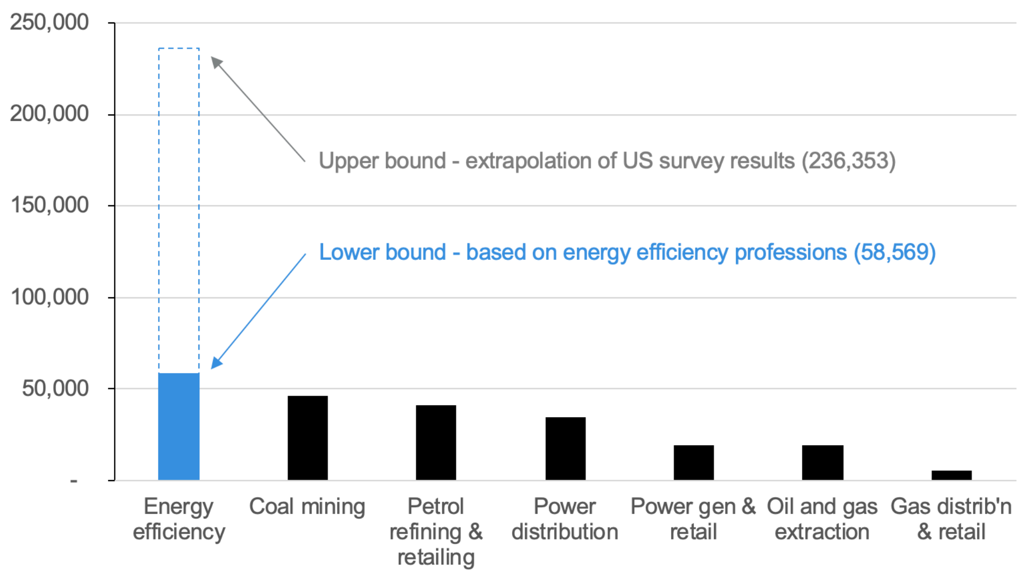
Australian statistical agencies in their various surveys and other data-gathering exercises have not attempted to evaluate the extent to which members of the workforce are engaged in activities that improve the efficiency with which we use energy. In the absence of such direct survey data, this report has employed two techniques that provide guideposts to the potential range of people currently employed in activities that improve energy efficiency:

1. An extrapolation of energy efficiency employment survey results by the United States Department of Energy (DoE) to the Australian context. This takes estimates of the proportion of workers within different industries that are engaged in energy efficiency activities within the United States and applies those to the number of people employed in these same industries in Australia; and

2. An alternative, more finely grained approach that provides a lower bound, conservative estimate of Australian employment in energy efficiency by identifying those working in professions and industry sub-sectors within the 2016 Australia Bureau of Statistics (ABS) Census that are likely to be engaged in designing, specifying, installing, and maintaining equipment that consumes energy.

If we saw similar proportions of people engaged in energy efficiency in Australia as occurs within the US, then the level of employment in energy efficiency in Australia would be close to 236,000. Using the more conservative technique of only considering those people employed in professions that design, specify, install and maintain energy consuming equipment provides a likely lower bound for energy efficiency employment of just under 59,000 people. As illustrated in Figure 1-1, the number of people engaged in activities that improve energy efficiency, irrespective of which estimation technique is employed, is noticeably larger than other energy producing sub-sectors that are currently measured by the ABS.

Figure 1-1 Indicative Australian employment in energy efficiency relative to other Australian energy industry sectors



Sources: Green Energy Markets analysis based on information from the US Department of Energy (2017) US Energy and Employment Report; and Australian Bureau of Statistics Census – 2016. Jobs associated with the construction of new generation (e.g. renewable energy) are captured under the construction industry in the census.

1.2. Future additional employment from upgraded energy efficiency policy

In addition to this current level of employment engaged in improving energy efficiency, further jobs would be created by additional government policies that unlock the cost-effective potential for energy efficiency. Numerous studies have identified the potential for a significant uplift in energy efficiency in Australia, which would create jobs and deliver large economic gains; improvements in health and wellbeing; and carbon emission reductions.

This report provides an approximate estimate of the number of jobs that could be created by an effort to implement a modest selection of these cost-effective upgrades. This report has not attempted to be comprehensive and cover the entire scope of upgrades that have been identified as cost-effective. Instead it has focussed on some of the lowest-hanging fruit, involving upgrades that meet two criteria:

1. The technologies used in the upgrades are mature and proven; and
2. The upgrades deliver financial returns in line with or exceeding households' and businesses' cost of capital or alternative low risk investments.

Table 1-1 lists the range of upgrade opportunities considered in this report and the expected direct employment likely to be created by implementing them to the full scope of the available opportunity. Even though this report has only considered a limited suite of the available cost-effective energy efficiency opportunities, the employment that could be created by these upgrades is considerable: 120,411 job years would be involved in rolling out these upgrades. Further detail surrounding what each of the upgrade opportunities involve, and the employment associated with them, is included in Section 4 of this report.

Table 1-1 Potential employment from energy efficiency upgrades

Efficiency upgrade	Employment (job years)
Replace electric storage water heater with heat pump	8,056
Replace LPG water heater with heat pump	1,291
Install or top up insulation	4,339
Draught sealing	1,388
Install single efficient heat-pump heater/cooler in households dependent on electric resistive and/or gas non-ducted heaters	4,827
Replace ducted gas heating with several efficient heat pump heater/coolers	12,146
Replace LV halogen downlights with LEDs	2,265
Commercial building efficiency upgrades	47,545
Mining sector efficiency upgrades	7,627
Manufacturing efficiency upgrades	29,283
Water & Waste Services efficiency upgrades	621
Transport sector efficiency upgrades	1,023
TOTAL	**120,411**

To tap the full scope of the economic benefits and employment associated with the upgrades detailed in the table above will require a mix of new and existing government policies and programs, including but not limited to:

- Energy efficiency ratings for buildings, appliances and equipment that enable consumers to make informed decisions.
- Building the capacity of businesses to manage their energy use through training, support and other programs.
- Minimum health, safety and performance standards for buildings and equipment, especially in circumstances where product suppliers may not have an incentive to meet reasonable standards (e.g. minimum standards for rental properties).
- Reforming distortions in the energy market.

A critical part of this policy mix is the use of market-based incentive schemes. These programs are ideally designed in such a way that offers financial incentives to products and services that can demonstrate verifiable energy savings over Business As Usual (BAU) activity, while delivering equal or better levels of functionality and quality as the product they replace.

Governments set a legal requirement for power companies to achieve an energy savings target and a framework for measuring the energy savings from energy efficient products, while ensuring only quality products are eligible. Governments then leave it up to businesses to compete and make their own choices about which energy efficient products they wish to promote and roll-out to consumers. Under these market-based schemes the products that deliver energy savings at the lowest cost will ‘win out’ – in other words they will out-compete more expensive approaches to saving energy and be installed in homes and businesses.

Such types of programs are already in place in NSW, Victoria, the ACT and South Australia. However, there is room for them to be expanded and extended as well as implemented across other jurisdictions.

Table 1-2 sets out that these market-based incentive schemes could be expected to assist in capturing on average around 35% of the available scope of cost-effective energy efficiency upgrades considered in this report. This would stimulate 43,077 job years in the installation of these upgrades. Further detail on the employment creation from market-based schemes is detailed in Section 5 of this report.

Table 1-2 Employment expected from upgrades driven by market-based energy efficiency incentives

Efficiency upgrade	Participation rate	Employment (job years)
Replace electric storage water heater with heat pump	25%	2,014
Replace LPG water heater with heat pump	40%	516
Install or top up insulation	40%	1,735
Draught sealing	50%	694
Install single efficient heat-pump heater/cooler in households dependent on electric resistive and/or gas non-ducted heaters	50%	2,414
Replace ducted gas heating with several efficient heat pump heater/coolers	30%	3,644
Replace LV halogen downlights with LEDs	85%	1,926
Commercial building efficiency upgrades	35%	16,641
Mining sector efficiency upgrades	35%	2,669
Manufacturing efficiency upgrades	35%	10,249
Water & Waste Services efficiency upgrades	35%	217
Transport sector efficiency upgrades	35%	358
TOTAL		**43,077**

2 Introduction and purpose – Uncovering the energy efficiency worker

Australia's energy efficiency workers are often invisible to the general community and our elected representatives in government.

They work in the background ensuring the homes they help build stay comfortable irrespective of how cold or hot the weather. They make sure our offices and workplaces are attractively lit. They make sure our food is kept fresh and safe to eat. And they work to keep our factories and mines operating efficiently and productively.

When they do their job well we see and feel the difference in the comfort of the home and office and the productiveness of a workplace, but the fact that they have also saved substantial amounts of energy is often not immediately apparent. The changes are often subtle. The home or workplace will look similar to one we are used to, but it will consume significantly less energy. The changes might be better oriented and specified windows, lights that look little different to those in place beforehand except that they provide better light using much less energy, an adjustment to a fan, a seal applied to fix a leaking steam pipe, or an extra electronic sensor here and there combined with new software controlling a heating system.

The fact that we often can't readily see the changes means that the community doesn't realise that better energy efficiency not only saves us money but also supports substantial employment.

Workers that deliver improvements in heating, lighting, ventilation, refrigeration, and the movement and the processing of goods will rarely carry the label of 'energy efficiency worker'. Instead they are usually known by titles such as engineer, mechanic, builder, architect and electrician. And unlike the products of workers that construct and install such things as wind farms or solar systems, energy efficiency is not a stand-alone object, but the invisible outcome of good design, maintenance, retrofit and operation of buildings and equipment.

Furthermore, many of the workers that can enhance Australia's energy efficiency can only do so with the right training, incentives and regulations. If workers are rushed, inadequately resourced, poorly trained or given the incentive to 'cut corners' it leads to bad outcomes. For example, builders don't pay for the long-term cost of running a building. This means that there can be pressure on builders to cut upfront costs even if it leads to worse long-term financial outcomes for residents. Policies like minimum standards and energy efficiency ratings are essential to enable workers to deliver the full potential of better performing buildings.

While it's not always easy to see the employment generated by energy efficiency improvements, it most definitely exists. Achieving improved energy efficiency is primarily about putting more time and effort into the design, installation and maintenance of buildings and energy-consuming equipment to optimise outcomes over their lifetime. It requires more attention from engineers, tradespeople and managers on how we build and run our workplaces and buildings and the equipment they use. In essence, energy efficiency is partly about substituting gas, coal and oil with people's brainpower.

In Australia, our statistical agency, the ABS, measures how many people are employed in coal mining, in oil and gas extraction and in our power plants and transmission sectors. A few years ago they also started measuring employment in the renewable energy sector. However, because energy efficiency work and those that deliver it is usually inextricably bound up in a range of activities that go well beyond delivering gains in energy efficiency, quantification of employment in this area has been lacking in Australia. The business management researcher Tom Peters observed “what gets measured gets done”. The corollary of this is that unfortunately what isn’t measured, even if it is important, is often ignored.

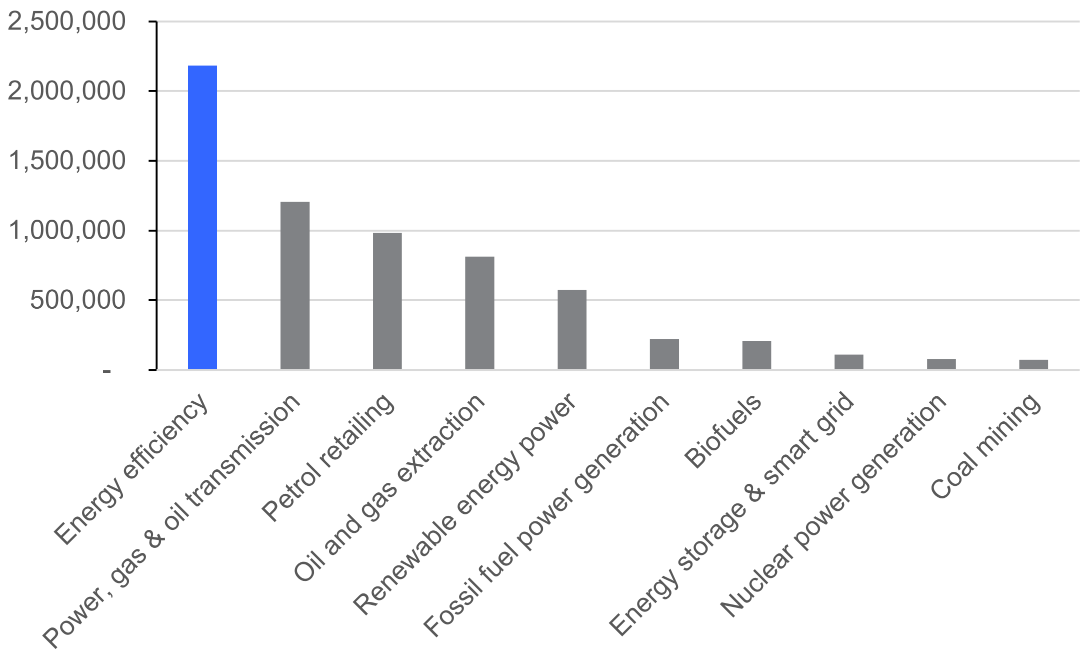
3 Estimating current employment in energy efficiency

3.1. Insights from the US Energy and Employment Survey

In 2015, the US Government recognised it had the same blind spot in energy efficiency employment that Australia currently has. As a result, the US DoE commissioned detailed research that involved identifying 382,500 establishments with energy-related employment and a further detailed survey of 30,000 of these businesses to assess the proportion of staff engaged in energy-related activities including energy efficiency.

This study discovered that energy efficiency employed more people than the mining and extraction of coal, oil and gas; more than power generation across all fuel types, and more than the power, oil and gas transmission and distribution sector (see Figure 3-1).

Figure 3-1 US Employment - energy efficiency and other energy-sectors

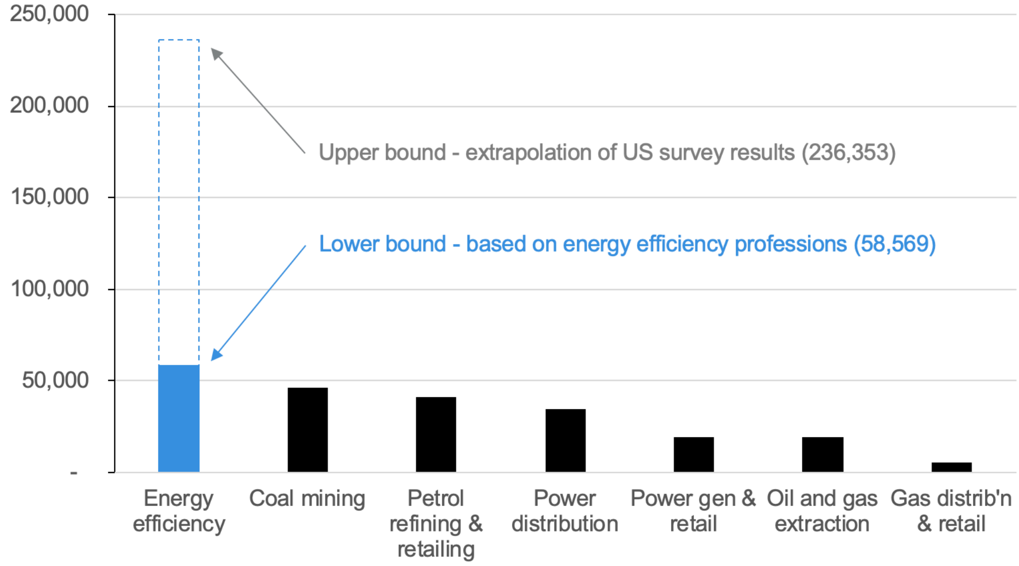


Source: US Department of Energy (2017) US Energy and Employment Report

The study found that within the construction industry, 21% of workers were engaged in activities that were focused on enhanced energy efficiency. This included such activities as fitting improved insulation, installing high efficiency heating, ventilation and cooling systems, and installing high efficiency lighting such as Light Emitting Diodes (LEDs). The study also found 2% of staff across manufacturing, wholesale trade and professional services were engaged either directly in energy efficiency efforts or in assisting businesses that provided enhanced energy efficient products and services.

If similar ratios were to apply across Australian industries of construction, manufacturing, wholesale trade and professional services it would imply employment in energy efficiency activities of around 236,000 people. Figure 3-2 puts these numbers into context by comparison with employment in other Australian energy-related industry sectors according to the 2016 Census.

Figure 3-2 Indicative Australian employment in energy efficiency relative to other Australian energy industry sectors based on an extrapolation of US survey findings



At present, we lack detailed survey data to confirm that Australia has similar levels of energy efficiency activity across the industries of construction, wholesale trade, manufacturing and professional services. There are some factors that would suggest it would be similar or even higher, in particular, Australia's considerably higher electricity and gas prices relative to the US. However, our milder climate, previously low energy prices and generally less advanced energy efficiency policy suite would suggest the proportion of employees engaged in improved energy efficiency would be lower. Yet even if our allocation of worker effort to energy efficiency was half that in the US (which seems unlikely given our much higher energy prices), it would imply levels of employment in enhancing energy efficiency that are two-and-a-half times larger than coal mining and six times larger than all the employment in power generation and retailing or oil and gas extraction.

While energy efficiency workers are not necessarily highly visible, these numbers suggest they are probably far larger in number than those engaged in sectors that tend to loom large in debates over energy policy across Australia.

3.2. An examination of the professions with responsibility for energy efficiency

As an alternative to the detailed survey approach employed by the US DoE to identify workers engaged in energy efficiency, it is possible to identify professions and industry sub-sectors where energy efficiency is likely to be a key priority. This more finely grained approach can help provide a lower bound, conservative estimate of Australian employment in energy efficiency.

The US Energy and Employment Report in identifying workers engaged in energy efficiency focussed on the following areas:

- Insulation;
- Advanced energy efficient building materials;
- LEDs and other efficient lighting;
- Heating ventilation and cooling equipment, control systems and services;
- EPA Energy Star rated appliances (the USs' Energy Star label is an endorsement label signifying only best practice energy efficiency. It is not like Australia's star rating labels, which applies to all models sold with differential star ratings to allow consumers to identify not just high performing but also poor performing products);
- Recycled building materials; and
- Reduced water consumption products and appliances.

This list, and the fact that over one-fifth of the construction workforce in the US was assessed to be occupied by energy efficiency, provides a clear indication that energy efficiency is a primary occupation of those involved in the building and construction professions and trades. This is reasonably obvious once you think about it for a moment, because these are the very people that design, specify, install and maintain equipment that consumes energy. But it should extend beyond building and construction to also consider workers involved in the design, specification, installation and maintenance of manufacturing production equipment such as heat and steam systems and mechanical drive systems.

Based on a review of the Australian 2016 Census, Table 3-1 lists the professions and trades, which have a high degree of influence over energy efficiency, and the number of people that work in them. It then narrows this down further to consider only those who work within industries for which their skills would be likely to be applied to saving energy (the column labelled 'In EE applicable industries') – for example mechanical engineers working in the arts and recreation services industry are excluded.

Table 3-1 Number of people working in energy-efficiency related professions in Australia

Profession	Total	In EE applicable industries
Architects & town planners	37,318	30,554
Construction managers and building technicians	148,343	129,795
Mechanical engineers and technicians	25,131	23,585
Engineers – electronics, chemical and general	43,478	37,462
Engineering technicians and tradespeople	31,591	13,411
Air conditioning and refrigeration mechanics	18,749	18,749
Electronics trades workers	23,354	21,595
Electricians	115,152	113,830
Facility Managers (2008 action agenda estimates)	112,000	112,000
TOTAL	**555,116**	**500,981**

Source: Australian Bureau of Statistics 2016 Census, except for Facility Managers, which is derived from the Facility Management Association's Action Agenda of 2008.

Some of the people listed in the table above will have energy efficiency as their primary focus, particularly those employed in the businesses that are members of the Energy Efficiency Council (EEC) and the Energy Savings Industry Association (ESIA). However, the vast majority of workers that deliver improvements in energy efficiency will also be working on many non-energy related matters.

The US DoE's research found that construction-related organisations dedicate around one-fifth of their workforce to activities that enhance energy efficiency. Meanwhile those in professional services, manufacturing and wholesale trade allocate 2% of their workforce. Given the list above is a selective list of those professions and trades that design, specify, install and maintain energy-consuming equipment, it is expected that a higher proportion of their time would be concerned with energy efficiency.

On average households and businesses in Australia spend 3% of their expenditure on energy. Given these professions are specifically concerned with energy-using equipment then it is reasonable to expect that they would allocate a substantially greater proportion of their time to enhancing energy efficiency.

Mechanical engineers and technicians are the profession with the greatest degree of expertise and responsibility over energy consuming equipment. This is because they are the professionals typically responsible for the design and equipment selection of electric motor driven systems, which make up between 43% and 46% of all global electricity consumption.[1] It is reasonable to expect that they would allocate at least the 21% average workforce allocation found in the construction industry within the US DoE Survey, and as such this report assigns 25% as an approximation.

The same principle has been applied for air conditioning and refrigeration mechanics. This profession has primary responsibility for the installation and maintenance of heating and ventilation equipment, which is responsible for over half of energy consumption in commercial buildings[2] and 40% of residential buildings[3]. In addition, refrigeration is responsible for approximately 8% of electricity consumed in Australia.[4]

For other engineers (excluding civil and mining engineers) as well as their related technicians, this report assumes these workers would still spend a significant proportion of their time – 10% – on activities that enhance energy efficiency, but less than mechanical engineers. These other areas of engineering are very important to enhanced electronic controls and software that assist in optimising the energy efficiency of major energy consuming equipment and processes, while chemical engineers make key process decisions in highly energy intensive industries.

Commercial and residential buildings are responsible for almost 50% of Australia's electricity consumption and 15% of gas consumption while offering some of the greatest opportunities for improved energy efficiency. Architects and town planners carry the responsibility for the design of these buildings and the urban environment in which they are placed. Meanwhile, construction managers and building technicians that include draftsman and building inspectors are responsible for the ultimate implementation of energy efficiency measures, as well as playing an important role in the design and specification of energy-related aspects of buildings.

A little over a decade ago, it would be reasonable to say that energy efficiency was given little consideration in building design and construction in Australia. However, the introduction of energy efficiency requirements for new buildings and substantial renovations has forced building and urban designers to pay far more attention to energy efficiency. Also consumers' awareness and desire for better energy efficiency has increased over this period – mainly in new commercial office buildings, which have benefitted from mandatory disclosure of energy efficiency performance (although residential consumers still lack access to information disclosing the energy efficiency of homes).

The US DoE survey found that the construction industry, of which these professions are a core part, had 21% of workers engaged in energy efficiency. However, we have estimated an allocation lower than this, at 15%, given Australia's energy efficiency policies continue to lag

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[1] International Energy Agency (2011) Energy-efficiency policy opportunities for electric motor-driven systems

[2] Pitt and Sherry (2012) Baseline Energy Consumption and Greenhouse Gas Emissions in Commercial Buildings in Australia, published by the Commonwealth Department of Climate Change and Energy Efficiency

[3] Energy Consult (2015) Residential Energy Baseline Study: Australia, prepared for the Department of Industry and Science on behalf of the trans-Tasman Equipment Energy Efficiency Program

[4] Expert Group (2013) Cold Hard Facts 2 – A study of the refrigeration and air conditioning industry in Australia, prepared for the Commonwealth Department of Sustainability, Environment, Water Population and Communities

behind those in the US. A review undertaken for State and Federal Governments on compliance with the energy efficiency requirements within the Australian building code found that, ‘‘compliance with the Code’s energy performance requirements is generally poor, and that our energy performance is far from best practice.” If governments address these shortcomings in enforcement of the building code, then the proportion of time allocated to energy efficiency would rise closer to levels seen in the US.

Once large commercial buildings have been constructed the task of operating and maintaining them becomes the responsibility of facility managers. They are typically the workers dealing with the day-to-day decisions regarding lighting, heating, and cooling equipment maintenance, system management and controls, as well as replacement and possible upgrades. This will be done in conjunction with qualified trades like electricians and electronic trades workers as well as air conditioning and refrigeration mechanics. Given energy represents 3% of costs for most businesses, a facility manager could be expected to allocate at least twice that proportion of time – 6% – to enhancing the efficiency of its use given their greater degree of responsibility for energy-using equipment.

This then leaves electricians and electronic trades workers. We’d expect that they would spend less time than engineers on the task of enhancing energy efficiency. But they carry primary responsibility for the installation and proper commissioning of many pieces of equipment that consume electricity or the systems that help control energy-consuming equipment. Like facility managers we assume they would allocate at least twice the proportion of their time to energy efficiency activities that energy occupies as a proportion of businesses’ and households’ expenditure (6%).

Table 3-2 details the number of workers engaged in enhancing energy efficiency that flows from the above analysis and set of assumptions. In addition to the estimates above we have added those working in the manufacture, distribution, sale and installation of insulation. According to the Insulation Council of Australia and New Zealand there are 4,000 people employed in this area. Given insulation is predominantly used for enhanced thermal energy efficiency this report assigns them all as energy efficiency workers.

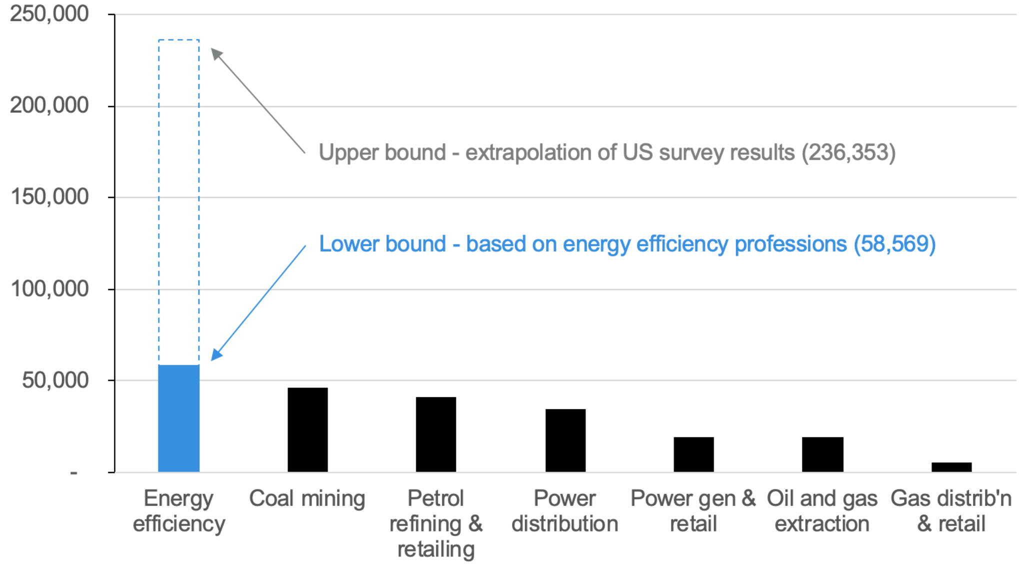
This gives a number of 58,569 workers dedicated to enhancing energy efficiency.

Table 3-2 Likely lower bound estimate of number of Australian energy efficiency workers based on professional categorisation

Profession	Industry applicable	Time allocation	No. of EE workers
Architects and town planners	30,554	15%	4,583
Construction managers & building technicians	129,795	15%	19,469
Mechanical engineers & technicians	23,585	25%	5,896
Engineers – electronics, chemical, general and managers	37,462	10%	3,746
Engineering technicians & tradespeople	13,411	10%	1,341
Air conditioning & refrigeration mechanics	18,749	25%	4,687
Electronics trades workers	21,595	6%	1,296
Electricians	113,830	6%	6,830
Facility Managers	112,000	6%	6,720
Insulation manufacture, distribution and install	4,000	100%	4,000
TOTAL	**504,981**		**58,569**

This estimate falls well short of the ratio of energy efficiency workers within the US economy as identified within the US DoE Survey. While Australia has typically lagged well behind the US in terms of energy efficiency policy, it is unlikely that Australia's allocation of the workforce to energy efficiency would trail the US to such a degree. Consequently, this estimate should be seen as an attempt to obtain a partial picture of the Australian energy efficiency workforce. Naturally there will be a range of unskilled and uncategorised workers that will support these experts in energy-consuming equipment, who are missing from the table above. Yet, in spite of this approach providing only a partial estimate of the number of workers engaged in enhancing energy efficiency, it shows energy efficiency to be significant source of employment. The 58,000 or so specialist workers allocated to helping Australia save energy are larger in number than any other major sub-sector of energy production including coal mining, electricity generation or oil and gas production.

Figure 3-3 Indicative Australian employment in energy efficiency relative to other Australian energy industry sectors – upper and lower bounds



Sources: Green Energy Markets analysis based on information from the US Department of Energy (2017) US Energy and Employment Report; and Australian Bureau of Statistics Census – 2016

4 Potential employment from a 2030 upgrade strategy

4.1. Introduction

There is a significant economic and technical potential for Australia to improve its energy efficiency. These findings come from overseas studies by organisations including the International Energy Agency, the US National Academy of Science and business consultants McKinsey and Company. Similar findings have also been provided by studies focussed specifically on Australia published by groups such as the Council of Australian Government's (COAG) Equipment Energy Efficiency Program, Energetics, ClimateWorks and CSIRO.

Australia not only lags behind these detailed technical and economic estimates of its 'energy efficiency potential', but also lags behind many of our international competitors. A recent global analysis placed Australia last out of the developed countries that were assessed for energy efficiency performance and policies.[5]

The purpose of this report is not to replicate the detailed analysis undertaken by these groups on the potential for energy efficiency upgrades that would benefit our economy and energy consumers. Rather, it aims to very approximately quantify the number of jobs that could be created by an effort to implement a selection of these cost-effective upgrades. It should be noted that this report has not attempted to be comprehensive and cover the entire scope of upgrades that have been identified as cost-effective. Instead it focusses on some of the lowest-hanging fruit, involving upgrades that meet two criteria. The upgrades selected for this study:

1. Involve well-known, mature technologies; and
2. Deliver financial returns in line with or exceeding households' and businesses' cost of capital or alternative low risk investments.

A further limitation of this report was that the upgrades we could consider were constrained to those where sufficient information was available to estimate their potential employment impact.

Because this report is narrowly focussed on a select few energy efficiency upgrade opportunities it understates the level of employment that would be created by a concerted Australian effort to upgrade our level of energy efficiency. No doubt some energy efficiency professionals will identify additional energy efficiency opportunities they believe represent a greater priority than those considered in this report. Hopefully this will stimulate further work by others to improve on the estimates provided in this report.

Irrespective of these limitations, the employment that could be created by the roll out of upgrades considered in this report is considerable, at 120,411 job years (see Table 4-1). Further detail surrounding what each of these upgrade opportunities involve and the employment associated with them is detailed in subsequent sections of this report.

[5] American Council for an Energy Efficient Economy (ACEEE), 2018 International Energy Efficiency Scorecard 2018, ACEEE, Washington DC.

Table 4-1 Potential employment from energy efficiency upgrades

Efficiency upgrade	Employment (job years)
Replace electric storage water heater with heat pump	8,056
Replace LPG water heater with heat pump	1,291
Install or top up insulation	4,339
Draught sealing	1,388
Install single efficient heat-pump heater/cooler in households dependent on electric resistive and/or gas non-ducted heaters	4,827
Replace ducted gas heating with several efficient heat pump heater/coolers	12,146
Replace LV halogen downlights with LEDs	2,265
Commercial building efficiency upgrades	47,545
Mining sector efficiency upgrades	7,627
Manufacturing efficiency upgrades	29,283
Water & Waste Services efficiency upgrades	621
Transport sector efficiency upgrades	1,023
TOTAL	**120,411**

Note in this section of the report the amount of employment created in the design and installation of energy efficiency upgrades is measured in job years. If 20 people work full time for 6 months to retrofit a building to best practice levels of energy efficiency, that would be the equivalent of 10 job years (20 people multiplied by 0.5 years = 10 job years). 1 job year = one person working a standard 37.5-hour work week for one year minus four weeks annual leave and public holidays.

4.2. The role of government policy

Australia will require a range of government policy reforms to capture the substantial employment and energy bill reductions that could be delivered through enhanced energy efficiency. This report does not aim to provide a comprehensive blueprint of the reforms that are necessary to capture the potential of energy efficiency.

However, there is extensive literature and research on the barriers to energy management. Addressing those barriers will enable the upgrades outlined in this report, and the jobs associated to be delivered with both public and private benefits.

Based on progress to date, Australia's current National Energy Productivity Plan will not drive the upgrades described in this report.[6] A new strategy needs to be developed based on a comprehensive inventory of Australia's energy use applications, and an evaluation of how to achieve enhanced levels of energy efficiency in these applications between now and 2030.

[6] For details on this plan see: http://www.coagenergycouncil.gov.au/publications/national-energy-productivity-plan-2015-2030

4.3. Residential buildings

Relative to our developed country peers, Australian governments were very late in introducing minimum standards for key features of buildings, and many homes lack even basic passive measures to inhibit homes becoming uncomfortably hot or cold. Victoria was the first state to introduce minimum standards, but progress in the rest of Australia was limited until the introduction of BASIX in NSW and five-star provisions within the Building Code in 2005-2006. Even so, these regulations have generally been poorly enforced, with non-compliance known to be common and widespread.[7]

This is made worse by the lack of trustworthy, independent information about the energy efficiency and likely thermal comfort of houses for prospective home buyers and renters (with the exception of the ACT). This is in spite of a joint federal-state ministerial agreement back in 2004 to introduce such a regime to make it mandatory to provide energy efficiency ratings at sale or lease.

In addition to gaps in Australia's building policy, Australia has several shortfalls in its standards regime for major energy-consuming residential equipment. Gas heaters currently have no efficiency standards, while standards for air conditioners have substantially lagged behind international best practice. A 2007 commitment to phase out inefficient incandescent light globes is still to be properly implemented, while another 2007 government initiative to substantially upgrade the efficiency of water heaters was abandoned.

The end result is that there is a very significant opportunity for improvement in the energy efficiency of residential buildings in Australia where the savings on energy bills would outweigh the costs.

4.3.1. Energy efficiency upgrade opportunities

This report considers employment flowing from four key opportunities for improving energy efficiency in the residential sector that if implemented would deliver substantial reductions in household energy use:

- Replacing electric-resistance storage and LPG-fuelled water heaters with heat-pumps;
- Improving the building's thermal shell through insulation and draught-proofing;
- Replacing gas and electric resistance heaters with efficient heat-pumps also commonly referred to as reverse-cycle air conditioners; and
- Replacing halogen downlights with LEDs.

These are by no means the only opportunities for improved energy efficiency in the residential sector but are the ones that would target the largest sources of energy consumption in Australian homes.

[7] Pitt & Sherry and Swinburne University (2014) National Energy Efficient Building Project, prepared for the Department of State Development – South Australian Government

4.3.2. Residential energy savings

In the headings below we detail the additional employment that could be created through rolling out these opportunities, but the ultimate reason for why these upgrades make sense is because they will substantially reduce households' energy bills well beyond their installation cost.

Table 4-2 details the amount of energy that could be saved by implementing these upgrades and the resulting savings that would flow to householders' bills if they were implemented to their maximum potential. In aggregate almost $2.5 billion in annual bill savings could be realised. Overall gas use would be reduced by 26,322 gigawatt-hours per annum (equal to 94.8m gigajoules), while electricity consumption would drop by 2,381 Gigawatt-hours per annum.

Table 4-2 Energy and bill savings from residential building upgrades[8]

Efficiency Upgrade	Change in gas usage (GWh)	Change in electricity usage (GWh)	Net change in energy use (GWh)	Net energy bill reduction ($m)
Water heating efficiency upgrades				
Replace electric resistance water heaters with heat pumps	-	-4,803	-4,803	$865
Replace LPG water heaters with heat pumps	-1,633	489	-1,144	$179
Thermal comfort efficiency upgrades				
Upgrade thermal shell and replace ducted gas heating with several heat-pumps	-20,385	3,185	-17,200	$760
Upgrade thermal shell and replace non-ducted gas heaters with single heat-pumps	-4,303	820	-3,483	$182
Upgrade thermal shell and replace electric resistive heating with heat pumps	-	-1,238	-1,238	$302
Lighting efficiency upgrades				
Replace halogen downlights with LEDs	-	-835	-835	$201
TOTAL ANNUAL SAVINGS	**-26,322**	**-2,381**	**-28,703**	**$2,488**

[8] Explanations and supporting sources for the potential for cost-effective energy savings from the upgrades listed in this table are detailed in subsequent sections discussing each specific efficiency upgrade with much of the data on existing energy consumption practices derived from: Energy Consult (2015) Residential Energy Baseline Study: Australia, prepared for the Department of Industry and Science on behalf of the trans-Tasman Equipment Energy Efficiency Program. Residential energy prices for gas and electricity are for the energy usage component only, not fixed daily charges, these are derived from prices quoted by major energy retailers across each Australian state.

To put these savings into perspective, these upgrades would more than halve total gas consumption by Australian households.[9] It would free up an amount of gas for other industries equal to almost a quarter of that required by the Australian manufacturing sector.[10] It would exceed the amount of gas that the Australian Energy Market Operator forecasts will be needed for electricity generation across the entire East-coast National Electricity Market in the next decade.[11] It effectively represents one of Australia's biggest unexploited gas fields.

These residential upgrades result in some fuel-shifting from gas towards electricity, so the reduction in overall electricity consumption is smaller than the reduction in gas consumption. However, the reduction in electricity use is still absolutely substantial - equal to the electricity consumption of over half a million households.

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[9] Australian Government Department of Environment and Energy (2017) Australian Energy Update 2017

[10] Australian Government Department of Environment and Energy (2017) Australian Energy Update 2017

[11] Australian Energy Market Operator (2018) 2018 Gas Statement of Opportunities

Water heating

As part of an effort to underpin electricity demand in the middle of the night to support the inflexible nature of coal fired generators, over several decades state government utilities heavily encouraged the uptake of inefficient electric-resistance element storage water heaters. While it is useful to be able to shift electricity demand into periods where electricity supply is plentiful relative to demand, these water heaters consume around two-and-a-half times more electricity than off-the-shelf heat pump technology.[12] Furthermore, heat pumps also have storage tanks, which enable the time shifting of heating water into periods when power supply is plentiful.

In addition, a number of households have installed water heaters that operate on very expensive LPG fuel. While these water heaters are cheaper to purchase than a heat pump, they cost three times as much to run as a heat pump, costing a household an extra $600 per annum. In the past it may have made financial sense to use LPG in circumstances where grid connected electricity supply was unavailable. However, with the very large reductions achieved in solar photovoltaics, off-grid households would also realise large operating cost savings using electricity in preference to LPG.

According to 2015 Residential energy baseline study prepared for the COAG Equipment Energy Efficiency Program, there are 3,458,963 medium-to-large electric storage water heaters and 554,410 LPG water heaters installed in Australia.[13]

Feedback from industry participants is that replacing these water heaters with a heat pump would involve approximately 4 person-hours of labour. Therefore, such a replacement program if it were to successfully replace the entire existing stock would generate over 8 million labour hours of employment, which equates to 9,347 job years.

Table 4-3 Employment generated from replacing inefficient water heaters

Efficiency upgrade	Number of inefficient stock	Person hours to replace	Employment (job years)
Replace electric storage with heat pump	3,458,963	4	8,056
Replace LPG with heat pump	554,410	4	1,291
TOTAL			**9,347**

[12] Pitt & Sherry (2012), "Running Costs and Operational Performance of Residential Heat Pump Water Heaters".

[13] Energy Consult (2015) Residential Energy Baseline Study: Australia, prepared for the Department of Industry and Science on behalf of the trans-Tasman Equipment Energy Efficiency Program.

Building thermal shell

As mentioned in section 4.1 above, Australia has been slow to implement standards ensuring homes are built with minimum levels of efficiency in thermal comfort. A range of features can help homes to minimise the need for active heating and cooling to keep homes at a comfortable temperature. These include insulation; positioning windows and utilising shading to enable solar heat gain in winter months while minimising it during hotter months; minimising air leaks through proper sealing of windows and doors, and the use of materials that add thermal mass.

Unfortunately, once a house is constructed it can be very difficult to incorporate some of these features. However, the retrofitting of ceiling insulation and draught-proofing (where air leaks are sealed, mainly around doors and windows) can be reasonably straightforward to implement in many existing Australian homes. Given insulation is installed across millions of homes around the globe every year without serious incident, including all new homes constructed in Australia, it is entirely within Australia’s capabilities to roll out a retrofit program safely. Notably, if governments also encourage the replacement of halogen downlights with more efficient LEDs, this would remove the source of ignition behind fires that have been erroneously blamed on insulation in the past.

In order to assess the potential for cost effective improvements in the energy efficiency of existing homes built prior to the 5-star building standard, the Victorian Government agency Sustainability Victoria undertook a detailed physical evaluation of 60 homes built before the standard applied.[14] These homes were selected to provide a variety of ages and building styles that were reasonably representative of the overall pre-2005 building stock.

This study found that 21 out of the 60 houses had either a low level of ceiling insulation (R1.5 or lower) or none at all. While this sample is Victorian based, it is reasonable to expect that housing in other jurisdictions would have similar or most likely higher prevalence of sub-optimal levels of ceiling insulation given Victoria mandated ceiling insulation in 1991, more than a decade before other states adopted energy efficiency requirements for new homes. This is corroborated by the last ABS survey of households’ energy use and conservation practices in 2014. 32% of respondents indicated that they either didn’t have insulation or were unaware whether their house was insulated. While 68% of respondents said their house had “some form of insulation”, no assessment was made of its quality and a reasonable proportion could be expected to be of low insulating value.

The Sustainability Victoria study also found that 19 out of the 60 homes would achieve a payback of 6 years or less on draught-sealing upgrades.

To determine the total pool of dwellings where ceiling insulation could be expected to provide substantial energy savings, this report used ABS 2016 Census data to estimate the number of dwellings in postcodes where the climate was characterised by 4 months or more of average temperature minimums below 10 degrees Celsius (which in many cases also require substantial air conditioning to remain comfortable during Summer). This report then excluded dwellings in apartment blocks of more than 2 stories and also non-permanent structures. This added up to more than 3.5 million households. In the case of draught sealing, we also included all dwellings in apartment blocks, which added up to more than 3.7 million dwellings.

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[14] Sustainability Victoria (2015) Energy Efficiency Upgrade Potential of Existing Victorian Houses

Feedback from industry participants is that retrofitting insulation into a suitable home with an open roof cavity would take 6 person-hours. Meanwhile draught sealing would require 2 person-hours.

Table 4-4 pulls these figures together indicating that upgrading all applicable households would generate 5,726 job years of employment.

Table 4-4 Employment generated from upgrading thermal shell

Efficiency upgrade	Dwellings in climate zones requiring heating or heating and cooling	Proportion of dwellings applicable for upgrade	Person hours to upgrade	Employment (job years)
Install or top up insulation	3,548,396	35%	6	4,339
Draught sealing	3,762,990	32%	2	1,388
TOTAL				**5,726**

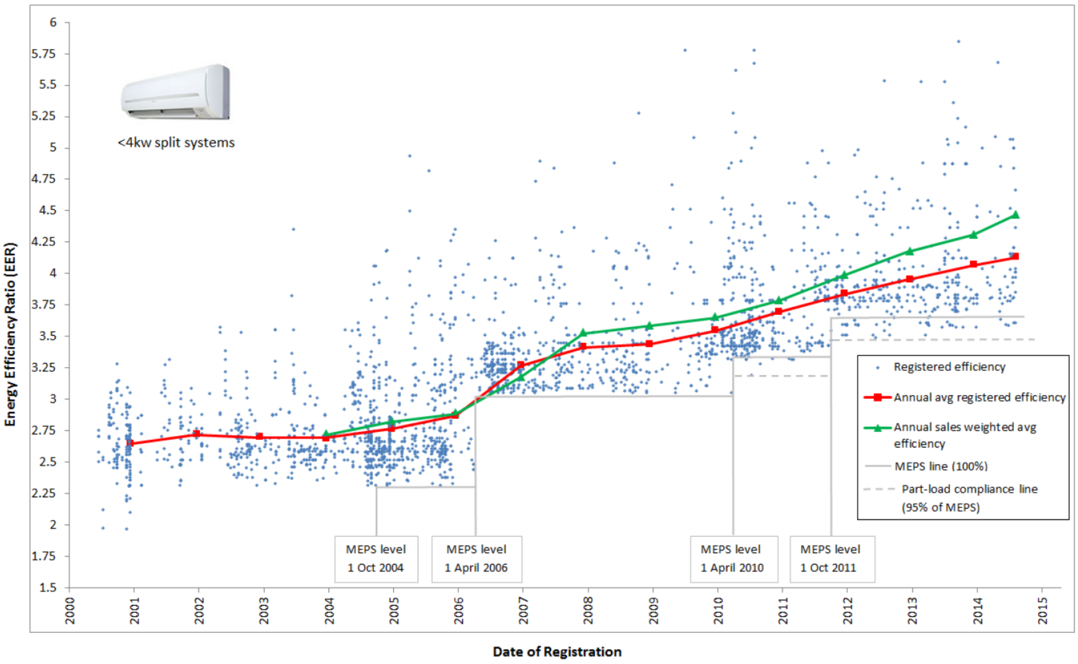
Replace inefficient heaters

In the past two decades there have been major advancements in the energy efficiency of reverse-cycle air conditioners, also referred as ‘heat pumps’. Reverse-cycle air conditioners now represent a significantly more energy efficient and lower cost option than gas for heating Australian homes.

Modern air conditioners can be extremely energy efficient for both heating and cooling. This is because they use energy to move energy from inside to outside a house, or vice versa. As a result, one unit of energy can create multiple units of heating or cooling. Contrary to the myth that gas heaters are substantially cheaper than electric heaters, electric air conditioners are now far cheaper to run. This myth has contributed to large segments of the population having gas heaters that are far more expensive to run than reverse cycle air conditioners.

Figure 4-1 shows the energy efficiency ratio (the kilowatts of electrical energy consumed to deliver a kilowatt of cooling or heating) of the average heat-pump air conditioner in Australia (of 4kW or less) improved from about 2.6 in 2000, to about 4.4 in 2015. What this means in practical terms is that the amount of electricity the average heat pump air conditioner required to deliver a given amount of cooling or heating dropped by more than 40%. This has been assisted by several upgrades to the stringency of Minimum Energy Performance Standards (MEPS) that have phased out low-efficiency models of air conditioners.

Figure 4-1 Energy efficiency ratio of air conditioners less than 4kw capacity in the Australian market



Note: the energy efficiency ratio illustrated above is for cooling, which is closely in line with heating energy efficiency ratios (or Co-efficient of Performance) over time as well. Source: E3 Program (2016) Consultation Regulation Impact Statement – Air Conditioners and Chillers

According to detailed climate and heating appliance energy usage modelling by the Alternative Technology Association, reverse-cycle air conditioners would require around 85% less energy input than a gas heater to heat an entire home floor space to the same temperature.[15] While electricity is more expensive than gas per unit of energy, overall operating costs are 50% to 70% lower for heat-pumps across regions with intensive heating requirements like Canberra and Melbourne. In Adelaide, which has higher electricity prices and lower heating requirements, operating costs are around 30% lower. Where a household has the option of using a solar PV system to power their air conditioner for heating purposes, the operating costs for heating using heat pumps are even lower.

According to 2015 Residential energy baseline study prepared for the COAG Equipment Energy Efficiency Program there are around 1.3 million households with ducted gas heating installed.[16] Replacement with between 2 to 4 split system heat pumps (depending on house size) would provide equivalent levels of comfort while delivering substantial energy cost savings as well as carbon emission reductions as the grid decarbonises.

In addition, we estimate there are around 2 million households that are likely to be reliant on either conventional electric resistance heaters or non-ducted gas heaters (excluding the Northern Territory and Queensland with a simplifying assumption that their heating requirements on average are modest). A single split system heat pump would deliver a substantial improvement in the efficiency and probably effectiveness of heating in the living areas of these homes.

The occupants of households with inefficient heaters are often renters on low incomes who struggle with the expense of operating these heaters, with the result that they reduce their heater use and endure significant discomfort over the winter months. This can harm householders' health imposing additional costs on the public health system. In addition, these gas heaters sometimes lack external exhausts, which can lead to poor air quality inside the home, causing heart and lung ailments and occasionally even carbon monoxide poisoning.

Feedback from industry participants is that a single split-system heat pump installation requires around 4 person-hours of labour. Replacement of a gas central heater with around 3 to 4 split systems would involve 16 person-hours.

Table 4-5 sets out that a successful full replacement of inefficient heaters would generate just under 17,000 job years of employment.

[15] Alternative Technology Association (2018) Household fuel choice in the National Energy Market.

[16] Energy Consult (2015) Residential Energy Baseline Study: Australia, prepared for the Department of Industry and Science on behalf of the trans-Tasman Equipment Energy Efficiency Program.

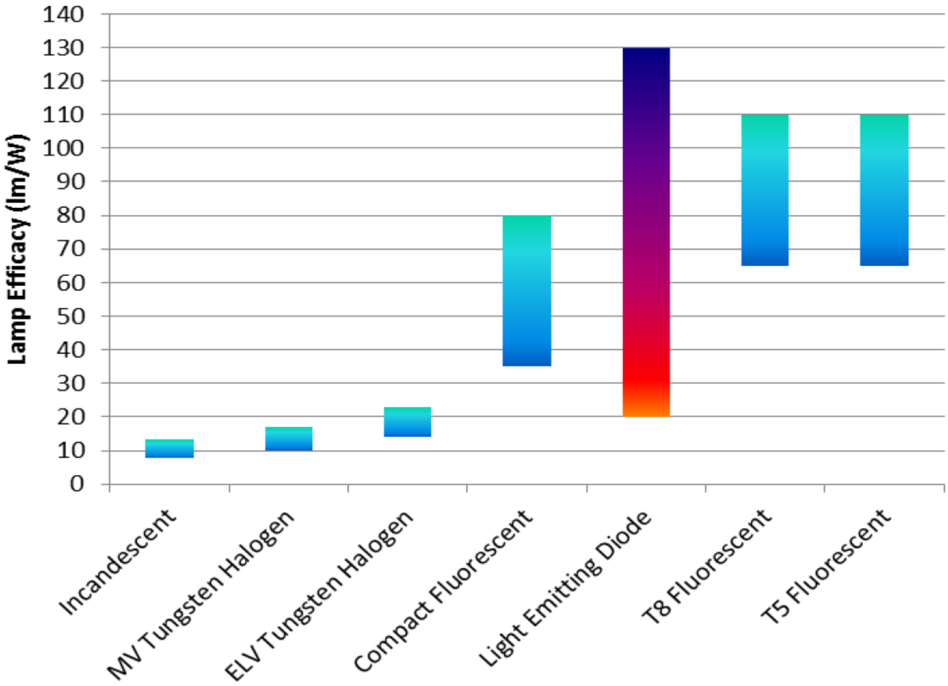
Table 4-5 Employment generated from replacing inefficient space heaters

Efficiency upgrade	Number of dwellings	Person hours to replace	Employment (job years)
Install single efficient heat-pump heater/cooler in households dependent on electric resistive and/or gas non-ducted heaters	2,072,801	4	4,827
Replace ducted gas heating with several efficient heat pump heater/coolers	1,303,782	16	12,146
TOTAL			**16,973**

Replace inefficient halogen downlights

Figure 4-2 provides a comparison of the energy efficiency of different lighting technologies. It illustrates that by replacing incandescent and halogen lighting with either compact fluorescents (CFLs) or LEDs, households can typically achieve a three-to-fivefold reduction in energy use. Further improvements can be achieved through use of T8 and T5 fluorescent tubes, however these require different light fittings to those commonly in use in homes, while CFLs and LEDs are straightforward replacements with existing fittings.

Figure 4-2 Energy efficiency of different lighting technologies (lumens of light per watt of energy consumed)



Source: Federal Department of Environment and Energy (2018) Decision Regulation Impact Statement: Lighting

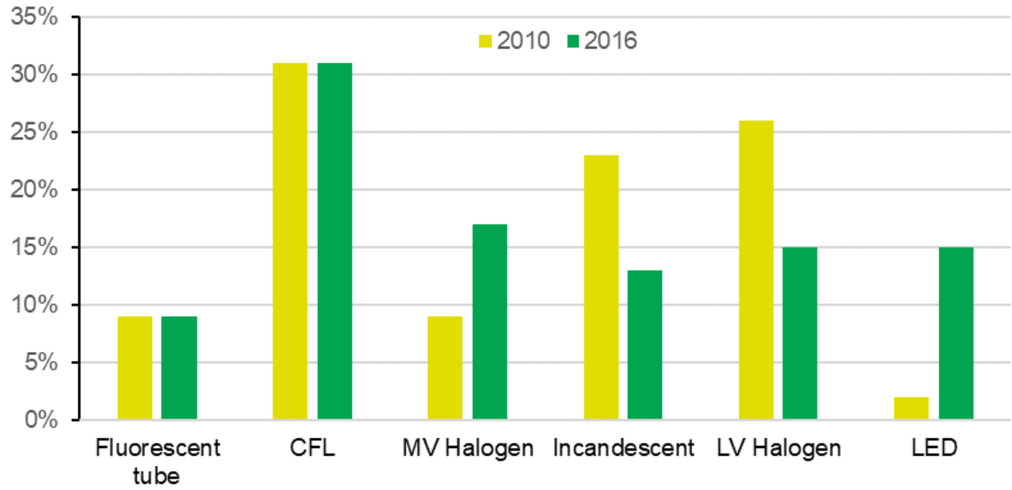
Both LEDs and CFLs cost more to purchase than inefficient halogens and conventional incandescents, but last far longer. The combination of their longer life and much lower operating costs (due to lower energy consumption) means that LEDs and CFLs deliver substantial financial savings for consumers. The Federal Government Department of Environment estimated in 2016 that over ten years an LED bulb would incur a total purchase and operating cost of $39, versus $48 for CFLs and $148 for inefficient halogen globes.[17]

However, the 2007 Government proposal to phase out inefficient incandescent globes to replace them with efficient alternatives has never been properly followed through. While it was possible to achieve a dramatic improvement in efficiency by moving from conventional incandescents to CFLs and LEDs, governments introduced quite weak standards for the efficiency of halogen globes.

[17] Federal Department of Environment (2016) Public Consultation Sessions Lighting Consultation RIS

Surveys of lighting in residential homes commissioned by the joint State and Federal Governments' E3 program show that the share of efficient CFLs and fluorescent tubes did not change at all between 2010 and 2016 under the phase out of incandescents (see Figure 4-3). While LEDs did manage to capture a significant gain in share, a large proportion of households elected to replace their inefficient conventional incandescent globes with lower priced but highly inefficient mains voltage halogens.

Figure 4-3 Proportion of lamps by technology in 2010 versus 2016



Source: Federal Department of Environment and Energy (2018) Decision Regulation Impact Statement: Lighting

While Australian Governments have agreed to completely phase out sale of halogens suitable for standard globe sockets by 2020, halogen downlights won't be affected. Halogen downlights represent the majority of energy consumed by halogen lights. According to the Federal Government the exemption of downlights is due to concerns over the purchase price of alternative downlights and potential for compatibility problems with some low-voltage transformers and dimmer switches.

While LEDs have made rapid in-roads in the last few years, this has partly been a function of government lamp replacement programs, particularly the Victorian Energy Efficiency Target (VEET). The E3 program's 2016 survey of residential lighting use found that: "This data suggests that programs such as VEET, which have reached more than 30% of Victorian households, are having a significant impact on the overall lighting efficacy in the residential sector. We expect that in the absence of further replacement programs, LED growth will soon plateau, much like what occurred with CFLs.

LEDs are in most cases a straightforward replacement for halogen downlights. They are also a superior economic option for consumers. However, while LEDs have achieved dramatic reductions in price and further reductions are likely, their upfront purchase cost is still higher than halogen downlights, and this is likely to remain the case for some time to come. As we can see with the persistence of low efficiency lighting over 2010 to 2016 - in spite of the phase out of incandescents – a large proportion of consumers consistently neglect to consider operating costs in their purchase decisions.

A survey of consumers' lighting decisions undertaken for the E3 program found that while respondents said they thought energy efficiency was very important, 40% of respondents didn't actually select globes by evaluating their efficiency of delivering a given amount of light or lumens. Indeed, 24% of respondents actually evaluated the brightness of globes based on how much energy they consumed (their wattage), which favours less efficient globes. Another 13% simply selected globes based on whether they looked the same as the globe they sought to replace. For those households that indicated halogen light bulbs were the most common in their home, 51% said the reason they selected these globes was based on a simple guide of looking to replace like for like. Another 18% did so because of a lower purchase price.

Given governments continue to remain reluctant to phase out inefficient halogen downlights, this behavioural research, as well as past history with CFLs, suggests that halogen downlight replacement programs that extend beyond Victoria's VEET program will deliver substantial benefits over BAU.

According to the 2016 residential lighting survey undertaken for COAG's E3 program, 38% of houses had lighting energy use per square metre above the building code standard. In addition, 30.5% of houses in the audit had average lighting efficiency below 35 lumens/watt, which suggests these households continue to be predominantly reliant on halogen or incandescent lighting. This represents almost 3 million dwellings. This survey also revealed that 25% of households had 5 or more low voltage halogen lamps installed, which equates to almost 2.5 million dwellings. If it is assumed that low voltage LED downlights more than doubled their share from the 2016 survey result of 4.3% to 9% over the next few years, then this would still leave 20% or slightly more than 1.9 million dwellings worth targeting for halogen downlight replacement.

According to feedback from businesses engaged in halogen replacement under the VEET, one hour of labour time is involved in identifying households that would benefit from halogen replacement, communicating to them and then ultimately installing the lamps. Another hour is consumed in undertaking ancillary supporting activities such as paperwork, stock management, travel time, outbound sales calls, management co-ordination and auditing. Multiplying that across the 20% of Australian households that would benefit from replacement would create 2,265 job years of employment.

Table 4-6 Employment generated from replacing halogen downlights with efficient LEDs

Efficiency upgrade	Number of dwellings	person hours to replace	Employment (job years)
Replace LV halogen downlights with LEDs	1,945,424	2	2,265

4.4. Commercial buildings

Given the vast majority of commercial building space tends to be leased rather than owned by the occupier, this sector is even more prone than the residential sector to split incentives. A ‘split incentive’ is where the person/entity bearing the responsibility for the cost of the energy bill is separate to the person/entity bearing the cost of purchasing and maintaining the equipment that impacts the energy bill. In such a situation there tends to be a temptation for building owners to save money by skimping on energy efficient equipment and better maintenance practices, because the owner captures the savings in reduced equipment and maintenance costs, while the tenant bears the cost of increased energy bills.

This is further exacerbated by the need for organisations larger than a few people to divide up decision-making responsibilities across multiple people. This often leads to decisions that optimise a sub-component of the business at the expense of the overall system. For example, the decision on which building to occupy may be driven largely by a marketing department concerned about being close to customers, while the person responsible for managing the energy bill has no input on which building is rented. This is on top of the simple fact that, just like the residential sector, people occupying commercial buildings generally lack the expertise and time to understand, evaluate and seek to improve the aspects of their buildings that drive energy costs.

While the landlord-tenant split-incentive problem is less prevalent in commercial buildings such as schools and hospitals that are owned by governments, a similar split incentive issue prevails because budget responsibilities are split up across people and organisations that result in incentive structures that can drive serious sub-optimisation problems. The ‘use it or lose it’ approach that is often endemic to government budgeting processes (and also prevalent in large private sector organisations) can often remove the incentive for managers to allocate scarce capital to projects, which save money on energy bills. This is because the reward for such decisions is that the money saved leads to a reduced budget allocation.

Lastly, the businesses that occupy commercial buildings are almost always managed by people who have expertise in areas that lie outside energy efficiency and engineering disciplines. Given energy represents a small proportion of expenditure in almost all industries in the commercial and government sectors, at 3% or less, the amount of management attention to improving its efficient use is understandably small.

It wasn’t until 2006 that commercial buildings in Australia were subject to minimum standards governing energy efficiency. In addition, the standards that were introduced were set at levels that fell well short of the cost-effective potential of technology available at the time, technologies, which have since further improved.

Fortunately, unlike the residential sector, in 2010 the Federal Government mandated that in the case of office buildings with greater than 2,000 square metres of floor space (since lowered to 1,000 square metres), owners must disclose to renters the energy efficiency rating of the overall building and tenancy lighting systems. This policy has had an important role in driving improvements in the energy efficiency of these office buildings, in conjunction with governments imposing minimum requirements for their own tenancies. However, it has still left a substantial amount of commercial buildings where energy ratings are not provided. And energy ratings are at best only a partial solution to bounded rationality and split incentives, which inhibit optimal levels of energy efficiency.

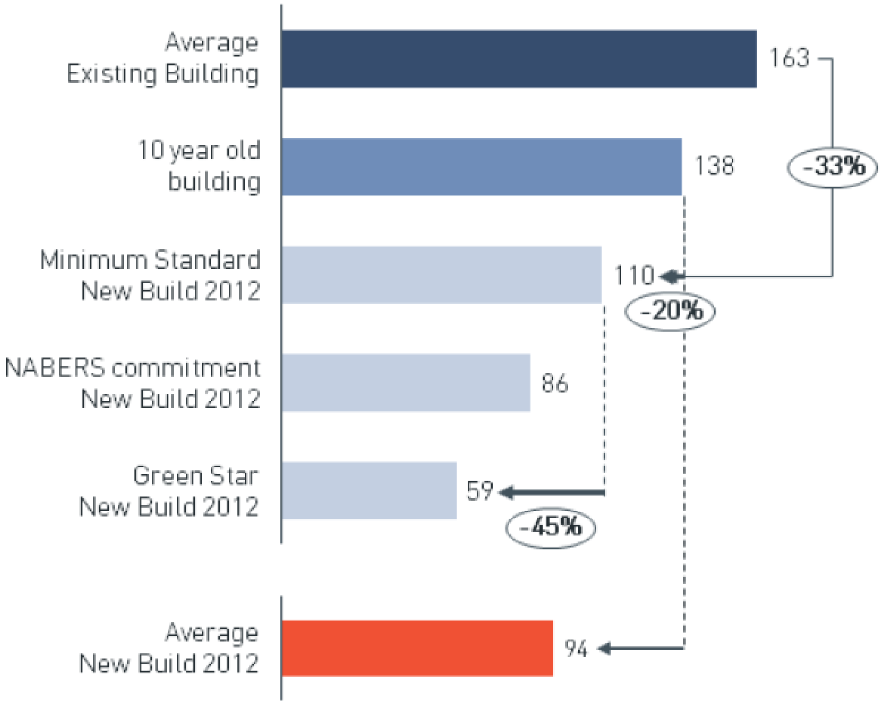
Feedback from a range of building energy efficiency experts suggests that energy efficiency ratings for offices have been quite effective in lifting the energy efficiency performance of the more modern, high-end office stock located in Australia's CBDs. Owners of these buildings are keen to attract government departments and large corporations as tenants who often have sustainability requirements for the buildings they occupy. These buildings are typically referred to in the commercial real estate industry as 'premium' and 'A grade' office buildings. However most other office stock remains inefficient, according to Ernst & Young research:

> *Whilst many premium and A-grade buildings have already undertaken energy efficient upgrades and either have, or are moving towards Green Star certification and high (4 star+) NABERS Energy ratings, the rest of the commercial office building sector – the B, C, and D-grade assets (generally referred to as the 'mid-tier') have not been as active in implementing energy retrofits*.
>
> *Research has shown that on average, Green Star certified buildings produce 62% fewer greenhouse gas emissions than average Australian buildings and use 66% less electricity than average Australian buildings. In addition, they also use 50% less electricity than if they had been built to meet minimum industry requirements (Section J of the National Construction Code), so the opportunities for energy efficiency improvements [demonstrated] in these buildings are significant.*[18]

Research undertaken by ClimateWorks, detailed in Figure 4-4, shows a large gap between the CO2 intensity (and therefore energy consumption) of the average existing office building and a best practice office building. It also illustrates that there is large room for improvement between standard or average practice for new build and best practice office buildings.

[18] Ernst & Young Mid-tier commercial office buildings in Australia: Research into improving energy productivity

Figure 4-4 Comparison of emission intensity factors for office buildings (kg CO2/m2)



Source: ClimateWorks Australia (2013) Tracking progress towards a low carbon economy - buildings chapter

Further analysis by ClimateWorks suggested that the energy use per square metre of floor space of commercial buildings could be reduced cost-effectively by 33% for new build and 23% by retrofits to upgrade the energy efficiency of existing commercial buildings.[19]

[19] Australian Sustainable Built Environment Council (2016) Low carbon, High Performance – How buildings can make a major contribution to Australia's emissions and productivity goals

4.4.1. Energy efficiency upgrade opportunities

To date, much of the research examining the scope for upgrading energy efficiency in commercial buildings has focussed on office space, probably because this represents the greatest amount of commercial building floor space. Research on offices still provides considerable insights into other commercial building types such as hotels, retail, hospitals, education and other public buildings because they often employ the same types of equipment for the main energy-consuming purposes of lighting and HVAC.

As explained above, mid-tier offices are understood to offer significant potential for cost-effective energy efficiency improvement and have been subject to research that has provided useful data to inform employment estimates.

The Ernst & Young research on mid-tier offices observed:

> *[Mid-tier offices] are more likely to have outdated heating, ventilation and air-conditioning (HVAC) equipment, less efficient lighting systems, and weaker thermal performance, offering additional potential for improved energy productivity across the country.*

Sustainability Victoria undertook a program several years ago that used 20 mid-tier office buildings across a range of building types and settings to identify, implement and evaluate cost-effective measures to improve the energy efficiency of these buildings.

The upgrades that were implemented aimed to address some of the issues identified by Ernst & Young, such as outdated and poorly functioning HVAC equipment and low-efficiency lighting. The measures that were implemented focussed on what could be done to improve efficiency while avoiding major changes to the buildings and disruption to tenants. These included:

- Installing modern temperature sensors to ensure that heating and cooling is responsive to real ambient and indoor temperatures;
- Fixing jammed dampers to enable fresh air to be brought into the building;
- Clearing blocked coils and ducts to reduce the amount of energy needed to pump air through buildings;
- Installing modern building management systems to optimise how plant and equipment work together, and to detect and rectify problems quickly;
- Balancing air to measure air flow rates and recommissioning dampers and controls to distribute air flow more effectively;
- Replacing inefficient fluorescent lighting tubes with LED lamps;
- Installing occupancy sensors to reduce unnecessary lighting in common areas;
- Recommissioning timers to make sure equipment is only operating when necessary;
- Installing variable speed drives for fans and pumps so that they can throttle in response to demand;
- Installing sub-metering to give facility managers better visibility as to where energy is being used in buildings; and

- Installing carbon monoxide sensors in car parks, so that exhaust fans run only when a build-up of exhaust gases is present.

According to Sustainability Victoria, on average buildings achieved a 29% reduction in energy consumption with paybacks on investment of 3 years or less. This was achieved while also realising improvements in tenant comfort.[20]

While research on other commercial building types is not as well developed, there are numerous case examples across hotels, retail outlets, hospitals, schools and educational facilities that demonstrate similar savings are possible through the same types of upgrades employed in offices. Lighting upgrades that involve switching over from fluorescent tubes to LEDs combined with smart controls have achieved energy savings for lighting purposes of around 70% in settings such as hospitals, retail, schools and TAFEs.[21] In buildings such as universities and public buildings simply upgrading controls and optimising operational settings have delivered energy savings in heating, cooling and ventilation of 15% to 20%. The Australian Institute of Refrigeration, Air conditioning and Heating (AIRAH) has observed that better controls and system optimisation can reduce energy use in HVAC systems by as much as 50%.[22] These theoretical estimates are backed up by real life examples. One large Australian hotel recently replaced its HVAC and pool water heating equipment and reduced its gas usage by 60%.[23]

Research undertaken by the Cooperative Research Centre for Low Carbon Living, which examined a range of commercial building types, found that relative to the current building code requirements implemented in 2016, the following cost-effective energy use reductions could be achieved in new build:

- 31% reduction for hotels;
- 34% for retail shops;
- 35% for hospital wards;
- 56% for school buildings; and
- 22% for office buildings.[24]

This research was focussed on new builds, consequently there are limitations to the applicability of this research to the entire existing stock of buildings. But given most of the existing stock of buildings will have been built to a standard of energy efficiency far worse than that required under the 2016 building code (see Figure 4-4), it serves to illustrate the scope for large energy savings across the range of commercial building types.

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[20] Sustainability Victoria (2016) Energy Efficient Office Buildings: Transforming the mid-tier sector

[21] See case studies provided in: Energy Efficiency Certificate Creators Association (2017) Energy Savings Schemes Industry Report 2016-17

[22] NSW Office of Environment and Heritage and the Australian Institute of Refrigeration, Air conditioning and Heating (2015) I am your optimisation guide – heating ventilation and air conditioning systems.

[23] Airmaster Case Study – Sheraton Mirage Gold Coast

[24] Australian Sustainable Built Environment Council (July 2018) Built to Perform: An industry led pathway to a zero carbon building code

Employment estimates from upgrading commercial buildings

Table 4-7 details that energy efficiency upgrades across commercial buildings listed could be expected to create slightly more than 47,000 job years of employment. This is derived from an expectation that energy savings of 30% could be achieved from commercial buildings based on upgrade investments with an average payback of 6 years.

Table 4-7 Employment generated from commercial building upgrades

Commercial building type	Annual savings based on 30% reduction ($m)	Investment based on 6 year payback ($m)	Labour expenditure ($m)	Employment (job years)
Mid-Tier Offices	$389	$2,337	$430	8,079
Hotels	$262	$1,573	$289	5,438
Retail	$1,020	$6,121	$1,125	21,162
Hospitals	$267	$1,604	$295	5,546
Schools	$138	$829	$152	2,866
VET buildings	$40	$238	$44	823
Universities	$155	$930	$171	3,214
Public buildings	$20	$121	$22	418
TOTAL	**$2,292**	**$13,751**	**$2,529**	**47,545**

Sources: Energy consumption data from Pitt and Sherry (2012) Baseline Energy Consumption and Greenhouse Gas Emissions in Commercial Buildings in Australia, published by the Commonwealth Department of Climate Change and Energy Efficiency. Energy consumption is for the year 2020. Mid-tier offices estimated to represent 50% of floor stock while having 90% higher energy consumption than the premium and A grade stock, as derived from Figure 4-4. Energy costs for electricity assumed to be $200/MWh and $20/GJ for gas, which are derived from The Centre for International Economics (2018) Consultation Regulation Impact Statement – Energy Efficiency of Commercial Buildings, prepared for the Australian Building Codes Board.

Energy savings of 30% are slightly above those estimated by ClimateWorks for existing commercial buildings (23%) while below what they had estimated for new build (33%).[25] While existing buildings account for most of the energy consumption a higher saving of 30% was considered justified. This was informed by the fact that Sustainability Victoria's buildings tune up program managed to achieve 29% energy savings within just a three-year payback period on average. Meanwhile 6-year paybacks would be more in line with the kind of discount rates that make sense from a government policy perspective and more rational decision-making

[25] Australian Sustainable Built Environment Council (2016) Low carbon, High Performance – How buildings can make a major contribution to Australia's emissions and productivity goals.

processes by individuals. With this longer-term investment threshold, it should be possible to match if not exceed the savings achieved by Sustainability Victoria's program.

A 30% reduction in commercial building energy consumption is estimated to deliver almost $2.3 billion in annual energy bill savings across commercial buildings (excluding premium and A Grade office buildings, which are assumed to have limited opportunity for further efficiency gains). Achieving this with a 6-year average payback would necessitate expenditure of $13.8 billion. This would involve a mixture of expenditure on industries involved in construction as well as repair and maintenance services. According to ABS analysis about 16.1% of expenditure in the construction industry goes towards labour, while in repair and maintenance it was 23.6% in 2015-16.[26] This report assumes a 70% to 30% split in this expenditure respectively between these industries, which provides an overall average of labour expenditure of 18.4%, which implies $2.5 billion of the investment in energy efficiency is spent on labour. Dividing by the average wage across these industries converts this to 47,545 people employed for a year (although such upgrades would logically be rolled out over several years).

[26] Sourced from Australian Bureau of Statistics (2017) 8155.0 - Australian Industry, 2015-16, http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8155.02015-16

4.5. Industry

Studies spanning several decades have identified that uptake of energy efficient technologies and practices across a wide range of industries and geographies tends to lag noticeably behind cost-effective levels. As an example, the International Energy Agency has consistently identified large gaps between best practice and what is commonly deployed. It has noted that if today's best available technologies were deployed globally, industrial energy use could be reduced by 20%[27]. The US National Academy of Sciences concluded in 2010 that 14% to 22% of industrial energy use in the US could be saved through cost-effective energy efficiency improvements (those with an internal rate of return of at least 10% or that exceed a company's cost of capital by a risk premium).[28]

Research undertaken for the Australian National Framework on Energy Efficiency identified the potential for an 18% improvement in energy efficiency through the implementation of sub 4-year payback projects across Australian industries including mining, food and beverage processing, machinery and equipment manufacture, and metals and materials processing.[29] The Australian Alliance to Save Energy in its own analysis of the potential for energy efficiency improvement in manufacturing noted that: "While doubling energy productivity may sound ambitious, practical experience of major consultants working with manufacturers (e.g. Energetics) indicates that energy reductions of 25% or more are possible in many industries.[30]

Experience and research across Australia and overseas examining energy efficiency practices in industry tends to commonly find businesses apply different, highly simplistic decision-making rules to investments in energy efficiency than they do in other areas that represent a central core function of the business. These rules-of-thumb usually involve requiring simple paybacks on energy efficiency investments of no more than 3 years and often less than 2 years.

Research undertaken for the US Government DoE and Environmental Protection Agency observed in relation to energy efficiency opportunities in the industrial sector that:

> *Company staff are often aware of profitable energy saving opportunities, and many companies have a solid record of developing these projects to save money. However, focus is often on projects that can pay off in one or two years. Other projects that have substantial potential long-term benefits, but that have higher initial costs and longer payback periods, are left on the table.*[31]

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[27] IEA (2009) Energy Technology Transitions for Industry – Strategies for the next industrial revolution

[28] National Academy of Sciences, National Academy of Engineering, and National Research Council. (2010) *Real Prospects for Energy Efficiency in the United States*.

[29] Energetics (2004) NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector.

[30] Australian Alliance to Save Energy (2014) Re-energising Australian Manufacturing – Doubling energy productivity by 2030 to improve the competitiveness of the manufacturing sector

[31] State and Local Energy Efficiency Action Network. (2014). Industrial Energy Efficiency: Designing Effective State Programs for the Industrial Sector. Prepared by A. Goldberg, R. P. Taylor, and B. Hedman, Institute for Industrial Productivity.

ClimateWorks found similar practices in a review of Australian businesses' Energy Efficiency Opportunity Assessment reports. This indicated that the intention to implement energy efficiency improvements decreased strongly above a payback of 2 years.[32] Such payback requirements imply financial returns on investment that can exceed 100% and are often greater than 30% per annum. Such financial returns substantially exceed likely conceivable returns on investments in other parts of the business, which will tend to apply more sophisticated financial evaluations based on net present value or return on investment.

This approach likely reflects a need to ration limited management attention and time. While energy efficiency investments may offer highly attractive returns, given energy typically represents less than 5% of most industries' cost structure – it doesn't represent a make or break issue for most businesses. The end result is that the level of energy efficiency in industry falls noticeably short of the economically optimal level.

In addition, evidence suggests this issue may be worse in Australia than other nations. The Australian Alliance to Save Energy notes that Australia lags behind many other nations in energy productivity performance, with a growth rate over the period 1995–2012 of 1.1% per annum in energy productivity, compared with a G20 average of close to 2% per annum over the same period.[33] A 2012 survey by the Australian Industry Group found that the majority of Australian manufacturers have not begun to manage their energy costs and invest in energy efficiency. Of those surveyed, slightly more than half stated that it was not judged to be important. And over 35% stated that it had simply not occurred to them to do so.[34]

4.5.1. Energy efficiency upgrade opportunities

This report's assessment of the employment creation from upgrading energy efficiency across Australia industry builds on analysis undertaken by ClimateWorks. Their research involved a comprehensive review of Energy Efficiency Opportunity Assessment and National Greenhouse and Energy Reporting data that all large energy consuming firms in Australia were required to submit to Government.[35] Under the Energy Efficiency Opportunities (EEO) program large energy consuming firms were required to put in place processes to measure, manage and report their energy use and identify opportunities for cost-effective savings and outline which of these they intended to implement.

The EEO program provided a rich dataset on the potential for energy efficiency improvement in Australian industry. It covered any facility consuming more than 0.1 petajoules of energy per annum for companies in the mining; manufacturing; water and waste services; construction and transport, postal and warehousing sectors. The Abbott Government abolished the EEO program in 2014 on the basis of 'cutting red tape'. However, the abolishment of the EEO program was expected to deliver just $17.7 million per annum in reduced administrative costs, while leaving

[32] ClimateWorks Australia (2012) Inputs to the Energy Savings Initiative modelling from the Industrial Energy Efficiency Data Analysis Project

[33] Australian Alliance to Save Energy (2014) Re-energising Australian Manufacturing – Doubling energy productivity by 2030 to improve the competitiveness of the manufacturing sector

[34] Australian Industry Group. (2012). *Energy shock: Pressure mounts for efficiency action*.

[35] ClimateWorks Australia (2012) Inputs to the Energy Savings Initiative modelling from the Industrial Energy Efficiency Data Analysis Project

the EEO program in place would have delivered $323.2 million in annual energy savings to Australian businesses.[36]

The analysis by ClimateWorks in 2012, followed up by further work in the joint ClimateWorks and CSIRO Low Emissions Roadmap noted that significant energy efficiency gains and/or CO2 emission reductions could be achieved across the following applications:[37]

- Process heating in metals, materials, chemicals and food processing.
- Implementing higher efficiency equipment using the same or similar heating process and fuel – e.g. higher efficiency boiler.
- Electrification and fuel switching where equipment using direct fuels such as coal would be replaced with electric equivalents, or switching to a less emissions intensive fuel – e.g. electric induction melting and switch from coal to gas-fired boilers.
- Ambient or waste heat utilisation: utilising heat pump technologies, or capturing and re-using waste heat from industrial processes or electricity generation equipment.
- Renewable heat: utilising solar, geothermal or bioenergy for heating.

Mining materials transport and processing

- Larger, more efficient or hybrid haul trucks.
- Operational improvements, including route and payload optimisation, improved driver practices.
- At some sites, haul trucks and loaders could be replaced with in-pit crushers and electric conveyors.
- Vertical mills and high pressure grinding rolls that are much more efficient than current technologies.
- High intensity and selective drilling and blasting to reduce the amount of material handled throughout a mining operation.
- Ore-sorting pre-concentration to exclude waste material earlier in the process to reduce downstream comminution (crushing) energy requirements.

Electric motor-drive systems

- Installation of variable speed drives and frequency drives involving control systems that allow for motor output to be better matched to demand.
- Operational improvements such as reducing demand for compressed air, minimising leaks and continued maintenance as well as overall system optimisation (including load management design, optimised sizing of the pipes and efficient ancillary equipment energy).

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[36] Australian Government (2014) Energy Efficiency Opportunities (Repeal) Bill 2014 – Explanatory Memorandum. Sourced from: http://parlinfo.aph.gov.au/parlInfo/download/legislation/ems/r5232_ems_bd8bdcfb-d27d-469d-8bb5-acdbd1afd05a/upload_pdf/394170.pdf;fileType=application%2Fpdf

[37] CSIRO (2017) Low Emissions Technology Roadmap

- Use of high efficiency electric motors, incorporating rotor and magnet developments, such as brushless permanent magnet and synchronous-reluctance technology.

ClimateWorks' analysis in 2012 identified $3.1 billion in annual energy savings (in 2010 dollars) across oil used in transport as well as electricity and gas. It estimated this would grow to $7.76 billion by 2020 (adjusted to 2017 dollars), as a result of expansion in economic activity and expected rises in energy prices.[38]

Of these energy efficiency opportunities, ClimateWorks had found companies were likely to implement about 36% of the savings as a matter of course (BAU). These were largely dominated by projects determined to have a payback of 2 years or less with about four-fifths of the savings from longer payback projects left unimplemented. Extraordinarily, even in the case of the projects with 2-year or less paybacks, companies indicated that 48% of them wouldn't be implemented either.

To determine the employment opportunity we deducted the energy savings from transport, which are not within the scope of this report. Then we deducted the energy efficiency opportunities likely to be implemented under BAU, which are not additional. This leaves an untapped opportunity of just under $2.9 billion of annual savings as detailed in Table 4-8 under the column 'Non-BAU electricity & gas savings'.

Based on ClimateWorks' analysis, the average payback of the savings opportunities left unimplemented under BAU appears to lie at around 3.35 years. So to capture the almost $2.9 billion in energy savings would require expenditure of $11.15 billion. Of this we estimate 18.4% would be spent on labour. This is based on the same assumption as used for commercial buildings that 70% of expenditure would go towards construction style activities upgrading equipment and 30% towards maintenance industry style activities with their associated allocation of spend on labour.

As set out in Table 4-9, this expenditure would then translate to 38,544 job years of employment activity based on average wages in construction and maintenance industries also based on ABS data.[39]

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[38] ClimateWorks Australia (2012) Inputs to the Energy Savings Initiative modelling from the Industrial Energy Efficiency Data Analysis Project

[39] Australian Bureau of Statistics (2017) 8155.0 - Australian Industry, 2015-16, http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8155.02015-16

Table 4-8 Annual electricity and gas savings from efficiency upgrades in 2020

Industry	Total annual savings ($m)	Non-BAU Electricity & Gas Savings ($m)
Mining	$2,560	$567
Manufacturing	$3,983	$2,178
Water & Waste Services	$75	$46
Transport	$1,141	$76
TOTAL	**$7,760**	**$2,867**

Note: Figures in Table 4-7 have been scaled up to 2017 dollars, original ClimateWorks estimates were in 2010 dollars.

Source: Derived from ClimateWorks Australia (2012) Inputs to the Energy Savings Initiative Modelling from the Industrial Energy Efficiency Data Analysis Project

Table 4-9 Employment generated from industry efficiency upgrades

Industry	Total investment to capture energy savings ($M)	Investment expenditure spent on labour ($M)	Employment (job years)
Mining	$2,206	$406	7,627
Manufacturing	$8,469	$1,557	29,283
Water & Waste Services	$180	$33	621
Transport	$296	$54	1,023
TOTAL	**$11,151**	**$2,050**	**38,554**

Sources: Total investment derived from payback data in ClimateWorks Australia (2012) Inputs to the Energy Savings Initiative modelling from the Industrial Energy Efficiency Data Analysis Project. Expenditure spent on labour and resulting employment derived from Construction and Repair and Maintenance industry data in Australian Bureau of Statistics (2017) 8155.0 - Australian Industry, 2015-16.

Again, as in other sections of this report, we should emphasise that this analysis of the likely energy efficiency opportunity in industry is not intended to be comprehensive. These estimates essentially are for what could be considered low-hanging fruit opportunities with rapid paybacks that involve very mature technological options. ClimateWorks noted in relation to its primary data source the following points, which suggest that scope of energy efficiency opportunities is likely to be larger than they were able to quantify:

> *Finally, the data from the confidentialised EEO database appears to have a disproportionately high volume of energy savings potential with a payback of less than 2 years compared to projects with a longer payback period …It is expected that opportunities above a 4-year payback would only be partially reported as there is no requirement to report such opportunities under the EEO program. Although reported data may represent the actual spread of opportunities by payback period, this distribution could also indicate that companies intentionally focus their efforts on identifying energy efficiency opportunities that have a low capital cost and high returns at the expense of costlier options. Advice from the technical consultants also suggests that there could be more opportunities in the 2-4 year payback range than are reported.*[40]

It is also worth noting that since ClimateWorks' research was compiled in 2012 there have been large increases in electricity and gas prices, which have substantially expanded the scope of energy efficiency upgrades that are likely to be cost effective. This suggests the employment opportunity is likely to be larger than estimated in this report. While ClimateWorks and Energetics have undertaken further, more recent analysis on energy efficiency opportunities in industrial and mining sectors, these analyses lack some critical pieces of information needed to estimate employment creation. [41]

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[40] ClimateWorks Australia (2012) Inputs to the Energy Savings Initiative modelling from the Industrial Energy Efficiency Data Analysis Project

[41] ClimateWorks Australia (2017) Solving the gas crisis – A big problem deserves a big solution; ClimateWorks Australia (2014) Pathways to deep decarbonisation in 2050: How Australia can prosper in a low carbon world – Technical Report; Energetics (2016) Modelling and analysis of Australia's abatement opportunities, Report to the Department of the Environment – Meeting Australia's 2030 emissions reduction target.

5 Employment from enhancing market-based energy efficiency incentives

5.1. Introduction

As discussed in Section 4.2, to effectively tap the available opportunity for cost savings from energy efficiency, a combination of policy instruments are required, which act to reinforce and support each other. A full analysis of the policy requirements is beyond this document, and is covered in reports like the EEC's '*Australian Energy Efficiency Policy Handbook'*. Some of the policies that could unlock these energy efficiency opportunities include, but are not limited to:

- Energy efficiency ratings for buildings, appliances and equipment that enable consumers to make informed decisions. On a national basis most people are familiar with the Energy Star Rating Label carried on many white goods such as refrigerators.
- Building the capacity of businesses to manage their energy use through training, support and other programs.
- Minimum health, safety and performance standards for buildings and equipment, especially in circumstances where product suppliers may not have an incentive to meet reasonable standards. Australia has had appliances standards since the 1990s, building standards since the mid 2000s and numerous jurisdictions are currently looking at minimum standards for rental properties.
- Correcting distortions in the energy market.
- Energy efficiency schemes, such as the NSW Energy Savings Scheme and Victorian Energy Upgrades (VEU) program (formerly VEET).

This report particularly focuses on energy efficiency schemes. Incentive programs such as rebates usually focused on single types of products or grants to businesses based often on subjective or poorly defined criteria have also been tried on and off, typically in an ad hoc fashion across both state and federal governments over many decades.[42] However, incentive programs can be designed to work in a more sophisticated manner that harnesses the efficiency and innovation of competitive markets. This involves creating a long-term market open to a broad range of products and services rewarded primarily on the objective metric of how much energy and/or carbon emissions they save.

At present NSW and Victoria have put in place market-based schemes that create tradeable energy savings certificates (white certificates) for certain types of accredited energy saving improvements. South Australia and the ACT have implemented similar Energy Efficiency Obligation (EEO) schemes (the SA Retailer Energy Efficiency Scheme (REES) and ACT Energy Efficiency Improvement Scheme (EEIS)), although they do not incorporate the functionality for tradeable energy saving certificates. In addition to these government programs focussed on energy savings, the Small Scale Renewable Energy Scheme (SRES), operated by the Federal Government supports energy efficient heat pump and solar water heaters using a market-based mechanism with tradeable certificates.

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[42] Grattan Institute (2011) Learning the hard way: Australia's policies to reduce emissions

Similar broad-based energy efficiency incentive programs have also been rolled out across a range of states in the US and in Europe where they are often known as Energy Efficiency Resource Standards or white certificate schemes.

The power of such market-based programs is in their flexibility. They can and should be designed in such a way that offers financial incentives to any type of product or service that can:

a) demonstrate verifiable energy savings over BAU activity; while also

b) delivering equal, or better, levels of functionality and quality than the product they replace.

Governments set a legal requirement for power companies to achieve an energy savings target and a framework for measuring the energy savings from energy efficient products while ensuring only quality products are eligible. They then leave it up to firms to compete and make their own choices about which energy efficient products they wish to promote and roll-out to consumers. As a result, the products that prevail deliver energy savings at the lowest cost.

Such types of programs have regularly managed to deliver larger volumes of pollution reductions and/or energy savings at lower cost than governments and industry experts anticipated.[43] Competition amongst firms will usually drive innovation that leads to the discovery of novel products or processes that weren't in place previously, which drives down prices. Market-based incentive schemes' combination of flexibility and competition deliver pleasant surprises that other government energy efficiency programs are not as well equipped to take advantage of.

While rebates and grants can make a useful contribution to improving energy efficiency, they are best used in a supporting, tailored role. Market-based incentive schemes, because of their openness to a wider range of technological options and participants will generally do a better job of delivering energy savings in bulk while keeping costs low. Grants and rebates can then be used to fill gaps where they can be justified to address issues such as social equity goals or where technology or skills require further development but offer large future potential.

5.2. Employment opportunity

Market-based incentive schemes can capture a significant proportion of the energy efficiency upgrade opportunities considered in this report, but they can't be expected to capture the entirety of these opportunities.

Unlike a regulatory mandate, which applies to the entire stock of product sold in Australia and is compulsory, market-based incentives rely heavily on energy efficiency businesses seeking out homes and businesses for which efficiency upgrades are applicable, beneficial and cost-effective and persuading these energy consumers to undertake the upgrades. Of course, a number of consumers will proactively seek to take advantage of the incentives on offer to undertake upgrades. But in a large proportion of cases, households and businesses do not proactively identify and implement energy saving options, even if they have significant concerns about their energy bills.

[43] Grattan Institute (2010) Markets to reduce pollution – Cheaper than expected

Consequently, significant outbound marketing and sales costs can be involved in finding consumers that can benefit from efficiency upgrades. In addition, even when offered a product that represents a vastly superior economic option to their existing equipment and which has been vetted by a government authority, many customers will remain sceptical and resistant to taking up the offer. Indeed, this can be the case even when the product is offered free of charge. This means that market-based incentive schemes will tend to have participation or uptake rates that fall short of the entire scope of circumstances where upgrades would be cost-effective to households and businesses.

Taking into account likely participation rates by upgrade type, Table 5-1 sets out estimates of the amount of employment from upgrades driven by market-based incentive schemes. This report estimates that, in total, more than 43,000 job years of employment could be generated by market-based incentive schemes via the energy efficiency upgrades considered in this report. As noted previously, these are not the only energy efficiency upgrades that could provide net benefits, and so employment generation from market-based incentive programs could be greater than indicated.

Table 5-1 Employment expected from upgrades driven by market-based energy efficiency incentives

Efficiency upgrade	Participation rate	Employment (job years)
Replace electric storage water heater with heat pump	25%	2,014
Replace LPG water heater with heat pump	40%	516
Install or top up insulation	40%	1,735
Draught sealing	50%	694
Install single efficient heat-pump heater/cooler in households dependent on electric resistive and/or gas non-ducted heaters	50%	2,414
Replace ducted gas heating with several efficient heat pump heater/coolers	30%	3,644
Replace LV halogen downlights with LEDs	85%	1,926
Commercial building efficiency upgrades	35%	16,641
Mining sector efficiency upgrades	35%	2,669
Manufacturing efficiency upgrades	35%	10,249
Water & Waste Services efficiency upgrades	35%	217
Transport sector efficiency upgrades	35%	358
TOTAL		**43,077**

The basis for these estimated participation rates is detailed below. Participation rates are in many cases much higher than what has been experienced to date under the existing schemes, but are considered achievable if the following policy reforms were to be put in place:

- The existing energy efficiency incentive schemes that are currently in place in Victoria, NSW, SA and ACT are expanded with more activities, and similar schemes are introduced to other jurisdictions across Australia;
- The energy savings targets for these schemes are increased and extended to 2030 to provide greater investor confidence in the schemes that will spur higher levels of company participation and investment in the development of new efficiency products and services and more efficient processes for the roll-out of upgrades;
- Incremental reforms are made to these schemes, which would improve their administrative efficiency;
- Complementary policies are put in place by governments, which serve to improve energy consumers' awareness and interest in the bill savings they could achieve from energy efficiency upgrades;
- The existing market-based incentives are supplemented by new, separate measures that seek to address: 1) the health risks (and costs to the public health system) associated with homes being susceptible to excessive heat and cold, particularly in rental stock; 2) the costs to all energy consumers from paying for poorly utilised power supply infrastructure required to meet the short spikes in electricity peak demand.

5.2.1. Discussion on participation rates

The participation rates in Table 5-1 are informed by a combination of:

Historical experience with Australia's existing market-based incentive schemes

Past experience with Australia's existing schemes helps to provide a guide to what kind of participation rates are possible. Indeed many of the upgrades considered in this report are already eligible under some of the existing schemes. For example, the VEU has already been very successful in driving the roll-out of LED replacements for inefficient halogen downlights, but other state schemes are yet to adopt the same kind of regulatory framework to support such a roll-out.

However, it is important to take into account the fact that market-based schemes operate on a competitive market model, which drives businesses to focus on the lowest cost upgrade options available at a given point in time. This means these schemes tend not to drive multiple types of upgrades at high volume all at the same time. Instead they heavily favour the single cheapest option until the point at which it has achieved a very high level of uptake. Once the upgrade opportunity approaches saturation, the market will then tend to discover and heavily focus on a new, lowest cost upgrade option. Interestingly, historical experience is that market participants, once they shift to the new upgrade option, innovate such that they tend to be able to roll-out this new upgrade option with an incentive amount that wasn't higher than what was required to roll-out the previous favoured upgrade option.

While many of the upgrades considered in this report are already eligible under existing market-based incentive schemes, other upgrades, particularly lighting, have been cheaper and easier to roll-out and therefore higher cost upgrades have been neglected. But over time we expect these other upgrades will become competitive as lighting upgrades reach saturation. Also, our analysis incorporates the potential for governments to implement additional policies that would act to complement market-based incentive schemes to improve their efficiency.

Experience and analysis from similar schemes operating in the US

A large number of states in the US operate similar programs to Australia's market-based incentives, which they commonly call Energy Efficiency Resource Standards. US energy utilities are required to achieve energy saving targets and provide a range of incentives to encourage the uptake of energy efficiency upgrades to achieve these targets. Analysis by the American Council for an Energy Efficiency Economy (ACEEE) examined how such utility-driven incentive programs could drive a major wave of new energy efficiency upgrades – many of which are similar to those considered in this report.[44] The participation rates they estimated for these upgrades options have helped inform our own estimates in several cases.

The reasoning behind these participation rates are further explained below.

Water heater upgrades

- ***Replacement of electric storage water heaters with heat pumps – 25% participation***
- ***Replacement of LPG water heaters with heat pumps – 40% participation***

Analysis by the ACEEE estimated that participation rates of 50% were achievable for utility incentive programs targeting replacement of electric resistance water heaters with heat pumps. However, this was partly underpinned by an assumption that the US would introduce a nation-wide minimum efficiency standard for water heaters that would target the phase-out of inefficient electric resistance water heaters by 2026. The US has already implemented standards that have done this for heaters with a storage volume greater than 208 litres.[45] Such a standard would drive scale economies, greater levels of competition between suppliers in the heat-pump market, and greater efforts by water heater manufacturers to drive up sales of heat pumps via their distributors compared to their other offerings. This would then make it easier for utilities to drive uptake of heat pump water heaters in advance of the 2026 standard because heat pumps would come down in cost and installers and distributors would be forced to upgrade their understanding and support for the roll-out of such products.

It is critical to recognise that householders in both the US and Australia are, not surprisingly, less than engaged in water heater technology and product options. In fact feedback from water heater manufacturers is that householders don't actively think about water heater purchase until their existing unit fails. At which point, householders' primary consideration is rapid replacement and the lowest upfront cost. This puts suppliers and plumbers in a very powerful position to influence purchasing decisions. Unfortunately, because plumbers don't bear the operating cost

[44] American Council for an Energy Efficient Economy (2015) New horizons for energy efficiency: Major opportunities to reach higher electricity savings by 2030

[45] American Council for an Energy Efficient Economy (2015) New horizons for energy efficiency: Major opportunities to reach higher electricity savings by 2030

of the unit, they tend to go with the technology they are most familiar with and find easiest to install, which tends to be electric resistance in areas where these are already common.

In addition, when heat pump water heater technology was originally introduced into the market it suffered from highly variable quality across suppliers and many models suffered from high levels of noise. This acted to undermine plumbers' confidence in the technology and many fail to realise the technology has substantially improved since then, nor do they know which suppliers offer suitable quality product. This has historically not been the supplier they have been used to dealing with, who would usually have a stronger competitive position in electric resistance water heaters.

The Australian Government had committed to introduce a standard to phase out inefficient electric resistance water heaters back in 2007, but never followed through. While such a standard in Australia would probably deliver net economic benefits, given past history we have not assumed such a standard would be introduced here. This means we expect a lower participation rate of 25% for replacement of electric resistance water heaters. This is higher than what Australia has achieved to date under the SRES. Nonetheless, given the US is now introducing standards and programs to accelerate uptake of heat pump water heaters we expect their cost will decline noticeably over the next decade. In addition, we assume that governments will implement communication and training programs targeting not just householders but also plumbers and distributors about the advantages of heat pump water heaters. In addition, we also assume governments will introduce programs targeted at encouraging landlords to upgrade the energy efficiency of their homes, which are described in more detail under thermal shell and heater upgrades.

In terms of LPG water heater replacement, we expect much higher participation rates of 40% can be achieved. LPG heating tends to be used in areas that are not connected to the main electricity grid; or in cases where mains gas is not available and householders have failed to appreciate the exorbitant operating costs of using such units. Due to the steep fall in the cost of solar PV systems and the very high operating cost of LPG water heaters, heat pumps now represent a very cost-effective choice for those without mains electricity. Also, the overwhelmingly superior economics of heat pumps in replacing LPG should make it easier to drive their uptake than in replacement of electric resistance units, where operating costs are lower.

Residential thermal comfort upgrades

- ***Install or top up insulation – 40% participation***
- ***Draught sealing – 50% participation***
- ***Replace electric resistive and single room gas heaters with heat pump – 50% participation***
- ***Replace gas ducted heating with several heat pumps – 30% participation***

The participation rates we have estimated for upgrading heaters and residential thermal shell energy efficiency are noticeably higher than the rates currently being achieved for these upgrades where they are eligible under existing schemes. We would acknowledge that the significant upfront cost of these upgrades even after energy efficiency market incentives (with the exception of draught sealing) will act to deter their uptake even though they typically represent a better lifetime value option than alternatives.

However, we believe a 2030 efficiency upgrade strategy should deploy a range of policy measures that would support market-based incentives in driving these upgrades, including:

- Mandatory energy rating assessments for homes are prominently disclosed in web advertisements for homes being sold or leased;
- Requirements and/or inducements for landlords to upgrade their rental properties to meet a minimum energy efficiency standard; and
- Assisting those with health conditions that make them susceptible to severe heat or cold, or those on energy concessions through provision of rebates to help offset the cost faced by landlords to undertake these efficiency upgrades.

There are good reasons for implementing these additional measures because the poor standard of thermal efficiency of Australia's homes is not just a problem in terms of greenhouse gas emissions. It also has serious consequences for people's health, social equity, and the overall economic efficiency and reliability of our electricity system.

In observing that Australians have a significantly higher rate of death due to cold weather than Swedes or Canadians, Adrian Barnett, associate professor of public health at Queensland University of Technology, attributed much of the blame to the poor thermal energy efficiency of our housing noting:

> *Many Australian homes are just glorified tents and we expose ourselves to far colder temperatures than the Scandinavians do. People with less money are more vulnerable as they may not be able to afford to heat their home or may live somewhere that's harder to keep warm because it's not well insulated.*[46]

As touched upon by Barnett above, poor levels of thermal efficiency are also a social equity concern. This is because rental homes tend to be less likely to be insulated than owner-occupied homes and have less efficient and effective heaters and more likely to lack air conditioning. The higher operating costs to keep these homes comfortable further exacerbates the disadvantage of low-income groups that can't afford their own home.

Better levels of insulation in Australian homes would also greatly assist in lowering the relatively short peaks in electricity demand that are driven by cooling and heating demand in Australia (more by cooling, but heating remains important too, particularly in Tasmania). These demand peaks impose substantial costs in extra network and generation capacity that is only very infrequently utilised.

Also as the level of solar PV increases to very high levels in Australia's grid, insulation offers greater value as a means of facilitating the time-shifting of demand for electric cooling. Once a home is well insulated, it then becomes feasible to pre-cool a home during the daytime period when solar PV power output is high. Once people return to their home in the late afternoon and evening from work and school when solar PV output drops, the air conditioner will require far less power to keep the home at a comfortable temperature (it requires less power to maintain a home at comfortable temperature than to cool it down once it has been allowed to become hot).

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[46] Barnett (2015) Cold weather is a bigger killer than extreme heat – here's why, The Conversation - https://theconversation.com/cold-weather-is-a-bigger-killer-than-extreme-heat-heres-why-42252

Now it is true that the roll-out of air conditioners to homes that don’t presently have them will act to increase electricity peak demand - all other things being equal. However, we expect that overall peak demand can actually be reduced through a well-designed roll-out of these upgrade measures. This is because:

- An extensive roll-out of insulation should reduce the load placed on the power system from air conditioners already in place;
- If new air conditioners are required to be of high levels of energy efficiency, and are coupled with insulation, it should actually add relatively small amounts of additional electricity demand;
- New air conditioners should be coupled with internet-enabled smart load management devices that enable them to be controlled remotely to pre-cool homes when solar PV output is high on those days of high peak demand;
- There should also be a program to accelerate the replacement of old, inefficient air conditioners with modern, high efficiency air conditioners. Air conditioners installed a decade or more ago on average require about twice the power input as the average air conditioner sold on the market today. Given an average old air-conditioner would consume something close to 2 kilowatts of power, replacing it with a new one could reduce peak demand by a kilowatt. To meet a kilowatt of additional electricity demand imposes a ball-park cost of around $900 in network infrastructure and another $800-$1000 in power plant generating capacity, so the savings to the power system from replacing inefficient air conditioners are considerable relative to the cost of a new air conditioner.[47, 48]

In addition, there need to be some reforms made to the energy efficiency market schemes to reduce the compliance costs associated with use of insulation in particular. At present, even though incentives are available under the VEU for installing insulation, the value of these incentives is substantially outweighed by the compliance requirements the scheme applies. These requirements go well beyond what is required to manage the safety risks associated with installing insulation. This means it is noticeably cheaper to install insulation without the financial support provided by the scheme so participation is negligible.

It is unfortunate that insulation has been demonised as unsafe to install. The Housing Insulation Rebate program rolled out under the Rudd Government in 2009 was undertaken in a rushed manner and was undoubtedly subject to a range of faults – particularly around quality controls of the products used and the effectiveness of their installation. But the reality is that, over the last three decades, insulation has been installed across millions of homes in Australia (and the world) with negligible safety issues, and has delivered very large improvements to thermal comfort and occupant health.

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[47] See section 3 within Low Carbon Living CRC (2018) Building Code Energy Performance Trajectory – Interim Technical Report

[48] Based on the capital cost of an open cycle gas turbine as listed in: ACIL Allen Modelling Assumptions workbook prepared for the Energy Security Board in their analysis of the National Energy Guarantee; and the Australian Energy Market Operator’s 2018 Integrated System Plan Modelling Assumptions listed in their assumptions workbook.

Unfortunately, the bad publicity that surrounded the Rudd Government's household insulation program has left governments extremely wary of encouraging the use of insulation in the large number of Australian homes with non-existent or inadequate roof insulation. This has been a particular pity for low-income households, as they tend to occupy rental properties with poor levels of insulation and inefficient appliances, leading to unnecessarily high energy bills and/or considerable discomfort and health problems.

Provided the complementary policy initiatives mentioned above are implemented, it should be possible to make substantial in-roads particularly into improving the efficiency of Australia's rental stock. However, these upgrade measures do have an out of pocket expense for home owners and landlords and, combined with landlords' tendency to ignore energy efficiency measures, take-up will fall short of optimal levels. This was demonstrated by the very low rates of uptake in the rental stock of insulation under the Home Insulation Program, even though in many cases the insulation was offered free of charge. For these reasons we expect uptake beyond 50% without regulatory standards will be very difficult and ultimately regulatory standards will be required to deliver the full energy savings opportunity.

Draught sealing is relatively inexpensive and so penetrating half of households should be possible prior to minimum standards.

In addition, we expect that installation of a reverse cycle air conditioner in homes dependent on electric resistance heaters or single room gas heaters will be a measure that landlords will readily grasp as improving the attractiveness of their home for rental purposes. It will also be something homeowners are likely to find attractive due to the added utility of cooling in addition to more efficient and effective heating. Therefore 50% participation should be achievable.

Replacing gas central heaters with several efficient reverse cycle air conditioners will be a more difficult proposition though, because it will involve a significantly higher upfront cost. In addition, air conditioners are not at this stage perceived as a clearly superior option to gas central heating by consumers. We'd expect that this option would be heavily dependent on replacement at the point of failure of the gas central heater, which will slow uptake. For these reasons we expect it would be challenging to achieve participation levels much beyond 30%. Although as reverse cycle air conditioners become a more common choice for heating purposes, particularly for new build, we expect perceptions will change as more people come to realise the benefits of air conditioners for heating purposes over gas. Also gas pipeline charges will likely rise as household gas usage declines, which will further assist in lifting participation rates. For insulation the upfront cost after incentives is more modest than a replacement of gas central heaters and it won't be subject to an equipment failure lag before home-owners consider it. However, because insulation is a passive product and hidden from view it represents a more difficult sales proposition than installing a reverse cycle air conditioner in homes that are dependent on room heaters. Consequently participation below 50% and closer to 40% is more realistic. Of note is that some US and Canadian utility programs have achieved participation rates of 70% to 85% of eligible homes but these have been in quite small geographic areas.[49]

[49] American Council for an Energy Efficient Economy (2015) New horizons for energy efficiency: Major opportunities to reach higher electricity savings by 2030

Replacement of halogen downlights with LEDs

- ***85% participation***

The ACEEE estimated that 85% participation should be achievable from an effort to replace halogen downlights with LEDs and is the rate we have selected as achievable for Australia. This high level of participation is supported by the experience of the VEU scheme in rolling out this upgrade. According to the 2016 residential lighting survey undertaken for COAG's E3 program, 30% of homes surveyed in Victoria had their halogen downlights replaced by LEDs under the program. Given 25% of homes nationwide had 5 or more halogen downlights according to the same survey, having replaced halogens in 30% of all homes in Victoria indicates an extremely high proportion of homes reliant on halogens have had their lights replaced by LEDs.

Commercial building efficiency upgrades

- ***35% participation***

Commercial building efficiency upgrades involve a combination of better electronic controls and use of thermostats, incremental improvements to HVAC equipment and settings and in some cases complete replacement of HVAC equipment and also the roll-out of high efficiency lighting and controls, and in some cases improvements to the building shell where viable. In its analysis of utility incentive opportunities to 2030 the ACEEE examined the potential roll-out of a number of measures relevant to commercial building upgrades:

- better lighting controls;
- building HVAC controls;
- higher efficiency fan, compressor and pump systems (used in HVAC systems);
- the roll-out of more advanced energy efficient commercial air conditioning equipment;
- comprehensive commercial building retrofits.

It concluded that 50% participation was achievable for lighting upgrades, 39% for higher efficiency fan, compressor and pump systems; 37% for advanced air conditioning, 35% for smart building controls and 20% for comprehensive retrofits of commercial buildings, which extended to changes to the buildings' thermal shell.

The level of energy savings considered in this report (30%) should not require the level of extensive and high capital cost expenditures envisaged by the ACEEE in its analysis of comprehensive commercial building retrofits and so we expect participation rates should exceed the 20% level they estimated for this measure. We would also agree that participation in lighting upgrades will probably be higher than the 35% participation rate we've applied to commercial buildings. However, feedback from energy efficiency building practitioners is that persuading owners of mid-tier office buildings and other commercial building operators to spend capex on efficiency measures outside of lighting is difficult even when the financial returns are compelling due to split incentives. In the interests of being conservative we've therefore assumed a participation rate of 35%, which is consistent with what the ACEEE estimates for smart building controls and similar to that of advanced air conditioning equipment.

Industrial energy efficiency upgrades

- ***Mining, manufacturing, water & waste services, and transport sector energy efficiency upgrades – 35% participation***

The ACEEE examined a number of measures relevant to upgrading the energy efficiency of production facilities such as manufacturing plants, mines and waste and water:

- ***Strategic energy management systems – participation rate: 50%;***
- ***Enhanced efficiency of motor-drive systems supported by labelling – participation rate: 39%; and***
- ***Smart manufacturing through greater use of internet-enabled sensors and controls to reduce waste – participation rate: 35%.***

The ACEEE proposal for strategic energy management is quite similar to a program the Howard Government implemented, which required all large energy users to put in place systems to measure, manage and report on their energy usage as well as identify, document and report on energy efficiency savings opportunities. This program, called Energy Efficiency Opportunities (EEO), also required senior executives to sign-off on these reports and report publicly on their adoption of energy efficiency projects.

As mentioned earlier, in spite of analysis suggesting the program delivered economic benefits substantially outweighing its cost, the Abbott Government abolished the Howard Government program in 2014. Governments should consider reinstating programs like the EEO program as a first step towards capturing energy efficiency opportunities in industrial facilities.

Also, at present a large proportion of industrial facilities (typically deemed as emissions-intensive and trade-exposed) currently face no regulatory incentives to minimise the considerable carbon emissions associated with their electricity usage. They are exempted from any requirements under the existing energy efficiency market incentive schemes as well as the Renewable Energy Target (RET) and various proposals for implicit and explicit pricing of carbon. While these facilities have been exempted from contributing towards any of the costs or emission reductions associated with these schemes, they will be substantial beneficiaries of the reduced wholesale electricity prices these schemes are expected to deliver.

Under a number of energy efficiency resource standard programs in the US, rather than entirely exempting these companies, they have allowed them to count any energy savings they achieve within their own facilities as their contribution towards their electricity retailer's compliance with these programs. Such a reform to Australia's energy efficiency market programs, in combination with the reinstatement of the EEO program, could encourage more considered evaluations of the viability of energy efficiency investments than the arbitrary two-year payback threshold that has historically been common amongst these companies.

Provided such reforms were implemented we expect participations rates of 35% can be achieved, which are similar to those the ACEEE expected for enhanced efficiency of motor-drive systems and smart manufacturing controls.

Notes

ENERGY EFFICIENCY COUNCIL (EEC)

The Energy Efficiency Council is Australia's peak body for energy efficiency, energy management and demand response. The Council is a not-for-profit membership association which exists to make sensible, cost effective energy efficiency measures standard practice across the Australian economy. The Council works on behalf of our members to promote stable government policy, provide clear information to energy users and drive the quality of energy efficiency products and services.

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ENERGY SAVINGS INDUSTRY ASSOCIATION (ESIA)

The Energy Savings Industry Association is the peak national, independent association for businesses that are delivering energy-saving upgrades to homes and businesses through energy savings schemes. Members include Australia's leading product suppliers, service providers and certificate creators accredited under energy savings schemes and complementary initiatives across Australia. Our members are at the forefront of the energy savings industry: driving investment in a robust, competitive market that delivers innovative, quality, energy-saving products and services.

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