LOW CARBON LIVING CRC

Government Procurement for Sustainability Outcomes

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Authors	Philip Harrington, Strategy. Policy. Research.; Mark Johnston, 2XF Advice
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The project was delivered by:

- Philip Harrington, Principal, Strategy. Policy. Research
- Mark Johnston, Principal, 2XF Advice.

Strategy. Policy. Research.

Making the business case for sustainability

Opportunities for Low Carbon & High Energy Performance Government Procurement Policies
– Final Report

Prepared for:	**CRC for Low Carbon Living**
Date:	**June 2019**

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Executive Summary

This project, commissioned by the Co-operative Research Centre for Low Carbon Living (CRCLCL), aims to advance an important aspect of the *National Energy Productivity Plan*: specifically, Item 12, 'improving energy productivity in government'.

In 2015, the COAG Energy Council agreed that each government within the Council should endeavour to improve the energy productivity of their own operations. The Plan commits jurisdictions to work with each other and with stakeholders to share learnings in the development and implementation of government energy productivity and efficiency measures, to improve government energy use using the most effective approaches.

In this context, the CRCLCL commissioned this project to analyse a range of prioritised opportunities, as nominated by governments themselves. These were:

1. New high efficiency, all electric and low carbon buildings (offices, data centres, places of education, hospitals)
2. Requiring higher energy productivity buildings (driving retrofits)
3. Consideration for carbon neutral certification through the National Carbon Offset Standard (NCOS) – although it was later agreed that carbon neutral certification would not be investigated as part of this report
4. High efficiency and lower carbon internal combustion engine vehicles - where duty cycles are not suited to electric vehicles (EVs)
5. EVs where duty cycles are appropriate plus provision of EV charging infrastructure
6. Energy procurement – consideration of power purchase agreements (PPAs) for renewable energy and provision for local energy trading from a microgrid ecosystem featuring renewable energy and storage on building sites.

Officials representing the Australian Government, the ACT and NSW Governments, and also the University of Melbourne, contributed data and other inputs, and participated in a Project Steering Committee. This Final Report incorporates comments received from the Steering Committee on an Exposure Draft Final Report.

Key Findings

Governments are very large consumers of services, including energy, transport and accommodation amongst others. Total government spending for all purposes in 2016-17 was $624 billion, although includes much expenditure that was not 'procured'. In the same year, the Australian Government alone reported a total procurement value of $47.4 billion across 64,092 contracts.

Existing procurement guidelines encourage the objective of *value for money* to be considered in a broad context including:

- considering the financial and non-financial costs and benefits of procurement
- considering the environmental sustainability of the goods or services (such as energy efficiency and environmental impact, use of recycled products, etc)
- considering whole of life costs such as initial price, maintenance, consumables and disposal costs.

All governments that examined this project have some government efficiency or resource sustainability policies and programs in place. The ACT Government, notably, is procuring renewable energy power purchase agreements (PPAs) to help meet its energy and carbon goals, as considered in Chapter 6, and the NSW has just recently updated its Government Resource Efficiency Policy. All governments examined have policies that encourage procurement of energy efficient buildings. However, many of these policies are now relatively old, with targets that are, arguably, out of date. From this perspective alone, there are cost-effective opportunities to strengthen sustainable procurement policies in many jurisdictions. We were unable to find examples of formal evaluations of government sustainable procurement policies in Australia.

Buildings

Both new buildings and retrofits of existing buildings offer significant opportunities to realise energy cost and emissions savings. It is now common for the majority of government accommodation and building requirements to be leased from the private sector, rather than being government owned. This means that governments must be informed buyers and make good use of their buying power to encourage high standards of efficiency. In smaller and regional cities, in particular, government purchasing power is disproportionately large, meaning that private building owners will tend to follow the lead of government procurement policies – whether they are ambitious or otherwise. This provides additional incentive to ensure such policies are kept up to date with changing market realities and opportunities.

In the new building market, and for governments targeting low or zero emissions, high-efficiency and all-electric buildings, teamed with renewable electricity, provide a cost-effective and readily-available pathway. 100% renewable electricity can be cost effectively procured (power purchase agreements are discussed in this report) and electric equipment such as HVAC systems are far more efficient than their gas counterparts. Accordingly, new buildings can be designed for all-electric operation from the very beginning and powered by renewable energy.

Examples of retrofits of existing buildings realising 60% - 80% savings are offered, and many of these also offer attractive investment paybacks. However, each building is unique, and opportunities for energy retrofits, and the project economics associated with them, will vary from building to building. Retrofitting existing buildings for all-electric operation can face challenges in some circumstances. A comprehensive program of ratings and audits will identify buildings to prioritise for retrofits.

Vehicles

Governments are also large purchasers of vehicles and related services (fuel, fleet management, etc). Even within the conventional, internal combustion engine (ICE) segment of the market, it is often the case that the vehicles with the lowest emissions in each class also have the lowest whole-of-lease costs, in part due to their higher fuel efficiency. Those same, more-efficient vehicles will continue to reduce energy costs and emissions in the second-hand vehicle market for at least a decade after their government fleet duty is over.

The benefits of government procurement of low emissions vehicles would extend well beyond the savings associated with the specific vehicles that are bought and leased. The advent of mainstream electric vehicles (EVs) and readily available 100% renewable electricity makes the achievement of zero transport emissions from light vehicles a realistic possibility in the medium term. However, the average emissions of the entire Australian vehicle fleet are being held higher than they might be by the lack of EV availability. Government driven procurement (by government or their leasing companies) of 200-500 examples of a specific model would be sufficient to ensure that manufacturers introduce that model to the Australian market.

Common concerns about EVs are that they can have high up-front costs, resale values are somewhat uncertain, range is limited, and public charging points are not widely available. However, none of these issues should prevent governments adding EVs to their fleets. Purchase costs and resale values can be well-managed through bulk buy negotiations. EV range is already beyond 200km, and public charging will not be a requirement for a large portion of fleet vehicles. By the mid-2020s range will have improved and there will be more publicly available fast charging points due to technological and market forces. In the meantime, we suggest that governments could speed the private delivery of public fast-charging, from 100% renewable electricity, by making the presence of fast-charging at service stations a requirement under government fuel/charge procurement contracts.

Electricity

Renewable electricity PPAs are rapidly growing in Australia, and some state, territory and local governments are already making use of them to realise significant financial and environmental benefits. They offer access to the benefits of utility-scale solar and wind projects, with their low and steadily declining costs, which can overcome site-based limitations on self-generation of renewable energy. It is widely reported that new renewable energy PPAs are being concluded at costs lower than those available through conventional NEM contracts. They also offer longer terms, of up to 15 years, if required, and thereby provide price certainty benefits that are not otherwise able to be accessed, other than via ownership of self-generation facilities. At the same time, a PPA frees governments and other clients of the need to install and manage renewable generation facilities. Given their financial as well as environmental benefits, there is very large scope for additional use of PPAs to deliver benefits to governments around Australia.

Overall

This study indicates that governments can realise sustainability benefits, including greenhouse gas emissions reductions, *at the same time as* they realise significant financial benefits, through more innovative approaches to procurement. While it is not possible to say that the performance of every building, fleet or energy procurement arrangement could be improved cost-effectively in this manner, it is likely that very many could. In each area examined, there are cautions expressed, as well as references to best-practice guides and experiences that can help to avoid the inevitable pitfalls. Overall, the generally attractive business cases and case studies described in this report should encourage governments to examine their own specific opportunities more closely.

Some of the opportunities described in this report are evolving rapidly and are expected to continue to do so into the future. Electric vehicles and renewable energy PPAs are two important examples. Building energy efficiency has also been improving steadily in the general market, and with genuine speed at the premium or A-grade end of the market, as represented, for example, by the *Better Building Partnership*. The pace of development of opportunities means that governments need to undertake regular market research and testing if they are to identify the best and most cost-effective solutions available.

The role that government procurement policies play in sending signals – both positive and negative – to market and suppliers should not be under-estimated. Government procurement is influential. Stronger policies will elicit more innovative and high-performance solutions from the market; while if governments, through their actions or policies, choose to procure at lower standards of efficiency and sustainability, then markets will also tend to deliver to those lower standards.

Recommendations

We offer the following recommendations for consideration:

1. Sustainable procurement should be the default approach to procurement of government supplies and services. This reflects:
    a. The scale of environmental impacts associated with government procurement activities.
    b. The scale of opportunities that government procurement provides to leverage positive environmental outcomes, in addition to value for money.
2. Agencies should make greater efforts to give effect to (often) existing sustainable procurement policies and guidelines or develop them if not already in place. Practices should be improved by following a reasoned and risk-managed sustainable procurement process, and by instilling sustainable procurement practice as the norm. A 5-step process is recommended:
    a. Understand your impact
    b. Understand your opportunities

c. Understand your willingness to pay and/or to accept risk

d. Test the market

e. Know and grow your market.

3. Where a new building is being commissioned by government – including where the building is to be privately-owned and leased long-term to government – the option of procuring a 100% electric building, with high energy efficiency and 100% renewable electricity supply, should be investigated.

4. Governments should ensure that their building leasing policies are maintained at best practice, by reviewing and revising them as appropriate at intervals of not more than 3 years. Where NABERS star ratings are specified, these should be the highest star rating that is cost effective. This is likely to be at least 5.5 stars, but this may vary from market to market.

5. Governments should ensure that their building leasing policies are enforced and complied with. At a minimum, all agencies should disclose the extent to which the facilities they occupy comply with the policies. Where compliance is less than complete, agencies should indicate the strategies they intend to use to reach full compliance, and the expected timeframes to do so.

6. For buildings owned by governments and intended to remain in government ownership for at least three years, the economic potential for upgrading the energy performance of each building should be established via level 3 audits.

7. Governments should facilitate upgrading the energy performance of government-owned buildings that are intended to remain in government ownership for at least three years by co-ordinating procurement for facility audits and upgrades, including arranging for innovative finance where needed, including enabling energy performance contracting.

8. Governments should update their vehicle procurement policies to give clear and high priority to fuel efficiency, greenhouse gas emissions and air pollution performance. EVs should be selected where a fit for purpose model is available. High fuel efficiency Euro VI vehicles should be selected in vehicle classes where EVs are not yet available. Precise performance standards/selection criteria should be regularly updated – every 1 to 2 years – over the next decade as technology and market change is expected to be rapid.

9. Joint purchasing of EVs and Euro VI vehicles should be pursued – to bring models to the Australian market that are available overseas. Future fuel purchasing arrangements for fleet vehicles should include a criterion that 100% renewable energy fast-charge points are available at service stations.

10. We recommend that renewable energy power purchase agreements be considered in all electricity procurement processes, noting the potential for price reductions and long-term price hedging, in addition to greenhouse gas abatement benefits. Joint procurement by

governments can maximise the cost-effectiveness of PPAs and should be pursued where practical.

1. Introduction

1.1. Background

This project has been commissioned by the Co-operative Research Centre for Low Carbon Living (the CRC), working in close collaboration with the Australian Government and, through it, a number of state and territory governments. It aims to assist with the implementation of Item 12 of the *National Energy Productivity Plan* (NEPP)- 'improving energy productivity in government'.

In 2015, the COAG Energy Council agreed that each government within the Council should endeavour to improve the energy productivity of their own operations. The NEPP Work Plan notes (p.10) that:

> *Governments can improve their energy use in a wide range of activities including: building requirements and green leasing tools; transport fleets; infrastructure development; schools and hospitals; and procurement. An effective programme may include minimum performance requirements, targets, metrics and monitoring.*

The Plan commits jurisdictions to work with each other and with stakeholders to share learnings in the development and implementation of these programmes to improve government energy use using the most effective approaches.

The CRC is a national research and innovation hub to enable a globally competitive low-carbon built environment sector. It is supported by the Cooperative Research Centres (CRC) programme. The CRC's mission includes developing new social, technological and policy tools for facilitating the development of low carbon products and services to reduce greenhouse gas emissions in the built environment. Consistent with this mission, the CRC is assisting with the delivery of a number of NEPP projects.

This project commenced in June 2018 with a project inception meeting in Canberra, attended by representatives of the Australian Government Department of the Environment and Energy, the ACT Environment, Planning and Sustainable Development Directorate, and the NSW Office of Environment and Heritage, who have volunteered to participate in a Project Steering Group, along with Dr Robert Crawford, Associate Professor in Construction at the University of Melbourne.

At the project inception, it was agreed that a scoping paper would be beneficial to help focus both the project and potential government contributions to it, including from jurisdictions that did not participate in the inception meeting. That paper:

- Summarised the project intentions and scope
- Defined the scope of government procurement in question
- Summarised current government procurement policies and guidelines
- Identified some of the main goods and services that are procured by government and their environmental impacts

- Explored opportunities to use procurement to improve energy and greenhouse gas (GHG) emissions performance and lower other environmental impacts
- Suggested a selection of priority opportunities for close investigation
- Requested data from the Project Steering Committee to assist opportunity investigation.

1.2. Scope and Timeline

This project aims to identify a small number of high-impact opportunities in the energy area where the potential to drive significant and cost-effective sustainability outcomes via government procurement strategies may exist. Our focus is on compiling evidence about the strength of these opportunities, with the aim of encouraging state, territory and federal governments to capture these through their procurement practices.

Since government procurement potentially covers a very wide field, key focus areas were nominated by governments, in the scoping phase of the project, as:

1. New high efficiency, all electric and low carbon buildings (offices, data centres, places of education, hospitals)
2. Requiring higher energy productivity buildings (driving retrofits)
3. High efficiency and lower carbon internal combustion engine vehicles - where duty cycles are not suited to electric vehicles (EVs)
4. EVs where duty cycles are appropriate plus provision of EV charging infrastructure
5. Energy procurement – consideration of power purchase agreements (PPAs) for renewable energy and provision for local energy trading from a microgrid ecosystem featuring renewable energy and storage on building sites.

Governments also requested the research team to identify any areas where different arrangements might be justified for capital cities and regional areas.

2. Government Procurement in Action – what goods and services are purchased?

2.1. Definitions

Procurement

The Australian Government's *Commonwealth Procurement Rules: Achieving value for money* states that:

> *Procurement is the process of acquiring goods and services. It begins when a need has been identified and a decision has been made on the procurement requirement. Procurement continues through the processes of risk assessment, seeking and evaluating alternative solutions, and the awarding and reporting of a contract.*
>
> *In addition to the acquisition of goods and services by a relevant entity for its own use, procurement includes the acquisition of goods and services on behalf of another relevant entity or a third party.*[1]

Sustainable procurement is defined by the Australasian Procurement and Construction Council (APCC) as:

> *A process whereby organisations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organisation, but also to society and the economy, whilst minimising damage to the environment.*

This definition was developed by the UK Government and has since been adopted by the APCC, the UN and is used in the Australian Government's *Sustainable Procurement Guide* and in state and territory guidance.

A related term, green procurement, has been defined as:

> *The selection of products and services that minimise environmental impacts. It requires a company or organization to carry out an assessment of the environmental impacts of a product at all the stages of its lifecycle. This means considering the environmental costs of securing raw materials, and manufacturing, transporting, storing, handling, using and disposing of the product.*[2]

[1] Paragraphs 2.7 and 2.8, Department of Finance, 2018, *Commonwealth Procurement Rules*, Commonwealth of Australia , 20 April 2019.

[2] United Nations Department of Economic and Social Affairs Division for Sustainable Development Policy Integration and Analysis Branch, 2008, *Sustainable Development Innovation Briefs - Public Procurement as a tool for promoting more Sustainable Consumption and Production patterns*

This definition could be also used for 'environmental' procurement. The UN explains that green or environmental procurement is narrower in scope than sustainable procurement which incorporates social considerations as well as environmental factors.

2.2 Current policies and objectives of government procurement

The *Commonwealth Procurement Rules* are "the keystone of the Government's procurement policy framework".[3]

The chief objective of the Rules is to ensure that the Australian Government receives value for money on goods and services that are procured. The rules state:

> *Achieving value for money is the core rule of the CPRs. This requires the consideration of the financial and non-financial costs and benefits associated with procurement.*

Value for money is considered in broad terms – it certainly does not merely entail selecting the good or service with the lowest upfront cost.

Key points, for the purpose of this project, are that obtaining value for money involves:

- considering financial and non-financial costs and benefits of procurement.
- Considering the environmental sustainability of the goods or services (such as energy efficiency and environmental impact).
- Considering whole of life costs such as initial price, maintenance, consumables and disposal costs.

More detail concerning the procurement rules are provided in Appendix A.

2.3. Current guidelines

The Department of Finance steers the Australian Government's procurement practice. They publish the *Rules* and other information. General guidance is provided online at the Department's "Buying for the Australian Government" webpage.[4]

Specific guidance is provided for certain types of procurement including ICT, vehicles and air travel.

ICT specific information is provided by the Australian Government's Digital Transformation Agency which has established numerous panels for cloud services, data centres, ICT hardware and other services and equipment[5].

[3] Department of Finance, 2018, Foreword
[4] See https://www.finance.gov.au/procurement/procurement-policy-and-guidance/buying/

[5] See https://www.dta.gov.au/what-we-do/policies-and-programs/ict-procurement/

Vehicle procurement and contract management for the Australian Government is handled by the Department of Finance's Australian Government Fleet team who have appointed sgfleet as the fleet manager from Feb 2013 to July 2019.

Travel procurement is coordinated under the Whole of Australian-Government Travel Arrangements. All domestic and international air travel and domestic ground travel must be booked through the single appointed Travel Management Company.

2.3.1. Guidance on sustainability – Australian Government

The *Commonwealth Procurement Rules* require that environmental sustainability is taken into account under value for money considerations.

The "Buying for the Australian Government" webpage also has a specific section on "Incorporating Sustainability" that consists of 4 principles, as set out below[6].

Incorporating Sustainability - Principles

1. For procurement, *sustainability* refers to a capacity for development that can be sustained into the future. Officials should employ sustainable practices when undertaking procurement, such as promoting reduced energy consumption and minimising waste where possible.
2. Value for money is the core principle underpinning Australian Government Procurement. In conducting a procurement, officials must take into account all relevant costs and benefits over the entire life of the procurement. Sustainability should be considered as part of this total cost assessment.
3. Designing sustainable approaches improves the value for money achieved by the procurement and introduces greater innovation in designing and implementing procurements.
4. Sustainable procurement practices can be demonstrated by:
   - including strategies that reduce demand or unnecessary consumption and end-of-life disposal;
   - considering future sustainability issues and policies in the planning process (such as higher energy costs and energy intensity targets);
   - encouraging sustainable solutions and innovation in tenders; and
   - measuring and improving sustainability throughout the life of the procurement.

[6] See https://www.finance.gov.au/procurement/procurement-policy-and-guidance/buying/policy-framework/incorporating-sustainability/principles.html

The Australian Government Department of the Environment and Energy has published a *Sustainable Procurement Guide.* This guide is available online in the National Waste Policy section of the Department's website.[7] There is a link to the guide on the Department of Defence's (who dominate Australian Government procurement spending) webpage on sustainable procurement.[8]

2.3.2. Guidance – States and Territories

The Australasian Procurement and Construction Council Inc (APCC) is a peak council with members involved in procurement and construction for the Australian, state and territory and New Zealand Governments.

Several states and territories provide sustainable procurement guidelines. Commonly they reference the APCC publication *ANZ Government Framework for Sustainable Procurement* published in 2007. The APCC also publish a *Sustainable Procurement Practice Note* and *Sample Templates for Sustainable Procurement Processes.*[9]

2.3.3. International Guidance

An international standard - *ISO 20400 Sustainable Procurement (Guidance)* was released in 2017. It is a guidance document rather than a standard designed for certification purposes.[10]

2.4. What do Governments Spend?

Government spending is not the same as procurement, as the latter refers to goods or services procured for the use of government. However, it is useful to appreciate the main areas of spending as this has a strong influence on procurement. Major categories and their shares of spending by all levels of governments are shown in the ABS chart below.

[7] See http://www.environment.gov.au/protection/waste-resource-recovery/publications/sustainable-procurement-guide (2018 edition)

[8] http://www.defence.gov.au/estatemanagement/governance/policy/environment/sustainableprocurement/default.asp

[9] http://www.apcc.gov.au/SitePages/Procurement.aspx

[10] See https://www.iso.org/publication/PUB100410.html

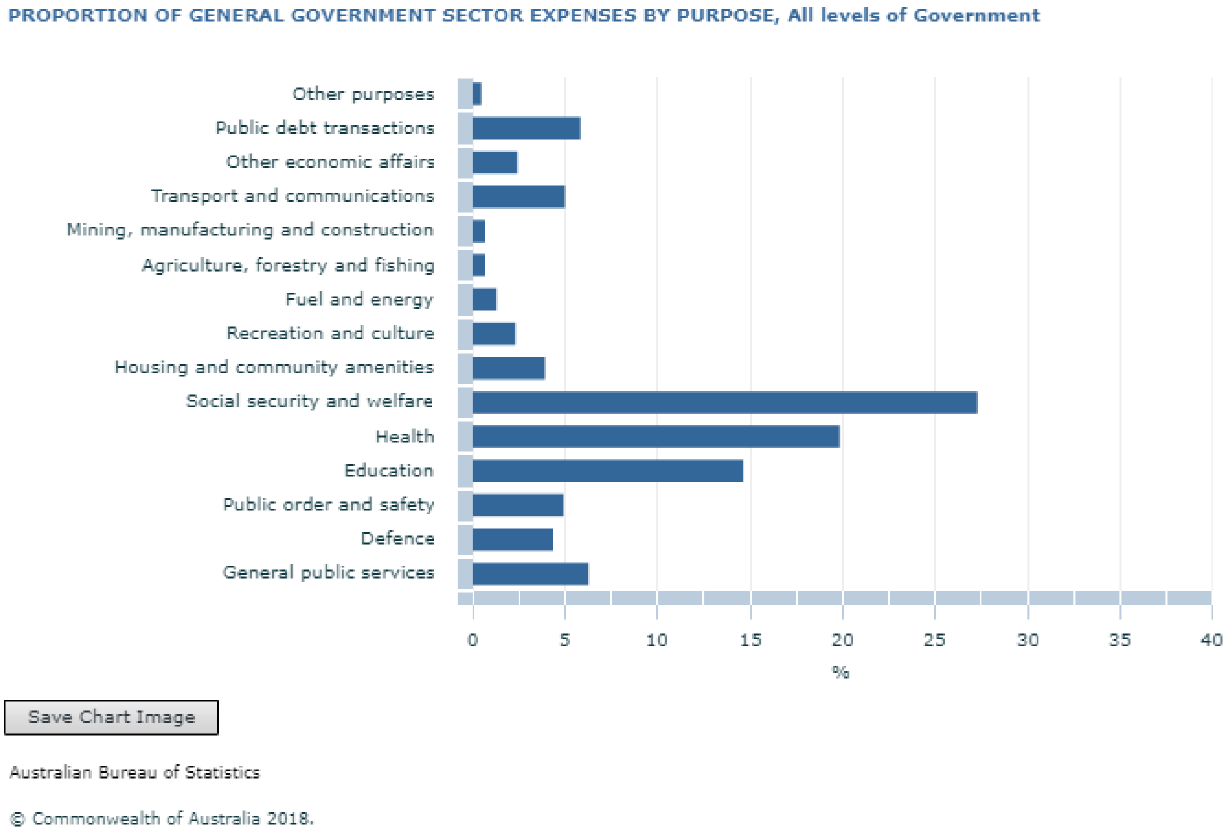

Figure 1: Categories and shares of government spending in 2016/17

The table below shows the amount of spending by category for each of the Australian, state and territory governments.

Table 1: Breakdown of 2016/17 Government spending

	Cwth	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	All Levels(b)
	$m	$m	$m	$m	$m	$m	$m	$m	$m	$m
General public services	25 121	3 362	1 620	2 081	321	517	233	110	663	39 167
Defence	27 340	-	-	-	-	-	-	-	-	27 340
Public order and safety	5 123	7 253	6 545	4 733	1 803	3 357	508	744	407	30 709
Education	33 368	18 821	14 259	12 349	4 502	7 058	1 466	1 158	1 120	91 271
Health	74 705	20 731	16 599	15 738	5 618	8 672	1 744	1 468	1 444	123 860
Social security and welfare	153 846	6 034	4 215	3 168	1 741	2 171	418	472	308	170 428

	Cwth	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	All Levels(b)
Housing and community amenities	7 714	3 059	3 260	1 529	975	1 526	172	609	240	24 478
Recreation and culture	3 568	1 294	767	1 260	425	790	208	228	174	14 354
Fuel and energy	6 641	26	180	634	76	470	4	158	27	8 209
Agriculture forestry and fishing	2 391	694	359	688	168	361	82	60	-	4 310
Mining manufacturing and construction	3 216	195	-	273	97	185	7	32	30	4 405
Transport and communications										
Road transport	6 977	4 188	2 403	2 483	646	1 619	246	243	300	17 866
Water transport	369	166	-	130	33	35	1	3	-	725
Rail transport	1 271	1 875	3 928	1 787	58	41	46	4	-	7 733
Air transport	183	-	-	1	2	10	-	7	-	217
Communications	835	1 523	193	1 077	548	638	5	39	94	4 796
Total	9 636	7 751	6 524	5 479	1 287	2 342	299	297	394	31 337
Other economic affairs	9 212	1 368	1 197	958	310	663	142	212	70	15 033
Nominal interest on superannuation	8 445	1 334	692	514	345	156	235	83	293	12 096
Public debt transactions	16 491	2 126	1 927	1 726	202	783	10	212	183	24 359
Other expenses	63 775	1 742	46	1 364	200	263	146	115	2	2 981
Total expenses	**450 594**	**75 790**	**58 189**	**52 493**	**18 070**	**29 314**	**5 674**	**5 957**	**5 355**	**624 337**

Source: ABS, 2018, *5512.0 Government Finance Statistics, Australia 2016-17*

2.5. What do Governments Procure?

A large quantity of Australian Government spending is made up of payments, rather than procurements. The largest areas of payments are social security and allocations to the states and territories for purposes like health, education and transport infrastructure.

Nevertheless, the volume of Australian Government procurement is large in terms of both value and number of transactions. In 2016/17 the Australian Government reported, via Austender, a total procurement value of $47.4 billion across 64,092 contracts.

Over 40,000 (66%) of those contracts were for goods or services below $80,000 in value; but making up just 3% of total value. The remaining 34% of contracts were for goods and services of $80,000 and up – these accounted for 97% of total AusTender reported Australian Government spending.

The Australian Government agency with the largest procurement task is the Department of Defence with a 69% share totalling $32.7 billion. The Department of Education and Training was next with 2.9% of procurement for $1.3 billion.[11]

Vehicles are the largest category of spending, followed by consulting services. The top 20 categories are listed in the table below.

Table 2: Australian Government Procurement: Top 20 Categories for Goods and Services (2016-17)

Category Title	Value $m	% of Total Value	% of SME Participation
Commercial and Military and Private Vehicles and their Accessories and Components	12,473.1	26.3	7
Management and Business Professionals and Administrative Services	9,164.3	19.4	44
Building and Construction and Maintenance Services	5,487.9	11.6	12
Information Technology Broadcasting and Telecommunications	3,304.2	7.0	44
Engineering and Research and Technology Based Services	3,196.7	6.7	45
Defence and Law Enforcement and Security and Safety Equipment and Supplies	2,767.1	5.8	27
Travel and Food and Lodging and Entertainment Services	2,619.0	5.5	1
Education and Training Services	1,705.8	3.6	24
Healthcare Services	1,338.4	2.8	15
Public Utilities and Public Sector Related Services	861.3	1.8	37
Politics and Civic Affairs Services	690.3	1.5	53
Transportation and Storage and Mail Services	650.3	1.4	47
Financial and Insurance Services	381.1	0.8	35
Laboratory and Measuring and Observing and Testing Equipment	267.3	0.6	75
National Defence and Public Order and Security and Safety Services	266.7	0.6	42
Environmental Services	248.2	0.5	60
Structures and Building and Construction and Manufacturing Components and Supplies	179.4	0.4	22

[11] Department of Finance, "Statistics on Australian Government Procurement Contracts" webpage, Department of Finance website. Last accessed on 2 June 2018 at https://www.finance.gov.au/procurement/statistics-on-commonwealth-purchasing-contracts/

Category Title	Value $m	% of Total Value	% of SME Participation
Electronic Components and Supplies	163.7	0.3	64
Chemicals including Bio Chemicals and Gas Materials	162.6	0.3	1
Drugs and Pharmaceutical Products	155.0	0.3	7
Total of Top 20	46,082.4		

Source: https://www.finance.gov.au/procurement/statistics-on-commonwealth-purchasing-contracts/

Buildings

The Australian Government provided certain data on its use of buildings. In total, 2.7 million sqm of building space is noted in this data set, distributed across 1,121 properties around Australia, of which over 92% were leased from the private sector, just under 2% leased from state governments, with the balance (just under 6%) owned by the Commonwealth. Of these properties, and as at 30 June 2017, just under 39% had NABERS ratings, with an average NABERS rating of 3.4 stars. 26% of the properties are rated 4 stars or more, and just over 12% are rated 5 stars or more. While energy consumption is not noted, the annual energy cost totals almost $79 million. This indicates the potential to achieve significant energy cost savings is likely to exist, as explored in Section 4.2 on existing building retrofits.

2.5.1. State and territory procurement

State and territory procurement areas are similar to the Australian Government, but the shares differ due to the splits in responsibilities of the levels of government. Defence is handled solely by the Australian Government while the states and territories procure more in the areas of hospitals, road construction and other social and economic infrastructure and services.

2.6. Impacts of government procurement on the environment

There are numerous direct and indirect environmental impacts related to government procurement. Some of the major procurement areas and related high-level impacts are tabled below.

Table 3: Procurement types and environmental impacts

Area of procurement	Some significant environmental impacts
Vehicles	Fuel use - GHG emissions and pollution. Supply chain pollution and waste. Operational waste – tyres etc.
Services – management, engineering, education, transport etc	Building and travel energy use by service providers – GHG emissions, pollution. Waste generation by service providers.
Health – hospitals, community health, products, transport	Energy use - GHG emissions and pollution. Products & equipment supply chain pollution. Waste
Construction – roads, buildings and other infrastructure	Cement use – GHG emissions. Operational impacts on energy use and emissions. On-site ecological impacts
ICT services and equipment	Data centre and equipment energy use – GHG emissions. Waste
Building services (occupancy related)	Energy use - GHG emissions. Waste
Defence and police equipment	Material use – associated energy, GHG emissions, pollution, waste
Health & education equipment	Material use - associated energy, emissions, waste
Travel services – flights, car hire and accommodation	Aircraft, car & building energy use – associated GHG emissions and pollution
Energy (electricity, gas, etc)	GHG emissions, on-site ecological impacts, pollution

3. Opportunities to Lower Environmental Impacts Associated with Government Procurement

3.1. Current Action in Australia

Examples of sustainability-focused procurement activities and policies include:

- The Australian Government's Energy Efficiency in Government Operations (EEGO) policy. EEGO dates from 2006 and sets minimum energy intensity targets for agency office use. Targets are achieved through use of Green Lease Schedules which uses NABERS to measure the energy efficiency of office buildings. EEGO also requires energy performance reporting by agencies and that the Department of Defence uses a comprehensive energy management system.
- NSW has recently updated its Government Resource Efficiency Policy (GREP). GREP aims to reduce the NSW Government's operating costs and lead by example in increasing the efficiency of its resource use. The GREP has 13 measures that set targets, standards and reporting requirements across energy, water, waste and clean air. It applies to all general government sector agencies but not to state owned corporations or local councils, although they are encouraged to follow the policy. Improvements to the GREP include:
    - the requirement for agencies to implement energy efficiency upgrades at eligible sites has been made simpler and clearer with the aim of encouraging increased compliance (aggregate savings approach)
    - minimum energy performance ratings for government buildings (owned, leased and newly built) and new appliances have been strengthened to remain at the forefront of market trends and deliver increased cost savings to government
    - a requirement for agencies to install solar PV to contribute to the government's solar target of 25,000 MWh per year by 2021 and 55,000 MWh per year by 2024.
- The NSW Government has a new NSW Electric and Hybrid Vehicle Plan[12], as part of the Future Transport 2056 series. The Plan has an excellent discussion of the benefits and challenges associated with a transition to electric vehicles. The Plan also states NSW's commitment to "set a 10 per cent target for new NSW Government general purpose passenger fleet cars from 2020/21 – with 10 per cent of new vehicles purchased or leased by agencies to be electric or hybrid vehicles".The ACT Government has a goal to achieve carbon neutrality for government activities by 2020. This will be achieved through a variety

[12] NSW Government, NSW Electric and Hybrid Vehicle Plan: Future Transport 2056. Available at https://future.transport.nsw.gov.au/plans/nsw-electric-and-hybrid-vehicle-plan

of means including procurement of 100% use of renewable electricity and the lease of electric passenger vehicles.[13]

- The Victorian Government has a Social Procurement Framework.[14] This includes some sustainability focused features that include working towards the offsetting of all travel GHG emissions and asking potential suppliers to explain how they act sustainably. Another Victorian initiative is the procurement of renewable energy certificates from wind and solar farms. About half of the solar farm electricity output will be linked to the consumption of Melbourne's trams.[15]

It is also useful to note the recent Senate report *Never waste a crisis: the waste and recycling industry in Australia.* Chapter 7 of the report calls for national leadership on management of waste and recycling. It notes that procurement policies will need to address issues such as waste reduction and material choice/recyclability. The report recommends concerted efforts to establish a circular economy and that "the development of domestic markets should be supported through the prioritisation of sustainable procurement of recycled content in all levels of the government supply chain".[16]

We recognise that waste and recycling is not the chief focus of the Steering Committee. However, the proposed inclusion of any sustainability requirement into procurement processes is positive and presents an opportunity to extend sustainability requirements to include energy and emissions considerations.

3.2. International Recommendations and Good Practice in Sustainable Procurement

This section briefly discusses some of the ways that procurement is used to advance government objectives around improved sustainability, energy and environmental performance.

Broadly speaking, it is clear that governments should be seeking to procure sustainably. Goal 12 of the UN's Sustainable Development Goals – developed by the international community – is to "Ensure sustainable consumption and production patterns". Target 12.7 is to "Promote public procurement practices that are sustainable, in accordance with national policies and priorities".[17]

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[13] See https://www.environment.act.gov.au/cc/what-government-is-doing/act-government-operations

[14] See http://www.procurement.vic.gov.au/Buyers/Social-Procurement-Framework

[15] Victoria's Renewable Energy Action Plan, see https://www.energy.vic.gov.au/renewable-energy/victorias-renewable-energy-action-plan

[16] Paragraph 7.8, page 113, The Senate Environment and Communications References Committee, June 2018, *Never waste a crisis: the waste and recycling industry in Australia*

[17] United Nations, Department of Economic and Social Affairs, Sustainable Development Knowledge Platform Website, Sustainable Development Goal 12 webpage, see https://sustainabledevelopment.un.org/sdg12

Many governments are acting on this target across a wide range of sustainability issues. Figure 2 shows the 29 issues addressed by 41 national governments who participated in the UN's *Global Review of Sustainable Procurement 2017.* Resource efficiency is the most common area of endeavour, pursued by 71% of the participating governments. **Figure 3** below shows the many categories of products and services where sustainable procurement is applied.

The UN expects that the new standard, *ISO 20400 Sustainable Procurement* released in 2017 will further aid governments and other organisations in the implementation of sustainable procurement practices.[18]

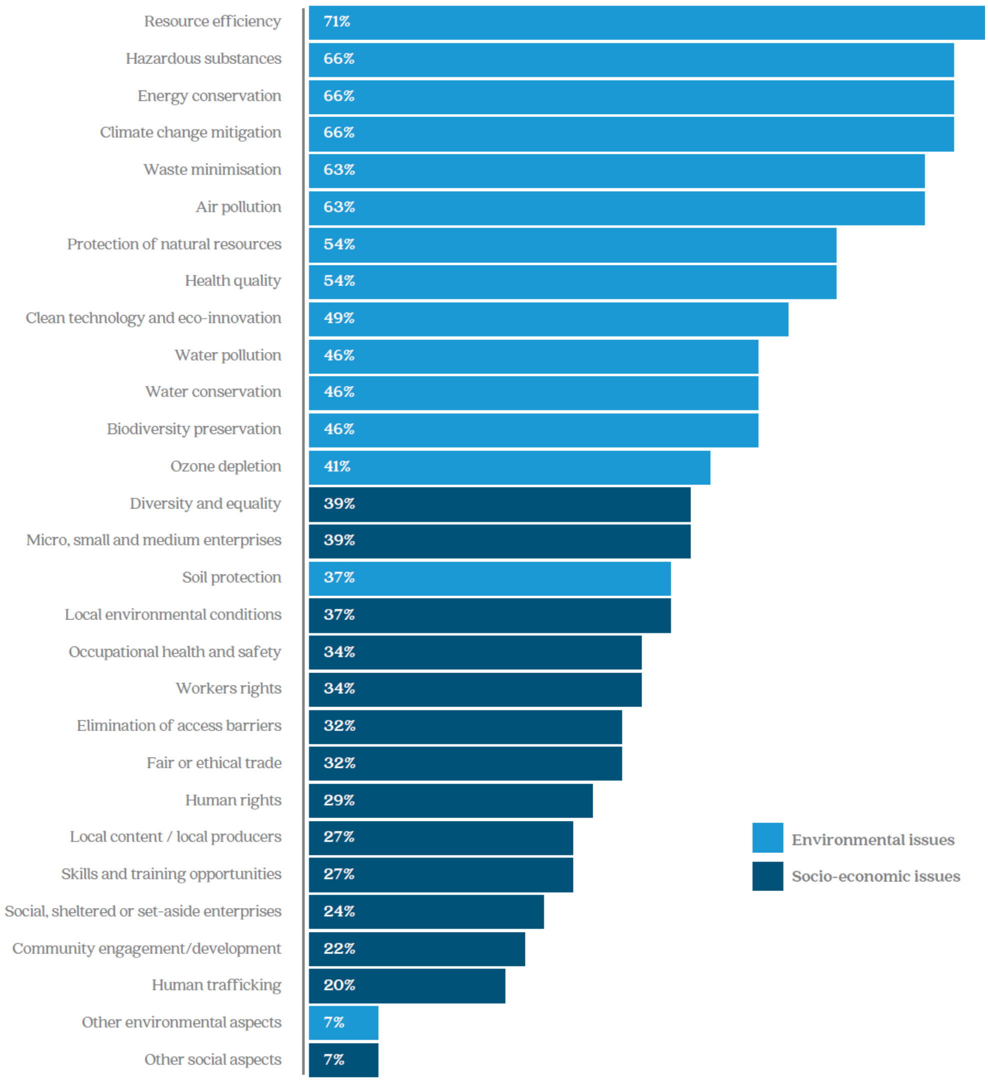

Figure 2: Issues addressed by Government sustainable procurement practices

Source – Figure 10 in UN, 2017, *Global Review of Sustainable Procurement 2017*

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[18] See ISO website - https://www.iso.org/news/Ref2178.html

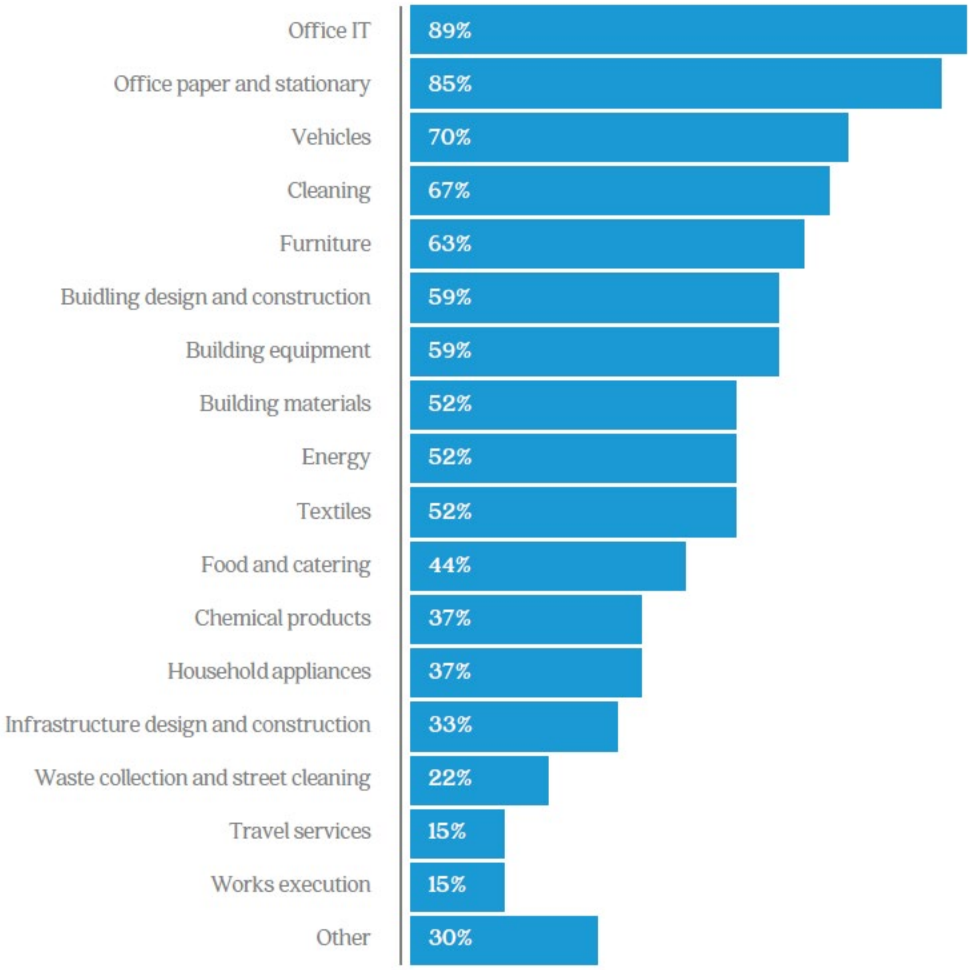

Figure 3: Priority areas of sustainable procurement for national governments

Source: Figure 13 in UN, 2017, *Global Review of Sustainable Procurement 2017*

The UN notes that there is a positive move towards the inclusion of sustainability criteria across multiple categories of products and services. There are also more efforts being made to use tightly defined and specific criteria (clear requirements and standards as opposed to general concepts) to ensure that measurable contributions to goals such as emissions reductions and the creation of a circular economy are made.

These governments implement sustainable procurement programs for at least four reasons. These are:

1) improved lifecycle cost effectiveness;
2) the ability to directly achieve impacts in social and environmental areas (such as equal opportunity employment and lower emissions);
3) the ability to influence market suppliers to shift to more sustainable practices and technologies – spreading the impacts of direct procurement across non-government market dynamics;

4) the ability to raise awareness, then demand, among non-government consumers for more sustainable products and services by demonstrating leadership and setting an example.

These last two reasons can be combined under the term market transformation.[19]

3.2.1. Market Transformation

Market transformation initiatives, including government procurement strategies, are promoted by the International Energy Agency (IEA) in the area of clean energy and energy efficiency.[20] Sustainable market transformation can be defined as:

> *the strategic process of intervening in a market to create lasting change in market behaviour by removing identified barriers or exploiting opportunities to accelerate the adoption of sustainable products and services that are cost effective; so that sustainable characteristics become widely available across a class of products or services*.[21]

Procurement has long been used to contribute to market transformation in several areas of procurement, including equipment, vehicles, buildings and energy services.

The extent of market transformation can be particularly high when government purchases have a significant market share – such as in construction, health services and public transport[22].

The construction market is a good example of where procurement policies can positively influence market dynamics.

An important commercial risk for suppliers of products and services is that innovation, or offering higher than market-norm sustainability performance may not be justified by the extent of existing market demand. This is particularly the case where standards have been static over long periods of time (eg, the National Construction Code; state/territory office procurement standards). Procurement policies can overcome this commercial risk by introducing a minimum level of demand for higher performance products and services.

Over time, for example in the Adelaide office market, the average level of energy and emissions performance can shift substantially up, achieving a 'market transformation' outcome.

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[19] United Nations Department of Economic and Social Affairs Division for Sustainable Development Policy Integration and Analysis Branch, 2008, *Sustainable Development Innovation Briefs - Public Procurement as a tool for promoting more Sustainable Consumption and Production patterns*

[20] IEA, 2010, *Transforming Global Markets for Clean Energy Products – Energy Efficient Equipment, Vehicles and Solar Photovoltaics*

[21] This definition is a broader version of the energy efficiency focused definition published by the American Council for an Energy Efficient Economy (ACEEE). See https://aceee.org/portal/market-transformation

[22] OECD, 2015, *Going Green – best practices for sustainable procurement*

3.2.2. Joint Procurement

When governments come together to pool their purchasing power and undertake joint procurements, higher direct impacts and greater market effects are achieved. LED street lighting is an area where local governments are collaborating to accelerate the realisation of significant energy savings. In NSW, the Light Years Ahead program involved joint procurement by nine Western Sydney Councils and was facilitated by WesROC, the Western Sydney Regional Organisation of Councils. This program led to almost 14,000 LED street lights being installed across Western Sydney, saving participating Councils $20million and 74,000 t CO2-e over 20 years. Similar schemes are running right around Australia. While the key theory of action here is economies of scale, the other benefits from this approach include rapid learning, sharing of successes and failures, negotiating leverage not only with LED lamp suppliers but, critically, with electricity network businesses (who perceive energy efficiency as a threat to their business model).

3.2.3. Low Emission Vehicles

The vehicle market is another area where governments can achieve transformative impacts on markets while also achieving cost, fuel and emissions savings.

The availability of a choice of low emission vehicles, such as electric vehicles (EVs), is a necessary enabler of improvement in the average emissions performance of a fleet.

A recent study of the Australian Electric Vehicle Market Study found that Australian has much lower availability of EV models than other comparable countries and markets.[23] This is demonstrated in the chart below.

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[23] Energeia, 2018, *Australian Electric Vehicle Market Study*, report for Australian Renewable Energy Agency and the Clean Energy Finance Corporation

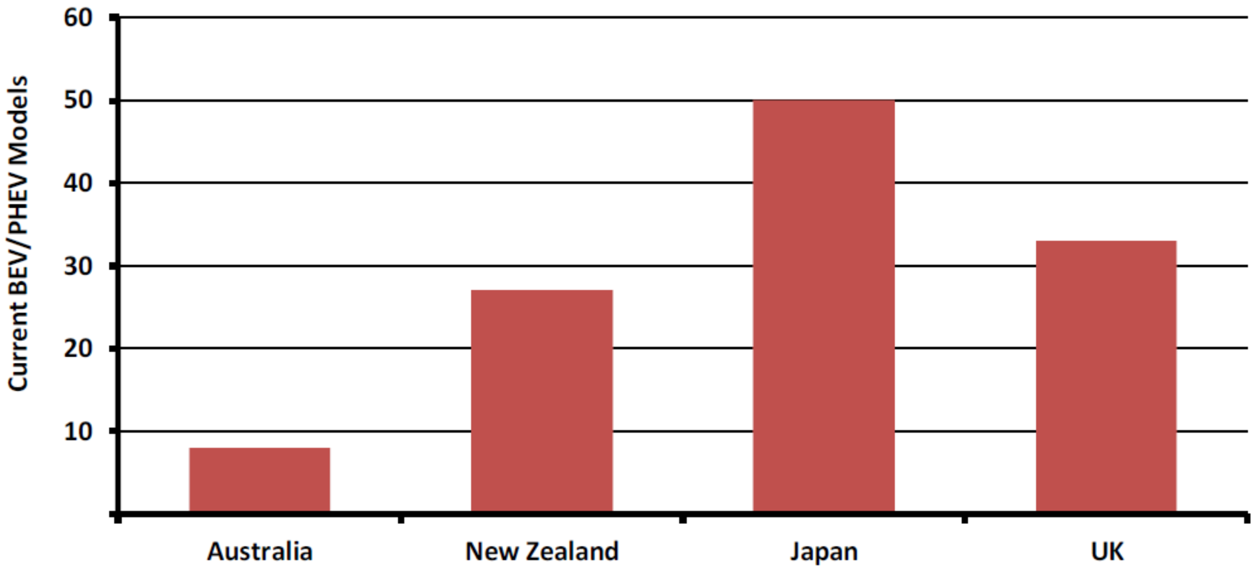

Figure 4: EV model availability in right hand drive markets (Source: Energeia)

It is to be expected that Australia has a smaller choice of models than Japan - a major car manufacturing nation with a population over 120 million. However, Australia is a sizable market with almost 1.2 million new vehicle sales in 2017 so the almost complete absence of EV choice is striking.[24]

The study found that procurement targets would be effective in boosting EV model availability in Australia. A government program involving the annual purchase of 200-500 particular models per year bought through a fleet arrangement was estimated to be sufficient to introduce the scale of demand required for car makers to bring those models to the Australian market. The underlying demand, supplied by government procurement, would help achieve an earlier transition to EVs than would be otherwise achieved under current policy settings.

Government vehicle requirements are sizable; the purchase of 200 to 500 examples per year of a specific model is plausible. Government fleets total over 200,000 vehicles and in 2015 governments across Australia purchased 50,000 vehicles.[25]

3.2.4. Examples of good international performance in sustainable procurement

Ghent

Belgium's City of Ghent has a population over 250,000 and an annual procurement spend of over 400 million euros. Ghent adopted a sustainability action plan in 2008 which included aim of

[24] Federal Chamber of Automotive Industries, web article, "Record Year for Motor Industry in 2017", see https://www.fcai.com.au/news/index/index/year/2018/month/all/article/515

[25] Parliament of Victoria, Economy and Infrastructure Committee, May 2018, *Inquiry into electric vehicles*

integrating sustainability criteria into all contracts. A procurement specific strategy was developed to aid implementation from 2012 and updated in 2014. Achievements include:

- Use of 100% renewable electricity since 2008
- Use of cradle-to-grave certified cleaning products in all buildings
- Cleaning services supplied by socially vulnerable groups
- Requirements since 2012 for passive-house and nearly energy-neutral buildings
- Purchase of hybrid electric and battery electric vehicles for the City fleet.[26]

Energy Star in US states

Energy Star is an energy performance label that indicates that a product or system such as a computer or HVAC equipment is in the top tier of energy efficiency within a product class.

Massachusetts, is one US state that specifies an Energy Star purchasing requirement through an Executive Order. Massachusetts state agencies are required via Executive Order 515 to procure only Energy Star rated office equipment, appliances, HVAC equipment, and other ENERGY STAR rated products unless such products can be demonstrated to be cost prohibitive over their life.[27]

Vancouver - City owned buildings

Vancouver, Canada, brought in its Greenest City 2020 action plan in 2011. One of the actions is that all new city owned buildings must be constructed to Leadership in Energy and Design (LEED) Gold standard. Vancouver also aims above LEED Gold in certain cases. The Creekside Community Centre was built to the highest LEED standard of Platinum.[28] Vancouver's VanDusen Botanical Garden Visitors Centre targeted the Living Building Challenge – which involved on-site generation of renewable energy, very high energy and water efficiency and on-site capture and treatment of water.[29]

3.3. Sustainable Procurement Practice

It is one thing for government to adopt broad sustainable procurement policies or guidelines. However, it is not always evident that governments are translating these broad policies and guidelines into effective practice.

[26] United Nations Environment Programme, 2017, *Global Review of Sustainable Public Procurement 2017*
[27] US EPA, Energy Star website. See page https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products/purchasing-case-studies

[28] See https://vancouver.ca/green-vancouver/green-city-facilities.aspx

[29] See https://living-future.org/lbc/case-studies/vandusen-botanical-garden-visitor-centre/

Barriers to sustainable procurement

There are various reasons for the disconnect between broad intent and action. There is little evidence that this approach to procurement is prioritised or required within government at state/territory and national levels or by senior government officials. A focus on 'value for money', as many procurement policies do, should encourage sustainable procurement, but in practice does not appear to. Annual budget considerations appear to remain the primary consideration, while opportunities to maximise public benefits are less often considered.

Some of these barriers are not easily overcome. Politics will continue to move in cycles and procurement will remain a dry subject. Nevertheless, the objective of achieving value-for-money through procurement is a principle that has long been agreed by all governments and senior officials. Sustainable procurement aids the achievement of value-for-money, by enhancing the total benefits obtained for a given level of expenditure. Accordingly, agencies should strongly embed sustainability into their procurement processes. We suggest a method below.

Adopting sustainable procurement practices

How should sustainable procurement be embedded? Which procurement processes should be prioritised? What criteria should be specified? How can these be evaluated objectively?

There are choices to be made, which may for example reflect the scale of procurement activity. If the scale is small, a simplified approach may suffice, at least to get started.

We suggest a first focus on the major opportunities reviewed in this report: procurement of energy, buildings and vehicles – which are relatively small and simple areas of government procurement. If the scale of procurement is larger, a social benefit cost analysis may be justified, to identify specific damage costs associated with the procurement activity, and also those opportunities with the largest net benefit.

We recommend a 5-step process, as follows.

1. **Understand your impact**

Each agency's operations and supporting procurement process will create a unique mix of impacts, even if there may be common elements, such as those reviewed in subsequent chapters. An internal or commissioned review aimed at quantifying these impacts will generate the beginnings of a prioritised sustainable procurement plan. This process should aim to list, for all significant procurement activities:

- Procurement type (eg, electricity, vehicles, waste disposal)
- Value (eg, from previous year)
- Quantity/activity indicators (no. of vehicles, litres of fuel, vehicle kilometres travelled, MWh of electricity, MJ of gas, etc)

- Quantifiable environment impacts (tonnes of greenhouse emissions, quantity of air/water emissions (eg, from vehicle use, electricity consumption)) – note that an attempt should be made to keep the number of categories as few as possible, to facilitate comparative assessment and ranking.
- Rank opportunities using a simple multi-criteria analysis frame – for example, each criterion (cost, ghg emissions, units of waste) can be ranked from 1 (for the highest impact in each category) to x. The resulting ranking does not a represent a final decision, but rather an indication of which activities should be prioritised for the next evaluation phase.

2. Understand your opportunities

- In order of priority from the initial ranking, investigate the specific opportunities to procure more sustainable outcomes. Examples of this are provided in the subsequent chapters. Broadly the task is to establish what are the best practices/opportunities available, or that could be available, in each market. This research – which could again be conducted internally or with the assistance of service providers – will quantify the unit reduction in impact that is available, such as reduction in greenhouse emissions per unit of energy consumption and in total, reduction in vehicle emissions per km and in total, etc.
- Estimate the potential savings in terms of avoided impacts – such as tonnes of greenhouse gas emissions or litres of fuel. If a social benefit cost analysis framework is used, this could include a quantification of avoidable damage costs. However, a less formal process could rank the opportunities either in units of impact (tonnes of emissions or air emissions, etc) or by value (avoided cost).
- Re-rank opportunities from step 1 in order of expected savings. This could be based on a formal valuation of avoidable net social cost or, more simply, expected scale of savings. Clearly, comparing the importance of one emission or impact with another may not be readily apparent. Social benefit cost analysis provides an option to do this, but it may also be that a less formal approach will enable the highest impact opportunities to be identified. Also, if it is intended that all or most of the noted opportunities will be targeted for realisation, then precise valuations and rankings are less important.

3. Establish your willingness to pay/accept risk

- Low-impact options may be associated with new technologies, processes or products that, to varying degrees, may involve some degree of risk for the procuring agency. In some cases, there will also be additional costs, although in other cases there will be financial savings. The agency's willingness to bear these potential risks and costs could be established in advance – for example, if risks related to critical missions or operations, then the tolerance for risk, or minimum acceptable performance characteristics, should be quantified.
- Therefore, before testing market opportunities, it is important – as with any procurement process – to be clear about critical or minimum-acceptable performance criteria. This can

include fitness for purpose criteria, performance criteria, acceptable failure rates/repair time, and business continuity considerations. It is important that, to the extent possible, such criteria are specified in a manner that is performance- and outcome-based, and do not inadvertently preference a less sustainable supplier (or incumbent) or exclude a more sustainable one. At the same time, it is legitimate for all procuring agencies to set acceptable performance parameters and to reject offers that cannot meet them. However, it should be understood that poorly-specified or unnecessary performance requirements can exclude more sustainable suppliers. Agencies should review procurement terms to ensure that such risks are minimised.

4. Test the market

- Expression of interest processes can then be used to determine the willingness of suppliers to offer more sustainable alternatives and at what cost. The procurement process must specify the impact parameters and metrics that suppliers should quote against – ambiguity here will lead to offers that are difficult to compare and evaluate. Minimum performance benchmarks could be specified – but these would need to reflect research undertaken at step 2, to ensure they are deliverable by the market – or they could be open-ended, asking the tenderer to identify their best offer.
- To the extent that this process identifies that premiums may need to be paid to secure specific sustainability benefits, again it would be possible to evaluate the extent to which these represent value for money from a societal perspective using social benefit cost analysis. This could include indicators of (relative) cost effectiveness, such as the marginal abatement cost of opportunities in units such as $/tonne of avoided carbon. Alternatively, less formal processes could be used to establish the agency's willingness to pay to secure particular outcomes.

5. Know and grow your market

- Competition between suppliers can induce the market to invest, innovate and improve quality. An active process of government procurement that seeks to leverage outcomes both in terms of improved environmental impacts and reductions in cost/improvements in performance/quality, is known as market transformation, as noted above.
- Some research may be required by agencies – or, better still, governments – to identify their potential market leverage in key impact areas (eg, emissions, vehicle choice). Joint procurement can enhance this leverage, and of course is already generally to seek lowest cost outcomes, for example, through centralised vehicle leasing or electricity contract procurement. However, this same process can – and should – be used to identify the largest opportunities to leverage improved sustainability performance.
- Beyond the scale of procurement, other parameters will be important in determining the market's response, including over time, to sustainable procurement practices. The term of procurement contracts is important, for example. This should be sufficiently long so as to

enable the supplier to make what may be necessary investments in new capacity or technology, in order to deliver a sustainability benefit. At the same time, there is a risk that if such an arrangement is for 100% of a market, then all other potential suppliers will be 'frozen out', and potentially for many years, with potentially damaging consequences for sustainability outcomes overall. Similarly, too large a procurement process may not be accessible by newer and smaller market players with innovative and more sustainable offers.

- To successfully grow and transform markets for sustainability outcomes, governments must know their markets, and actively seek to grow the market for more sustainable outcomes. Too much or too little; too large or too small; too soon or too late – each of these could lead to sustainability opportunities being missed. An active approach based on market research, clear performance metrics, and clarity about tolerance for risks and/or cost premiums.
- Finally, social benefit cost analysis could again be used to determine the extent to which additional costs incurred in a government procurement process may be more than outweighed by wider social benefits over time. As an example, government procurement of low emission and/or electric vehicles could help develop and grow the availability of such vehicles in the second-hand market, with benefits that may persist for a decade or more beyond the initial procurement life.

Recommendations

From the material covered in this Chapter and Chapter 2, we offer the following over-arching recommendations:

1) Sustainable procurement should be the default approach to procurement of government supplies and services. This reflects:
   a) The scale of government procurement in Australia, and the consequent opportunities it provides to leverage positive environmental, social and economic outcomes in addition to value for money.
   b) The scale of environmental, social and economic impacts associated with government procurement activities.
2) Agencies should give effect to (often) existing sustainable procurement policies and guidelines by following a reasoned and risk-managed sustainable procurement process, and by instilling sustainable procurement practice as the norm. This process and practice should be based on a 5-step process:
   a) Understand your impact
   b) Understand your opportunities
   c) Understand your willingness to pay and/or accept risk
   d) Test the market

e) Know and grow your market.

3.4. Opportunities for Detailed Analysis

The government members of the Project Steering Committee for this project report to the COAG Energy Council. It is recognised that the Steering Committee does not have the ability to make or change departmental or whole of government procurement policy. Nevertheless, one of the Energy Council's principles is that greater productivity, energy efficiency and sustainability are core goals. This paper aims to help governments understand the opportunities and overall business case for specific procurement options, as nominated by the governments themselves. The prioritised opportunities were identified as:

1. New high efficiency, all electric and low/zero carbon buildings (offices, data centres, places of education, hospitals)

2. Requiring higher energy productivity buildings (driving retrofits)

3. High efficiency and lower carbon internal combustion engine vehicles - where duty cycles are not suited to electric vehicles (EVs)

4. EVs where duty cycles are appropriate plus provision of EV charging infrastructure

5. Energy procurement – consideration of power purchase agreements (PPAs) for renewable energy and provision for local energy trading from a microgrid ecosystem featuring renewable energy and storage on building sites

For efficiency, these six opportunities have been grouped into three main chapters below, covering:

- Buildings (new and existing)
- Low-emission and electric vehicles (and charging infrastructure)
- Renewable energy procurement.

This prioritisation should not be read as indicating these are *necessarily* the most productive areas for attention within the overall field of sustainable procurement. However, they do represent major areas of procurement cost for virtually governments and agencies across Australia, and they also present significant opportunities for both cost and harm reduction. For particular agencies, there may be other and more important procurement categories, and the practices noted at Section 3.3 above would enable these to be identified and evaluated as opportunities.

4. Buildings

4.1. New High-Efficiency, All-Electric and Low/Zero Carbon Buildings

4.1.1. Introduction

Electricity is already the dominant fuel (energy carrier) for most buildings in Australia. The Commercial Building Baseline Study notes that around 90% of total energy consumption in offices, on average across Australia, is electricity. Electricity also accounts for 65% of energy in hotels, on average; 69% in universities; 90% in schools; over 95% in retail shopping centres; up to 100% in supermarkets.[30] Indeed, hospitals was noted as the only building class where, on average, natural gas and LPG exceeded electricity use (51% gas + LPG). This is due to the use of gas for steam-raising, laundries, cooking as well as space-heating, while co- or tri-generation from gas is common in hospitals, due the more balanced nature of electrical and heat loads than are found in many other building classes. While not documented in the Baseline Study, it is also understood that there are significant regional variations in fuel mix, with greater use of gas in the cooler climates of the ACT and Victoria (but not Tasmania, due to the limited availability of gas).

Traditionally, decisions about the fuel mix in new buildings has reflected:

1. The utility offered by the available fuels
2. The availability of substitute fuels and technologies
3. The relative costs of delivered energy services via different available fuel and technology pathways.

Utility is well illustrated by the example of lighting: while it is technically feasible to use gas or other fuels (kerosene, paraffin) for lighting, electricity is preferred in close to all applications due to the absence of combustion by-products and superior lighting intensity and quality. Similarly, while there have been start-ups promoting hydrogen fuel-cell powered laptops,[31] it may be some time before electricity is replaced by other fuels in information technology, office equipment and related end-uses. The fuel choice for these end uses is not determined by relative cost considerations, but rather by perceptions of utility and the lack of viable substitutes.

While lighting and IT may be dedicated electrical end-uses, space heating, hot water heating and cooking in commercial buildings can and often do use gas. In the past, the lower cost of gas saw it be used for space heating and hot water applications in particular, at least in regions of Australia where it is reticulated, and notably in Victoria where gas prices where traditionally the lowest in Australia. In commercial kitchens, gas may be the most common fuel for cooking (although little

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[30] COAG National Strategy on Energy Efficiency, *Baseline Energy Consumption and Greenhouse Gas Emissions in Commercial Buildings in Australia, Part 1 – Report*, November 2012.
[31] https://qz.com/439998/a-grid-free-laptop-powered-by-fuel-cells-is-in-development/, viewed 13/11/2018.

data on the energy use of commercial kitchens in Australia is in the public domain), even if induction hobs are increasingly being used in this application (see below).

Gas uses vary by building type and climate zone, but typical gas profiles are shown below for office base buildings (tenancies generally use close to 100% electricity) (Figure 5) and hospitals (Figure 6) These are drawn from the 2012 Baseline Study and therefore now somewhat dated, but also unlikely to be significantly changed.

Figure 5: Average Office Base Building Gas End-Uses

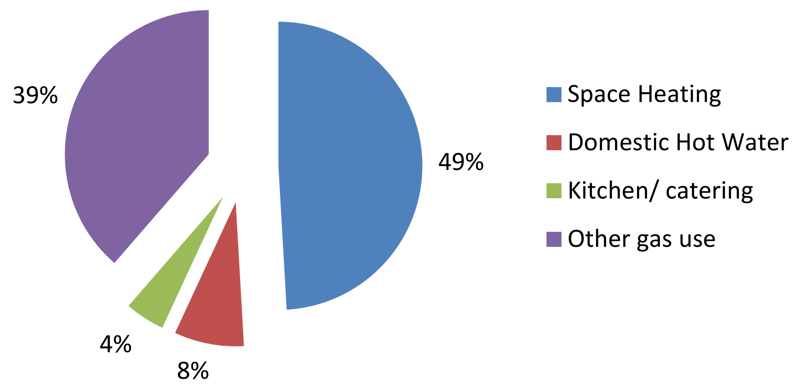
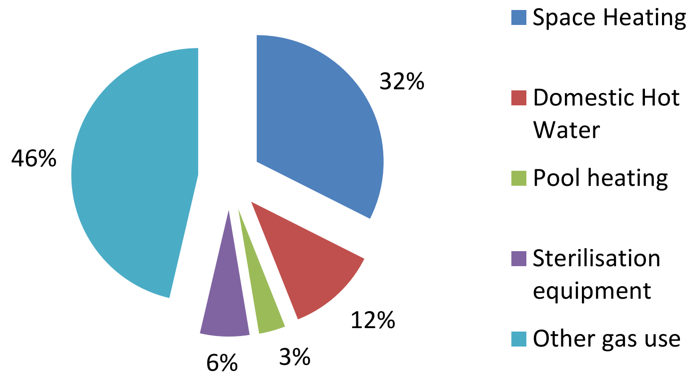


Figure 6: Average Hospital Gas End Uses



Hospitals show a greater number of different gas end uses than other building types. The large share of 'other' gas use in hospitals is likely to include cogeneration and steam raising in gas boilers for use in laundries. For offices, 'other gas' consumption is not defined in the underlying data source but is likely comprise cogeneration for the most part (noting, from the source data, that only 5/191 buildings in the relevant sample consumed gas for this 'other' purpose).

For other building types that may be government owned, data from the ACT showed that 92% of gas use in schools in that territory was for space heating and 8% for domestic hot water. Also, a limited sample of law courts showed that, on average, 90% of gas use was for space heating, 8% domestic hot water, and 2% kitchen/catering.

Today, the optimal fuel mix for buildings is being reconsidered for three main reasons:

1. Relative price changes for electricity and gas
2. The efficiency of new electrical technologies in end-uses previously dominated by gas, and changes in the relative prices of gas and electrical technologies
3. The changing implications of fuel and technology choices for greenhouse gas emissions.

The prices paid for electricity and gas at the point of consumption (for example, for a commercial office building or hospital) are increasingly opaque, as energy tariffs multiply in number and complexity, and standing offer tariffs play a smaller and smaller role in retail markets. However, an insight can be gleaned from the 2017 *Independent Review into the Electricity and Gas Retail Markets in Victoria*, as this study captured actual bill data (for May 2017). It found that the actual delivered cost of energy for a typical small business at that time was $14.85/GJ for gas and $81.39/GJ for electricity. Both prices had increased by around 200% since 2000, implying no change in the relative price of the two fuels on average, although Figure 7 shows that price relativities have varied significantly, and in different directions, over time.

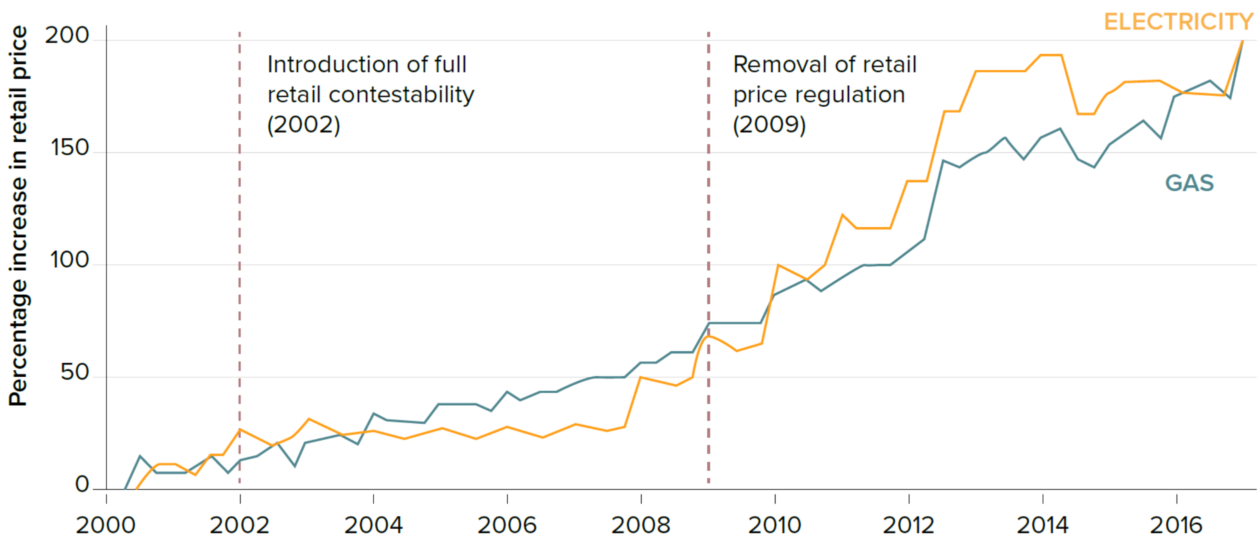


Figure 7: Electricity and Gas Price Index, 2000 – 2017, % change

Source: *Independent Review into the Electricity and Gas Retail Markets in Victoria, 2017, Figure 4, p.6.*

As noted, electricity is considerably more expensive than gas on a delivered energy basis, reflecting its higher utility, at least in many applications, along with its status as a secondary or derived energy source. However, in Chapter 6 we review contemporary developments in the cost of renewable electricity, which is continuing to fall due to ongoing performance improvements and cost reductions for solar (in particular), but also wind, energy. New solar/wind energy appears to have reached the tipping point whereby new projects can deliver firm energy at below the marginal cost of *existing* fossil fuel generators.[32] The prospect of very low cost of renewable electricity – including self-generated electricity at suitable sites – is having a significant impact on fuel mix choices in buildings, and this is very likely to continue in future.

Low Carbon or Zero Carbon?

Indeed, with the cost of renewable electricity now often available at less than, or at least no premium to, the general electricity market, while gas prices have risen strongly, there seems little point in targeting 'low' carbon outcomes for building, as distinct from zero (operational) carbon emissions. The latter phrase is easier to define than low carbon, which must always be defined relative to something else, and may be ambiguous about the extent to which natural gas or other fossil fuels are permitted. As discussed below, different building design considerations may apply for all-electric, as compared to mixed fuel, buildings. Further, given the long economic life of HVAC equipment, a decision to install gas equipment in a new building may not be reversed for decades, even if relative fuel prices, policy drivers or other factors change in ways that may disfavour gas use. Preferably it should be unambiguous that zero carbon buildings do not consume any fossil fuels in their operational phase.

Working from the US Department of Energy definition of a zero-energy building as "…an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy", [33] we can add the qualifier that, for a zero *carbon* building, any 'delivered energy' must be 100% renewable. This would be our preferred definition.

While a building *could* be defined as 'net zero carbon' (as distinct from 'zero carbon') if it consumed fossil fuels on-site but then exported an amount of renewable energy to fully offset the carbon emissions, this may risk confusing consumers and undermining the zero carbon 'brand'. A zero carbon building, in an ordinary understanding, should have zero carbon emissions during its operational phase.

Ideally, net exports of renewable energy from a zero carbon building over time would, in addition, be sufficient to fully offset emissions associated with the building's construction materials and processes. However, this would be a complication and additional cost, as it would require careful accounting for embodied emissions and net renewable energy exports over potentially decades. Nevertheless, this could be an aspirational target, or voluntary best practice, by owners of zero carbon buildings.

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[32] https://reneweconomy.com.au/plunging-costs-make-solar-wind-and-battery-storage-cheaper-than-coal-83151/, viewed 16/11/2018.
[33] US DOE, *A Common Definition for Zero Energy Buildings*, September 2015.

NABERS

In this context, we note that NABERS ratings – which are commonly used for offices, in particular, as an important indicator of the energy and emissions performance of buildings – express key performance metrics in carbon, rather than energy units, and also apply NEM-region-average values for the emissions-intensity of electricity consumption in a given state. Increasingly, however, the actual emissions-intensity of electricity consumed by a particular building, and the emissions-intensity of the National Energy Market (NEM) region in which the building is located, may bear no relationship to each other. The rapid rise in 100% renewable power purchase agreements – as discussed in Chapter 6 below – means that it may necessary for NABERS to adopt 'market' rather than 'regional' emissions factors to properly express a building's actual emissions impact. NABERS does recognise Green Power contracts, but not other forms of 100% renewable contract. We also note that the use of 'NEM region' metrics discriminates against buildings in the ACT, in particular, given that the emissions-intensity of all electricity consumed in the ACT is approaching zero, while it remains high in the NSW NEM region. Given that the first 'key principle' underpinning NABERS is that "NABERS measures actual impact, not intent", this issue seems to warrant urgent attention.[34]

New vs Existing Buildings

The economics of building fuel choices are very likely to be different for existing and new building: the focus of this section is on the latter. With existing buildings (see Section 4.2 below), there are considerations of sunk cost, not only in gas-using equipment and gas supply and connections, but also potential additional cost considerations such as the potential need to change work practices, retrain staff, and change building management systems and controls. There may also be practical constraints such as space/weight considerations for building floorplates, design of plant rooms, and continuity of service delivery during works. The latter can be particularly challenging for buildings with 24/7 operating hours such as hospitals. A further potential cost associated with fuel switching in existing buildings is the extent to which local distribution transformers, and building switchboards and circuits, can accept the additional electrical loads without costly upgrades.

More generally, all-electric buildings are likely to place higher peak loads on electricity networks than mixed fuel buildings, although this is not inevitable. The tendency towards higher loads may be ameliorated by a) higher building and equipment energy efficiency and b) the inclusion of solar generation and/or batteries on buildings and/or in distribution networks. With a rising share of renewable electricity already in evidence in Australia, and electrification not only of buildings but also of transport in future, networks will need to be augmented in some ways in response. This may include increasing demand response/management, local generation and storage, but it may also require higher capacity transformers and distribution networks, and these factors should be costed into the overall value proposition, along with the social value of avoided carbon that this pathway can offer.

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[34] NABERS, *The Key Principles and Defining Features of NABERS, Version 1.0*, September 2014, p. 9.

For new buildings, however, there is the opportunity to design and construct buildings to suit the requirements of all-electrical building services, as discussed below. The significant opportunities include:

- Energy cost savings and other benefits from high-efficiency electrical end-use equipment (discussed further below)
- The ability to source 100% renewable electricity, either from on-site generation, renewable energy power purchase agreements (as discussed in Chapter 6) or Green Power, or a combination of these, thereby reducing the operational Scope 1 and 2 emissions footprint of the building to zero, and managing future carbon risks
- Compatibility with contemporary and emerging demand management strategies including distributed (building-based) batteries
- Avoiding dual energy connection costs and associated fixed charges.

4.1.2. Technical Opportunities and Challenges

Energy Efficiency

High energy efficiency in new commercial buildings can be achieved through appropriate building design – that makes best use of available natural resources including solar energy, natural light, fresh air and thermal mass – and also appropriate mechanical plant design, materials selection, construction quality, commissioning and operation, including control and maintenance strategies. Buildings must, of course, be fit for purpose,[35] and that is best achieved through an integrated design approach that includes the end-user or their representative in the design and development team. However, this does not always occur, and a 'least first cost' rule is often applied to minimise developer's costs. Also, it is very common for energy performance goals or features to be specified but then abandoned due to cost over-runs in other areas. Default design, materials and plant solutions reflect industry and company practices that may be far from global best practices, particularly in a context where energy performance standards are dated and low.[36] Similarly, building product markets supply building elements – such as glazing, HVAC equipment and materials – primarily to meet Australian minimum requirements, and then the limited demand for above-minimum-requirement solutions. In this context, some higher performance products (such as glazing) can attract significant cost premiums.

We acknowledge that in some markets, such as premium offices in CBD locations, and high-end retail developments, high standards that are well above minimum Code requirements have long

[35] Increasingly, design for flexibility is also important, to ensure that commercial buildings remain valuable and useful for long periods of time, during which market demands may change considerably.

[36] Energy performance requirements for non-residential buildings were last updated in 2009. A regulatory proposal to update them in 2019 is anticipated but has not been endorsed by COAG at the time of writing.

been the norm for new developments.[37] This also reflects the presence of policy interventions in this segment, such as NABERS and (for larger offices) Commercial Building Disclosure. Outside these markets,for the vast majority of new commercial buildings in Australia, achieving high standards of energy efficiency is discretionary and requires additional motivation, information and effort on the part of both clients and the building design and construction team. It may well involve additional capital cost– even if, as noted in Section 4.1.3 below, low-cost or cost-saving strategies are available and many efficiency options offer attractive rates of return on investment.

Space Heating

Space heating is typically the most important gas end-use in buildings that use gas, particularly now that cogeneration is less common than in the past. For this end-use, electrical chillers or heat pumps[38] offer a ready and proven alternative to gas boilers. Both benefit from very high energy efficiencies, because electricity is used essentially to pump heat into or out of buildings from the ambient environment, using a vapour compression refrigerant cycle, rather than directly for heating purposes. The *degree* of efficiency is affected by the degree of loading, ambient temperature conditions, humidity and other factors, but minimum requirements in Australia are in the range of 250% - 340%, for air-cooled devices and up to 600% for larger, water-cooled chillers.[39] These can be compared with gas boiler efficiencies of around 85% for conventional boilers and 92% - 95% for condensing boilers.[40] Best practice water cooled chillers achieve COPs above 10 in part-load operation (1000% efficiency, cooling energy out for electrical energy in).[41] These use scroll compressors that are oil free and that use magnetic bearings for very low friction losses. It should be noted that water-cooled chillers may not a practical direct swap-out replacement for gas boilers for space heating purposes – air-cooled heat-pumps with lower COPs (but still many times higher than gas boilers) maybe more practical. This will depend upon the availability of suitably balanced heating and cooling loads, local climatic conditions and other factors.

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[37] See http://www.betterbuildingspartnership.com.au/, for example.

[38] The terminology can be confusing, as heat pumps and chillers create both heat and coolth. In practice, the terms are used to denote the primary purpose of the system, with 'heat pump' more commonly used for air-to-air heating/cooling systems, and 'chillers' for air-to-water cooling systems. However, both air-cooled chillers and heat pumps can be used for both heating and/or cooling purposes in buildings.

[39] E3 Equipment Energy Efficiency, *Consultation Regulation Impact Statement – Air Conditioners and Chillers*, February 2016, p. 26.

[40] HVAC HESS, *Fact Sheet – Boiler Efficiency*, undated, p. 1.

[41] http://www.turbocor.com/literature/pdfs/product_literature/General_Presentation.pdf, viewed 16/11/2018.

Figure 8: Air Cooled Chiller

Source: daikinapplied.com

While not common, particularly in Australia, ground-sourced heat pumps are a highly-efficient option that can be considered in the context of a new build, as they are generally installed during the early building construction phase. The US Department of Energy notes that ground-sourced heat pumps can be up to 44% more efficient than air-source heat pumps.[42] Stakeholder feedback notes that ground- and water-sourced heat pumps may face higher maintenance costs than air-source systems, and also occupy a greater footprint within buildings, and these factors may contribute to their limited uptake in Australia to date.

The higher efficiency of heat pumps as compared to boilers generally more than offsets the higher cost of electricity per GJ. For example – and noting again that comparisons are fraught by assumptions about load conditions, ancillary loads (pumps, fans, cooling towers, etc), and system versus unit efficiency – if electricity costs 60% more than gas per GJ, and a 93% efficient condensing gas boiler is used as a reference, then a chiller with a COP of only 1.5 will cost less energy to run for a given heat output. A chiller with a COP of 5 will cost around 30% of the cost of the gas boiler.

There are some technical differences between gas boilers and heat-pump based alternatives. Gas boilers typically deliver higher-temperature water (up to 85° Celcius, as compared to ~45° for heat-pump based systems). Higher-temperature heat pumps are available if required.[43] Heat pump performance can degrade in very low (sub-zero) ambient temperatures, but these are uncommon in Australia. That said, in climates such as that found in the ACT, frosting of outdoor condenser coils is understood to be an issue, albeit for a small percentage of running hours in a year. This can demand the installation of supplementary heating or coil defrosting systems, adding cost and complexity. The ACT also notes that new variable refrigerant volume (VRV) or flow (VRF) heat pump systems are less prone to this problem, as well as being up to 70% more efficient that constant air

[42] https://www.energy.gov/energysaver/choosing-and-installing-geothermal-heat-pumps, viewed 14/11/2018.
[43] See, for example, http://www.rheem.com.au/Products/CommercialProducts/HeatPumps, viewed 14/11/2018.

volume (CAV) systems or Variable Air Volume (VAV) systems with electric reheat.[44] New 3- or 4-pipe air cooled heat pumps with VRV or VRF capabilities, and sometimes with heat recovery as well, are capable of providing heating and cooling to different parts of buildings simultaneously, as can be required during autumn and spring in particular. The ACT Government notes that the North Building in the ACT is operating with such a system.

Feedback on a draft of this report suggested that heat pumps and also smaller (gas fired) condensing boilers may have shorter economic lives than conventional gas boilers, depending upon the maintenance regimes followed. The US Government study cited above notes that VRF systems studied outperformed Variable Air Volume (VAV) systems with electric reheat on a lifecycle basis taking capital and maintenance costs into account, due to their much lower operational energy consumption. VRF systems have limited space requirements inside buildings, as they do not rely on extensive ductwork (but use fan coil units instead to distribute heat/coolth) and are therefore generally suitable for retrofit into existing buildings, including heritage buildings.[45]

Gas boilers occupy a smaller footprint than heat-pumps for an equivalent heat output, but this is offset to an extent by the extra requirements of flues, valves and safety equipment. Also, virtually all commercial buildings with gas-based heating systems will also require chillers for cooling, as most commercial buildings are cooling- rather than heating-dominated, even in cool-mild climates. This can mean that plant and systems are at least partially duplicated, whereas heat-pump based systems designed to deliver both space heating and cooling can realise significant space and well as cost efficiencies. The ACT notes that 4-pipe heat pump systems are available that have the capacity to supply both heating and cooling simultaneously.

The importance of space considerations is large for commercial buildings, as the value of those buildings is mostly related to their net lettable area, and this is reduced by plant rooms and related infrastructure.

Heat-pump based systems including air-cooled chillers are generally located on roofs, in order to access ambient air, whereas gas boilers are conventionally located in basements – although the ACT notes that it is not uncommon for mid-sized offices to have boiler plant located near to chillers and close to rooftop plant. The roof-based location of most heat pump-based systems means that buildings must be designed to carry the relevant loads, and there must be sufficient space for their installation. This is readily-achieved for new buildings designed for purpose, but these considerations may constrain conversion of existing buildings with gas boilers to heat-pump-based heating systems. While there could be an incremental construction cost associated with the requirements of a heat-pump based system, these are likely to be offset at least to some degree by the reduced basement space requirements.

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[44] Thornton, Brian (December 2012). Variable Refrigerant Flow Systems (pdf). *General Services Administration* (Report), p. 6. US Federal Government, viewed 13 February 2019.
[45] Ibid, p. 7.

Other electrical space heating solutions that may be appropriate for some buildings and spaces include direct resistive heating and radiant heating. These have the advantage of being relatively inexpensive in capital cost terms, and they can be appropriate, or preferred solutions, for large spaces where the goal is to warm people rather than air. The energy efficiency of such heating systems is lower than heat-pump based ones, but still better than condensing gas boilers, and their overall energy consumption can be low due to better targeting of heating requirements. Also, these systems can be used to supplement heat-pump based heating systems, as an alternative to over-sizing systems to ensure that there is sufficient capacity available for high-load days.

Domestic Hot Water/Pool Heating

There are many domestic hot water solutions for non-residential buildings. Most larger buildings tend to generate their (limited) domestic hot water needs from a calorifier or another heat exchange technology, drawing heat from either a gas boiler or a chiller to heat fresh water. In these cases, domestic hot water supply is essentially integrated into the wider HVAC design, we can be 100% electrical, as discussed in the previous section. This approach can be highly efficient, particularly where heat that may otherwise have been wasted is recovered for hot water heating. Heat recovery can be expensive, however, and may not be justified when only relatively small volumes of domestic hot water are required. Also, there are significant energy losses (heat and pumping energy) associated with any hot water reticulation system, regardless of the energy source.

Heat pump based hot water systems can deliver hot water at 65^{o} or more, with electrical efficiencies of 400% or better.[46] Solar boosting/preheating will be an option for buildings with modest hot water requirements and are noted to require less roof space than solar photovoltaic systems. While electric storage systems can be used in smaller buildings, the overall system efficiency, including hot water distribution losses, is likely to be low. A solution in some applications will be instantaneous hot/warm water heater distributed around a building or facility (eg, a hospital or tertiary campus), to minimise storage and distribution losses. Such systems can also be used to boost solar-heated hot water and are relatively inexpensive.

Swimming pool heat-pump-based water heaters are essentially the same as those already described, and typically use scroll compressors for higher efficiency.

Kitchens

According to one Australian source, food preparation accounts for only some 35% of the energy consumption of a typical commercial kitchen: lighting, refrigeration and sanitation – that, along with HVAC, account for the balance – will already use electricity.[47] As noted above, HVAC may also use 100% electricity. Food warmers are typically electrical as well, generally in the form of infra-red lamps. Heat pumps can be used for hot water generation for washing and cleaning purposes.

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[46] Ibid.
[47] http://www.environment.nsw.gov.au/resources/eetp/RestPres2P1.ppt, viewed 14/11/2018.

For food preparation, commercial induction hobs offer not only very high energy efficiency, by transferring heat directly to cooking pans, rather than via a cooking surface. They also offer ultra-rapid cooking times, very precise heat control and reduce the ambient heat in kitchens. This in turn reduces space cooling requirements and improves occupant comfort. While the energy consumption of induction hobs is low, they do place a significant load on electrical systems (up to 3 kW per hob at full load). This could be a consideration where demand tariffs are in use. However, the key advantages are that – unlike most gas burners in kitchens – induction hobs are only turned on when required, rather than left on potentially for the whole day/night, while their energy consumption when in use is also lower than alternative cooking technologies.

Laundries

Gas is used in many commercial and industrial laundries for steam-raising, drying, rotary ironers and combined washer dryers. Conventional drying technologies using warm air heated by gas or steam (which may be generated in a gas boiler) to extract moisture. The resulting waste air stream contains significant energy, which is often lost as the temperature of the air is relatively low, making heat recovery more challenging. Heat pump dryers offer a highly-efficient electrical drying technology. First, as noted above, heat pumps represent a high efficiency method to generating heat for drying, to low-medium temperature. Second, an evaporator is used to cool and dehumidify the waste air stream, returning this to the dryer, mixed with heated air from the heat pump.

Ozone injection is an important efficiency technology that can be used either with gas or electrical washers. Ozone injected into water streams acts as a solvent and a disinfectant, enabling compliance with AS/ANZ 4146:2000, Laundry Practice, while using cold water rather than high temperature hot water. This process is credited with realising electricity savings in industrial laundries of up to 85% and gas savings of up to 48%, as well as significant fresh and waste water costs.[48,49]

[48] https://www.crownlinen.net/blog/how-energy-efficient-is-your-hotel-laundry-equipment
[49] http://www.ozonelaundry.com.au/savings/, viewed 15/11/2018.

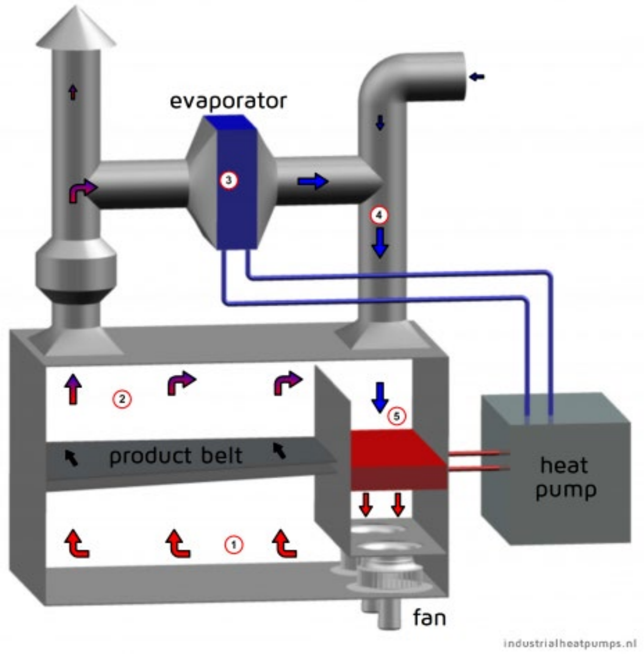

Figure 9: Heat Pump Industrial Drying

Source: http://industrialheatpumps.nl/en/applications/drying_processes/

4.1.3. Benefits and Costs

New buildings are complex systems with many different opportunities for choices to be made with respect to design, specifications, materials, control strategies and other factors. The costs associated with energy performance are rarely reported. Where a design-led process is taken, it can be difficult even to determine which costs are 'additional' and which are not, as choices about design, envelopes and other factors serve multiple ends, and not only energy efficiency.

Also, while at least some of the resulting benefits can be calculated, to do so requires agreement about the counterfactual, or what represents the norm against which to compare an energy efficient building. Generally, this is assumed to be a building that just complies with the National Construction Code but, as noted, this may be too low a benchmark for certain markets, but may be too high a benchmark if non-compliance and non-realisation of claimed savings is as common as currently assumed.[50] Potentially large health, wellbeing and productivity benefits, and also enhanced commercial values, attributed to high-performance and low-energy buildings are not always taken into account, as they can be difficult to quantify and are not widely promoted within

[50] See ABCB/The CIE, *NCC 2019 Consultation Regulation Impact Statement: energy efficiency of commercial buildings*, March 2018, Appendix D, p.104.

the sector. However, groups like the World Green Building Council have extensive resources in this area, and some important studies have also been completed in Australia.[51,52]

The *Green Star Financial Transparency* project, was undertaken by the Green Building Council of Australia in 2016.[53] This study captured data from 30 Green Star projects over the 2014 – 2016 period, including data on implementation costs (incremental construction costs) and documentation (or reporting) costs. The study also highlights the practical difficulty in isolating incremental costs, noting (p. 5):

> *All projects are unique. They vary in size, location and complexity. Within each project there are also multiple pathways to achieving a Green Star rating… Project teams choose pathways based on the best value for their particular project in a holistic way, rather than using the cheapest option. As an example, for one project the end of trip facilities cost $50,000 to implement, making it a relatively 'expensive' credit to achieve, however these were something that was valuable to the building's tenants and its owner… There are also variations (by owner and by sector) in what are considered to be the base case scenarios; these are not accounted for in the results. As an example, one owner might consider the specification of a certain material to be business as usual (not an additional cost), whereas another developer may have to upgrade to meet the credit and this would show an additional cost.*

Key findings included that developers were achieving 5 star Green Star ratings with an incremental cost increase of 2.7% and 6 star for 3.2%. For context, the average cost increase for 6 star (relative to minimum Code compliance) was $147/sqm out of an overall project cost of $4,588/sqm, or (for example), $2.9 million in a $91.8 million build cost (20,000 sqm building). It is likely that this cost premium will have reduced significantly over time, noting that this data may be 4 – 5 years old. Also, the study notes that LED lighting was an important contributor to incremental costs (p. 8), yet in 2018 this is virtually a default solution. Finally, Green Star star ratings are not only indicative of energy efficiency but also take into account other sustainability performance dimensions. Therefore, this data likely overstates the incremental cost of achieving energy efficiency improvements. The study also notes that there was a very large variation in the incidence of incremental costs across the sample, from an average of 0.5% for education buildings to an average of 10.4% for (two) industrial buildings.

The incremental costs and benefits of achieving higher efficiency new buildings in Australia have also been explored in detail recently in several research projects. These include:

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[51] https://www.worldgbc.org/benefits-green-buildings, viewed 15/11/2018.

[52] https://3-api.cdn.aspedia.net/sites/default/files/uploaded-content/website-content/building_better_returns.pdf, viewed 15/11/2018.

[53] https://gbca-web.s3.amazonaws.com/media/documents/gbca-research-paper---financial-transparency-2016.pdf, viewed 15/1//2018. This research was to be updated annually, but there have been no updates published to date.

- The Australian Sustainable Built Environment Council's (ASBEC) Code Trajectory project – published as *Built to Perform: an industry led pathway to a zero carbon ready building code*, with the Technical Report published by the Co-operative Research Centre for Low Carbon Living as SP0016 *Building Code Energy Performance Trajectory Final Technical Report*
- the Australian Government's Code Trajectory project, *Achieving Low Energy Commercial Buildings in Australia* project, which is expected to be published shortly
- in 2017 the Australian Building Codes Board commissioned a regulatory proposal for new energy performance standards for non-residential buildings in the 2019 version of the National Construction Code, leading to a series of technical papers by Energy Action and a consultation regulation impact assessment by The Centre for International Economics.

For transparency, we note that SPR was a delivery partner in all three projects (but not the RIS). Starting with the RIS (as this regulatory proposal is expected to be implemented in 2019), a weighted average improvement of 23% is expected relative to current minimally-Code-compliant buildings (Figure 10).

The RIS points out that the expected average 23% improvement in energy efficiency proposed in that study (relative to current minimum standards) is largely associated with *reduced capital costs* for buildings, not higher. Indeed, the RIS shows that compliance costs are expected to be negative in all states and territories.[54] This does not, of course, mean that every single building, regardless of design or Class, is expected to experience construction cost reductions, compared to the previous building cohort, but rather that this result is expected to occur on average. The result is attributed primarily to Code changes that are expected to discourage highly-glazed designs, leading to reduced window-to-wall ratios and improved façade performance at reduced construction cost. The proposed energy efficiency improvements are modest – particularly when compared with the two studies below. This is due to the RIS a) not considering solar generation potential, and b) targeting a much higher benefit cost ratio – the expected outcome has a BCR of 9.3.[55]

[54] Ibid, Table 5.13.
[55] ABCB, *NCC2019 Consultation RIS, energy efficiency of commercial buildings*, 2018, p. 69.

Climate zone	Location modelled	Hotel	Office	Retail	Health	Average
		Per cent	Per cent	Per cent	Per cent	Per cent
1	Darwin	-25	-27	-21	-32	-24
2	Brisbane	-33	-35	-15	-39	-24
3	Alice Springs	-30	-21	-20	-34	-23
4	Wagga Wagga	-34	-31	-10	-19	-16
5	Sydney	-35	-37	-20	-37	-29
6	Melbourne	-34	-30	-8	-21	-15
7	Canberra	-39	-29	0	-4	-17
8	Thredbo	-36	20	23	29	-14
	Average					-20
	Weighted average					-23

Figure 10: Estimated Change in Annual Energy Use – NCC 2019

Source: ABCB/The CIE, NCC 2019 Consultation Regulation Impact Statement: energy efficiency of commercial buildings, March 2018, pp. 24-25.

The ASBEC-commissioned research (which, as noted, is substantially similar to the Australian Government research) finds that, when compared to a current minimally-Code-compliant building, and allowing for both energy efficiency improvements and building-based solar PV investments that deliver a benefit cost ratio between 1 and 1.5, the following average reductions in energy consumption are already cost effective:[56]

- Hotels: 33.2%
- Offices: 18.2%
- Retail: 53.1%
- Hospital ward: 48%
- School: 78.8%.

We note that the school and retail buildings in the above studies are assumed to be all-electrical buildings, while the office archetype is assumed to have a 7% gas share; the hotel, 10%; and the hospital ward, 32%; on average across the climate zones studied.

To illustrate the likely benefits and costs associated with high-efficiency, all-electric buildings, we construct a number of worked examples, drawing on the above body of research. Worked examples should not be interpreted as outcomes that can be expected to occur with any or every building of

[56] Co-operative Research Centre for Low Carbon Living, *SP0016 Building Code Energy Performance Trajectory Final Technical Report*, October 2018, Table 3-19, p. 71.

the same class, as there is a great diversity of building sizes, designs, functions and climate considerations even within a given Class. The diversity of results across of sample of 30 real buildings is illustrative of this problem. However, the examples can be regarded as typical or average results. For these examples, we assume a gas price of $25/GJ, an electricity price of $0.20/kWh and a solar feed-in tariff of $0.10/kWh.

Worked Example 1 – 9,000 sqm NLA office, Climate Zone 7

This office archetype has been modelled for numerous policy analysis purposes.[57] It is a 10-storey office with 10,000 sqm GFA or 9,000 NLA.

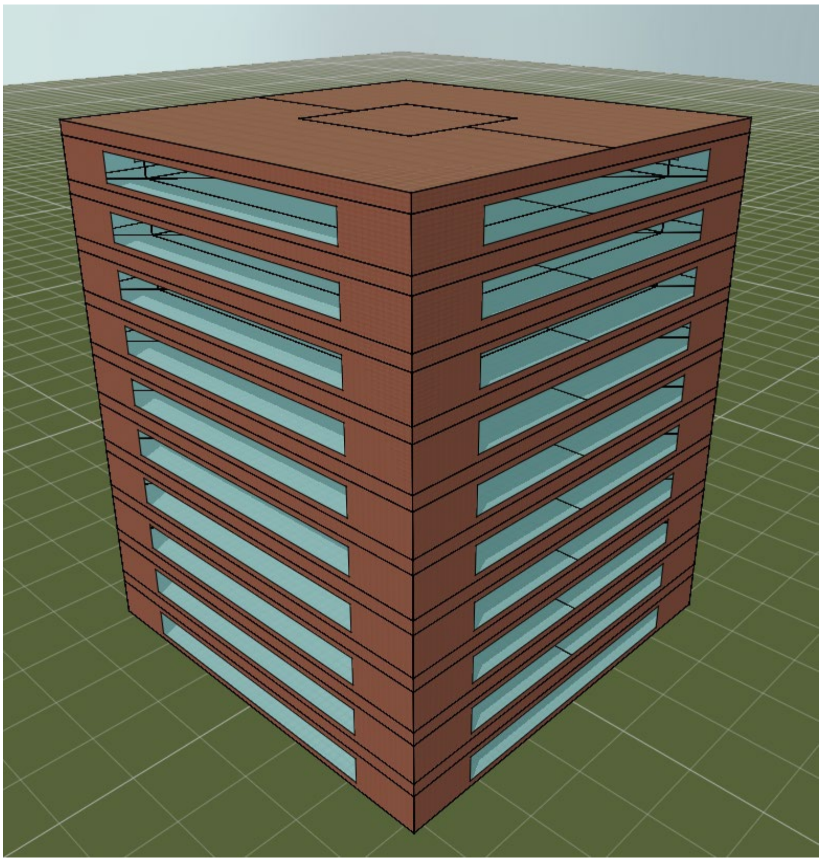

Figure 11: Office Archetype

Element	Value	Comments
NLA	9,000 sqm	
Storeys	10	

[57] It is described in detail in Co-operative Research Centre for Low Carbon Living, *SP0016 Building Code Energy Performance Trajectory Final Technical Report*, October 2018, Appendix F.

Element	Value	Comments
Equipment loads **Lighting**	11 W/sqm 4.5 W/sqm	
Occupants	75W sensible heat gain pp 55W latent heat gain pp 14 sqm/pp	
Electricity consumption intensity	254 MJ/m^2.a	NB: excludes unregulated demands such as lifts/travellators
Gas consumption intensity	7 MJ/m^2.a	Not quite zero, but very low. This gas demand would be able to be eliminated at no net cost, particularly as this would avoid gas connection and safety costs.
Peak demand	235 kW	
Installed solar capacity	16 kW	
Solar export allowance	10%	Installed capacity is assumed to be low, with peak solar output well below peak building electrical demand (except weekends)
Annual gas cost reduction	\$13,447 (89%)	Relative to NCC2016 (current Code)
Annual electricity cost reduction (incl. due to PV output)	\$62,991 (34%)	Relative to NCC2016 (current Code)
Annual energy cost reduction	\$76,438 (38%)	Relative to NCC2016 (current Code)
Incremental construction cost (incl. PV cost), est.	\$423,800	
Internal rate of return	17%	
Simple payback	5.5 years	

Table 4: Office Archetype Features

This example indicates that is very cost effective to achieve a 38% reduction in energy costs, relative to current Code minimum energy performance requirements, via a combination of energy efficiency improvements and a modest solar array, in Climate Zone 7 (eg, Canberra, Hobart). This building uses a small amount of gas, as it has a condensing boiler for space heating. As noted in Section 4.1.2 above, this could be replaced at design stage by dual purpose heat-pump/chillers without any overall cost premium, noting that this would enable gas connection costs and supply infrastructure to be avoided, in addition to the boiler costs. Also note that the solar assumptions are conservative, and a larger PV system may well be able to be fitted to this office cost-effectively.

Worked Example 2 – Hospital Ward

In the also Code Trajectory studies, a single-storey hospital ward archetype is described. [58] This is not intended to represent a whole hospital (including more energy intensive areas), but rather a patient ward that might be found within a wider hospital campus. It has 500 sqm floor area (475 useable area) and, due to its ward function, 24/7 operation with high levels of occupancy (85%). The HVAC design is similar to the Office archetype, including a condensing gas boiler in addition to a variable speed drive centrifugal chiller. Clearly, this form has significant potential for solar energy generation, particularly if it were oriented with the long axis east-west and if the building is not significantly over-shaded.

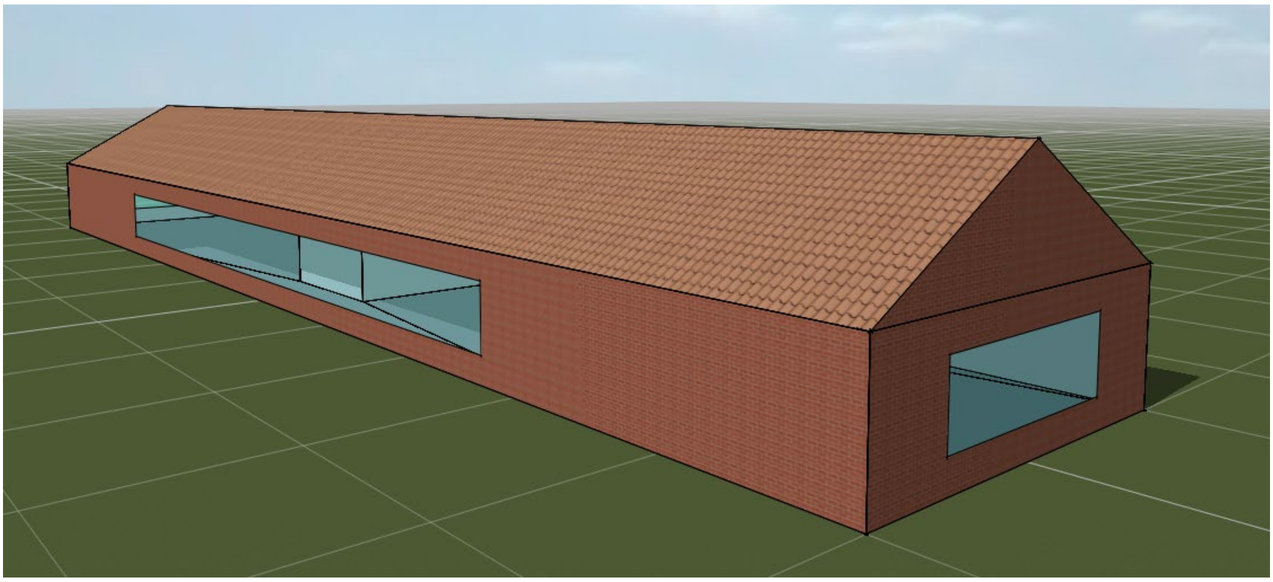

Figure 12: Hospital Ward Archetype

The option of a gas-free design for the ward was not investigated in the Trajectory studies, but a building of this size would be suitable for heating via packaged air conditioners and/or direct electric heating. It should be noted that this building form has a significantly higher heating load (in Climate Zone 7) than the office due to its high surface-area-to-volume ratio and smaller size, meaning that the impact of external variations in temperature on internal temperatures is larger. For this reason, the same form also has higher cooling loads (per sqm) in summer. Overall, its higher occupancy and continuous operation leads to 45% higher total energy intensity (that is, annual energy consumption

[58] Co-operative Research Centre for Low Carbon Living, *SP0016 Building Code Energy Performance Trajectory Final Technical Report*, October 2018, Appendix F.

per sqm) than the office in Climate Zone 7. In this cooler climate zone, in particular, the 24-hour operation of this building leads to significantly higher energy demand for heating purposes than would a similar building that only operated for 10 – 12 hours during the day.

Element	Value	Comments
NLA	475 sqm	
Storeys	1	
Equipment loads **Lighting**	5 W/sqm 2.5 W/sqm	
Occupants	75W sensible heat gain pp 55W latent heat gain pp 14 sqm/pp	
Electricity consumption intensity	254 $MJ/m^2.a$	NB: excludes unregulated demands such as lifts/travellators
Gas consumption intensity	7 $MJ/m^2.a$	Not quite zero, but very low. This gas demand would be able to be eliminated at no net cost, particularly as this would avoid gas connection and safety costs.
Peak demand	6 kW	
Installed solar capacity	23.3 kW	
Solar export allowance	50%	Peak solar output significantly exceeds peak demand, but 7-day operation reduces weekend exports (relative to Office)
Annual gas cost reduction	$1,696 (48%)	Relative to NCC2016 (current Code)
Annual electricity cost reduction (incl. due to PV output)	$10,484 (105%)	Relative to NCC2016 (current Code). 105% denotes net electricity exports over a year.
Annual energy cost reduction	$12,180 (90%)	Relative to NCC2016 (current Code)
Incremental construction cost (incl. PV cost), est.	$83,251	
Internal rate of return	13%	

Element	Value	Comments
Simple payback	6.8 years	

Table 5: Hospital Ward Archetype Features

This building is able achieve zero net energy consumption, due to the combination of improved energy efficiency, relative to the current National Construction Code, and a large roof area suitable for PV. At the same time, it delivers an attractive internal rate of return and simple payback of investment.

This ward building form does not, of course, represent a whole hospital campus. Also, if a building of a similar form were selected, but with 2 or more storeys, the potential for PV to cover the whole of the building's energy requirements would diminish. Depending upon the siting, building-integrated PV may be a possibility for both the ward and office buildings, but the risk of over-shading from adjacent buildings or other structures would have to be considered. On the other hand, and as discussed further in Chapter 6 below, renewable energy supply options are not constrained to those generated on-site: off-site renewable energy can be accessed securely, and on favourable terms, using power purchase agreements.

4.1.4. Procurement Potentials

The potential to procure high-efficiency, low-carbon and all-electric buildings exists today, although this is not a standard specification and therefore may be greeted with scepticism in Australia's conservative building industry. As noted above in the cited references and case studies, there is a premium to be paid for high-efficiency and also for PV (other renewable energy options are discussed below). However, these premiums are generally modest relative to the overall building cost – in the range of 1% – 3%, and they can be associated with attractive rates of return on investment, indicating that these are cost-effective investments.

From a technical perspective, and particularly for larger buildings, the decision to pursue an all-electric or a mixed fuel pathway is not a direct, like-for-like swap, but instead requires design and planning for all-electric operation from the start. The potential barriers to all-electric buildings, as discussed above, include the higher energy efficiency of water-cooled, as compared to air-cooled, chillers, and the greater heat output (per unit) of gas boilers than heat-pumps. The greater efficiency of water-cooled chillers sees them used in many Australian climates (but generally not humid ones, due to the lower efficiency of cooling towers in humid climates), and for larger buildings in particular, but these systems are not designed to operate in a heating mode. Also, it is not uncommon for buildings, particularly larger ones, to require both heating and cooling at the time, in different parts of the building, but this can be accommodated by heat-pump systems with variable refrigerant flow/volume and heat recovery can accommodate such needs without requiring recourse to gas boilers. For buildings with high cooling demand and limited (but not zero) heating demand, including larger buildings, an optimal all-electric solution could involve water-cooled chillers for cooling, and heat pumps (or direct electric heating) for heating. As noted, this may require greater plant room floor area (than the use of a gas boiler for space heating).

The impacts of choosing all-electric buildings in terms of greenhouse gas emissions will depend upon the location of the buildings or, more precisely, the greenhouse gas intensity of electricity that is supplied in that location. In the ACT or Tasmania, all-electric buildings will clearly deliver lower greenhouse gas emissions than building that use gas or other fossil fuels. However, that may or may not be the case in other states. Clearly, the strategy of selecting all-electric buildings will be most effective when paired with renewable electricity supply – enabling zero operational emissions.

There are multiple options for achieving 100% renewable electricity supply for new, all-electric buildings:

- High-efficiency and rooftop PV
- High-efficiency, building-integrated PV (with/without rooftop PV)
- Renewable energy power purchase agreements
- Green Power.

Rooftop, or 'building-added', PV (BaPV) has the primary virtue of increasingly lower cost, as well as very low maintenance costs and risks. As documented in the references cited above, it is already cost-effective, and will be increasingly so over time, provided only that it is appropriately oriented and installed so as to minimise over-shading risks. The key limitations are generally limited available roof area (particularly since there is very often competition for roof-top space for cooling towers, mobile phone tower, roof gardens or other facilities) and overshading risks – whether due to the competing roof-top structures, to the roof design and orientation, or from adjacent buildings. These limitations are greater with taller buildings and buildings in central business districts.

There is currently a cost premium for building-integrated PV (BiPV), and this technology is virtually unknown in Australia, even if it is becoming increasingly popular in North America and Europe. In the longer term, advocates of BiPV believe it may replace façade elements in new buildings in future, with this substantially offsetting the incremental costs, or even leading to cost reductions. Its key benefit, relative to BaPV, is the ability to cover a much larger surface area of the building. This can offset the limited roof area available for BaPV, particularly on taller buildings. However, the risk of over-shading remains, however, and may be aggravated for BiPV mounted on walls, at least in central business districts.

The Australian construction industry is, however, wary of risks around the performance of BiPV as a façade material, more so than from those associated with its energy output. This is because the cost associated with repairing facades, if that became necessary, and particularly on tall buildings, would be very high. Of course, there is no reason why BiPV materials would perform differently in Australia as compared to the US. The industry concerns here reflect a lack of familiarity with the materials and, overall, a culture that can be resistant to innovation. This is likely to change over time, but slowly.

Power purchase agreements are a relatively recent, rapidly-growing option that is reviewed in Section 4 below. Green Power, on the other hand, has been a renewable energy supply option for a number of decades now, but has experienced considerably reduced take-up in recent years, primarily because other options are more cost-effective.

The final consideration is a commercial one. For the reasons noted, the building industry is unlikely to deliver all-electric, high-efficiency buildings as a matter of default, at least not in the absence of market demand. Therefore, there is likely to be a need for the building's long-term tenant (or owner-occupier) to specify such as building at the start, and to ensure that this specification is not swapped out for more conventional, and probably cheaper capital cost, solutions during the design and construction process. In principle, governments are well-placed to play this role, as they often seek long term tenancies and traditionally, although less often these days, commissioned owner-occupied buildings as well. Where a government intends to be a foundation tenant for a (new) commercial building, it will need to negotiate with the owner to ensure that its requirements are in fact delivered.

4.1.5. Conclusions

High-efficiency, all-electric and low-carbon commercial buildings can be procured, with the expectation of a modest cost premium – in the range of 2% - 3% – that should be cost-effectively repaid by energy cost savings over 4 – 6 years on average. However, there is a great diversity of building solutions and needs, and so there will also be diversity in incremental costs and payback periods. What we can say with confidence includes:

- It is technically feasible to build high-efficiency, all-electric and low/zero carbon commercial buildings today.
- All-electric buildings, unlike mixed fuel ones, can operate at zero emissions through the simple expediency of a renewable energy power purchase agreement (PPA), on-site renewable energy generation, or a combination of these two. This solution therefore offers a pathway to zero emissions operations that is not offered by mixed fuel buildings.[59]
- High energy efficiency is a separate but complementary strategy, in that reducing energy demand and consumption lowers operating costs, including under a PPA, while reducing demand may also reduce demand-charges (where building users are directly exposed to such costs) and reduce electricity system costs. Where on-site generation is used, high efficiency will reduce the size of renewable energy installations required to cover demand, leading to capital cost reductions.

[59] The option of Carbon Neutral Building certification (which could be sought for mixed fuel buildings) is examined in the following section on existing buildings.

- All-electric buildings are not the default solution in Australia at present, and therefore a government wishing to procure such a building would need to be an 'active' purchaser or foundation tenant, to ensure that this outcome is delivered.

Recommendations

3) Where a new building is being commissioned by government – including where the building is to be privately-owned and leased long-term to government – the option of procuring a 100% electric building, with high energy efficiency and 100% renewable electricity supply, should be investigated.

4.2. Commercial Building Retrofits for Higher Energy Productivity

4.2.1. Introduction

This opportunity is framed as an examination of the potential to require higher energy productivity buildings (within the existing building stock) via government procurement processes. There are three key elements to such a proposition:

1. What is a higher energy productivity (or efficiency) building?
2. Is there government demand for higher efficiency buildings, and can that demand be met by the market?
3. How cost-effective are high-efficiency building retrofits, and can the market deliver them?

On the definition, we prefer and use here the term energy efficiency, as there is no agreed definition of energy productivity with respect to commercial buildings. A metric based on financial values (as productivity normally is) may be very hard to apply, even conceptually, to public buildings or those where market turnover is limited. Also, while there may be some relationship between the financial value of at least some building types and their energy consumption, it is unclear that these factors are causally linked as a general rule, casting doubt on the interpretation of an energy productivity indicator. Energy efficiency, on the other hand, can be directly and causally related to significant aspects of building and plant design and specifications.

The term 'higher' is relative, and benchmarks of energy efficiency change over time. For example, the average NABERS star rating has increased from 3.2 stars in FY2011 to 4.4 stars in FY2018 (excluding Green Power).[60] With Commercial Building Disclosure, there is an increasingly high share of the total office stock rated under NABERS, so this is an increasingly robust indicator of the average efficiency of at least the larger office stock in Australia. The NABERS annual report also notes that nearly 22% of offices rated achieve 5 stars or more, including 570 buildings rated at this level in FY2018 alone.

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[60] https://nabers.info/annual-report/2017-2018/office-energy.html, viewed 6/12/2018.

Noting that there is a discontinuity in NABERS star ratings after 5 star – with 5.5 representing a 25% improvement on 5 star, and 6 star representing a 50% improvement on 5 star – a contemporary benchmark for a 'higher' energy efficient office would be 5.5 stars or more. On the NABERS data, 9% of offices rated in FY2018 achieved this benchmark across Australia, and 12% of offices in NSW.

The increasing average NABERS rating over time is one indicator that there is a significant amount of building upgrade activity occurring across Australia. Unfortunately, Australian Bureau of Statistics Building Activity data do not reveal what portion of the current ~$10.4 billion spent each quarter on non-residential building work is for refurbishment of existing buildings.[61]

Market trends

The commercial building market is often examined by Grade, which is a ranking system based on commercial value. Premium and A-Grade buildings (typically offices) are often located in commercial business districts (because location is a key element of value, but also because CBD buildings tend to be larger and attract higher rentals than those elsewhere). It is generally considered – albeit without a great deal of supporting evidence – that Premium and A-grade offices operate with reasonably high energy efficiency.[62] This is essentially because there is a competitive market for CBD office space, and outgoings or operational expenditure is an important element of tenants' leasing decisions. Increasingly, too, these buildings will be covered by the Commercial Building Disclosure scheme, or otherwise have voluntary NABERS ratings, which help both tenants to select more efficient buildings and, in doing so, create incentives for less efficient ones to be upgraded, to increase their market attractiveness and value. Of course, other factors are relevant to attractiveness and value, and energy efficiency is only one amongst many.

Further, major institutional property owners are increasingly concerned with the sustainability credentials of their portfolios, aided by initiatives such as GRESB (the Global Real Estate Sustainability Benchmark) or the Carbon Disclosure Program. As GRESB notes:[63]

> *Expectations have changed for real asset investments. Leading institutional investors are incorporating environmental, social and governance (ESG) performance of real assets into their investment process. Regulators are mandating ever more ESG disclosures and improvements. And tenants, owners and other stakeholders are demanding more sustainable, greener and healthier buildings and infrastructure. GRESB is responding to this demand by providing high-quality ESG data and powerful analytical tools to the industry.*

The pragmatic reason why such initiatives are flourishing is that high sustainability rankings and ratings increasingly deliver value for building owners – increased market rentals, increased capital

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[61] http://www.abs.gov.au/ausstats/abs@.nsf/PrimaryMainFeatures/8752.0?OpenDocument, viewed 6/12/2018.

[62] Sustainability Victoria (2018), discussed below, finds that the average energy intensity of A-Grade buildings is 'notably better' than B-Grade, but that a significant number of prime assets (A-Grade) showed energy intensity values similar to B-Grade buildings (p. 5).

[63] https://gresb.com/about/#do, viewed 6/12/2018.

and portfolios, and therefore increased capacity to grow their businesses. This means that high-end CBD properties, which are mostly institutionally owned, face strong commercial pressures to deliver high standards of sustainability, including energy efficiency.

In Australia, the Better Buildings Partnership represents a collaborative initiative of leading property institutions, primarily based in Sydney, that aims to improve the sustainability of Sydney's commercial and public sector buildings, and to help achieve the City of Sydney's goal of a 70% reduction in greenhouse gas emissions by 2030 relative to a 2006 base.[64] By 2017, BBP represented more than half of Sydney (LGA)'s floor area, or 2.7 million sqm of largely premium properties. In total, this group of owners report a reduction of 43% in energy consumption (since 2006) and a 52% reduction in greenhouse gas emissions. These results were achieved despite a 14% increase in floor area within the BBP group.

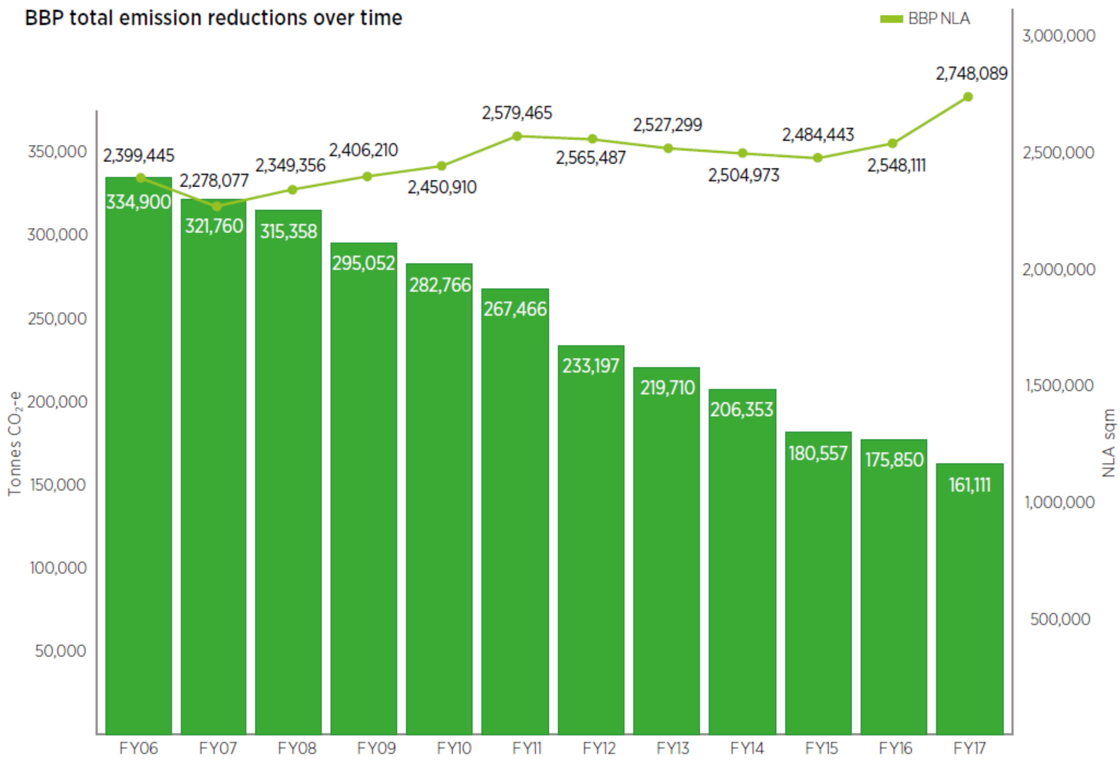

Figure 13: Better Buildings Partnership Emissions Reductions Over Time

Source: BBP 2017 Annual Report, p. 12.

At the other end of the spectrum lie the 'mid-tier' buildings, and particularly offices. These are defined as buildings that are less than Premium or A-Grade. A recent report by Savills finds that the majority of mid-tier offices are between 40 and 60 years old. Many are owned by private and overseas investors. Most do not have NABERS ratings. Those owned by institutional investors were

[64] http://www.betterbuildingspartnership.com.au/about/objectives/, viewed 6/12/2018.

more likely to have NABERS ratings, and higher ratings than other cohorts. Average NABERS ratings were 3.9 stars for institutionally-owned buildings, compared just 2.9 stars for privately-owned and 2.7 start for overseas-owned buildings. Also, many mid-tier buildings are strata-titled, which presents specific barriers to building upgrade investments. The report found that refurbishment activity is considerably more likely in prime buildings rather than in mid-tier buildings. It also notes that upgrades can often disrupt tenants and so are often deferred until a significant vacancy occurs. This can lead to plant remaining in operation well past its useful life.[65]

Locality	Number of Buildings	Premium Grade		A Grade		B Grade		C Grade	
		No. of Ratings	Average Rating	No. of Ratings	Average Rating	No. of Ratings	Average Rating	No. of Ratings	Average Rating
Brisbane	63	3	5.0	23	4.4	33	3.3	4	1.0
Sydney	111	13	4.6	50	4.6	41	3.9	7	2.8
Melbourne	65	10	4.0	35	4.1	14	3.5	6	3.3
Adelaide	40	1	4.5	17	4.5	12	3.4	10	3.3
Perth	62	6	4.8	25	4.3	25	2.5	6	2.9
National	341	33	4.6	150	4.4	125	3.3	33	2.7

Figure 14: Average NABERS Energy Star Ratings by Grade and Market

Source: Sustainability Victoria (2018), p. 50.

This same study notes that mid-tier buildings have the *potential* to operate as efficiently as prime properties. It cites a lack of professional facility management as the key barrier, leading – in particular – to HVAC systems that are poorly responsive to occupancy levels. This can mean that whole buildings are air-conditioned even if vacancy rates are 50% or more.

Overall, the commercial potential for building retrofits must take the reality of building markets into account. The following passage from Sustainability Victoria (2018, p. 73) is instructive:

> *The reasons for such low levels of uptake [of energy efficiency retrofits] vary from owner to owner, but generally there have not been sufficient reasons to compel many [mid-tier] owners to undertake such proactive measures. Pressure from lending institutions does not appear to be widespread, tenant demands have been less common to date and fears of stranded assets at the lower end of the market have often be countered by the perception there will always be tenants willing to put up with low-performing buildings due to affordability reasons (until the market turns, as is currently the case in the Perth CBD).*

Relatedly, there is likely to be a more limited supply of high-efficiency office buildings in regional markets, where lease terms may be longer, and competition limited and lease turnover less frequent, than in major capital cities. This may translate into a lower willingness for building owners

[65] Sustainability Victoria, *Mid-Tier Investment Performance Study*, 2018, prepared by Savills.

to invest in energy efficiency upgrades. However, we would argue that it precisely in these conditions – where the strong market drivers found in major capitals are largely missing – that there is a particularly important role and opportunity for government procurement policies to leverage outcomes that are otherwise unlikely to be realised.

Another perspective on the commercial challenges, or realities, associated with building energy refits is offered in a report by the Sustainable Built Environment National Research Centre. It notes that barriers to upgrade projects may occur due to financial factors, institutional or administrative complexities, awareness and skills, and market failures. That said, there are good sources of advice and best practice guidelines to assist with implementing successful upgrade projects.[66,67]

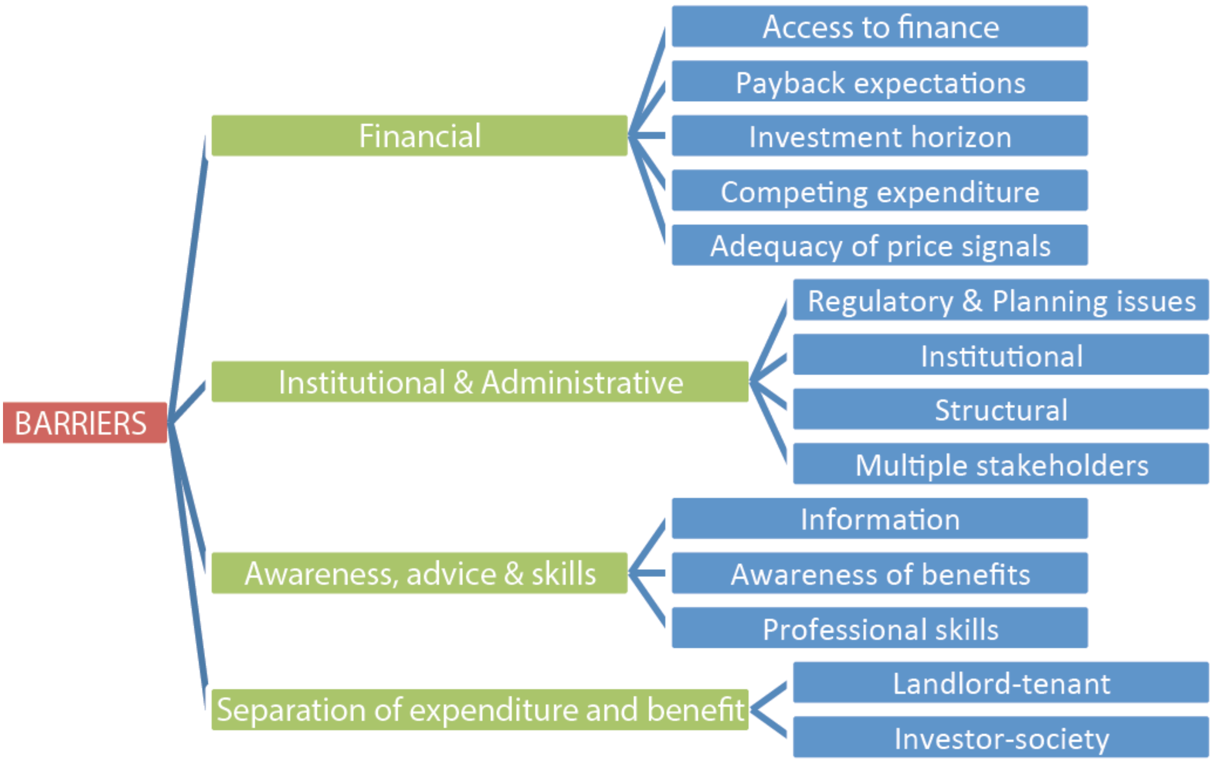

Figure 15: Main Barriers to Building Renovation

Source: SBENRC (2016), p. 20, originally from the Building Performance Institute of Europe

Government Demand

Given that governments are significant users of buildings, with particular leverage in smaller and regional cities, the extent to which governments insist on high energy efficiency may be the most important determinant of overall energy efficiency outcomes in those markets.

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[66] Sustainable Built Environment National Research Centre, *Retrofitting Public Buildings for Energy and Water Efficiency: part 2 retrofitting guidelines*, May 2016.
[67] http://www.eec.org.au/for-energy-users/energy-efficiency-in-commercial-buildings/overview#/overview, viewed 12/12/2018.

The Australian Government and many state and territory governments have had building efficiency targets in place, typically for newly-leased buildings and for newly-constructed government-owned buildings (which are increasingly rare), that they achieve a minimum of 4.5 stars under NABERS, or 5 stars in South Australia. Generally, these targets have applied only to office buildings, as take-up of NABERS ratings are not yet common for other building types, and because Commercial Building Disclosure applies only to (larger) office buildings. The Australian Government's Energy Efficiency in Government Operations policy was introduced in 2006 and established a target of 4.5 stars under NABERS for new tenancies.[68]

In NSW, the Government Resource Efficiency Policy, first introduced in 2014, has recently been updated.[69] The scope of this policy includes energy, water, waste and air emissions. In the energy area, it includes:

- agency/site level energy savings projects that aim for 10% energy savings in covered sites by FY2024
- owned and leased office buildings will achieve and maintain a NABERS Energy rating of at least 5 stars (without GreenPower) by June 2020, with leased office buildings in areas outside Sydney, Wollongong and Newcastle, and data centres, to achieve and maintain at least 4.5 stars by June 2020
- all new electrical equipment purchased by government must be at least 0.5 stars above the market average star rating or comply with specified high efficiency standards
- all new facilities, including office buildings, fit-outs and other building types with project costs over $10 million, will achieve and maintain minimum NABERS Energy and Green Star ratings, or be designed to these standards, of between 4 and 6 stars, as specified by region/building type
- agencies will install solar PV on suitable sites to implement the NSW Government's solar target of 25,000 MWh per year by 2021 and 55,000 MWh per year by 2024, equivalent to about 18 MW (2021) and 40 MW (2024)
- for vehicles, the average NSW Government purchase must be at least as efficient as the market average fuel efficiency by vehicle category by June 2020, and from FY2021, 10% of new general purpose passenger fleet cars purchased or leased by agencies are to be electric or hybrid vehicles
- purchase a minimum of 6% Green Power.

[68] Sustainable Built Environment National Research Centre, *Retrofitting Public Buildings for Energy and Water Efficiency: Part 2 Retrofitting Guidelines*, May 2016, p. 7

[69] State of NSW and Office of Environment and Heritage, *NSW Government Resource Efficiency Policy*, February 2019.

The original policy required agencies to maintain a NABERS energy rating of 4.5 stars for (office) buildings over 2,000 sqm.[70] An downloadable dataset (viewed in December 2018, but which does not appear to be available in June 2019) showed a total of 1370 offices, 19.9% of listed offices have a whole building rating; 16.9% have a base building rating; and 6.1% have tenancy ratings. For those buildings that were rated, the average ratings are 3.9 stars for whole buildings; 4.1 stars for base buildings; and 3.6 stars for tenancies.

The current Progress Report (for 2017-18) indicates that 64 government buildings had NABERS ratings of 4.5 stars or more, and splits these by ratings type, but does not enable the above percentages to be updated, as totals are not shown.[71] The report notes a 1.2% decrease in energy consumption in that year by 84 reporting agencies. 151 energy efficiency projects were implemented at 117 sites, leading to energy savings valued at $3.4 million.[72]

NSW appears to be the only jurisdiction that has revised its NABERS targets for offices (and other), despite the significant increase in the average office rating over time in Australia.

In Victoria, there is a Greener Government Buildings program that aims to improve the efficiency of existing government buildings through energy performance contracting, with $145 million invested to date.[73] Unfortunately, the outcomes achieved in terms of efficiency improvements is not stated. Also in Victoria, the Better Commercial Buildings program supported commercial building retrofits. While that program is now closed, it has left a legacy of useful case studies for reference.[74]

Sustainability Victoria ran the Energy Efficient Office Buildings program (now closed), which had a particular focus on 'mid-tier' or less than A-grade office retrofits. This segment is estimated at 80% of office buildings and 50% of total office floor space in Victoria.[75] The program placed $3.6 million into mid-tier energy efficiency upgrades over a three-year period, and 20 mid-tier buildings were recruited into the program. Unlike many others, the impacts of this program are very well documented. Typical retrofit activities were noted to include:

- 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

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[70] https://www.environment.nsw.gov.au/government/nabers-buildings.htm, viewed 6/12/2018.
[71] https://www.environment.nsw.gov.au/topics/energy-savings-and-resource-efficiency/nsw-government-resource-efficiency-policy-progress-report
[72] NSW Government, *NSW Government Resource Efficiency Policy: progress report 2016-17*, 2018.
[73] https://www.dtf.vic.gov.au/funds-programs-and-policies/greener-government-buildings, viewed 6/12/2018.
[74] https://www.sustainability.vic.gov.au/Business/Commercial-building-efficiency/Commercial-building-case-studies, viewed 6/12/2018.
[75] Sustainability Victoria, Energy Efficient Office Buildings: transforming the mid-tier sector, 2016, p. ii.

- Balancing air to measure air flow rates and recommissioning dampers and controls to distribute air flow more effectively
- 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
- Installing carbon monoxide sensors in car parks, so that exhaust fans run only when a build-up of exhaust gases is present.

Energy savings were noted to range between 6% and 62%, or up to 2 NABERS stars, with an average of 29% energy savings and a 1 star NABERS uplift. The average simple payback period was noted to be less than 3 years. Important benefits associated with these upgrades also include a higher frequency of comfortable operating conditions (in the 20° – 22° C, compared to a sample of pre-refit buildings that showed a range of 18° – 33° C). In addition, post-retrofit occupant surveys found the following results:

PARAMETER	CHANGE
Dissatisfaction with temperature	↓35%
Dissatisfaction with air movement	↓17%
Dissatisfaction with humidity	↓14%
Dissatisfaction with air quality	↓19%
Number of Sick Leave days	↓24.3%

Figure 16: Energy Efficient Office Buildings Program, Post-Retrofit Occupancy Survey Results

Source: Sustainability Victoria (2016, p. 12)

In 2008, the City of Melbourne launched a program to retrofit 1200 CBD buildings to achieve 4.5 NABERS star by 2020. Since 2010, more than 540 commercial office buildings have been retrofitted for improved energy and water efficiency.[76] Environmental upgrade finance has been a key instrument used to support retrofit activity.[77] A 2015 survey of results (which appears to be the latest) notes that, at that time, 541 buildings had undertaken retrofit work and a further 315 were

[76] https://www.melbourne.vic.gov.au/business/sustainable-business/1200-buildings/Pages/1200-buildings.aspx, viewed 6/12/2018.
[77] https://www.melbourne.vic.gov.au/business/sustainable-business/1200-buildings/funding-incentives/Pages/environmental-upgrade-finance.aspx, viewed 6/12/2108.

planning a retrofit over the next 5 years.[78] It notes that lighting upgrades and chiller upgrades (or replacement of air conditioning systems) were the most common retrofit types. The average cost of retrofits was $343,000 per building, but 12% of them cost over $1 million. The study notes that the most common motivation for a retrofit is to replace a broken asset (37%), although 33% cited 'to minimise energy consumption'. Similarly, the most common motivation for a building tune up was 'to extend the life of the asset' (26%). Unfortunately, no data was captured in this survey on the outcomes of the retrofits in terms of avoided energy consumption or cost. While some case studies are published on the 1200 buildings website, the majority do not include energy or emissions savings information.[79]

Other policies and programs support existing building upgrades. For example, Victoria, New South Wales, South Australia and the Australian Capital Territory all have energy efficiency targets and savings schemes, and these incentivise existing building upgrades to varying degrees – particularly commercial lighting upgrades. The *CitySwitch* program encourages higher efficiency and reduced emissions amongst building tenants. NABERS and Commercial Building Disclosure have been noted earlier. Nationally, the Clean Energy Finance Corporation (CEFC) is playing an important role in making low-cost finance available, including for commercial building upgrades. More than $600 million has been committed to finance clean energy and energy efficiency projects in the property sector.[80]

At the national level, a Green Building Fund operated between 2008 and 2012, providing grants of between $50,000 and $500,000 for up to half the cost of retrofitting or retro-commissioning commercial office, hotel or shopping centre buildings. $90 million was made available for this program.[81] However, there appears to be no information in the public domain about outcomes achieved under this program, and we can find no evidence that the program has been formally evaluated.

Environmental upgrade agreements (EUAs – also known as Environmental Upgrade Finance or Building Upgrade Finance) are supported by the NSW Office of Environment and Heritage, as well as underpinning the 1200 Buildings program in Melbourne. Victoria amended its local government act in 2015 in order to allow all Councils (and not only the City of Melbourne) to support energy upgrade finance. In South Australia, the same mechanism supports the Building Upgrade Finance mechanism.[82] In each case, the essence of an EUA is a 3-way agreement between a building owner, a financer and a local council, that enables the building upgrade finance costs to be levied as a charge again the land upon which the building is located. Thus, the loan is effectively secured by the property rather than the property owner, reducing loan risk and enabling discounted interest

[78] City of Melbourne, *1200 Buildings, Melbourne Retrofit Survey, 2015*.
[79] https://www.melbourne.vic.gov.au/business/sustainable-business/1200-buildings/retrofit-tips-advice/Pages/1200-buildings-case-studies.aspx, viewed 11/12/2018.
[80] https://www.cefc.com.au/where-we-invest/property/, viewed 6/12/2018.
[81] https://www.fmmedia.com.au/sectors/green-building-fund-to-improve-office-buildings/, viewed 11/12/2018.
[82] Department of Environment, Water and Natural Resources, *Building Upgrade Finance* (undated).

rates and longer terms to be offered, relative to the general market. It can also enable the costs associated with building upgrades to be shared equitably between owners and tenants, helping to overcome the 'tenant-landlord split' that otherwise discourages owners from investing in efficiency upgrades that primarily, or at least in the first instance, benefit tenants.[83]

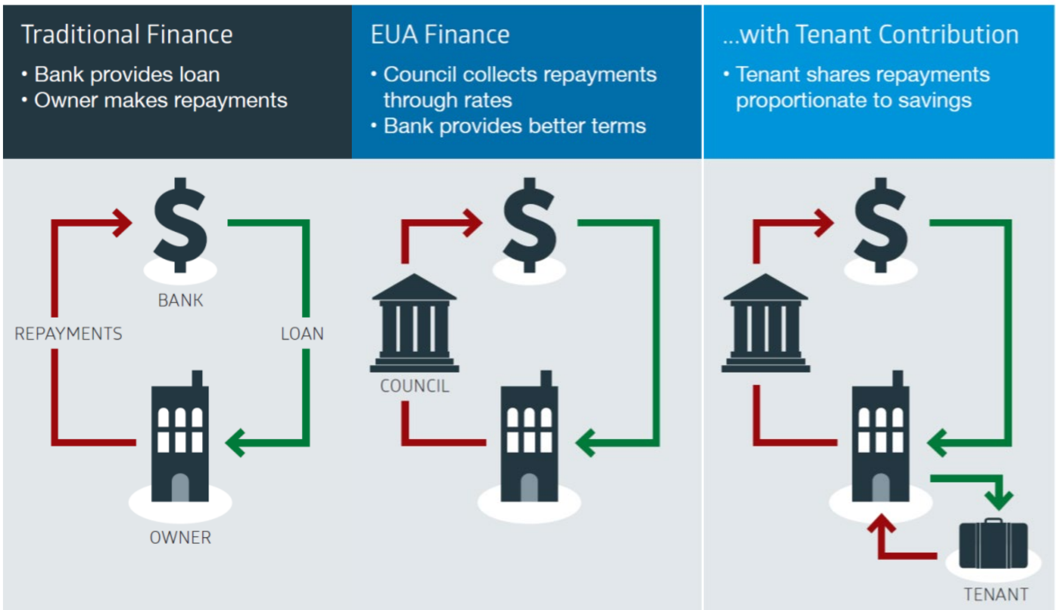


Figure 17: Environmental Upgrade Agreement schematic

Source: Sustainability Victoria, *Sustainable Finance – Environmental Upgrade Finance*, January 2018.

Energy performance contracting is another model that can enable building upgrades to occur with limited or no upfront capital invested by the building owner. In this model, an energy service company (ESCO) works with building owners or manages to first identify the extent of cost-effective upgrade potential, and then finances and implements the agreed measures, providing a contractual guarantee that the stated savings will be achieved. Generally, project costs are repaid over 3 – 7 years from the stream of energy cost savings realised.

While EUAs and EPCs can sound 'too good to be true', there are barriers to the take-up of these financing and project delivery models. Both involve complex and multi-party contracts – although various parties offer standard form contracts to help reduce complexity in this area.[84,85] Still, contract negotiations can be long, when compared to self-financed projects. Second, the longer

[83] It is sometimes overlooked, however, that efficiency upgrades can directly and immediately benefit owners, through increased building valuations and, over the longer term, through increased rental yields.

[84] http://www.eec.org.au/for-energy-users/tools-methodologies-menu/energy-performance-contracting#/energy-performance-contracting, viewed 12/12/2018.

[85] http://sustainablemelbournefund.com.au/wp-content/uploads/2014/03/TFE_eBOOK_FINAL1.pdf, viewed 12/12/2018.

contractual terms are not favoured by all, as they may present complexities should the owner wish to sell a building with an EPC in place. As noted, EUAs offer a distinct advantage in this regard.

4.2.2. Technical Opportunities

It would be technically feasible to upgrade the energy performance of most buildings in Australia. However, only a sub-set of these would be commercially cost-effective, and a smaller subset likely to proceed in the absence of new investment drivers. We noted above that for new buildings, there is a great diversity of building solutions and needs, and therefore equal diversity in incremental costs and payback periods for increasing levels of energy efficiency. The same is true for existing buildings, but to an even greater degree, as the designer must work with the peculiarities of the existing building and plant design, location/site, function(s) and other factors. These may constrain the choices that are practically available.

However, the most common efficiency upgrades involve replacement of lighting systems and HVAC plant and systems, including controls. In lighting, the most significant technical innovation, from a commercial perspective, has been the increasing longevity of lamps and ballasts, creating financial savings via reduced maintenance. Older magnetic ballasts failed more frequently than lamps, causing flicker that triggered an immediate service call. With the move to T5 fluorescent lamps, electronic ballasts become essentially standard-place, with the higher energy efficiency of T5 lamps essentially a bonus from a commercial perspective. LEDs continue to trend towards low maintenance, and therefore low cost, lighting. This factor led to the early adoption of LEDs even at a time when the technical efficiency of these lamps may have been lower than T5s, measured in lumens per Watt.

While LEDs are now almost the default solution for any new commercial building lighting application, and there has been a great deal of lighting retrofit activity in recent years, supported by state efficiency schemes in particular, there are still many older fit-outs with T8 or T5 lighting that could be upgraded. While a little dated, data analysed in Sustainability Victoria (2018) indicates that in 2015, between 17% and 28% of all net lettable area subject to CBD tenancy lighting assessments consumed more than 15W/sqm for lighting, as compared to best practices of 5W/sqm or less (p. 75).

HVAC retrofits are typically still triggered by ageing plant failures, as noted in the 1200 Buildings survey. While plant such as chillers and gas boilers are long-lived, up to 25 years, that means that buildings constructed prior to the mid-90s may be due for major plant replacement. Short of this, retro-commissioning and tuning of HVAC systems is being enabled by increasingly smart software tools and building management systems. These draw on information from sensors and sub-meters throughout a building to monitor indoor and outdoor conditions and (in some cases) the performance of individual system components, in order to optimise and schedule the operation of HVAC systems. Newer applications have learning capabilities that enable finer tuning over time as a function of changing seasons or building use patterns. Particularly where buildings have been poorly commissioned or maintained over time, such systems can achieve significant energy savings (as well as, often, improved comfort outcomes for occupants) at relatively low cost, and without necessarily replacing major items of plant.

Other retrofit options include hot water system upgrades, which will typically be triggered by plant failure or replacement schedules, and – much more rarely – changes to facades and glazing. For some building types or zones, refrigeration (including refrigerated display cabinets), IT (data centre) or cooking/food preparation may offer more specialised efficiency opportunities.

A concise summary of efficiency options is offered in Normal Disney & Young' guide to *50 Best Practice Initiatives*, which was commissioned by the Clean Energy Finance Corporation.[86] Many but not all of these will be suitable for retrofit applications, as some require integration into building designs 'at the earliest possible stages'. For example, the following strategies documented in *50 Best Practice Initiatives* may be suitable for retrofit applications (in order of appearance, rather than priority):

- Cool roofs, or high-albedo finishes (in warmer climates).
- Adding external shading (particularly for low-rise buildings – costs for retrofitting external shading to high-rise buildings can be prohibitive).
- Enhanced daylighting – may be possible in 'deeper' retrofits. For low-rise buildings, skylights and small light-wells may be able to be added at modest cost.
- Green roofs and walls – provided attention is paid to sealing and any structural limitations (green roofs are heavy and could potentially exceed design limitations).
- Insulated roller doors – eg, for shops.
- Enhanced insulation.
- Internal blinds.
- PV panels.
- Energy storage.
- LED lighting.
- Occupancy sensors.
- Daylight sensors.
- Lighting controls, including for user-control and flexible zones.
- Power factor correction.
- Sub-metering and Building Management Systems (BMS).

[86] Norman Disney Young/Clean Energy Finance Corporation, *Energy in Buildings: 50 best practice initiatives*, 2017.

- BMS analytics.
- Solar hot water – generally suitable for buildings with modest hot water loads.
- Trans-critical CO_2 chillers and heat-pumps (offering efficiency gains as well as a less-damaging 'natural' refrigerant).
- Condensing boilers – although these still use fossil fuels and may not be suitable if zero emissions are targeted.
- Low-load chillers and boilers.
- Variable rather than constant air volume HVAC designs.
- Economy cycles.
- Ceiling fans.
- Demand-controlled ventilation – enabled by CO_2, CO or VOC sensors.
- Electronically commutated fans – involving brushless DC, permanent-magnet motors, that do not require variable-speed drives to vary fan speed.
- Heat recovery ventilation systems – particularly in hot and cold climates (rather than mild).

Given this diversity of technical options, the best guide to upgrade potentials is case studies, in that they illustrate a range of technically and commercially feasible outcomes. Generally, they do not illustrate the maximum degree to which existing buildings could be upgraded, technically or commercially, as the designer's brief may be to achieve outcomes that are specified differently.

We note that there are remarkably few detailed retrofit case studies available in the public domain, with Sustainability Victoria's Energy Efficient Office Buildings program an important exception to the rule.[87] Many case studies that are available are now dated by 10 years or more and/or are incomplete. It appears that many government programs that support retrofits do not appear to require full disclosure of costs and benefits, in return for taxpayer support. This represents a significant lost opportunity, as fully detailed case studies are highly valued by building owners and managers considering, but uncertain about, retrofit opportunities. We would strongly encourage governments running such programs to require full disclosure – as the price of government support – and to make this information available in the public domain. This would significantly enhance the public benefit from these programs, at no additional cost.

A-Grade Offices

Innovation Place, Sydney – HVAC Diagnostics, Controls and Tuning

[87] Even in this relatively well-reported example, project costs are not reported, although payback periods are.

Innovation Place is a 23-storey A-grade office in North Sydney. It was designed to achieve NABERS 5 star energy. In 2013, a building diagnostics control and tuning software system known as PlantPRO was installed with aim of optimising HVAC energy consumption. The software enables and manages chiller sequencing and manages requirements for condenser water pumping and cooling towers, including fans, based on cooling demand. This project cost $59,000 and achieved an 11% reduction in energy consumption, generating savings valued at $42,600 per year, and representing a simple payback of investment of just 1.4 years.

Source: http://www.eec.org.au/uploads/images/NEEC/Information%20Tools%20and%20Resources/Tools%20Info%20and%20Resources/Airmaster%20-%20PlantPRO_CaseStudyInnovationPlaceOct14-FULL.pdf

Australian Central – Lighting Controls

This study dates from around 2011 and involved retrofitting daylight and occupancy sensors to a T5-based lighting system, along with minor changes to HVAC in a small data centre (widening temperature and humidity bands, changing duty/standby cycles of supplementary air conditioners), and reducing the time of use of external display lighting. Together these measures cost around $40,000 to implement and saved 93,000 kWh of electricity annually, valued at $16,000, for a 2.5 year simple payback.

Source: http://www.eec.org.au/uploads/images/NEEC/Information%20Tools%20and%20Resources/Tools%20Info%20and%20Resources/090630%20Aus%20Central%20Case%20Study.pdf

10-20 Bond Street, Sydney – LED Lighting

10-20 Bond street is a large office that achieved a 5 star NABERS energy rating, fitted with a mixture of T8 and T5 fluorescent lighting. This office was fitted with 250 LED fire stair lights with motion sensors, and 630 LED downlights. These fittings are designed for a minimum of 30,000 hours life. Prior to works, the buildings annual lighting costs were $52,254 including lamp maintenance. After works, lighting costs were reduced by 85% to $7,800 per year. Annual consumption savings of 18,300 kWh are expected.

Source: http://www.eec.org.au/uploads/Case%20Studies/10-20%20Bond%20St%20case%20study.pdf

40 Miller Street, North Sydney – LED Car Park Lights

Car-park lighting at 40 Miller Street comprised 107 twin T8 fluorescent tube battens (105 W) and 9 lowbays (250 W). These were replaced with Australian-made LED battens (22 W) and LED flat panel highbay lights (120 W). Total brightness was significantly improved, while annual energy consumption fell by 49,000 kWh, saving $13,500 per year in energy and maintenance costs, with a simple payback of 2.1 years. The study also notes that all lights were replaced in 2 days.

Source: http://www.eec.org.au/uploads/Case%20Studies/40%20Miller%20Street,%20Nth%20Syd%20-%20Case%20Study.pdf

City of Sydney Town Hall – Energy Performance Contract

The City of Sydney's Town Hall and other buildings were given major retrofits through an energy performance contract with Ecosave. The works involved lighting upgrades, HVAC upgrades, installation of variable speed drives, power management for computers, changes to building control systems and water saving initiatives. The projects cost $7.1 million and are returning annual savings of $1.2 million, for a 17% annual return on investment of 6 year simple payback.

Source: https://ecosave.com.au/news-insights/case-study/city-of-sydney/

Council House 2, Melbourne – BMS control upgrade, submetering and monitoring, HVAC refit

CH2 has a gross floor area of 12,536 sqm and was built in 2006. It was designed to be Australia's first 6 star Green Star building. However, by 2013, its NABERS rating had fallen to 3.2, due to failure of chilled ceiling panels, phase-change energy storage materials, and other factors. Following monitoring and investigations, works were carried out to upgrade the building management system control strategies, enable variable flow to the tenant condenser water system and to install submetering and monitoring. These works lifted the rating from 3.2 to 4.0 stars. A second round included revision of the base building packaged air conditioners and controls, revision of the tenant condenser water loop operation and optimisation of the HVAC operating schedule. These works further lifted the rating to 4.5 stars. Additional works are expected to lift the rating to around 5 stars. The study notes that the BMS upgrade alone achieved energy savings of around 10% (and ghg emissions reductions of 25%), with a value of $41,500 per year, and an 8% annual return on investment.

Source: https://www.melbourne.vic.gov.au/SiteCollectionDocuments/1200-buildings-ch2-case-study.pdf

Mid-Tier Offices

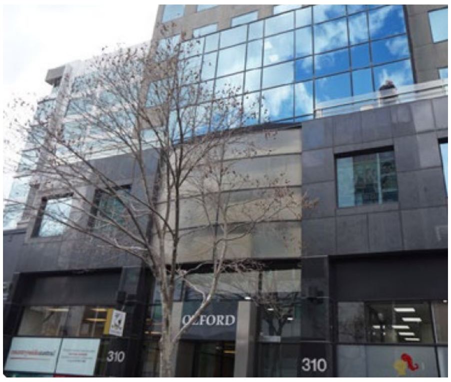
An Ernst & Young report (undated, but apparently from 2015) finds that commercial office buildings have the greatest potential for upgrades, equivalent to 5,142 GWh by 2020. It notes that there is greatest technical potential in mid-tier offices, as many premium and A-grade offices will already have been upgraded.[88] This source cites the 2015 Property Council of Australia Office Market Report, which looks at 25 urban centres around Australia, that notes that there is some 25 million

[88] Ernst & Young, *Mid-tier commercial office buildings in Australia: research into improving energy productivity*, 2015, p. 3.

square meters of mid-tier office space in these centres, with an average age of around 27 years, with more than 80% being over 10 years old.[89] This study documents potentials only, and therefore does not include results of competed upgrades.

The Victorian mid-tier offices program, the Energy Efficiency Offices Program, includes 20 case studies, with two of the more notable results summarised below.

310 King Street, Melbourne



310 King Street is a 10-storey, 6,000 sqm office tower, completed around 1970. The program audit found seized external air dampers and leaking ductwork. Repair of these (common) faults resulted in a 50% reduction in air leakage, and very significant HVAC cost savings. Major upgrade works then involved a new boiler, fans and variable speed drives; a new Building Management System; numerous sensors and controllers, including occupancy sensors for lighting; and economy cycle operation for HVAC. System documentation (largely absent) was also updated. This project was expected to realise 141 MWh of electricity savings and 1,126 GJ of gas savings, equivalent to a 62% reduction in annual energy consumption, and a 1 star NABERS uplift (which appears a conservative estimate).

Source: Sustainability Victoria (2016).

123 Lonsdale Street, Melbourne

123 Lonsdale Street is an 11-storey, 5,800 sqm office building built in the 1970s. Its major exposed façade is to the North. The retrofit activities focused on replacement and then tuning of major HVAC plant. A pre-works audit found that the HVAC system was constant-volume, and therefore not responsive to demand or external temperatures. There were significant blockages in the air distribution system, placing additional loads on fans and motors. In the refit, air handling units were replaced, with refurbishment of fans, filters, dampers and alarms. The system had variable speed drives installed throughout, enabling a variable air volume delivery. This, in turn, required extensive air balancing works, installation of sensors, variable flow controls and a new Building Management System. The building was occupied throughout the upgrade works. The pre-works NABERS rating is not stated but is likely to have been very low. Post-works, the rating (self-assessed) is 4.0 stars, with projected annual savings of 569 MWh of electricity and 3,197 GJ of gas. This represents a remarkable 60% reduction in annual

[89] Ibid, p. 5.

energy consumption. Project costs and returns are not stated. Lighting upgrades were noted as the next retrofit project.

Source: Sustainability Victoria (2016).

A final window on retrofit potentials is offered by the 2013 Beyond Zero Emissions Buildings Plan.[90] The study includes simulation modelling of the potential to upgrade:

A pre-1945 masonry-clad office tower (Brisbane)

A 1945 – 1980 curtain-wall tower

A 1940 – 1970 education building

A shopping centre (less relevant in the context of this report).

Note that newer technologies would be applied if these simulations were redone today, but the results remain broadly applicable.

The masonry-clad tower, pre-refit, has no insulation, single glazed windows (20% of the façade), minimal shading, an air-cooled chiller with fan coil units for distribution. The lighting power density is 17 W/sqm. Net lettable area is 1,566 sqm, and baseline energy consumption is 3,780 MJ/day.

The refit:

- replaces all lighting with LEDs
- upgrades glazing to double-glazing (u value 2, SHGC 0.64)
- applies R4 insulation to the roof and R2.5 to walls
- uses draught-proofing and air-locks to reduce air infiltration from 1 ACH to 0.1 ACH
- new chiller upgrades COP from 2 to 4
- gas boiler is replaced with a heat-pump, COP 4
- variable speed drives and controls are installed on pumps and fans
- night purging is incorporated with the building management system
- heat pump hot water replaces gas and electric storage systems
- water-efficient plumbing is installed
- energy management system with sub-metering
- training for on-site facility managers
- energy efficient office equipment is installed (LED displays, low wattage PCs, etc).

The net impact of this program is modelled to reduce energy consumption by 80%. Refit costs are not stated. This is depicted in Figure 18.

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90 Beyond Zero Emissions/Melbourne Energy Institute, *Zero Carbon Australia Buildings Plan*, 2013.

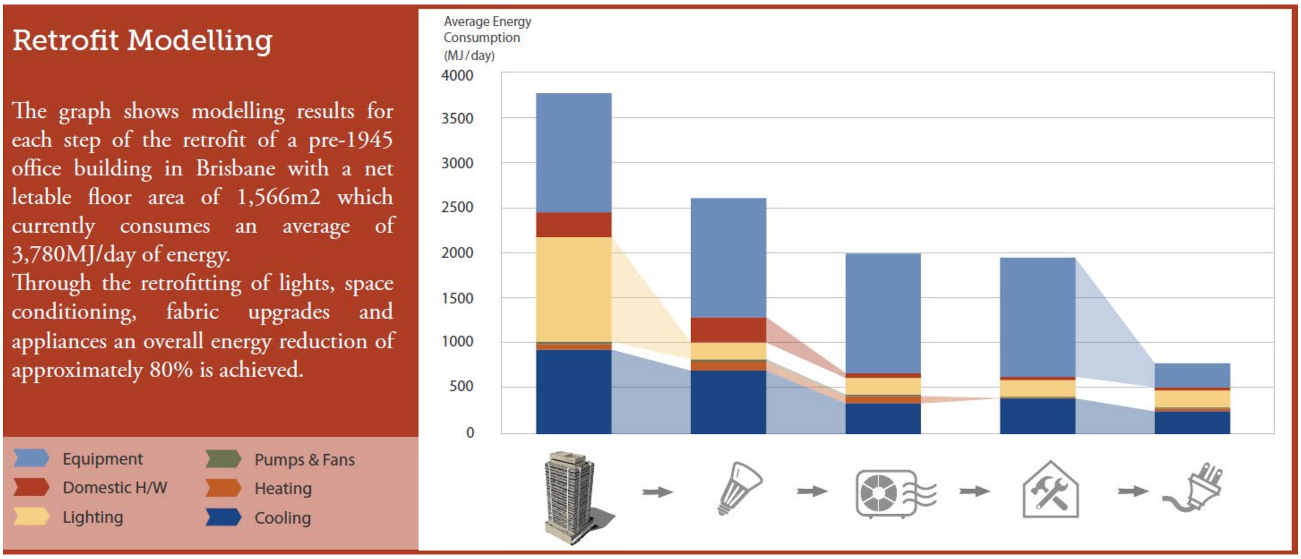

Figure 18: Pre-1945 Office Tower Refit

Source: Beyond Zero Emissions (2014), p. 151

Similar results, ranging from 63% to 83% energy reductions, are achieved in the other non-residential case studies. Looking across the end-uses within buildings, the BZE Plan notes the following technical potentials (p. 158):

End Use	Proposed Retrofit	Expected energy savings
Office Equipment	Computers, monitors, etc replaced with best practice models	73% (as per 11 W/m^2 to 3 W/m^2 in Office category)
Other Miscellaneous	Small savings from Energy Management System	15%
Domestic Hot Water	Heat Pump replace existing gas or electric service	~75% (Heat pump COP 4)
Lighting	LED replacements	78%
Air handling	VSDs and general maintenance	25% (based on interpretation of modelling results)
Space Heating	Heat Pump Boiler	~50% (Heat pump COP 4 then derate due to lower heat sources elsewhere in the building)
Space Cooling	A combination of fabric upgrades, internal heat load reductions, and limited improvements to existing equipment	50%
Pumping	VSDs and general maintenance	25% (based on interpretation of modelling results)
Cooking	Induction Cooktops and Electric Ovens	26% (base electric), 63% (base gas)

Table 6: BZE Buildings Plan: Upgrade Potentials by End-Use

4.2.3. Benefits and Costs

As noted above, some of the case studies provide indications of investment costs and returns. We also noted that the primary challenge is that every building and every retrofit is unique, and so generalisation is not feasible. Rules of thumb include that savings will be greater and more cost effective when:

- Current energy efficiency/NABERS ratings are low
- The building/plant is aged and/or poorly maintained
- There are no unusual site constraints, such as highly restricted plant rooms, or significant difficulties associated with service continuity (eg, this is more challenging for buildings with 24/7 operating profiles, including hospitals and aged care centres)
- The building owner and/or tenant (or prospective tenant) is motivated and well-informed
- The building is institutionally-owned and professionally managed.

SPR personnel have conducted detailed analyses of the cost and benefits associated with specific retrofit types, for example as published in the City of Sydney's *Energy Efficiency Master Plan Foundation Report*.[91] The underlying data draws on many actual retrofit projects conducted by Energy Action (or its predecessor, Exergy Pty Ltd) over a period of years. Some data may therefore be dated now. An example of this data is show below, for office building lighting upgrades, while similar data is shown for HVAC upgrades, controls upgrades and tuning, appliances and domestic hot water. Each dot represents an actual upgrade project.

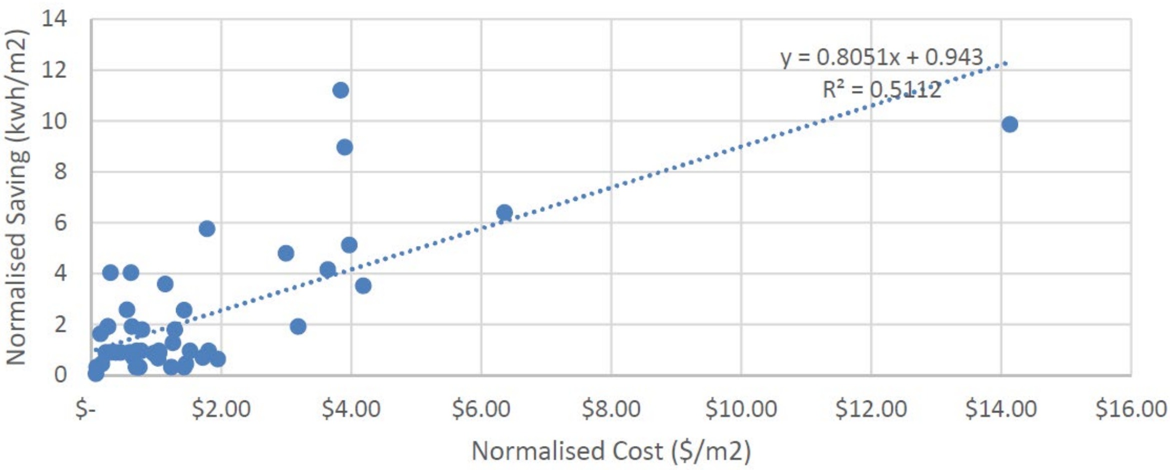

Figure 19: Lighting Upgrade Economics – normalised cost and energy savings

Source: pitt&sherry/Exergy (2015, p. 84)

[91] pitt&sherry/Exergy, *Energy Efficiency Master Plan – Foundation Report*, June 2015.

A summary table of commercial building upgrade options in the Plan was as follows:

Measure	Unit capital cost ($2014real/m^2)	Unit electricity savings (kWh/m^2.a)	Unit gas savings (MJ/m^2.a)	Simple payback (years)	Economic life of investment (years)
New Builds	$111.33	87.0	74.0	7.0	10
Lighting upgrades	$3.83	4.8	0.0	3.5	7
HVAC upgrades	$23.60	15.3	8.9	6.5	15
Lift upgrades	$144.27	6.1	0.0	102.7	25
Appliance/DHW upgrades	$0.75	1.6	0.6	2.0	7

Table 7: Commercial Building Upgrade Investment Parameters

Source: pitt&sherry/Exergy (2015, p. xv)

Another way to envisage this data is as abatement cost curves. These relate the volume of greenhouse gas emissions savings, under specific retrofit strategies, to their abatement cost, or average cost in $/tonne CO_2-e abated. Note that the x-axis is dimensionless as the opportunities may not be strictly additive. The key feature of this chart is that all upgrade options shown (lift upgrades have been excluded) have a negative cost of abatement. This indicates that the present value of energy savings over the equipment lifetime exceeds the initial incremental investment cost, which is another way of saying that the investments are all cost-effective on average.

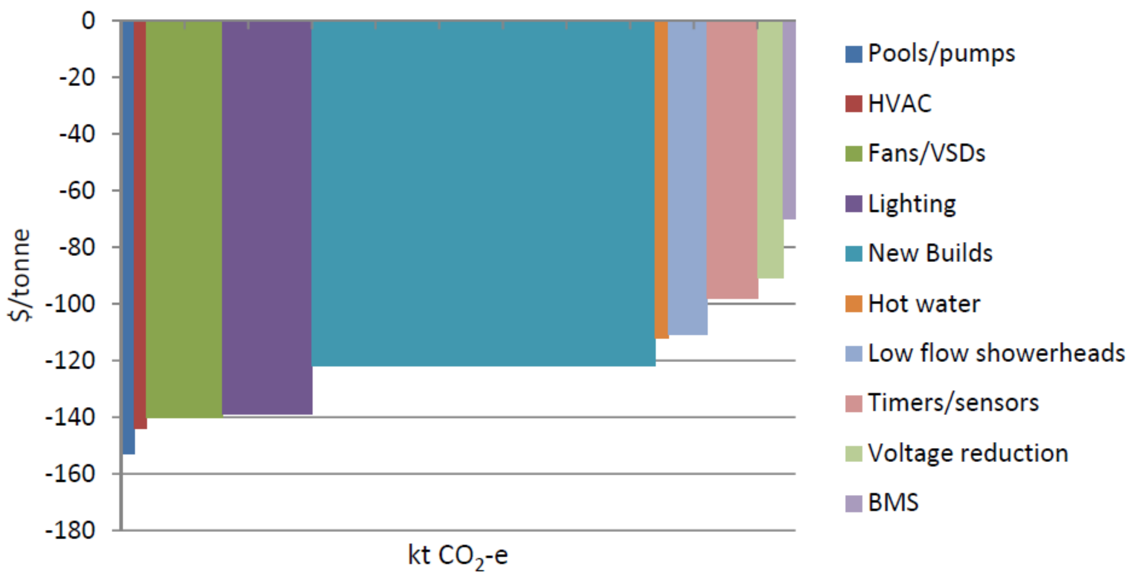

Figure 20: Marginal Abatement Cost (MAC) Curve – Commercial Building Upgrade Options

Source: pitt&sherry/Exergy (2015, p. 68)

Categories	Retrofit technologies
Building Envelope	• Improvement of fabric insulation level • Weather stripping windows and doors/ Increase air tightness • Use energy efficient window glazing, etc.
Passive technologies and energy efficient equipment	• Use of window shading to reduce solar heat gain in summer • Night ventilation • Use of thermal storage materials (e.g. phase change materials) • Energy efficient equipment and appliances, etc.
Lighting Upgrade	• Use of high efficiency lamps • Use of time scheduled control • Improvement of luminaries and installation of reflectors, etc.
HVAC, Building management and control	• Improve occupant behaviour through education • Use of heat recovery unit in HVAC • Replacement of inefficient HVAC equipment (e.g. Boiler, condenser etc.) • Use of BMS. • Adjusting the set-point, etc.
Renewable Energy	• Install Solar PV/PVT systems, wind power systems, geothermal systems, biomass systems etc. • Buy green power.

Figure 21: Categories of building energy retrofit measures

Source: SBENRC (2016), p. 20.

4.2.4. Procurement Potentials

As noted above, the nature of government building use has changed significantly in the last two decades, with fewer buildings owned and more leased. The opportunities for upgrades therefore need to be considered for each category separately.

Owner-Occupied Properties

While economy theory might suggest that owner-occupied buildings would tend to be more energy efficient than leased ones, the available data suggests the opposite. The Savills study cited above found this to be true, and research conducted by SPR for the City of Sydney has found the same result. It appears that the professional management of buildings that is generally found amongst institutional property owners (but less so private and overseas owners) more than outweighs the apparent self-interest that owner-occupiers have in running an energy efficient building.

Therefore, it is at least likely that government-owned buildings – and particularly older ones – may be excellent candidates for energy efficiency retrofits. At the same time, this potential should be considered in a wider facilities management context. For example, is the building near the end of its working life for other reasons (structural integrity, size, design, etc)? Also, is it intended to retain this building for at least 5 years? While not critical (in most cases), it may also be ideal to schedule an energy efficiency retrofit at the end of a period of occupation, when the building is partially or completely vacant, and to prepare the building for a new occupant.

Where these tests are passed, then a building may well be suitable for an energy retrofit. Depending upon the state, assistance and support may be available through centrally-organised energy performance contracting or building upgrade finance facilities. Alternatively, a classic self-financed approach would involve a level 3 audit, agreeing the scope and program of works, and project implementation arrangements including scheduling. While the scope of this study does not extend to implementation details, we noted that there are best practice guidelines available from government and non-government sources that could be used to assist with project implementation and management.

Leased Properties

When an agency is leasing a property, clearly there is greatest leverage to induce change prior to lease commencement, or at lease renewal. Prior to commencement, the key opportunity is to identify and occupy an efficient property. This is where ambitious procurement policies have their greatest power. If governments have unambiguous policies for procuring only energy efficient properties, then building owners and developers will have a strong incentive to meet those requirements. If, on the other hand, the policies are conditional or ambiguous, the industry may see the opportunity to negotiate on energy performance. Particularly in smaller and regional cities, government leverage over at the least the office market could be significant.

After property selection, it is critical that leases that are signed contain green lease clauses that provide for continuous review and improvement of energy/sustainability performance. Second, it will be critical to gain waivers of make-good clauses, at least with respect to any energy efficiency upgrades that may be undertaken or financed by the government as a tenant. Such waivers are best negotiated prior to lease commencement, to ensure that the option of future upgrade investment exists.

In situations where existing leases do not provide for sustainability upgrades, and where building owners refuse to negotiate reasonable terms, there may be little recourse other than legal action – if there are grounds for action provided by lease terms, for example, if a court may find the withholding of permission to upgrade unfair or unreasonable. Legal advice would need to be sought on a case by case basis. Short of that, governments can at least signal future leasing intentions by making strong and clear policies. Many building owners will not be insensitive to such policies, regardless of existing lease terms, as governments are generally 'good', long-term clients.

4.2.5. Conclusions

The general case for energy retrofits to existing buildings is strong, with the potential sometimes existing for energy and emission reductions of 60% - 80%, before PV (or other renewable energy procurement – see Chapter 4) is considered. At the same time, it is the case that every building is unique, and therefore rules of thumb do not offer much guidance. Some buildings may offer poor upgrade potentials and/or project economics. The best solution is for existing buildings to be objectively rated (eg, under NABERS) and/or subject to careful energy audits, by accredited and well-reputed service providers, to quantify both the opportunities and the project economics. Some expertise is required to manage successful upgrade projects, and it may be that government-wide service contracts, energy performance contracting model agreements, or building upgrade finance and related contract and project management models, will provide the confidence and capital to undertake the projects.

We have noted that a facility management perspective should be brought to bear on potential building upgrades, to ensure that the upgraded facility will be fit-for-purpose and valuable to government, and not subject to sale or demolition, into the foreseeable future. For leased properties, governments' best ally may an ambitious and unambiguous procurement policy, that is clearly communicated to the property industry. In markets where high-performance buildings do not already exist, government standing in the market as a 'green' buyer will be the most important factor that induces the industry to upgrade, and/or build new facilities, to the required standard.

Recommendations

4) Governments should ensure that their building leasing policies are maintained at best practice, by reviewing and revising them as appropriate at intervals of not more than 3 years. Where NABERS star ratings are specified, these should be the highest star rating that is cost effective. This is likely to be at least 5.5 stars, but this may vary from market to market.

5) Governments should ensure that their building leasing policies are enforced and complied with. At a minimum, all agencies should disclose the extent to which the facilities they occupy comply with the policies. Where compliance is less than complete, agencies should indicate the strategies they intend to use to reach full compliance, and the expected timeframes to do so.

6) For buildings owned by governments and intended to remain in government ownership for at least three years, the economic potential for upgrading the energy performance of each building should be established via level 3 audits.

7) Governments should facilitate upgrading the energy performance of government-owned buildings that are intended to remain in government ownership for at least three years by co-ordinating procurement for facility audits and upgrades, including arranging for innovative finance where needed, including enabling energy performance contracting.

5. Low Emission Vehicles and Charging Infrastructure

This section investigates the potential for procurement to lower the financial and environmental costs of government use of transport services. There is a particular focus on the potential for the procurement of low emissions vehicles to lower the costs and negative impacts of government fleets.

Low emissions vehicles are those with levels of carbon dioxide emissions that are near the lowest within a vehicle class.

There are three main technologies used in low emissions vehicles. Internal Combustion Engine (ICE) vehicles can qualify as low emissions, in either petrol or diesel form, when very efficient engines are used. Electric Vehicles (EVs) are driven by an electric motor. There are three sub-types of EV. Battery Electric Vehicles (BEVs) are powered by a battery which are charged with electricity. Fuel Cell Electric Vehicles (FCEVs) are powered by fuel cells that use hydrogen as the energy source. Plug in Hybrid Electric Vehicles (PHEV) have an electric motor with plug chargeable battery and can run as a pure BEV; they also have an ICE to extend range. All these EV sub-types can be zero emissions when using electricity or hydrogen from renewable sources. The third main type of low emission vehicles are Hybrid Vehicles (HVs) that use a combination of an ICE and electric motor – but these cannot be plugged in. HVs are energy efficient and have low emissions but cannot achieve zero emissions. Vehicle classes and technology types are further discussed in Section 5.2.

5.1. Introduction

The chief purpose of passenger cars, light commercial vehicles and heavy vehicles is to provide transport services – the movement of people and materials from place to place. The nature of transport services can vary enormously – depending on trip purpose, distance, time availability, the quantity of people being moved, the quantity and nature of materials being moved and so forth.

Governments are large users of transport services. Some of those transport service requirements are outsourced to service providers - taxi and similar companies, hire car companies, freight services companies, airlines and others.

Vehicle fleets are also used to meet a portion of the transport service requirements of governments. Here, rather than procuring a particular service (like a taxi ride or courier service), a government agency buys or leases a fleet of vehicles which are then available to perform a variety of transport services.

Government fleets are procured under two models. Self-managed fleets involve a government agency managing the purchase, operation and on-sale of fleet vehicles. A fleet services or leasing model is now more common, where the outright purchase, maintenance and on-sale of the vehicles is outsourced to a private leasing company. The Australian and ACT Governments, for instance, use the company SG Fleet Group to provide their passenger vehicle fleet services. Other governments self-manage fleets or use a combination of self-managed fleets and fleet-services.

The size and nature of fleets remain the choice of a government agency under both fleet management models. Governments can also retain the ability to select specific vehicles under both models.

Fleet make-up is determined, in simple terms, under a two-step process. Both steps present opportunities for procurement decisions to influence the value for money and environmental performance of government transport service use.

Step one involves an assessment of transport service needs and an assessment of how those needs will be met – by a fleet vehicle or a transport service provider.

This first step determines fleet make-up – as the fleet will be matched to the transport services that have been chosen to be delivered in-house. Vehicle categories broadly match the main transport service being provided – passenger, light commercial and heavy. These three main categories have numerous sub-categories such as small passenger cars, utility vehicles, medium vans, waste management trucks, buses and so-forth. Government fleets vary widely. The Australian Government, outside the Defence Department, tends not to run many heavy vehicles in its own fleet. State, territory and local government fleets reflect the very wide range of transport services that they need and provide. Some of these governments choose to run small fleets and outsource most of their transport service need, while others run very large and diverse fleets. While the scope of this report does not include tasks delivered by heavy vehicles (like waste movement), they are common in council fleets, and the procurement principles discussed here can be applied to all transport service and vehicle types.

Step two of selecting a fleet is selecting specific models within the desired vehicle sub-categories. Model selection starts with checking that a model is safe and capable of performing the intended tasks; that is, fit for purpose. This will include considerations such as the location of the vehicle (remote, off-road, urban), its duty cycle and other factors.

There are often several models in each sub-category that fulfil safety and capability requirements. Model choice then depends on satisfying a range of criteria which generally include ease of operation and maintenance, purchase price, resale value and operating costs. The Australian Government Fleet Vehicle Selection Policy states that:

> *When selecting vehicles within the Australian Government Fleet, procurement officials must ensure that the vehicle:*
>
> *1) Has a five-star ANCAP rating;*
>
> *2) Meets the minimum fit for purpose requirements;*
>
> *3) Provides value for money; and*
>
> *4) Addresses environmental considerations.*

Environmental considerations can be addressed by including minimum vehicle performance requirements within selection criteria. This is straightforward as all new passenger and light commercial vehicles are required to display their fuel and greenhouse gas emissions performance. Testing for the energy and emissions label is done in accordance with an energy consumption labelling standard (Australian Design Rule 81/02). The label shows the fuel consumption of the car in litres/100km and the CO2 emissions in g/km based on a standard test. Electric and hybrid vehicles are also covered with a label that shows the vehicles energy consumption in Watt hours/km, expected range when fully charged, fuel consumption in litres/100km and CO2emissions in g/km.

It is also possible to address air pollution emissions such as particulates and oxides of nitrogen through procurement. The minimum standard in Australia for new vehicles is currently Euro 5. However, some vehicles that meet the Euro 6 standard, that has applied in Europe from September 2014, are available in the Australian market. It is worth noting that the 2010 Final Regulation Impact Statement for Review of Euro 5/6 Light Vehicle Emissions Standards recommended that Euro 6 be introduced from April/July 2017 for models newly introduced to the Australian market and April/July 2018 for all new light vehicles. However, the nature and timing of any vehicle emissions standard are now under review, with the 2016 Vehicle emissions standards for cleaner air: Draft Regulation Impact Statement suggesting that the earliest commencement date for Euro 6 would be 2019/20.

While Australian Government procurement officials are required to take environmental considerations into account; minimum performance requirements for energy or emissions performance have not been set.

Fleet selection and procurement processes can be configured to achieve both value for money and environmental performance criteria. Figure 22 below is an example of simple process to achieve those aims.

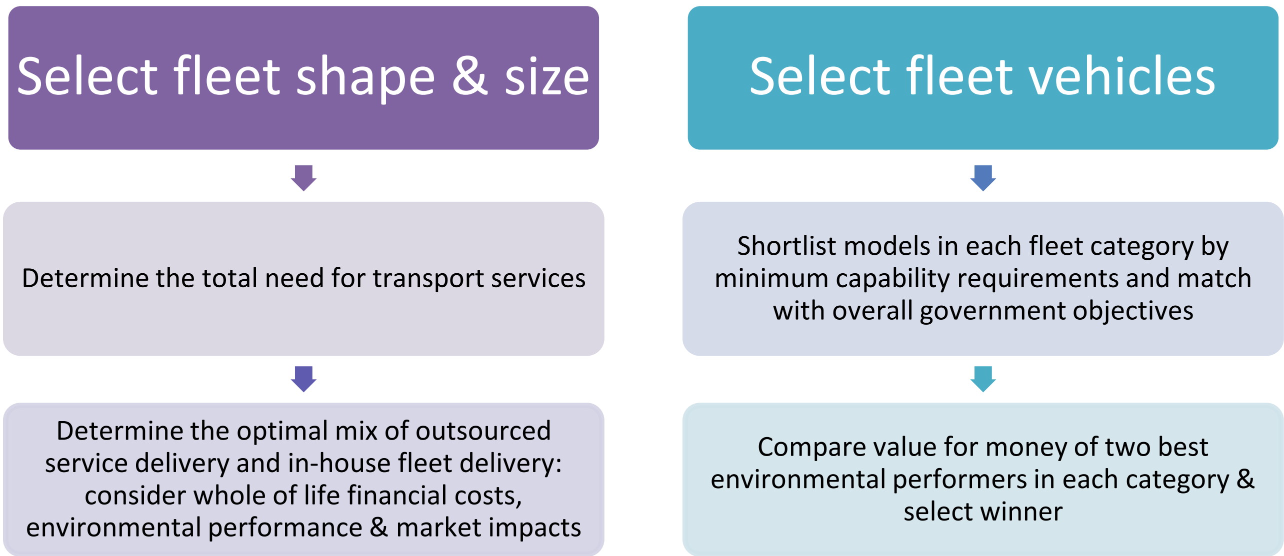

Figure 22: A fleet selection process with clear environmental and value for money criteria

5.2. Technical potential

The Section has two parts. The first investigates the potential to purchase lower emissions vehicles in the current market. The second discusses the likely opportunities to further lower vehicle emissions in the future.

5.2.1. Current technical potential

Australians, along with their governments do not generally emphasise environmental or fuel costs when they make vehicle procurement decisions. This leaves ample scope for improvement of the greenhouse gas emissions performance of both the government fleet and overall national fleet.

The national average greenhouse gas emission intensity across new passenger and light commercial vehicles purchased in 2017 was 181.7gm CO2 per km. The European average for passenger cars, by way of comparison was 118.5g CO2/km and 164g/km for light commercial vehicles. These intensity scores are based on the laboratory results from manufacturer testing for ADR81/02 – fuel consumption labelling for light vehicles – which stipulates the test method used in Europe.

Private buyers, in 2017, purchased light vehicles with better fuel and emissions performance than business buyers on average. Light vehicles purchased in 2017 by governments had poorer than average fuel efficiency and emissions performance, by around 10% . This is illustrated in Figure 23.

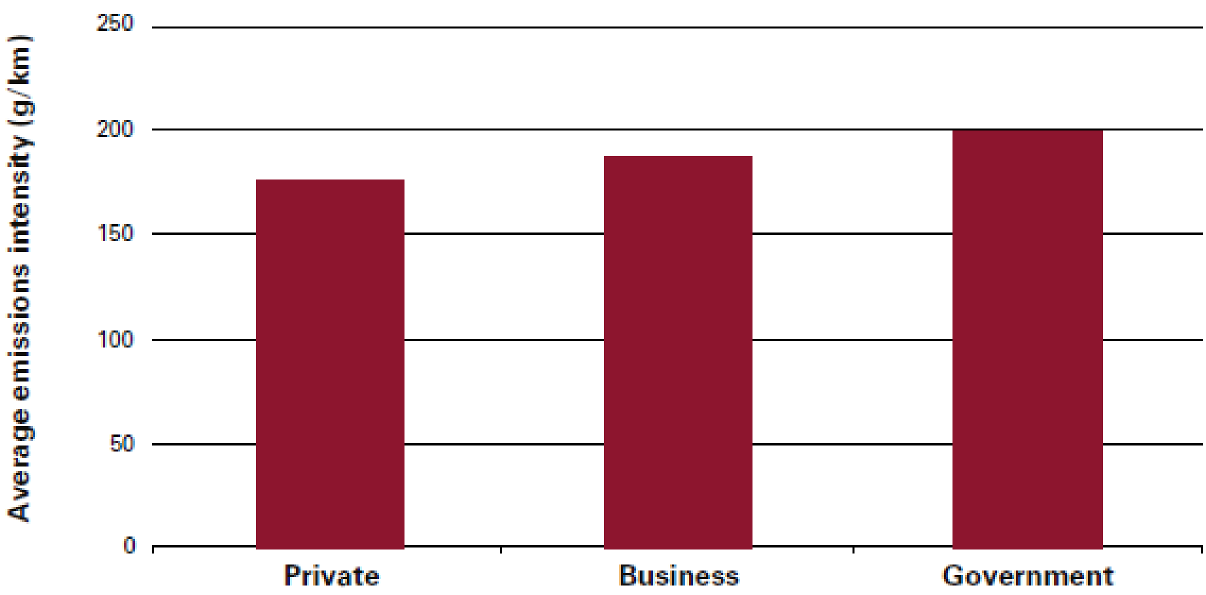

Figure 23: Average GHG emissions intensity for light vehicles by buyer type[92]

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[92] Figure 11, NTC, 2018, *Carbon Dioxide Emissions Intensity for New Australian Light Vehicles 2017*

The figure suggests that private buyers are giving more weight, in their purchase decisions, to fuel and emissions performance than business and governments.

One possible factor is that private buyers are mainly individuals whose available income is directly affected by their choice of vehicle and its running costs. Fleet managers don't themselves pay for vehicles and their costs – these costs are passed onto finance areas in an organisation. There is still a cost incentive to purchase fuel efficient vehicles but the signal is not felt at the level of individual incomes.

Another factor behind the high average emissions level of government vehicles is the procurement policies that applied in 2017, at Australian and some state government levels, to prioritise Australian built vehicles. Australian built vehicles sold in 2017 had an average emissions intensity of 219gm CO_2 / km – about 20% higher than the overall average of 181.7gm CO_2 per km. This policy is out of date following the closure of large-scale Australian car manufacturing – so a different result for 2018 might be expected.

There is less choice of low emissions vehicles in Australia than many overseas markets such as Japan, California and Europe. This lack of model availability particularly applies to electric vehicles which have the greatest potential to dramatically reduce fleet emissions. Nevertheless, there are significant numbers of low emission models available for purchase in Australia. The National Transport Commission (NTC) reports that if Australian new vehicle purchases for 2017 had been restricted to the best-in-class vehicles, average emissions intensity would have dropped to 76g CO_2/km.

The various vehicle classes/segments along with the best performers in each class in 2017 are shown in Table 8.

Many of the vehicles with the best emissions performance also have top end purchase prices. This means that despite low fuel costs, some of those vehicles would not be selected on a whole-of-life value for money basis. It is not realistic therefore, in the current market, for the average emissions of government fleets to fall from around 200g CO_2 per km to the 76g CO_2/km that could have been obtained by restricting choice to the very best performers.

Investigating the potential for lower emissions class by class

We examined the NSW Government's Approved Vehicle List (AVL) to assess the potential for achieving emissions and fuel savings across a cohort of vehicle models that are commonly considered by government fleet buyers. The AVL is a selection of vehicles that are approved for use by NSW Government agencies on both fit for purpose and cost-effectiveness grounds. This list does not include some of the best emissions performers offered by manufacturers targeting niche or prestige markets featured in Table 8, presumably due to their purchase price.

Segment	Make and model (fuel source/s)*	Best-in-class vehicle emissions intensity (g/km)
Micro	Fiat 500 (petrol)	90
Light	Toyota Prius C (petrol-electric)	90
Small	BMW i3 REX (electric-petrol)	12
	Toyota Prius C (petrol-electric)	80
Medium	BMW 330E (electric-petrol)	49
	Mercedes-Benz C300 BTH (diesel-electric)	105
Large	BMW 530E (electric-petrol)	46
	Mercedes-Benz E220D (diesel)	108
Upper large	BMW 530E (electric-petrol)	50
	Mercedes-Benz S300 BT (diesel-electric)	118
Sports	BMW i8 (electric-petrol)	49
	BMW 220D coupe (diesel)	107
People mover	Citroen C4 Grand Picasso (diesel)	120
SUV small	Mini Cooper (electric-petrol)	49
	Citroen C4 Cactus (diesel)	92
SUV medium	Mitsubishi Outlander (electric-petrol)	41
	Peugeot 3008 (diesel)	124
SUV large	Volvo XC90 (electric-petrol)	49
SUV upper large	Land Rover Range Rover (diesel)	182
Pick-up/chassis 4×2	Nissan Navara (diesel)	166
Pick-up/chassis 4×4	Nissan Navara (diesel)	172
Vans/cab chassis	Citroen Berlingo (diesel)	108
Light buses	Toyota Hiace (diesel)	228

Table 8: Light vehicle classes/segments and top performing models in the 2017 Australian market

Models of leading, middling and lagging performance within each of the main vehicle classes were selected. Models are first compared on per km basis by fuel use and carbon dioxide emissions. The emissions intensity shown is the combined cycle (a test cycle designed to reflect a mix of urban and non-urban driving conditions) result as reported on the label and listed on the AVL. Energy efficiency was also compared in kJ, as this allows the energy efficiency of EVs and ICE vehicles to be compared.

The second comparison looks the potential annual savings that would apply to a set of 500 vehicles travelling 14,000km per year. Here we used the combined cycle energy and emissions figures plus 25%. This adjustment allows for the predominately urban and stop-start use of fleet vehicles. The size of the adjustment is based on a rough average of the difference between the urban and non-urban emissions intensity results reported at the Green Vehicle Guide. Note also that real-world energy efficiency is commonly worse than that achieved under the laboratory test. The annual cost estimates are based on a diesel price of $1.65/l, a petrol price of $1.61 and an electricity price of $0.25/kWh

The tables are shown in Appendix A. The extent of the available energy and emissions savings varies from class to class, however in each instance the performance gap between the leading and lagging performers is significant.

5.2.2. Future technical potential

The Australian vehicle market has undergone gradual emissions performance improvement in recent times. Average emissions intensity dropped from 226.4g CO_2/km to 181.7g CO_2/km over the ten-year period from 2007 to 2017. This is largely a reflection of gradual improvements in ICE vehicle technologies.

This past trend of slow but steady improvement is on the verge of disruption; with rapid improvement in the functionality and price of EV and hybrid technologies together with increasing availability of EV models.

The main EV and hybrid technologies, including hydrogen fuel cell vehicles (which are a form of EV as the wheels are driven by an electric motor), are shown in Figure 24.

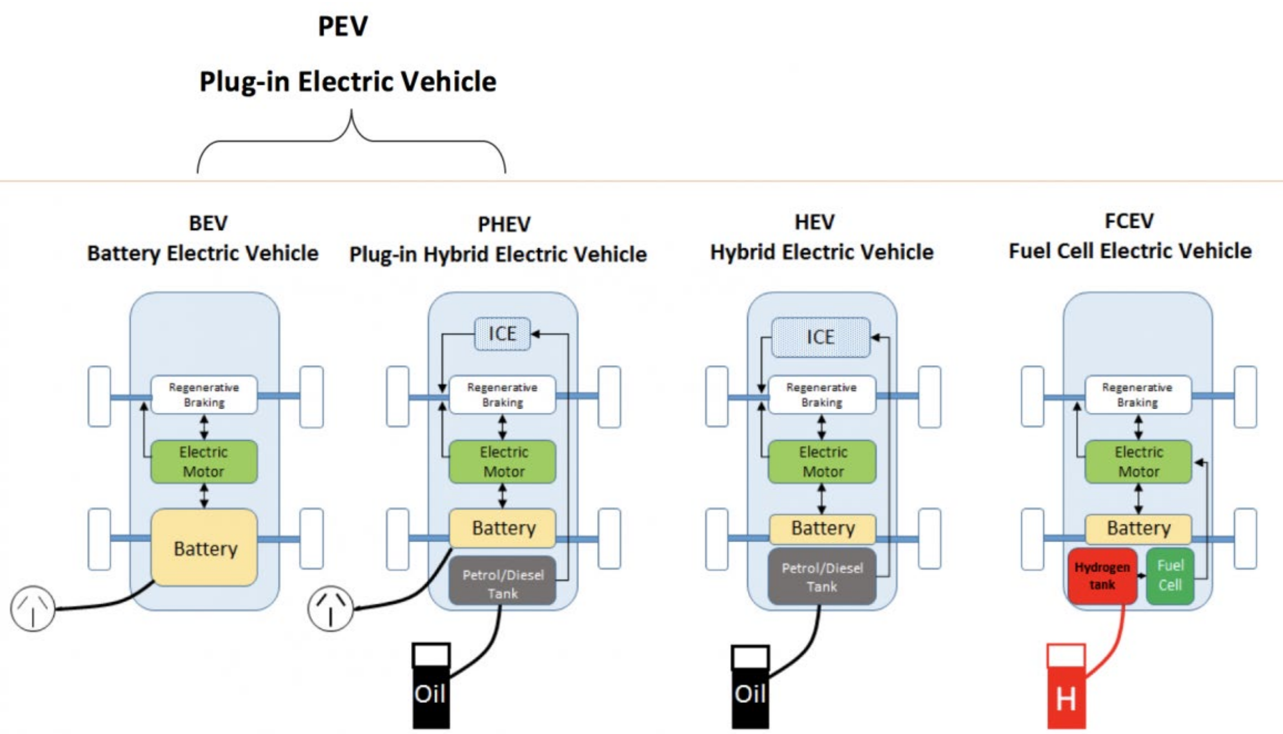

Figure 24: Electric Vehicle and Hybrid Types

The relative merits of the different electric vehicle types are much debated. However, the key point for this paper is that all forms of EVs can achieve much lower emissions than ICE vehicles. It is feasible, based on global car industry and market trends, that government fleets could entirely consist of zero emissions vehicles by 2025 or thereabouts. Utility class vehicles are an important vehicle class in many government fleets; these cannot currently be replaced by EVs in Australia. However, EV utility type vehicles are coming onto the global market. In Europe, Mercedes have recently released an EV version of their Vito van & Ford is releasing a PHEV version of their Transit Custom van and utility in 2019. The VW Transporter van and dual cab utility is expected to be available in electric form by 2022. These commercial, mass market vehicles are expected to be affordable and could easily fulfil the roles currently performed by ICE utilities.

5.3. Procurement potential

Significant emissions and energy cost savings could be achieved in today's vehicle market by selecting the best performer in each class from the NSW Approved Vehicle List. These vehicles already qualify for government purchase (or lease) on safety, fit for purpose and value-for-money grounds.

Section 5.2.1 looked at the annual emissions, energy use and costs by 500 vehicles in each class. The tables below build on that data to show per km and annual savings that can be achieved by selection of a class leading rather than lagging vehicle.

Table 9: Leading vs Lagging - Commercial Class savings per km & annual for 500 vehicles x 14,000km

Vehicle Category	fuel economy l/100km	energy efficiency GJ/km	energy efficiency %	emissions kg/km	annual emissions t/CO2e	annual $
4x2 utilities	3.5	893	25%	0.060	526	464,966
4x4 utilities	2.4	926	27%	0.065	571	346,290
Compact vans	6.5l/100km vs 15kWh/100km	1969	78%	0.155	1,356	584,719
Medium vans	2.6	616	29%	0.041	619	375,148
Totals					**3,073**	**1,771,123**

Table 10: Leading vs Lagging – Passenger class savings per km & annually for 500 vehicles x 14,000km

Vehicle Category	fuel economy l/100km	energy efficiency GJ/km	energy efficiency %	emissions kg/km	annual emissions t/CO2e	annual $
Light Cars	3.6	1231	48%	0.086	972	505,575
Small Cars	4.0	1368	54%	0.095	1,053	561,750
Medium Cars	3.6	1231	46%	0.086	751	505,575
Large Cars	3.2	870	31%	0.059	667	449,400
People movers	7.2	2462	62%	0.172	1,502	1,011,150
Small SUV	1.4	215	8%	0.013	292	173,513

Vehicle Category	fuel economy l/100km	energy efficiency GJ/km	energy efficiency %	emissions kg/km	annual emissions t/CO2e	annual $
Medium SUV	n/a	2291	78%	0.160	1,341	596,741
Large SUV	2.4	508	16%	0.033	291	309,715
Totals					**6,870**	**4,113,419**

Governments purchased 38,623 passenger and light commercial vehicles in 2017. Purchase numbers and average emissions intensity by tier of government are shown below. The small number of EVs purchased by governments last year is also shown.

Table 11: Government vehicle purchases and average emissions intensity in 2017

Tier of Government	Total Vehicle purchases#	Average Emissions intensity	EV sales
Federal	4,376	200g CO_2/km	1
State & territory	24,940	200g CO_2/km	31
Local	9,307	195g CO_2/km	5

 # Source: VFACTS

It should be noted that some governments now lease a portion of their vehicles from providers such as SGFleet, rather than purchase them outright. It is likely that some of the 1100 EVs bought in Australia last year were purchased by fleet provision companies and leased to governments. Unfortunately, we do not have the numbers of leased vehicles, so the discussion below relates only to fleet vehicles purchased by governments.

The annual savings that could be achieved across the purchase of 38,623 leading rather than lagging vehicles are shown below.

Table 12: Potential annual savings from a year's purchase of vehicles for government fleets (leading instead of lagging)

Vehicle Category	Assumed share of purchases	vehicles	Savings tonnes CO2	Savings $
Light Cars	5%	1,931	3,756	1,952,682
Small Cars	10%	3,862	8,133	4,339,294
Medium Cars	10%	3,862	5,800	3,905,365

Vehicle Category	Assumed share of purchases	vehicles	Savings tonnes CO2	Savings $
Large Cars	10%	3,862	5,156	3,471,435
People movers	5%	1,931	5,800	3,905,365
Small SUV	5%	1,931	1,128	670,157
Medium SUV	10%	3,862	10,361	4,609,587
Large SUV	5%	1,931	1,123	1,196,212
4x2 utilities	15%	5,793	25,134	16,923,247
4x4 utilities	15%	5,793	6,622	4,012,428
Compact vans	5%	1,931	5,236	2,258,359
Medium vans	5%	1,931	2,391	1,448,932
Totals	**100%**	**38,623**	**80,641**	**48,693,064**

Governments generally keep fleet vehicles for three years. The purchase of class-leading rather than lagging vehicles would deliver savings to governments and their communities in the order of 240,000 tonnes of CO2 and $150 million over their time under government use. The savings would then continue under second and third owners. Australian light vehicles have historically had a retirement age of 16 years. One year's purchase of around 38,000 class leading rather than lagging vehicles by government would achieve 1 million tonnes in emission savings when those vehicles reached 12.5 years in age. At that point energy savings for the cohort of vehicles would exceed $600 million.

Another procurement option would be for governments to write (independently or jointly) to manufacturers indicating our requirement for future vehicles. This has been done in the past, most recently by the Australian Government Fleet and the State/Territory Government Fleets writing to manufacturers requesting increased safety packages as a minimum to all vehicles. This led to ANCAP changing its requirements to achieve a five-star rating and most new vehicles coming in with high levels of safety equipment as standard.

5.4. Economics

5.4.1. Additional benefits of government procurement of low emissions vehicles

There are benefits, beyond direct savings, that would flow from a government procurement policy that rigorously selected low emissions vehicles. This especially applies to EVs with their unmatched ability to achieve zero emissions.

An important reason that governments only purchased a handful of EVs last year is that there were very few affordable models available to buy. This is also a key factor in the EV share of 0.1% of total Australian light vehicle sales.

The recent Australian Electric Vehicle Market Study found that procurement targets would be effective in boosting EV model availability in Australia. A government program involving the annual purchase of 200-500 particular models per year through a fleet arrangement was estimated to be sufficient to introduce the scale of demand required for car makers to bring those models to the Australian market. The underlying demand, supplied by government procurement, would help achieve an earlier transition to EVs than would be otherwise achieved under current policy settings. Given governments purchased almost 40,000 vehicles in 2017, a target of 2,000 + vehicles (around 5% of all government purchases) for the year 2019/20 is feasible.

It would be unwise to assume that EV availability in Australia will markedly improve over the next 5 years under a business-as-usual approach where government policy to encourage EVs is limited. Modest improvement should occur; Hyundai, for example, has released two fully electric models at the time of writing. It is also the case that vehicle manufacturers generally are accelerating the development and release of EVs. As of May 2018, car makers had announced over AU$200 billion of EV investment along with production targets totalling 13 million electric vehicles in 2025. This could be a little over 10% of expected global sales. However, with EV supply restricted to 10% of global sales (because of anticipated production constraints related to batteries and new model development), global demand for EVs could well exceed supply. This would see manufacturers divert their EVs to those markets where they are in most demand. This is precisely the situation Australia occupies at present. The affordable and effective 2nd generation Nissan Leaf has been in production for well over a year but remains unavailable in Australia because they are diverted to markets in California, Europe and elsewhere where government policy has lifted consumer demand for EVs.

5.4.2. EV charging infrastructure and range anxiety

The Clean Energy Finance Corporation arranged an EV Drive Day in Melbourne in November 2018 which was attended by 60 fleet buyers and managers. Attendee views on the attractions and concerns of EVs were collected. Range anxiety and public infrastructure was the greatest concern – as shown in the table below.

Table 13: Top 3 EV attractions & concerns for fleet buyers - CEFC survey

Top 3 EV attractions for fleet buyers	*Top 3 EV concerns for fleet buyers*
- **Low/no fuel and maintenance costs**	- Range anxiety/charging infrastructure
- **Reduced carbon emissions**	- Upfront cost of the EVs
	- Uncertain re-sale value

- Range suitability for regular shorter journeys	

Concerns about cost and resale values can be well-managed by governments and fleet companies purchasing for governments. Reasonable purchase and on-sell terms can be negotiated in return for bulk buys of several hundred vehicles. These concerns should not present a major barrier to governments that wish to steadily add EVs to their fleets.

Range anxiety is a more an issue for private rather than fleet buyers due to the concern that the vehicle won't be suitable for holiday road trips. However, the majority of both fleet and private vehicles do not travel more than 50km from home or work. Further, this concern is rapidly becoming baseless with technological advances. Early generation EVs could comfortably travel over 70km. The pure electric models destined for Australia in 2019-20 will have ranges well over 200km. High end models already have ranges over 400km and this extent of range is likely to be commonplace by the early to mid-2020s with battery technology advances. In the meantime, PHEV models are available which have the same range as ICE vehicles.

The limited availability of public charging at the present time likewise should not be considered a significant barrier to governments considering the gradual addition of EVs to their fleets. Fleet vehicles that travel less than 100km (or whatever the vehicle range) from the driver's home or workplace will not need public charging. The cost of installing basic charging infrastructure at workplace carparks is fairly modest. Similarly, the cost and difficultly of arranging 100% renewable electricity for charging is small.

Further, there already more public charging points than is perhaps appreciated and there are continuing moves from some businesses and governments to roll-out a network of public fast charging stations. A good example of a state government led roll-out is the Queensland Government's Electric Super Highway. The figure below shows over 600 public charge points in Australia at present with orange dots indicating DC quick-charging stations and green dots indicating standard AC charging points.

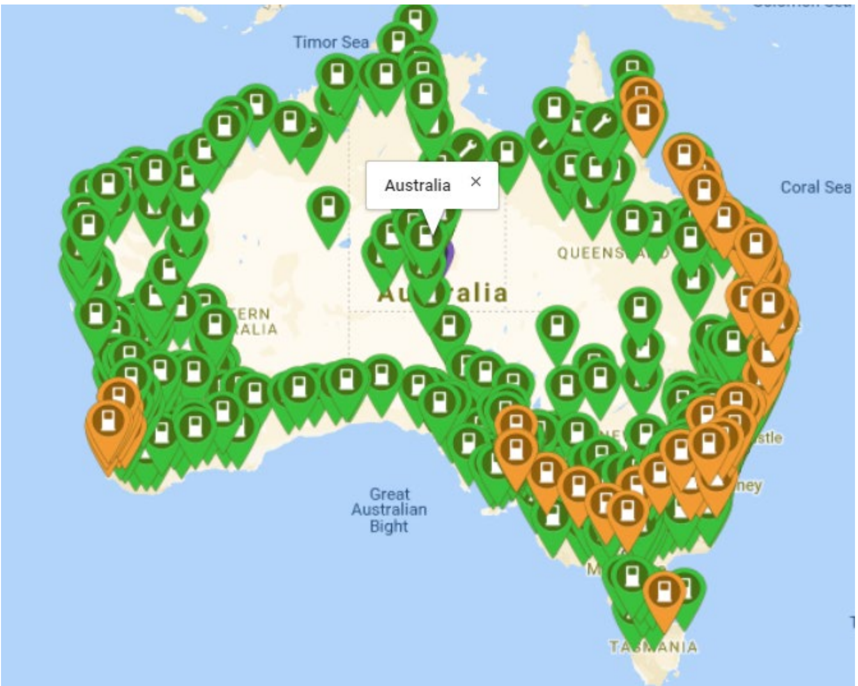

Figure 25 : Public charge points for EVs in Australia, 2018

In the short and medium-term, it would be sensible for governments to coordinate efforts to encourage the roll-out of public EV charging points. This will enable higher portions of fleets to move to pure electric vehicles and will also encourage private buyers to adopt EVs.

One simple and low-cost method of encouraging private investment in public charging points at existing service stations is via procurement. Governments or their fleet companies commonly use fuel cards – where fleet vehicles are refuelled at a particular chain of service stations. These fuel card arrangements are periodically up for tender. Future tender processes could include a requirement that EV charging points using 100% renewable electricity are available at service stations.

5.4.3. Case studies – low emission vehicle procurement in action

Melbourne Water

Melbourne Water is a water utility with a fleet of 364 light vehicles.

It has a target to transition to a zero emissions fleet by 2028, as part of an overall target to achieve carbon neutrality by 2030 as directed by Victoria's Minister for Water.

Melbourne Water has a simple and effective procurement policy that will very likely ensure that all vehicles will be zero emissions before 2028. No vehicles will be replaced by an ICE vehicle if an equivalent zero emissions electric vehicle is available. It is expected that this policy will see a complete switch of passenger vehicles by 2023. Light commercial vehicles outnumber passenger cars in the fleet with high numbers of dual cab utes. Melbourne Water expect that EV dual cab utes will be available by 2022 and will then begin replacing that part of the fleet.

In 2018, there are limited EV affordable passenger car options, so the transition has started in a gradual way. Two Renault Zoes have been purchased and another three will be purchased in 2018. The transition will begin in earnest in 2019 with the market arrival of vehicles like the Nissan Leaf and Hyundai Ioniq, which are larger than the Zoe and able to carry more passengers and materials.

The commitment to zero emissions vehicles will assist Melbourne Water achieve its transport emission goals and overall carbon neutrality target. It is also an example of tangible action to achieve the Melbourne Water strategic vision of "enhancing life and liveability"

ACT Government

The ACT Government has ambitious, territory wide targets to reduce greenhouse gas emissions. Targets include 100% renewable electricity by 2020 and net zero emissions by 2045.

Transport emissions will represent over 60% of ACT emissions once electricity comes from 100% renewable sources in 2020. Emissions from ACT Government operations will also be dominated by transport related operations after 2020.

The ACT's Transition to Zero Emissions Vehicles: Action Plan 2018-20 sets out numerous measures designed to shift private vehicles, business and government fleets to electric vehicles (potentially including hydrogen powered EVs in the future). The action plan and related strategies also contain measures that encourage electric bikes and public transport rather than cars. The ACT Government is also encouraging the community and government staff to choose active rather than vehicular travel options.

The ACT Government leases, rather than procures outright, its fleet of around 600 passenger vehicles from SG Fleet. Commitments to transition to zero emissions vehicles (which the ACT defines as a vehicle that has the ability to emit no greenhouse gas emissions including PHEVs) are:

- that at least 50% of newly leased vehicles will be zero emissions in 2019-20 (where fit for purpose)
- that all newly leased ACT Government vehicles will be zero emissions in 2020-21 (where fit for purpose).

At present the ACT and Australian Government both lease vehicles from SG Fleet (the ACT opted into the Australian Government's whole of government fleet arrangement). The ACT Government is hoping to work together with the Australian Government to ramp up its procurement of EVs. This would enable governments to negotiate better terms with SGFleet as it would allow SGFleet to arrange better terms with their vehicle providers. The ACT Government has also invited the Australian, state, territory and local governments to investigate joint procurement options for the years 2019/20 and beyond. Again, joint procurement would maximise the value-for-money of EV leasing and procurement arrangements. At the end of July 2018, over 20 governments had registered to join the discussions.

5.5. Conclusions

All governments use transport services, and this accounts for an important share of government emissions and operational costs.

Emissions and other costs of government use of transport can be cut in four ways. Transport service use can be avoided. Active travel options like walking can be encouraged. The procurement of outsourced transport services like couriers can make environmental performance a key requirement, for instance insisting that service providers use vehicles with class-leading levels of greenhouse and air-pollution emissions. Finally, government fleets can reduce emissions and running costs by ensuring low emissions is a core procurement criterion in vehicle selection. Government fleet emissions have been the main focus here.

Average per km emissions from government fleet vehicles were about 5% higher than the Australian average in 2017 and over 50% higher than the European average. While EV choice has been limited, there are numerous low emissions vehicles available on the Australian market that are suitable for government. The opportunity for governments to reduce fleet emissions is large and could be realised simply and quickly.

Governments purchased over 38,000 vehicles in 2017. The fleet savings that would flow from the selection of vehicles, on the NSW Approved Vehicle List, with class leading rather than lagging emissions are substantial. Annual savings would exceed 80,000 tonnes CO2 and $48 million. Over the three years that vehicles are held within government fleets the savings extend to over 240,000 tonnes and approach $150 million. The savings would then continue under second and third owners. A year's purchase of around 38,000 class leading rather than lagging vehicles would achieve 1 million tonnes in emission savings when those vehicles reached 12.5 years in age. At that point energy cost savings for the cohort of vehicles would exceed $600 million.

The benefits of government procurement of low emissions vehicles would extend well beyond the savings associated with the specific vehicles that are bought and leased. The average emissions of the entire Australian vehicle fleet are being held higher than they might be by the lack of EV availability. Government driven procurement (by government or their leasing companies) of 200-500 examples of a specific model would be sufficient to ensure that manufacturers introduce that model to the Australian market.

Common concerns about EVs are that they can have high up-front costs, resale values are somewhat uncertain, range is limited, and public charging points are not widely available. None of these issues should prevent governments adding EVs to their fleets. Purchase costs and resale values can be well-managed through bulk buy negotiations. EV range is already beyond 200km and public charging is not a requirement for a large portion of fleet vehicles. By the mid-2020s range and charging issues will have diminished further in importance under technological and market forces. In the meantime, we suggest that governments could speed the private delivery of public fast charging by making the presence of fast-charging with 100% renewable electricity at service stations a core requirement under fuel/charge procurement arrangements.

Some governments and government organisations are demonstrating leadership in the procurement of low emission vehicles. The ACT Government has committed that all new passenger vehicles leased in 2020-21 will be zero emissions where fit for purpose. Melbourne Water has committed to a zero emissions fleet by 2028 and expects that the entire passenger vehicle portion of the fleet will be zero emissions by 2023.

Government procurement of low emissions vehicles is straightforward and delivers significant benefits. We encourage all governments to follow the lead of the ACT and of Melbourne Water.

Recommendations

8) Governments should update their vehicle procurement policies to give clear and high priority to fuel efficiency, greenhouse gas emissions and air pollution performance. EVs should be selected where a fit for purpose model is available. High fuel efficiency Euro VI vehicles (or another definition of a low emission vehicle, if preferred) should be selected in vehicle classes where EVs are not yet available or fit for purpose. Performance standards/selection criteria may need to be updated regularly over the next decade, as technology and market change is expected to be rapid.

9) Joint purchasing of EVs and Euro VI vehicles should be investigated – including the with aim of accelerating the availability of additional models in the Australian market that are available overseas. Future fuel purchasing arrangements for fleet vehicles should include a criterion that 100% renewable energy fast-charge points are available at service stations.

6. Renewable Electricity Power Purchase Agreements

6.1. Introduction

The project brief calls for two power-related procurement options to be examined. The second – provision for local energy trading from a microgrid ecosystem featuring renewable energy and storage on building sites – is generally a residential solution at this time, with an example being White Gum Valley in Western Australia.[93] The Australian Renewable Energy Agency (ARENA) is also funding two virtual power plant trials in South Australia, the latter of which includes demand response options at 10 commercial businesses.[94,95]

Commercial sector trading platforms are starting to emerge, such as the *Trading Sunshine* initiative in Tasmania, which is intending to use blockchain technology to track and trade 1 MW of PV output on commercial buildings in the Merino Street precinct to neighbouring businesses.[96] A feasibility study examined the economics and potential for local energy trading between Councils in Victoria, but found generally poor results, as well as strong resistance from power companies.[97] Indeed, the extent to which local energy trading is legal under National Energy Market rules – without holding a retailers' licence, that is – has been called into question following the Australian Energy Market Commission decision to reject an enabling rule-change proposal put forward by the Property Council of Australia, the City of Sydney and others.[98]

Despite this, a number of powerful factors are combining to suggest that distributed generation, storage and trading will feature strongly in the future power system of Australia, despite the short-term opposition in some quarters. These factors include:

- Continuing declines in the cost of PV power in particular (highly suitable for generation on buildings and in urban precincts)
- Expected future declines in the cost of distributed storage
- Continuing high costs and perceptions of poor value from grid-supplied electricity services
- Rapid development and commercialisation of enabling 'soft' technologies, such as blockchain, and also smart meters, to support trading activities

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[93] https://westernpower.com.au/energy-solutions/projects-and-trials/white-gum-valley-energy-sharing/, viewed 13/12/2018.
[94] https://arena.gov.au/assets/2017/02/virtual-power-plants-in-south-australia-stage-2-public-report.pdf, viewed 13/12/2018.
[95] https://arena.gov.au/news/simply-energy-build-8mw-virtual-power-plant-adelaide/, viewed 13/12/2018.
[96] https://medium.com/power-ledger/trading-sunshine-nest-and-power-ledger-bring-renewable-energy-trading-to-launceston-656c104d2f4a, viewed 13/12/2018.
[97] http://www.naga.org.au/uploads/9/0/5/3/9053945/2018-05-03_fg_advisory_feasibility_study_-_local_energy_trading__interim_report_.pdf, viewed 13/12/2018.
[98] https://energyservices.com.au/aemc-says-no-on-rewarding-local-energy-sharing-and-industry-is-dismayed/, viewed 13/12/2018.

- Depending upon siting, building form and other factors, access to solar energy is and will remain unequal for many consumers, which suggests that generating and selling local surpluses to those with poorer solar access will be an ongoing feature of the built environment.

The primary barrier to the emergence of this model appears to be the threat that it poses to traditional network business models, based on one-way flow of power from centralised generators to distributed consumers. With over 2 million Australian households and a rapidly-growing number of businesses having solar generation systems – that is, being prosumers rather than consumers – it seems to be only a matter of time before the reality of the new clean energy paradigm is recognised and reflected in energy market laws and rules.

In the meantime, however, this Chapters focuses on an alternative model of renewable energy procurement that is readily available to governments today – renewable energy power purchase agreements or PPAs. Indeed, the ACT government is an example of one that is already making extensive use of PPAs as a key strategy to achieving its energy and climate policy goals.

6.2. What is a PPA?

A renewable energy PPA is only a variant of a long-standing, but generally wholesale, electricity market product, known generically as 'hedge' contracts. These contracts underpin most grid-based electricity supply. They are contracts struck between electricity generators and, generally, retailers (on behalf of their customers) that set out the volume of energy agreed to be purchased and the terms. There are many types of hedge contracts, with the simplest and perhaps most common being a 'contract for differences'. Here the retailer and generator essentially agree a price that both are willing to accept as fair and reasonable (the 'strike price'), and then contract to cover each other's financial risks to the extent that NEM market prices deviate from the agreed strike price in different trading intervals.

For example, if a strike price of $70/MWh is agreed, and then in one trading period, the average market price realised was $100/MWh, then the generated (who earned $100/MWh) pays the retailer the difference between the spot market and strike price, or $30/MWh. This means that the retailer, who had to pay the spot market price of $100/MWh, actually incurs a net cost of $70/MWh, while the generator earns net revenues of $70/MWh. If the average market price in a trading interval were instead $40/MWh, then the payment flows would be reversed, with the net effect that both parties receive/pay the strike price in net terms, at least for the volume of energy agreed under the contract. Conventional hedges have varying terms, but generally these do not exceed 1 – 2 years, and may be much shorter (eg, for a single trading interval), even if longer term contracts do exist.

A renewable energy PPA essentially takes this same contract structure as the basis of a long-term agreement between a renewable energy generator and a customer. Current market rules require that a licenced retailer acts as an intermediary in such a transaction and, of course, normal network charges also apply. The volumes of energy delivered annually under a PPA can be fixed or variable.

From a retailer's perspective, a renewable energy PPA is just one more in what will be a large 'portfolio' of hedges that they procure in order to meet their customers (expected) electricity needs. This particular hedge is distinguished a) by the fact that is with a renewable energy generator, b) that it (normally) has a long term, between 5 – 15 years (and may therefore include CPI or other indexation provisions), and c) it is 'assigned' to a particular customer or group of customers. In this sense, sourcing and on-selling PPAs is very close to business-as-usual for electricity retailers.

From the renewable energy generator's perspective, a long term purchase or 'take-off' agreement means a guaranteed stream of revenue over time, including a period of time long enough to finance the project in the first place (eg, up to 15 years). Thus, for a new renewable energy project, agreeing one or more PPAs, that cover all or part of the project's expected output, can largely or completely cover the project's financial risks, effectively underwriting the project. Of course, generators may not wish to be fully hedged, for a number of reasons. For example, if a project has largely or completely covered its financial risks through longer-term contracts for the majority of its expected output, then it may seek to sell any *surplus* generation volumes in a more targeted manner and for a higher price, thus adding to project returns. Also, a PPA is, for the generator, an obligation to supply (on agreed terms), and a renewable energy generator in particular may be uncertain about the volume of energy it will be able to supply in a particular trading period, as this may depend upon the weather and/or time of day. As discussed further below, such risks can be and are routinely hedged, but hedging has a cost, and so it may suit a particular generator to contract (via one or more PPAs) for more conservatively-estimated generation volumes, and so reduce its expected hedging requirements and costs.

From the customer's perspective, PPAs can present a value proposition that is not available to them through any other mechanism. As noted, retail contracts in the normal or 'black' power market are generally only offered for short terms, of 1 or 2 years. For larger customers, in particular, this aspect of the National Energy Market has perhaps been the largest source of frustration and also commercial risk – as, prior to the NEM, long-term and fixed price (or CPI indexed) contracts were routinely available, enabling those customers to achieve price certainty and to better manage their overall business risks. It is generally considered a market failure of the NEM that longer-term contracts are not more readily available, in particular because the mechanisms that would enable retailers to hedge the associated risks for them are exactly as described above.

A difference is that fossil fuel generators are, as a rule, less willing to sell power under long-term hedges, because a substantial portion of their business risk is (or can be) fuel price risk. This particularly affect gas-fired generators, but also black coal fired generators to a lesser degree. Renewable energy generators, on the other hand, have no fuel price risk to manage. Their risks are primarily associated with costs of capital required to establish the generation plant in the first instance, and these can be readily hedged, including over the long term, through conventional finance industry products such long term bonds (and, now, long-term PPAs). Indeed, it is not widely appreciated that the very low risk profile of renewable energy generation is one of the factors that is leading to its rapid adoption in the National Energy Market.

Of course, renewable energy projects are not free of risk. From a consumer's perspective, they wish to be supplied with power 24/7, regardless of any fluctuations in the output of a given renewable energy generation plant or project. In addition, if they are procuring 100% renewable electricity for environmental reasons (or related reasons such as corporate reputation), then it would not be acceptable for the variability in output from a given renewable energy generator to be 'topped up' with black power.

In fact, renewable energy generators are (generally) required to manage the risks associated with their own output variability themselves. They can do this in a number of ways. Recently, and encouraged by NEM rule changes, 'physical hedges' – such as large-scale storage facilities – are being used. However, more conventional financial hedge instruments can also be used, or a combination of the two. For example, 'firm' renewable energy PPAs are increasingly being offered, with 'firming' (covering generation shortfalls at particular times) services being provided by other renewable energy generators. The latter may include renewable generators with physical storage - such as hydro, pumped storage, or renewable energy projects that incorporate storage – and/or a 'portfolio' of intermittent generators that may be widely distributed spatially, and have generation technologies that differ from the one seeking the hedge, such that there is sufficient power available to firm the hedge in question. We note that such firming arrangements help to cover the risks of both renewable energy generators and their PPA customers.

6.3. Technical and Market Opportunities

The renewable energy PPA model is undergoing what may be described as an 'explosion' or, at least, a period of geometric growth, at present in Australia. Energetics has been tracking the number and size of corporate PPAs larger than 10MW in size. This data excludes large PPAs concluded by the ACT government and potential other non-corporate contracts, while the capacity shown is the project capacity, which may differ from the PPA contract volume.

Energetics notes that since 2016 corporate PPAs have supported projects with a combined capacity of nearly 3200MW, of which about 2750MW enabled investment in new projects; more than a third of the required 6400 MW required by the end of 2018 under Australia's Renewable Energy Target.

As at 7 December 2018, approximately 48% of the project capacity supported by corporate PPAs is solar, 9% a mix of wind and solar, with the remainder wind. Victorian projects continue to dominate, accounting for 44% of project capacity (about 1400MW) supported by corporate PPAs.

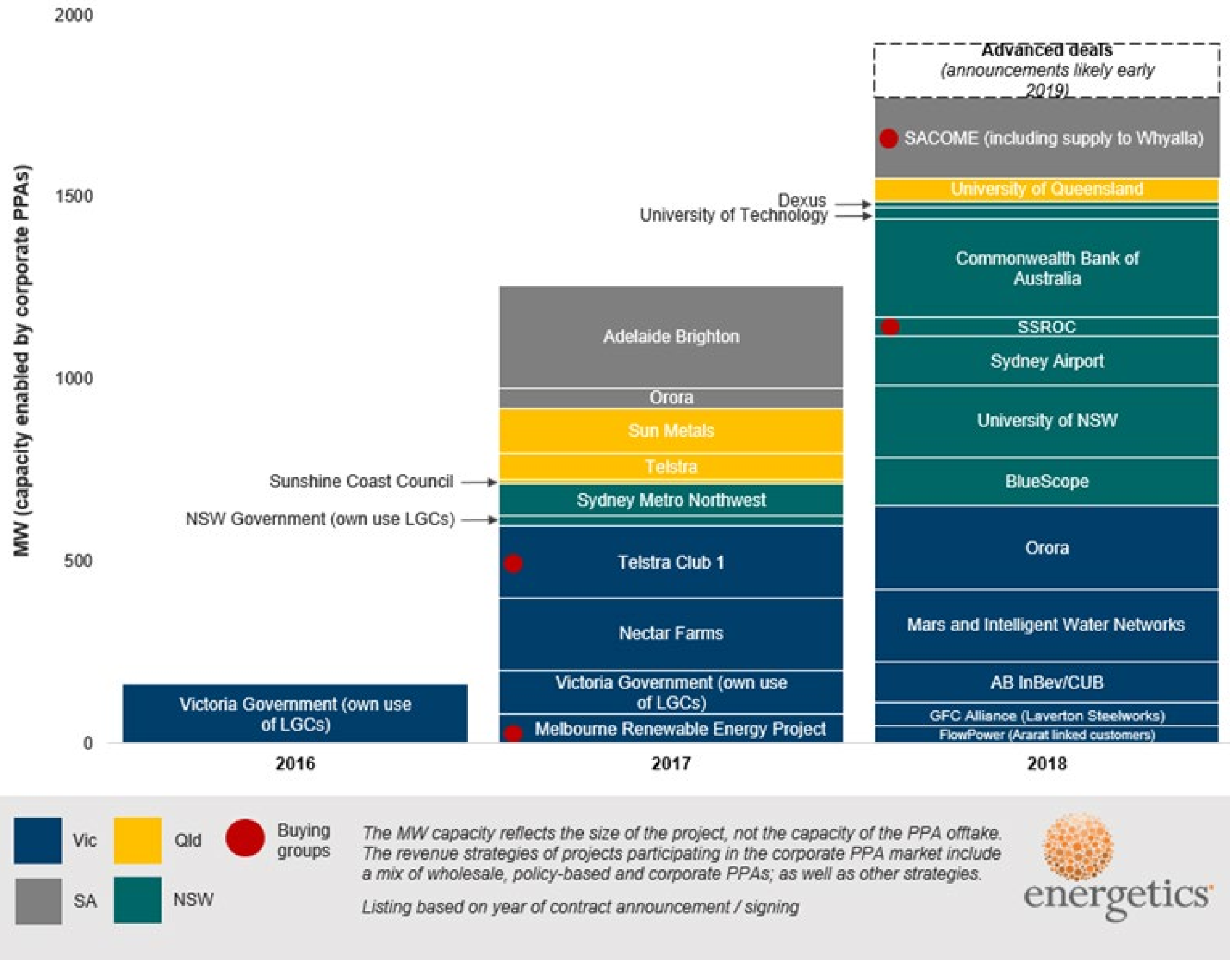

Figure 26: Number and Capacity of Corporate PPAs (>10MW), Australia

Source: https://www.energetics.com.au/insights/knowledge-centres/corporate-renewable-ppa-deal-tracker/, viewed 14/12/2018

Renewable energy PPAs are being purchased by some of Australia's largest companies and institutions, including Telstra, Sun Metals, the Commonwealth Bank, major universities and local governments. The ACT government is recognised as a leader in this field, with PPAs underpinning its policy of achieving 100% renewable electricity for the territory by 2020. The NSW Government announced in 2016 that it intended to secure 92 GWh of solar PPAs, while the Queensland Government is reported to have offered PPAs for 120 MW of solar.[99] The Business Renewables Centre Australia reports that PPA take-up is widely spread across many sectors of the Australian economy – see Figure 27.

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[99] https://reneweconomy.com.au/nsw-government-to-buy-solar-power-to-boost-solar-plant-prospects-77705/, viewed 14,12/2018.

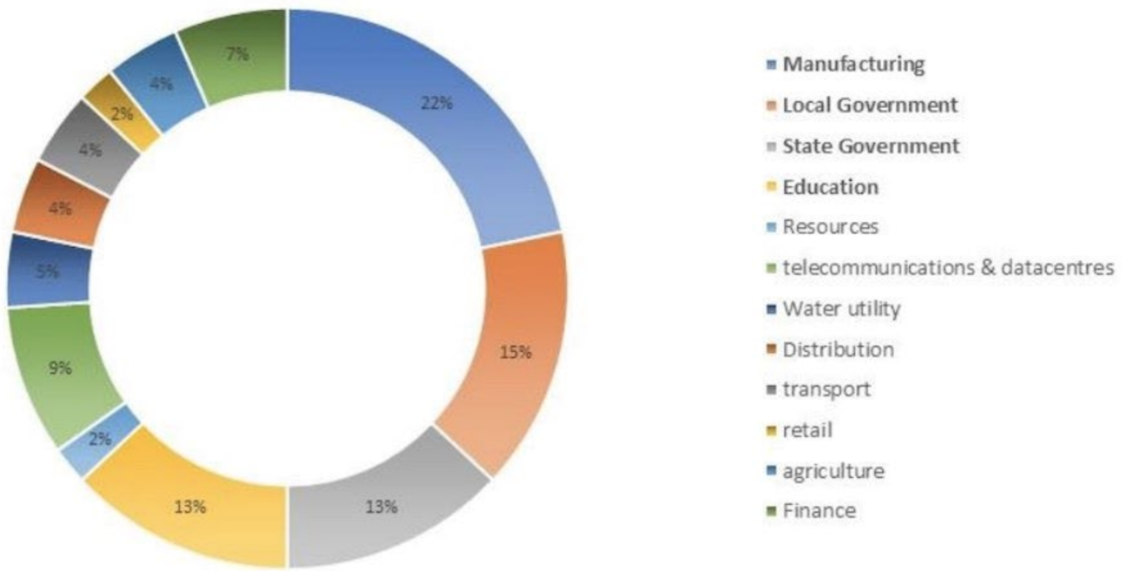

Figure 27: Renewable Energy PPAs by Sector (2018)

Source: https://reneweconomy.com.au/corporate-renewable-energy-contracts-are-a-new-force-for-australia-wind-and-solar-52217/, viewed 14/12/2018

6.4. Benefits and Costs (and Risks)

There are at least three major benefits associated with procuring electricity via renewable energy PPAs rather than conventional black power contracts.

1. **Price:** as set out below, renewable energy PPAs are setting new price (reduction) records with just about every deal announced to the market. Critically, it is now possible to secure a renewable energy PPAs at a price that is lower than average NEM spot price, potentially enabling an immediate cost reduction.
2. **Term:** As noted, PPAs are potentially available over 5, 10 or 15 year periods, enabling consumers to fix pricing terms into the future. Prices will likely be indexed, for example to the CPI. This degree of price certainty cannot be secured via any other form of electricity market contract, with the major alternative being for customers to invest in their own on-site generation if this is feasible.
3. **Risk Management:** In addition to electricity price risk management, as noted above, the 100% renewable nature of the PPA means that organisations can manage future carbon risks – including by fuel switching away from fossil fuels to renewable electricity – and related reputation risks.

Price

Electricity contract prices are typically treated as confidential, and so we have only partial indications of the prices that are being realised under renewable energy PPAs. Some examples recently reported include:

- Flow Power secured a 50MW PPA for a 10-year term, with a total delivered (not wholesale) price of "less than 10c/kWh". Managing Director, Matthew van der Linden said ""That is a game changer for businesses …. and could be the difference between business customers going broke and customers being able to operate".[100]
- Powershop (Victorian electricity retailer) CEO, Ed McManus, noted: ""The price that we get the energy from these new wind and solar farms is cheaper than the energy we can get from the normal wholesale market day to day".[101] He also noted, "I can't disclose the price but I am happy to tell you that prices we are getting these PPAs at is well below wholesale price of energy." He said the prices were "at or around" the less-than-$55/MWh price obtained by Origin Energy from the Stockyard Hill wind farm in Victoria, and "reports of below $70/MWh for solar projects". The PPAs appear to have 12-year terms.[102]
- Origin Energy is reporting contemporary PPAs costs as "mid-$40s/MWh" for solar energy and "low-$50s/MWh" for wind. These costs for solar energy were noted to be "around half the average price of wholesale electricity in most states this year".[103]

Some caution needs to be exercised in interpreting these quotes, in that quoted values sometimes refer to costs and sometimes to prices, with the generator's profit margin being the difference between the two. Also, it is not always clear whether quoted prices include or exclude the cost of Large Generation Certificates (LGCs), as discussed below. Nevertheless, it is clear that PPA pricing is at *least* competitive with black power, and may well much cheaper, depending upon the deal secured. Further, with renewable energy generation costs continuing to fall, PPA pricing is expected to continue to fall as well. Indeed, this factor is one of the risks that consumers need to consider: with falling prices, there is some risk of being locked-in to a contract that, in future, may represent above-market prices. This risk will be weighed against the value of price certainty and will be reflected in the contract terms that consumers are willing to agree to. The rapid growth in the PPA market suggests that, even before these expected future cost reductions, more and more consumers are finding it attractive to secure renewable energy PPAs.

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[100] https://reneweconomy.com.au/victorian-manufacturer-taps-cheap-renewables-in-ppa-with-flow-power-81850/, viewed 14/12/2018

[101] https://reneweconomy.com.au/cheap-wind-and-solar-allows-powershop-to-cut-tariffs-to-customers-66928/, viewed 14/12/2018

[102] https://reneweconomy.com.au/powershop-signs-huge-deal-for-solar-wind-projects-stunned-by-low-prices-11533/, viewed 14/12/2018.

[103] https://reneweconomy.com.au/origin-says-solar-cheaper-than-coal-moving-on-from-base-load-70999/, viewed 14/12/2018.

Risk Management

Where organisations wish to secure renewable PPAs for the purpose of reducing corporate greenhouse gas emissions, and/or to manage related reputation risks, they need to ensure that the renewable energy they secure is 'additional' to that that would otherwise be supplied to the market. If not, their consumption of renewable energy would simply displace another organisation's consumption, with no net change in emissions.

For the time being, the volume of renewable energy that is expected to enter the market in the absence of renewable energy PPAs has at least a floor set by the national Renewable Energy Target (nRET) scheme, and the LGC component of that scheme in particular. Therefore, and again for the time being,[104] the practical consequence is that organisations to secure LGCs equivalent to the volume of renewable energy purchased through the PPA. In some cases, these two products (electricity and LGCs) will be bundled together, but they can also be procured independently. With the LGC market saturated, analysts expect LGC prices to fall post-2020, but not below the effective 'floor' price which is effectively set by the price of ACCUs (currently \$12 - \$18/t CO_2-e).[105]

6.5. Procurement Potentials

Renewable energy PPAs are already being secured by governments in Australia, and there are few barriers in the way of more rapid uptake. As noted, in some cases at least, governments are already using their market leverage as large electricity consumers to help drive investment in renewable energy projects in their states, while also benefiting from the price and price stability aspects noted above.

In terms of practical guidance on how to go about securing PPAs, there is now excellent guidance material available, for example, from the City of Melbourne.[106] Some legal aspects of PPAs are discussed by Law Quarter[107] and by Baker McKenzie[108], inter alia. In addition, there are now many commercial service providers in this field.

6.6. Conclusions

Renewable energy PPAs offer an important procurement option for governments, attractive both for financial and environmental reasons. They enable consumers with limited solar access (including due to their tenancy status, location or other factors) to access the financial and emissions benefits

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[104] The nRET scheme is expected to continue to create demand for new LGCs until 2020, although market demand for LGCs may well saturate before that date.

[105] https://www.energetics.com.au/insights/thought-leadership/the-outlook-for-lgc-prices-from-a-corporate-perspective/, viewed 14/12/2018.

[106] https://www.melbourne.vic.gov.au/business/sustainable-business/mrep/Pages/renewable-energy-procurement-guide.aspx, viewed 14/12/2018.

[107] https://lawquarter.com.au/short-guide-power-purchase-agreements-ppa-australia/, viewed 14/12/2018.

[108] https://www.bakermckenzie.com/-/media/files/insight/publications/updated-wwf1443-corporate-ppa-reportonline--15-june-2018.pdf?la=en, viewed 14/12/2018.

associated with the rapid and continuing reduction in renewable energy costs, particularly from wind and solar. As noted, they can also provide long-term price stability, an attribute that conventional electricity procurement from the NEM has not been able to offer.

Recommendations

10) We recommend that renewable energy power purchase agreements be considered in all electricity procurement processes, noting the potential for price reductions and long-term price hedging, in addition to greenhouse gas abatement benefits.

Appendix A: Low Emission Vehicle Tables

Table 14: Commercial 4x2 utes – energy efficiency and emissions per km

Vehicle efficiency rating	Model	fuel use l/100km	energy efficiency kJ/km	emissions (kg/km)	Energy source
Leading	NISSAN NAVARA D23 SERIES 3 MY18 2.3T DIESEL RX DUAL 4X2 AUTO 4DR UTILITY	6.90	2663	0.188	Diesel
Middling	TOYOTA HILUX GUN136R MY19 2.8T DIESEL SR HI-RIDER DOUBLE 4X2 AUTO 4DR UTILITY	8.10	3127	0.220	Diesel
Lagging	TOYOTA HILUX TGN121R MY19 2.7 WORKMATE DOUBLE RWD AUTO 4DR UTILITY	10.40	3557	0.248	Petrol

Table 15: Commercial 4x2 utes - Annual consumption & emissions for 500 vehicles travelling 14,000km each

Category efficiency rating	Model Name	Fuel use litres	emissions tonnes CO2	Energy Cost $
Leading	NISSAN NAVARA D23 SERIES 3 MY18 2.3T DIESEL RX DUAL 4X2 AUTO 4DR UTILITY (REL. 02/18)	603,750	1,643	$995,584
Mid	TOYOTA HILUX GUN136R MY19 2.8T DIESEL SR HI-RIDER DOUBLE 4X2 AUTO 4DR UTILITY (REL. 08/18)	708,750	1,929	$1,168,729
Lagging	TOYOTA HILUX TGN121R MY19 2.7 WORKMATE DOUBLE RWD AUTO 4DR UTILITY (REL. 08/18)	910,000	2,169	$1,460,550

Table 16: Commercial 4x4 utes - energy efficiency and emissions per km

Vehicle Category	Model	fuel use l/100km	energy efficiency kJ/km	emissions (kg/km)	Energy Source
Commercial - 4x4 utilities	NISSAN NAVARA D23 SERIES 3 MY18 2.3T DIESEL RX DUAL 4X4 AUTO 4DR CAB CHASSIS (REL. 02/18)	6.6	2548	0.180	Diesel
Commercial - 4x4 utilities	ISUZU UTE D-MAX MY18 3.0 SX CREW 4X4 AUTO 4DR CAB CHASSIS (REL. 07/18)	7.9	3049	0.215	Diesel
Commercial - 4x4 utilities	TOYOTA HILUX GUN126R MY19 2.8T DIESEL SR DOUBLE 4X4 AUTO 4DR CAB CHASSIS (REL. 08/18)	9	3474	0.245	Diesel

Table 17: Commercial 4x4 utes - Annual consumption & emissions for 500 vehicles travelling 14,000km each

Category efficiency rating	Model Name	Fuel use litres	emissions tonnes CO2	Energy Cost $
Leading	NISSAN NAVARA D23 SERIES 3 MY18 2.3T DIESEL RX DUAL 4X4 AUTO 4DR CAB CHASSIS (REL. 02/18)	577,500	1,572	$ 952,298
Mid	ISUZU UTE D-MAX MY18 3.0 SX CREW 4X4 AUTO 4DR CAB CHASSIS (REL. 07/18)	691,250	1,881	$ 1,139,871
Lagging	TOYOTA HILUX GUN126R MY19 2.8T DIESEL SR DOUBLE 4X4 AUTO 4DR CAB CHASSIS (REL. 08/18)	787,500	2,143	$ 1,298,588

Table 18: Commercial compact vans - energy efficiency and emissions per km

Vehicle Category	Model	combined energy use l/100km or kWh/100km	energy efficiency kJ/km	emissions (kg/km)	Energy Source
Commercial - compact vans	RENAULT KANGOO COMPACT ZE[109]	15	540	0	electric
	VOLKSWAGEN CADDY VAN MY18 1.4 TSI220 92KW FWD BLUEMOTION DSG 4DR VAN	6	2316	0.143	Petrol

[109] This EV is not on the AVL, however we added it for illustrative purposes. It is available in 2018 and while it has a list price substantially higher than its class competitors, we strongly suspect large discounts could be negotiated for bulk orders.

	RENAULT KANGOO COMPACT AUTOMATIC	6.5	2509	0.155	Petrol

Table 19: Commercial compact vans - Annual consumption & emissions for 500 vehicles travelling 14,000km each

Category efficiency rating	Model Name	Energy use litres or kWh	emissions tonnes CO2	Energy Cost $
Leading	RENAULT KANGOO COMPACT ZE	1,312,500 kWh	-	328,125
Mid	VOLKSWAGEN CADDY VAN MY18 1.4 TSI220 92KW FWD BLUEMOTION DSG 4DR VAN (REL. 01/18)	525,000 l	1,251	842,625
Lagging	RENAULT KANGOO COMPACT AUTOMATIC	568,750 l	1,356	912,844

Table 20: Commercial medium vans - energy efficiency and emissions per km

Vehicle Category	Model	fuel use l/100km	energy efficiency kJ/km	emissions (kg/km)	Energy source
Commercial - Medium vans	RENAULT TRAFIC SWB TWIN TURBO 103KW	6.20	2393	0.169	Diesel
Commercial - Medium vans	VOLKSWAGEN TRANSPORTER T6 MY18 2.0 TDI340 103KW SWB FWD DSG 4DR VAN (REL. 01/18)	7.70	2972	0.210	Diesel
Commercial - Medium vans	HYUNDAI ILOAD TQ4 MY19 2.5 CRDI RWD AUTO 5DR VAN (REL. 05/18)	8.80	3010	0.210	Diesel

Table 21: Commercial medium vans - Annual consumption & emissions for 500 vehicles travelling 14,000km each

Category efficiency rating	Model Name	Energy use litres	emissions tonnes CO2	Energy Cost $
Leading	RENAULT TRAFIC SWB TWIN TURBO 103KW	542,500	1,476	894,583
Mid	VOLKSWAGEN TRANSPORTER T6 MY18 2.0 TDI340 103KW SWB FWD DSG 4DR VAN (REL. 01/18)	673,750	1,833	1,111,014
Lagging	HYUNDAI ILOAD TQ4 MY19 2.5 CRDI RWD AUTO 5DR VAN (REL. 05/18)	770,000	2,095	1,269,730

Table 22: Light passenger cars - energy efficiency and emissions per km

Vehicle Category	Model	fuel use l/100km	energy efficiency kJ/km	emissions (kg/km)	Energy source
Light Passenger Cars	TOYOTA PRIUS C NHP10R MY19 1.5 HYBRID FWD AUTO 5DR HATCHBACK (REL. 08/18)	3.9	1334	0.093	Petrol hybrid
	FORD FIESTA WZ MY15 1.5 TREND FWD POWERSHIFT 5DR HATCHBACK (REL. 05/18)	5.8	1984	0.138	Petrol
	HOLDEN BARINA TM MY18 1.6 LS FWD AUTO 5DR HATCHBACK (REL. 07/18)	7.5	2565	0.179	Petrol

Table 23: Light passenger cars - Annual consumption & emissions for 500 vehicles travelling 14,000km each

Category efficiency rating	Model Name	Energy use litres or kWh	emissions tonnes CO2	Energy Cost $
Leading	TOYOTA PRIUS C NHP10R MY19 1.5 HYBRID FWD AUTO 5DR HATCHBACK (REL. 08/18)	341,250	813	547,706
Mid	FORD FIESTA WZ MY15 1.5 TREND FWD POWERSHIFT 5DR HATCHBACK (REL. 05/18)	507,500	1,381	814,538
Lagging	HOLDEN BARINA TM MY18 1.6 LS FWD AUTO 5DR HATCHBACK (REL. 07/18)	656,250	1,786	1,053,281

Table 24: Small passenger cars - energy efficiency and emissions per km

Vehicle Category	Model	fuel use l/100km	energy efficiency kJ/km	emissions (kg/km)	Energy source
Small Passenger Cars	TOYOTA PRIUS ZVW50R MY18 1.8 HYBRID FWD AUTO 5DR HATCHBACK (REL. 01/18)	3.4	1163	0.081	Petrol hybrid
	HOLDEN ASTRA MY19 1.4T R FWD AUTO 5DR HATCHBACK (REL. 08/18)	5.8	1984	0.138	Petrol
	MITSUBISHI LANCER CF MY17 2.0 ES SPORT FWD AUTO 4DR SEDAN (REL. 10/16)	7.4	2531	0.176	Petrol

Table 25: Small passenger cars - Annual consumption & emissions for 500 vehicles travelling 14,000km each

Category efficiency rating	Model Name	Energy use litres or kWh	emissions tonnes CO2	Energy Cost $
Leading	TOYOTA PRIUS ZVW50R MY18 1.8 HYBRID FWD AUTO 5DR HATCHBACK (REL. 01/18)	297,500	709	477,488
Mid	HOLDEN ASTRA MY19 1.4T R FWD AUTO 5DR HATCHBACK (REL. 08/18)	507,500	1,381	814,538
Lagging	MITSUBISHI LANCER CF MY17 2.0 ES SPORT FWD AUTO 4DR SEDAN (REL. 10/16)	647,500	1,762	1,039,238

Table 26: Medium passenger cars - energy efficiency and emissions per km

Vehicle Category	Model	fuel use l/100km	energy efficiency kJ/km	emissions (kg/km)	Energy source
Medium Passenger Cars	TOYOTA CAMRY AXVH71R MY19 2.5 ASCENT HYBRID FWD AUTO 4DR SEDAN (REL. 08/18)	4.2	1436	0.100	Petrol hybrid
	HOLDEN ASTRA MY18 1.4T LS FWD AUTO 4DR SEDAN (REL. 07/18)	6.1	2086	0.145	Petrol
	TOYOTA CAMRY ASV70R MY19 2.5 ASCENT FWD AUTO 4DR SEDAN (REL. 08/18)	7.8	2668	0.186	Petrol

Table 27: Medium passenger cars - Annual consumption & emissions for 500 vehicles travelling 14,000km each

Category efficiency rating	Model Name	Energy use litres or kWh	emissions tonnes CO2	Energy Cost $
Leading	TOYOTA CAMRY AXVH71R MY19 2.5 ASCENT HYBRID FWD AUTO 4DR SEDAN (REL. 08/18)	367,500	876	589,838
Mid	HOLDEN ASTRA MY18 1.4T LS FWD AUTO 4DR SEDAN (REL. 07/18)	533,750	1,272	856,669
Lagging	TOYOTA CAMRY ASV70R MY19 2.5 ASCENT FWD AUTO 4DR SEDAN (REL. 08/18)	682,500	1,627	1,095,413

Table 28: Large passenger cars - energy efficiency and emissions per km

Vehicle Category	Model	fuel use l/100km	energy efficiency kJ/km	emissions (kg/km)	Energy source
Large Passenger Cars	FORD MONDEO MD MY18.75 2.0T DIESEL TREND FWD POWERSHIFT 5DR HATCHBACK (REL. 09/18)	5.1	1969	0.139	Diesel
	HOLDEN COMMODORE ZB MY18 2.0T LT FWD AUTO 5DR HATCHBACK (REL. 07/18)	7.4	2531	0.176	Petrol
	KIA OPTIMA JF MY19 2.4 SI FWD AUTO 4DR SEDAN (REL. 05/18)	8.3	2839	0.198	Petrol

Table 29: Large passenger cars - Annual consumption & emissions for 500 vehicles travelling 14,000km each

Category efficiency rating	Model Name	Energy use litres or kWh	emissions tonnes CO2	Energy Cost $
Leading	FORD MONDEO MD MY18.75 2.0T DIESEL TREND FWD POWERSHIFT 5DR HATCHBACK (REL. 09/18)	446,250	1,064	716,231
Mid	HOLDEN COMMODORE ZB MY18 2.0T LT FWD AUTO 5DR HATCHBACK (REL. 07/18)	647,500	1,543	1,039,238
Lagging	KIA OPTIMA JF MY19 2.4 SI FWD AUTO 4DR SEDAN (REL. 05/18)	726,250	1,731	1,165,631

Table 30: People movers - energy efficiency and emissions per km

Vehicle Category	Model	fuel use l/100km	energy efficiency kJ/km	emissions (kg/km)	Energy source
Passenger Cars - people movers	TOYOTA PRIUS V ZVW40R MY18 1.8 HYBRID 7ST FWD AUTO 5DR WAGON (REL. 02/18)	4.4	1505	0.105	Petrol hybrid
	KIA CARNIVAL PE MY19 2.2T DIESEL SI 8ST FWD AUTO 5DR WAGON (REL. 05/18)	7.7	2972	0.210	Diesel
	KIA CARNIVAL PE MY19 3.3 SI 8ST FWD AUTO 5DR WAGON (REL. 05/18)	11.6	3967	0.277	Petrol

Table 31: People movers - Annual consumption & emissions for 500 vehicles travelling 14,000km each

Category efficiency rating	Model Name	Energy use litres or kWh	emissions tonnes CO2	Energy Cost $

Leading	TOYOTA PRIUS V ZVW40R MY18 1.8 HYBRID 7ST FWD AUTO 5DR WAGON (REL. 02/18)	385,000	918	617,925
Mid	KIA CARNIVAL PE MY19 2.2T DIESEL SI 8ST FWD AUTO 5DR WAGON (REL. 05/18)	673,750	1,606	1,081,369
Lagging	KIA CARNIVAL PE MY19 3.3 SI 8ST FWD AUTO 5DR WAGON (REL. 05/18)	1,015,000	2,419	1,629,075

Table 32: Small SUVs - energy efficiency and emissions per km

Vehicle Category	Model	fuel use l/100km	energy efficiency kJ/km	emissions (kg/km)	Energy source
Passenger small SUV	MITSUBISHI ASX XC MY18 2.2 DID LS 5ST AWD AUTO 5DR WAGON (REL. 09/17)	6	2316	0.163	Diesel
	HYUNDAI KONA OS.2 MY19 1.6T ACTIVE 5ST AWD DCT 5DR WAGON (REL. 08/18)	6.7	2291	0.160	Petrol
	MITSUBISHI ASX XC MY19 2.0 LS 5ST FWD AUTO 5DR WAGON (REL. 09/18)	7.4	2531	0.176	Petrol

Table 33: Small SUVs - Annual consumption & emissions for 500 vehicles travelling 14,000km each

Category efficiency rating	Model Name	Energy use litres or kWh	emissions tonnes CO2	Energy Cost $
Leading	MITSUBISHI ASX XC MY18 2.2 DID LS 5ST AWD AUTO 5DR WAGON (REL. 09/17)	525,000	1,251	865,725
Mid	HYUNDAI KONA OS.2 MY19 1.6T ACTIVE 5ST AWD DCT 5DR WAGON (REL. 08/18)	586,250	1,595	940,931
Lagging	MITSUBISHI ASX XC MY19 2.0 LS 5ST FWD AUTO 5DR WAGON (REL. 09/18)	647,500	1,543	1,039,238

Table 34: Medium SUVs - energy efficiency and emissions per km

Vehicle Category	Model	combined fuel use l/100km	energy efficiency kJ/km	emissions (kg/km)	Energy source
Passenger Medium SUV	MITSUBISHI OUTLANDER ZL MY19 2.0 PHEV ES ADAS 5ST 4X4 AUTO 5DR WAGON (REL. 07/18)	1.9l & 15.5kWh /100km	650	0.045	PHEV
	KIA SPORTAGE QL MY19 2.0TD SI 5ST AWD AUTO 5DR WAGON (REL. 07/18)	6.4	2470	0.174	Diesel
	FORD ESCAPE ZG MY18.75 2.0T TREND 5ST 4X4 AUTO 5DR WAGON (REL. 06/18)	8.6	2941	0.205	Petrol

Table 35: Medium SUVs - Annual consumption & emissions for 500 vehicles travelling 14,000km each

Category efficiency rating	Model Name	Energy use litres or kWh	emissions tonnes CO2	Energy Cost $
Leading	MITSUBISHI OUTLANDER ZL MY19 2.0 PHEV ES ADAS 5ST 4X4 AUTO 5DR WAGON **(petrol use)**	166,250l	452	274,146
	MITSUBISHI OUTLANDER ZL MY19 2.0 PHEV ES ADAS 5ST 4X4 AUTO 5DR WAGON **(electricity use)**	1,347,500kWh	-	336,875
	MITSUBISHI OUTLANDER ZL MY19 2.0 PHEV ES ADAS 5ST 4X4 AUTO 5DR WAGON (total emissions & cost)	See above	452	611,021
Mid	KIA SPORTAGE QL MY19 2.0TD SI 5ST AWD AUTO 5DR WAGON (REL. 07/18)	560,000	1,335	898,800
Lagging	FORD ESCAPE ZG MY18.75 2.0T TREND 5ST 4X4 AUTO 5DR WAGON (REL. 06/18)	752,500	1,794	1,207,763

Table 36: Large SUVs - energy efficiency and emissions per km

Vehicle Category	Model	fuel use l/100km	energy efficiency kJ/km	emissions (kg/km)	Energy source
Passenger large SUV	FORD EVEREST MY19 2.0T DIESEL TREND 7ST AWD AUTO 5DR WAGON (REL. 07/18)	7.1	2741	0.193	Diesel
	TOYOTA FORTUNER GUN156R MY19 2.8T DIESEL GX 7ST 4X4 AUTO 5DR WAGON (REL. 08/18)	8.6	2941	0.205	Diesel
	TOYOTA KLUGER GSU55R MY18 3.5 GX 7ST AWD AUTO 5DR WAGON (REL. 01/18)	9.5	3249	0.226	Petrol

Table 37: Large SUVs - Annual consumption & emissions for 500 vehicles travelling 14,000km each

Category efficiency rating	Model Name	Energy use litres	emissions tonnes CO2	Energy Cost $
Leading	FORD EVEREST MY19 2.0T DIESEL TREND 7ST AWD AUTO 5DR WAGON (REL. 07/18)	621,250	1,691	1,024,441
Mid	TOYOTA FORTUNER GUN156R MY19 2.8T DIESEL GX 7ST 4X4 AUTO 5DR WAGON (REL. 08/18)	752,500	2,048	1,240,873
Lagging	TOYOTA KLUGER GSU55R MY18 3.5 GX 7ST AWD AUTO 5DR WAGON (REL. 01/18)	831,250	1,981	1,334,156

Contact

Philip Harrington

philip_harrington@strategypolicyresearch.com.au

0419 106 449

***Strategy. Policy. Research.* Pty Ltd**

ABN 38 615 039 864

www.strategypolicyresearch.com.au