AUSTRALIAN SUSTAINABLE BUILT ENVIRONMENT COUNCIL

Rapid and Least Cost Decarbonisation of Building Operations

Discussion Paper

14th February 2022

Strategy. Policy. Research.

DELTA Q

ASBEC welcome

ASBEC is the peak body of key organisations committed to a sustainable, productive, resilient built environment in Australia.

The “Rapid and Least Cost Decarbonisation of Building Operations” project – which encompasses new and existing, commercial and residential buildings – examines the lowest cost pathways to decarbonise building operations aligned with a net zero by 2050 target.

For possibly the first time, scenarios that combine actions at the building level coupled with strategies to decarbonise energy supply to achieve net zero will be explored together.

The purpose of this important project is to create resources for industry and government that set out the decarbonisation options available to building owners, managers and developers, and the likely take up of those options in various scenarios over time.

Specifically, the final report is intended to provide:

- A detailed inventory of operational emissions (scope 1 and scope 2) in residential and commercial buildings
- A detailed characterisation of decarbonisation options available to building owners, and the internal costs, benefits and barriers associated with each option
- Modelling which considers the likely take up of decarbonisation options in at least three divergent scenarios for decarbonisation of fuel sources (including electricity, gas, biofuels and hydrogen)
- Analysis of implications for industry and government.

This discussion paper is a first step to engaging the broad group of stakeholders that will contribute to Australia’s built environment achieving net zero operational emissions. In the paper you will find a link that allows you to provide your feedback - your ideas, knowledge and concerns as Australian cities, towns, homes and businesses transition to a more sustainable community.

We welcome your input and your contribution to this extraordinary transformation.

Ken Morrison
Chair, ASEBC Net Zero Buildings Task Group
Chief Executive – Property Council of Australia

Project Support

ASBEC acknowledges the sponsors of this project:

- The Australian Government Department of Industry, Science, Energy & Resources
- The NSW Government Department of Planning, Innovation & Environment

ASBEC would also like to acknowledge the support of the project consultants:

- ASBEC Project Manager: Bruce Precious
- Strategy Policy Research Pty Ltd - Philip Harrington, Dr Hugh Saddler
- DeltaQ Pty Limited - Dr Paul Bannister, Steve Castell, Grace Foo
- Watt Advocacy & Communications - Louise Yabsley

Acknowledgement of Country
ASBEC acknowledges the Traditional Owners of Country throughout Australia. We pay our respect to Elders past and present and recognise their continuing contribution to caring for Country.

Project background

ASBEC's Low Carbon, High Performance report identified the key actions to achieving zero emission buildings, consisting of energy efficiency, decarbonised energy sources and zero emissions electricity.

To date, much of our industry-led analysis has been dedicated to cost-effectively maximising building energy efficiency, through minimum standards for new buildings and a variety of measures for existing buildings.

However, more analysis is now required to appropriately map out a pathway for fully decarbonised building operations.

As a signatory to the Paris Agreement, Australia has committed to decarbonise its economy by mid-century.

The Green Building Council's Carbon Positive Roadmap was released in 2019 as industry's roadmap to the decarbonisation of Australia's built environment. It tells us that new buildings and fit-outs must have no greenhouse gas emissions from their operations by no later than 2030, and existing buildings and fitouts must have no greenhouse gas emissions from their operations by 2050 or earlier.

Among Australia's largest property companies, there is widespread support to decarbonise building operations and tackle climate change. An informal survey of Australia's largest developers and property companies indicated that 90 per cent have targets of net zero by 2030 or earlier.

Buildings constructed today will still be standing in 2050 and must be set on a trajectory to net zero in order to achieve our international commitments. Guidance on the least cost pathway to decarbonisation is necessary to support industry decision making and technology selection, as well as helping policy makers plan for the physical and regulatory infrastructure that is needed to support sector decarbonisation.

The project – which will encompass both new and existing, commercial and residential buildings – will examine the lowest cost pathways for building owners to decarbonise their building operations aligned with a net zero by 2050 target.

Timeline and governance

The project commenced in November 2021 and is planned to be complete with publication of a Final Report in July 2022.

This Discussion Paper represents the key output from the first phase of the project. Its specific purpose is to support engagement and debate over the period to April 2022.

Phase 2 will build on the Discussion Paper and stakeholder feedback to model a series of plausible but divergent pathways to zero emissions for the built environment. The framing of these scenarios is covered in this Discussion Paper, to ensure that we capture stakeholder perspectives on this prior to conducting the modelling.

Phase 2 will also model the impact that key policy or regulatory settings could have on the emissions trajectory.

The project is overseen by a Project Steering Committee comprising nominees from ASBEC's membership and project sponsors. In addition, a Technical Working Group has been established, comprising a small number of expert reviewers from the research, energy and property sectors, supported by the project consultants, SPR and DeltaQ.

Your feedback

The purpose of this discussion paper is to gather key stakeholder insights on decarbonisation of Australia's built environment. Your ideas and information on what should be considered within the different scenarios will be critical to providing the best advice to building owners and policy makers.

- Participate in a free, online webinar. Register now using this link.
- Make a written submission in response to the focus questions in this Discussion Paper via this survey link: https://www.surveymonkey.com/r/decarbonisationofbuildingoperationsdiscussionpaper

Closing date for submissions: 1 April, 2022.

A Changing Policy Context

In October 2021, Australia formally adopted the target of reaching net zero greenhouse gas emissions by 2050, clearly communicating to all sectors that we are, collectively and individually, on the pathway to net zero emissions.

Businesses need to identify how they transition to net zero and governments, along with their agencies must determine the actions that result in the decarbonisation of the whole Australian economy keeping in mind that pressure is likely build to decarbonise more quickly than 2050 in order to avoid the worst consequences of climate change.

- The Australian Government's **Long-Term Emissions Reductions Plan** promotes seven key low emissions technology fields, that it expects will enable least-cost abatement.[1]

While the end-goal and policy ambition is clear, it is not yet clear that policy and regulatory settings across the economy are fully aligned behind the net zero emissions goal – in particular, between the energy market and the property market.

One of the practical objectives of the project is to identify and highlight examples of policies or regulations that are acting as impediments to the required investments.

State Policies

ClimateWorks Australia notes that 'All Australian state and territory governments are now committed to net zero emissions by 2050 or earlier. These commitments cover all emissions produced within Australia's borders. The majority of states and territories have also set interim emissions targets. Current state and territory interim targets combined translate to an estimated 37-42 per cent reduction on 2005 emissions Australia-wide by 2030. While this is short of what is needed, it is higher than Australia's Paris commitment for 2030 of 26-28 per cent below 2005 levels.'[2]

There's a great variation in the challenges that each jurisdiction faces in moving to net zero. Policies need to be crafted to suit the local conditions but for the property industry poor policy coordination leads to confusion, inertia and higher costs.

The scenarios and recommendations developed in this project are designed to recognise regional variations while resolving actions that are consistent and relevant nationally. For instance, the ACT has a target to phase out gas use in buildings by 2045 while other states are only developing gas roadmaps now. For industry to respond to this challenge, national coordination would allow for a more efficient transition.

A Changing Market Context

Operational emissions from buildings in Australia account for approx. 100 million tonnes CO_2-e/annum, around one fifth of Australia's total emissions. Markets have moved quickly in response to – or even anticipating – national and international climate change policy commitments.

In the commercial property sector, for example, leading property institutions have already made very significant progress in improving the energy efficiency of their building portfolios, and in switching to renewable electricity.

The **Better Buildings Partnership** – a collaboration of leading property owners and industry influencers providing green leadership and sustainable innovation for Sydney's (and Canberra's) commercial and public buildings – had by 2020 reduced its 2007 emissions by a remarkable 61%.[3]

BBP members are targeting zero emissions by 2030, with efficiency improvement and electrification with renewable electricity (onsite and offsite) the key change strategies.

Nationally, rating tools like Green Star are driving commercial and residential buildings to decarbonise at speed with a specific focus on removing fossil fuels from heating, cooking, and hot water between now and 2030 for new buildings and now and 2040 for existing assets.

Efforts like this have led to Australia (and New Zealand) winning global recognition from the **Global Real Estate Sustainability Benchmark** (GRESB). For a remarkable 8 years in a row, the Australia and New Zealand real estate sector has out-performed all other regions, leading the world in environmental, social and governance (ESG) performance.[4]

For the leading players, world-class sustainability performance aligns closely with their business models, helping them to access low-cost finance and equity participation from around the world. At the same time:

- There is little evidence that owners of the vast majority of existing, older, non-CBD, and less 'premium' commercial buildings have yet taken similar steps.
- Existing market and policy drivers to upgrade the energy/emissions performance of non-premium buildings are relatively weak, and often affected by the tenant-landlord split incentive.
- While solar on commercial buildings has been encouraged through embedded retailer and network arrangements, it is discouraged by low feed-in tariffs, difficulties in obtaining connection agreements for systems that export (even when the building is not operating) – leading to widespread under-sizing of systems.
- Incentives for advanced energy management and distributed storage in buildings are weak, discouraging building owners from making full use of their potential to reduce system peaks.

In the residential sector, some 3 million houses, or 30% of all houses in Australia, now have rooftop solar – the highest take-up of any country in the world.[5] Yet here too there are contradictory policy signals:

- Feed-in tariffs have been significantly reduced in recent years.
- Export limits of 5kW have been imposed by distribution companies.
- The merits of 'solar taxes', or fees to export, are currently being debated.[6]
- Batteries remain unaffordable for many households.
- Efficiency standards for new housing have not changed since 2010.
- Apartment owners face significant barriers in accessing the benefits of rooftop solar.

Also, with housing prices amongst the highest in the world,[7] there is little room for market differentiation of higher and lower efficiency housing, and only the ACT requires disclosure of housing energy performance at the time of sale or lease.

Underpinning many of the market developments has been an unprecedented increase in energy prices – electricity and gas – over at the last 15 years.[8,9]

This, perhaps more than anything else, has householders and commercial owners across Australia seeking new and innovative solutions. With new technologies and new business models helping to create access to such solutions, it is very unlikely that the search will end anytime soon.

Literature review: AEMO's Integrated System Plan (ISP)

AEMO has produced two ISPs (2018, 2020) and recently released a draft 2022 Plan.

- The ISP's purpose is "… to establish a whole-of-system plan for the efficient development of the power system that achieves power system needs for a planning horizon of at least 20 years for the long-term interests of the consumers of electricity".

The draft plan considers four scenarios:

- *Slow Change* tests the impact of slower than expected decarbonisation, a slow economic recovery from the COVID-19 pandemic, and greater risk of industrial load closures.
- *Progressive Change* assumes progressively ratcheting up emissions reduction goals over time, to reach net zero emissions by 2050, including steady growth in numbers of EVs and, in the 2040s, some industrial electrification, and hydrogen use as blended pipeline gas and in transport.
- *Step Change* (considered most likely) assumes rapid consumer-led transformation of the energy sector, co-ordinated economy-wide action to reduce emissions, and a 'consistently fast-paced transition from fossil fuels to renewable energy in the National Energy Market (NEM)'. Increased digitalisation helps both demand management and grid flexibility, and energy efficiency is as important as electrification. By 2050, most consumers rely on electricity for heating and transport, and the global manufacture of internal-combustion vehicles has all but ceased. Some domestic hydrogen production supports the transport sector and as a blended pipeline gas, with some industrial applications after 2040.
- *Hydrogen Superpower* requires a near quadrupling of NEM energy demand to support exports of hydrogen.

AEMO is currently consulting regarding the development of a new low/zero carbon gases scenario. This scenario would explore a future where greater access to low or zero emission molecular fuel sources (such as blended hydrogen, biogas or other constituent gases), delivered through the gas network, can increase the potential role for molecules, rather than electrons, to reduce emissions.[10]

Literature review: Infrastructure Victoria's Interim Report, Towards 2050: Gas infrastructure in a zero emissions economy

This interim report considers the implications for the state's gas infrastructure of shifting the current uses of gas to zero emissions by 2050. Key (interim) conclusions include:

- There are over two million residential/commercial gas users in Victoria, consuming 53% of the state's total gas consumption. Space heating…makes up more than 75% of total household gas use, with winter gas use about three times higher than summer.
- The opportunity to repurpose existing natural gas infrastructure over the long term (beyond 2040) is considered limited, noting that over half of Victoria's onshore pipeline infrastructure is over 40 years old.
- The future of low or net zero emissions gases, such as hydrogen produced with renewable electricity and seawater (green hydrogen), and decarbonisation pathways such as CCS, remains uncertain. Hydrogen production and use is not yet proven at scale.
- Nevertheless, it suggests that careful development, blending and optimisation of biogas and hydrogen over the short to medium term could maximise re-use of some existing pipeline infrastructure.
- Under all scenarios, Victoria's reliance on natural gas will decline significantly in the years to 2050. Further expansion of natural gas infrastructure increases the risk of some assets becoming unused or stranded. (p. 5)
- The immediate focus for energy efficiency and demand management initiatives should continue to be the residential sector. There are opportunities to develop initiatives which focus on improving the thermal performance of existing buildings. (p.44)
- Changes required to Victoria's energy sector…may include switching fuels, upgrading appliances, adopting new technologies, and increasing energy efficiency efforts.
- The scale of the change required, and likely financial implications for energy users, suggest a clear role for government in managing affordability and equity issues associated with any transition away from gas, particularly given existing consumer concerns with energy affordability.'
- Opportunities remain to better align policies and regulation with net zero pathways, to provide a strong framework for achieving both interim and net zero 2050 targets' (p. 5).

Energy Networks Australia contests key findings of this reporting, noting that different infrastructure classes have different average ages and economic lives, and greater overall repurposing potential (GPA Engineering, Technical and Commercial Review of IV's Gas Infrastructure Interim Report, August 2021).

Literature review: Hydrogen & biogas

There is great interest in the potential for green (or emissions-free) hydrogen to replace natural gas in many applications. Green hydrogen is produced via electrolysis using renewable electricity and offers benefits in energy storage, transport and the potential to replace natural gas in industrial processes.

At least 30% of the energy contained in the electricity is lost in the conversion process, while storage, retrieval and combustion of the hydrogen reduces overall system efficiency to low levels – less than 50% and as low at 18%, compared to the round-trip efficiencies of lithium-ion batteries of up to 95%.[11,12]

A 2019 report by GPA Engineering and the Future Fuels Cooperative Research Centre, Hydrogen in the Gas Distribution Networks, argues that the first stage will be to blend clean hydrogen into gas distribution networks at a level of up to 10% by volume.

- This report identifies how this level of hydrogen may affect the various materials and types of equipment used in gas distribution networks, what changes to operating practices and procedures may be required, and which technical standards will have to be reviewed and possibly amended.
- A similar report from the same source, Hydrogen impacts on downstream installations and appliances (2019), focuses on the end-user level.

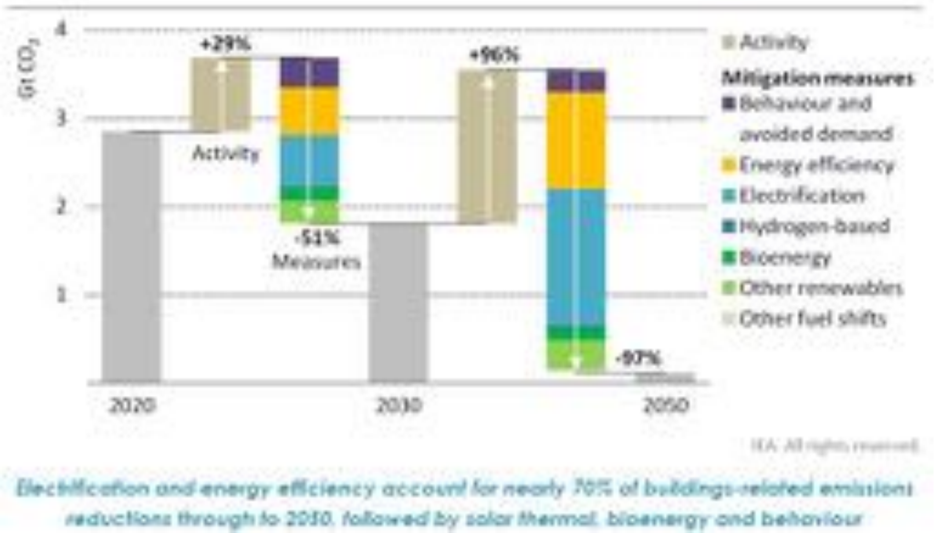
Energy Networks Australia launched a Gas Vision 2050 in 2017. It identifies three 'transformational technologies' – biogas production, hydrogen and carbon capture/storage.

Since then, ENA has commissioned technical reports dealing with key issues related to the deployment of these technologies, particularly hydrogen, and also several policy-oriented reports. These argue that using hydrogen and/or biogas in existing gas distribution networks will offer a lower cost path to decarbonisation of the non-transport energy system than electrification.

Literature review: International Energy Agency – Net Zero by 2050

The IEA's Net Zero roadmap provides decarbonisation pathways across a range of sectors including buildings. While the perspective is global the pathways provide guidance to the Australian situation. Key observations include:

- Energy efficiency and electrification are the two main drivers of decarbonisation of the buildings sector in the NZE (net zero emissions scenario). That transformation relies primarily on technologies already available on the market, including improved envelopes for new and existing buildings, heat pumps, energy-efficient appliances, and bioclimatic and material-efficient design.
- Zero carbon ready energy codes should recognise the important part that passive design features, building envelope improvements and high energy performance equipment play in lowering energy demand, reducing both the operating costs of buildings and costs of decarbonising the energy supply.



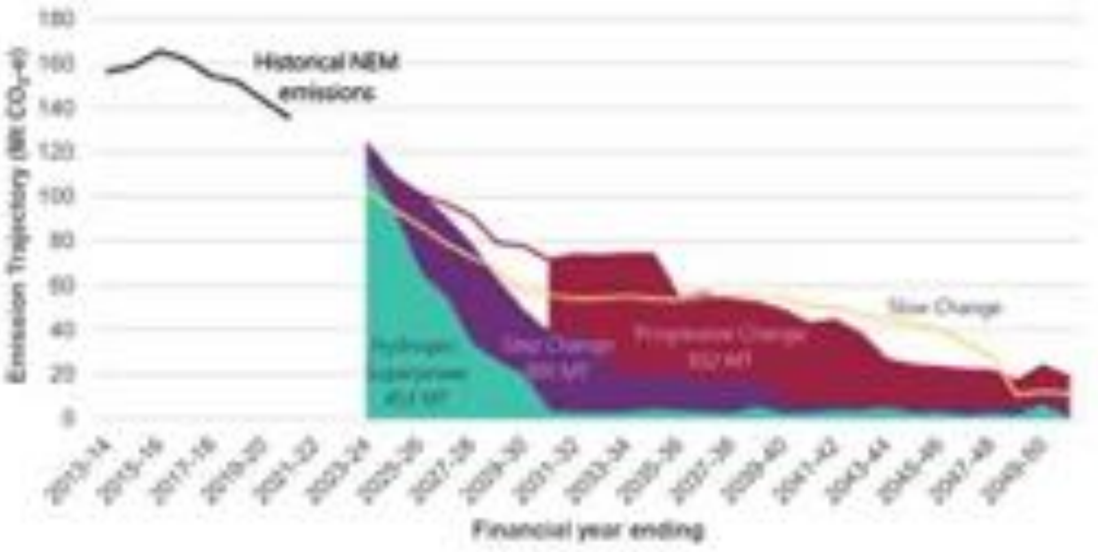
The IEA forecasts a small contribution globally from hydrogen in the net zero plan for buildings. In this chart Activity = change in energy service demand related to rising population, increased floor area and income per capita

Key Challenges and Opportunities

- Electrification is already underway in Australia, in part enabled by increasing access to low (and falling) costs of solar PV and (remote) wind energy sources. These have provided households and businesses with affordable strategies to limit the impact of rapid increases in grid-supplied electricity and gas.
- Solar and battery storage technologies, and the new business models that they enable, are disrupting traditional energy supply models but also creating significant value for consumers.
- Power Purchase Agreements (PPAs) allow customers to hedge electricity price risks at the same time as ensuring their consumption is fully supplied by renewable energy sources. They also enable building owners to choose a fully electric solution while achieving zero operational emissions immediately, ahead of full grid decarbonisation.
- Solar energy systems, batteries, and demand management require long-term investments, but returns are highly susceptible to short-term changes in tariffs and regulatory settings.
- The electrification of the transport sector, now underway around the world – albeit more slowly in Australia – will shift much of the transport energy demand to the built environment, with many electric vehicle (EV) drivers and fleets recharging their vehicles at home or at work, adding to building loads.
- EVs offer the facility of being ‘batteries on wheels’, with vehicle-to-load (VTL) possibilities, along with smart chargers, enhancing grid stability.
- A key concern for policy makers associated with electrification is the costs associated with rising peak electrical demand. However, where new electrical loads are not ‘co-incident’ with current peaks (winter space heating) or can be time-shifted (EV charging, stationary batteries, thermal storage, etc) then this effect is reduced.
- Rising PV output in the middle of the day is contributing to lower net grid demand, and low or even negative prices, during these periods. However, this presents a significant economic opportunity for low/negative cost EV charging, energy storage, hydrogen production, for example.
- In the short term, electrification with grid-sourced electricity could potentially lead to increasing emissions – particularly in states with high emissions electricity. However, these emissions would also fall automatically as grid emissions intensity falls (see AEMO scenarios), and consumers have the option of short-circuiting this process with PPAs and/or on-site renewable generation.
- The emissions-intensity of the grid is likely to be higher overnight than during the day, at least while coal and/or gas continue to generate at these times. However, this effect will reduce as a range of energy storage options grow in capacity.

AEMO’s Draft 2022 ISP notes (p. 48-49):

- Daytime minimum demand will initially be driven lower…but then driven up by electrification…and the opportunity for battery systems to charge during periods of excess solar generation.
- Evening peak demand will flatten as distributed storages…discharge through the evenings.
- EV charging during the day will further improve the operability of the power system.
- Operational electricity consumption will increase during winter more than summer.
- In later years, hydrogen production may provide new, flexible load. Electrolyser facilities will operate strongly during periods of excess supply, such as during the day where solar production is strongest.



AEMO’s draft 2022 Integrated System Plan anticipates that the “step change” scenario is most likely which would have NEM emissions intensity dropping by approx. 70% by 2030

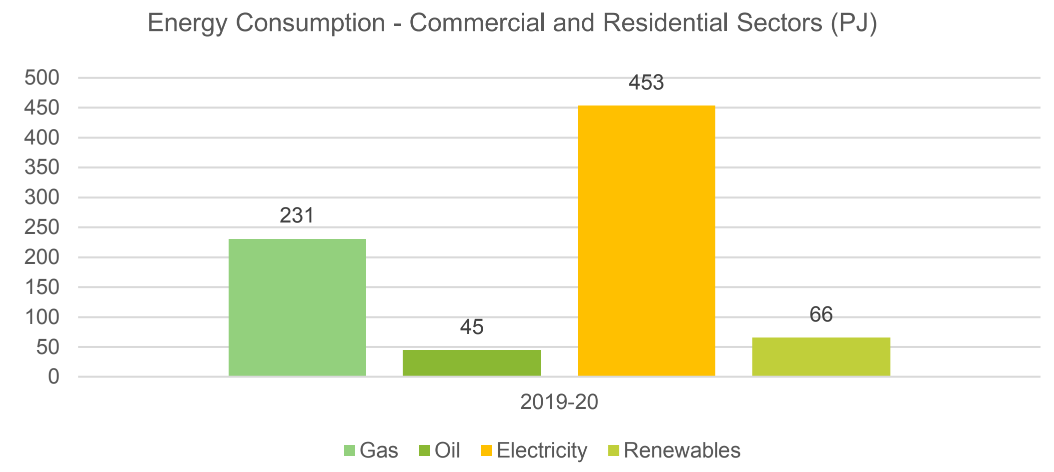
Built environment – energy and emissions inventory

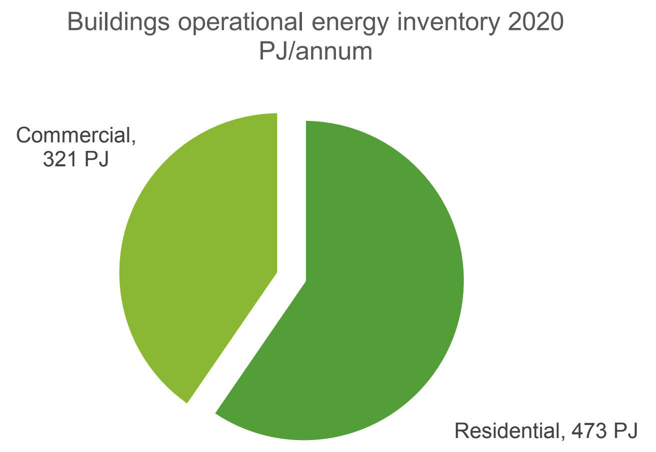
This Discussion Paper focuses on greenhouse gas emissions arising from energy use in the built environment (note: refrigerant use has been excluded).

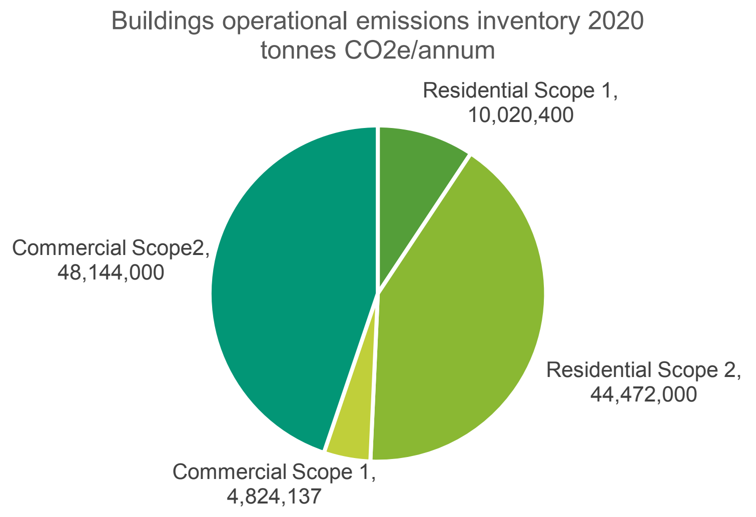
Scope 1 emissions arise from the use of fossil fuels, particularly natural gas used for heating, hot water and cooking while scope 2 emissions are emissions related to electricity consumption. End-use drivers of operational emissions are discussed in the next sections.

Overall, in FY2020, the residential and commercial sectors used 453 petajoules (PJ) of electricity (57% of their total energy use), 231 PJ of natural gas (29%) and smaller quantities of oil (eg, diesel), LPG, and non-electrical renewables, such as solar thermal energy and firewood.[13]

This project explores the combination of strategies that can be deployed on the energy supply side, for instance changing the source of energy to renewables, and the energy demand side, through efficiency measures including technology upgrades, that will together allow for rapid and least cost decarbonisation.



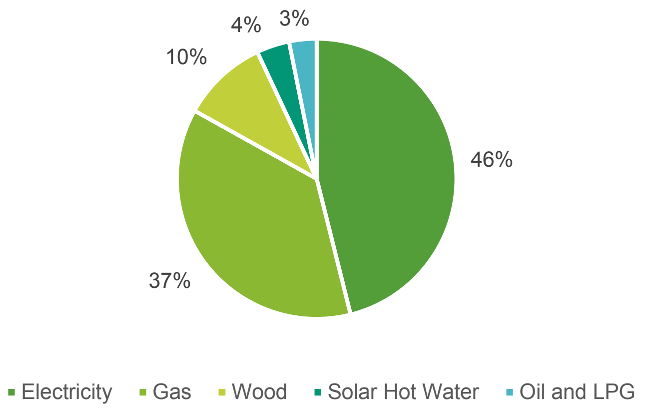




Residential Energy Use

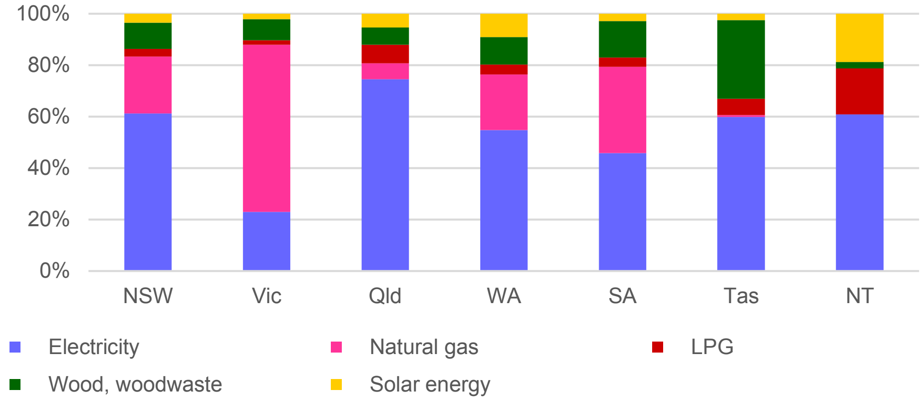
Electricity is the primary 'fuel', or energy carrier, used in the residential sector across Australia. However, gas – a fossil fuel – is the second largest energy source. Other fossil fuels, such as heating oil and LPG, have small shares of energy consumption in the residential sector.[14]

Residential Energy Shares, Australia, FY2020 (%)



- The residential fuel mix varies widely by jurisdiction
- This reflects differing resource endowments, historical infrastructure investments (eg, in gas distribution networks), climatic differences, energy price differences, and regional variations in building practices.
- The decarbonisation challenge also varies considerably by jurisdiction.

Residential Energy Consumption by Fuel and Jurisdiction, FY2020, (%)

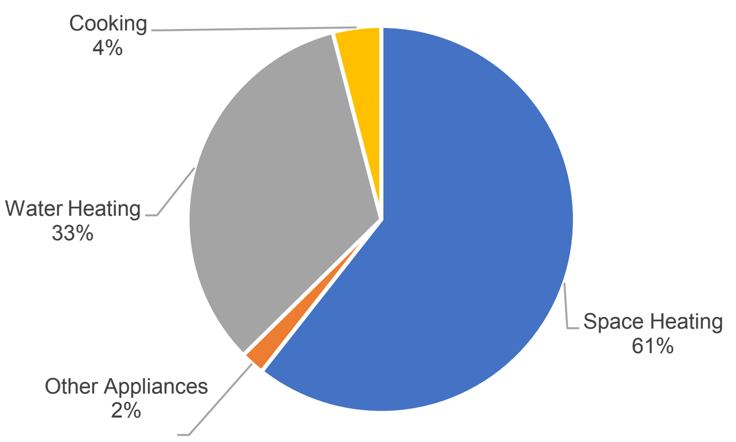


Derived from Australian Energy Statistics, Table F

Looking more closely at residential gas use by jurisdiction end use, two factors stand out:[15]

- Residential gas use is largely concentrated in Victoria, while if New South Wales is added to the picture, these two states are responsible for over 80% of all residential gas in Australia. The ACT is also a significant user of gas on a per-capita basis.
- Australia-wide, 61% of residential gas use is for space heating, and a further 33% is used for hot water. Cooking and other uses represent very small shares of total gas use.

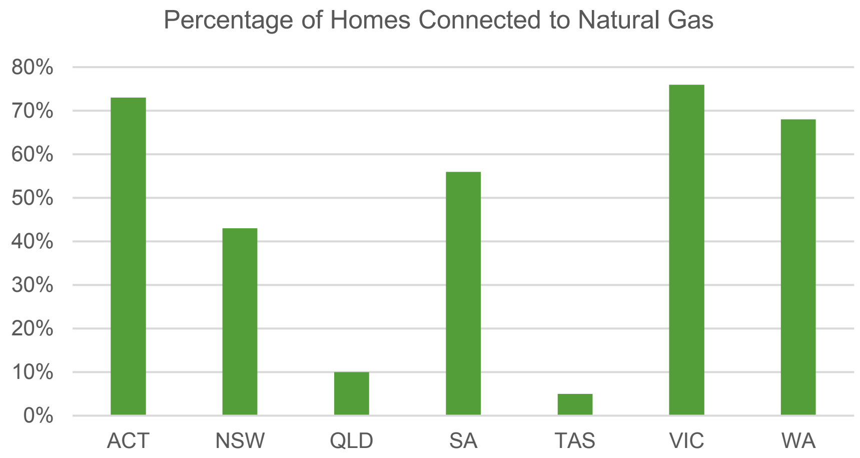
Residential Gas End-Use Shares (%)



- The primary decarbonisation challenge in this sector is therefore focused in two states and two end-uses.
- There are alternatives for space and hot water heating that can utilise renewable electricity, and these solutions are available today, supporting rapid decarbonisation.

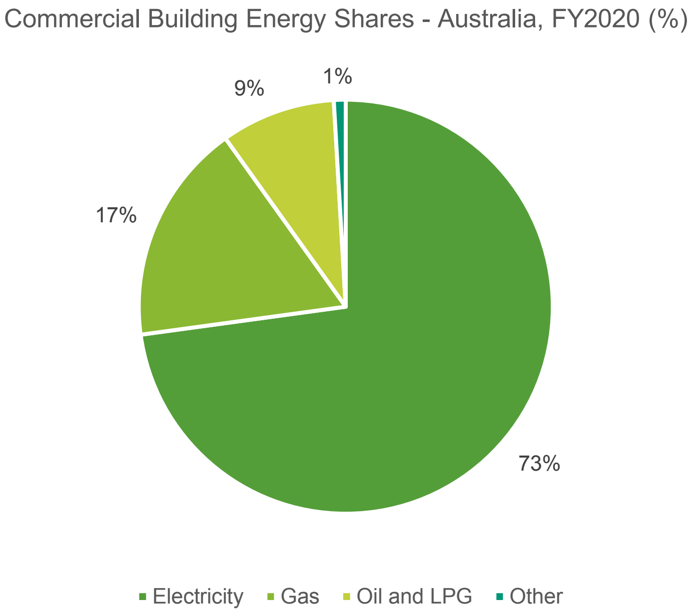
48% of houses in Australia are connected to natural gas, even if this picture varies considerably by jurisdiction.

The same source estimates that there are some 12.7 million gas-network-connected household appliances across Australia, with a further 6 million devices using bottled LPG.



Commercial Building Energy Use

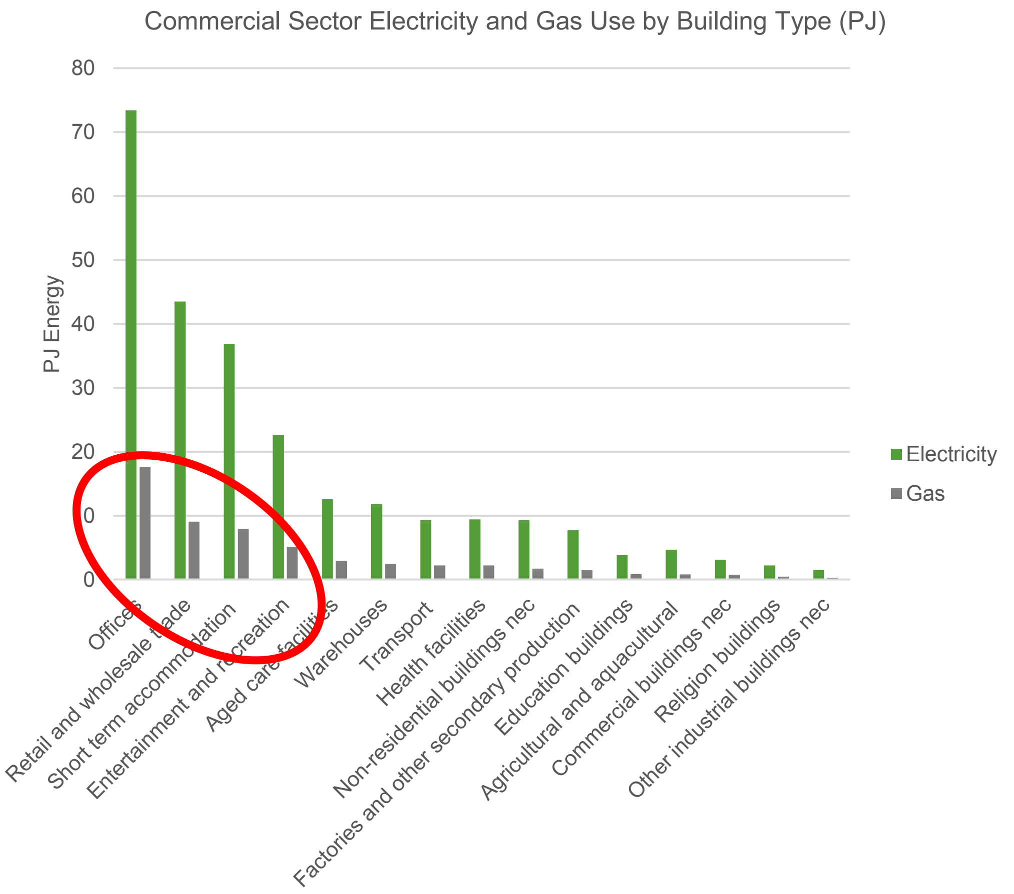
To a much greater degree for the commercial sector than for residential, electricity dominates overall energy use, at 73% of the total. Gas accounts for 17% of total energy consumption; oil (diesel) and LPG 9%, with 1% for other energy sources.[16]

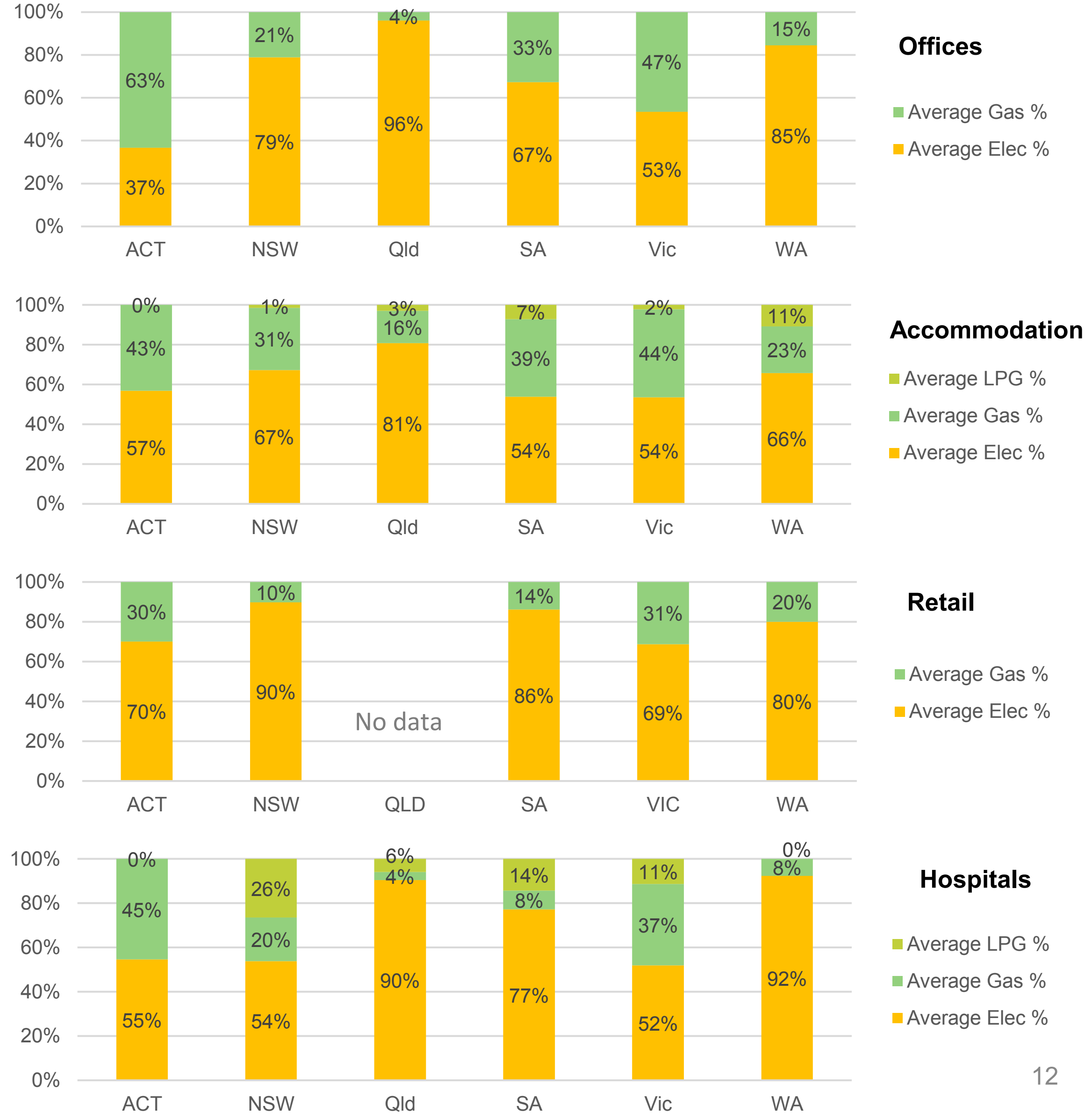


Commercial buildings are more diverse in function than residential ones, and the underlying drivers of energy use and emissions, and the fuel mix, are also more diverse.

Commercial building gas use is dominated by offices. Retail, accommodation and entertainment/recreation buildings also use significant quantities of gas. Hospital gas use in significant on a per-building basis, but small in terms of the national total.

The exposure of different key building types and markets to gas and LPG use is shown on the following page.

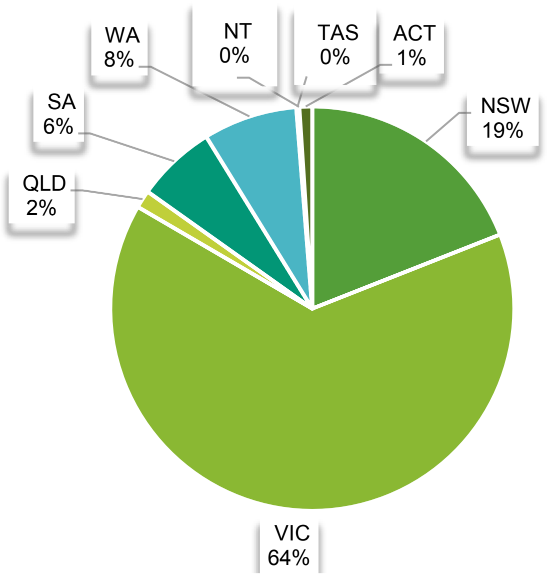




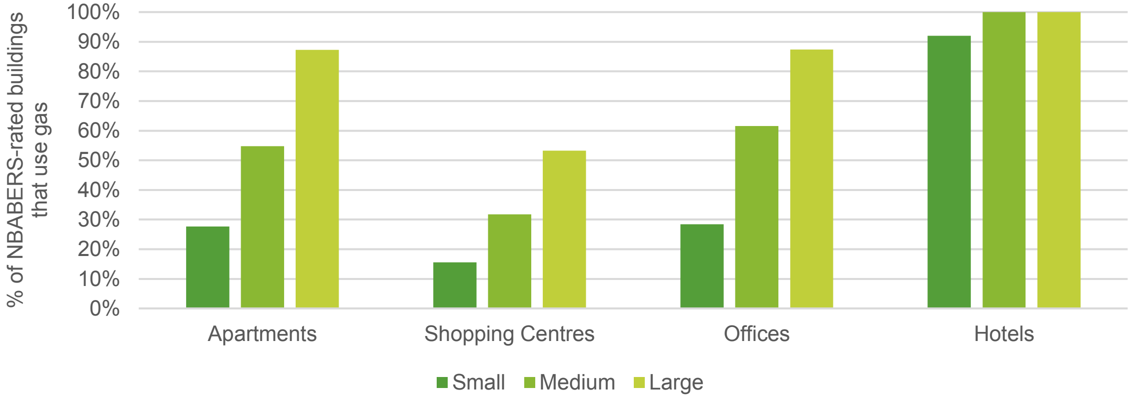
In commercial buildings gas use is most significant across just three building types, office, retail/wholesale trade and short-term accommodation.

The figure to the right shows the jurisdictional variation in gas use by building type.

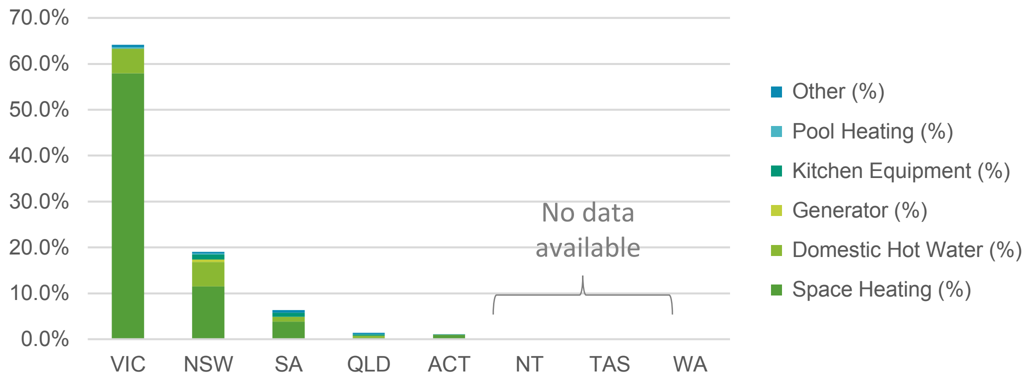
Victoria and NSW together account for 83% of Australia's total gas use in the commercial sector.[17]



Large buildings are more likely to use gas than smaller ones.[18]



Commercial gas use is also driven very largely by space heating, with domestic hot water a distant second.



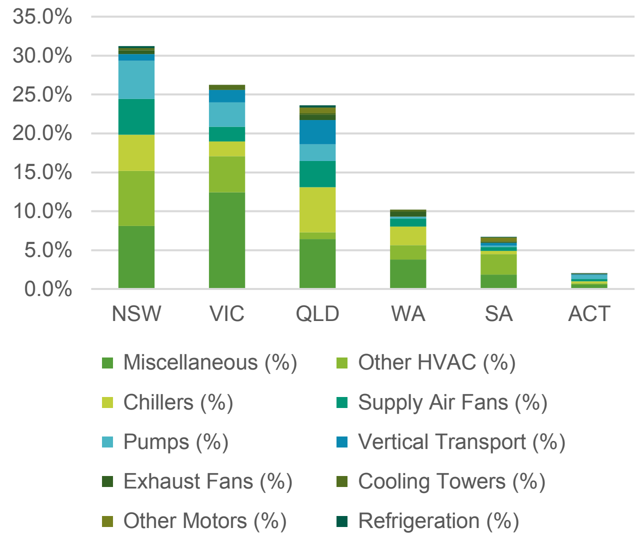
DeltaQ estimates that only around 50% of the gas supplied to commercial buildings for space heating and hot water actually supports the delivery of these energy services. The balance is lost in conversion/combustion, distribution losses and standing losses.

End Use	% Total Load
Total Space Heating	**80%**
Space Heating Services Delivered	*(40%)*
Combustion Losses	*(16%)*
Distribution Losses	*(12%)*
Standing Losses	*(12%)*
Total Domestic Hot Water	**12%**
Hot Water Services Delivered	*(6%)*
Combustion Losses	*(2%)*
Distribution Losses	*(2%)*
Standing Losses	*(2%)*
Kitchen Equipment	**4%**
Other	**4%**

Considering Scope 2 emissions from electricity use, DeltaQ's internal data shows the following average end-use breakdown:

Average Commercial Building Electricity End-Use

End Use	% Total Load
Total HVAC	**48.2%**
Chillers	*(11.7%)*
Other HVAC	*(22.7%)*
Cooling Towers	*(1.0%)*
Exhaust Fans	*(2.1%)*
Supply Air Fans	*(10.6%)*
Pumps	**12.9%**
Vertical Transport	**5.3%**
Lighting & Other	**25.7%**
Refrigeration	*(0.5%)*
Other Motors	*(1.2%)*
Lighting + Other	*(24.0%)*



Shares of Total Commercial Electricity Consumption by Jurisdiction and End-use

- For buildings that utilise grid-average-emissions-intensity electricity, there may be significant emissions associated with this energy use, depending upon the jurisdiction.
- The overall pace of reductions in the emissions-intensity of different grids will be critical for the pace of decarbonisation in these buildings.
- The relative sizes and times-of-use of different electrical loads within buildings can have different consequences for electrical networks, for example due to degree 'co-incidence' of peak building and peak system demands.

Focus Questions – future energy/emissions profile

- Are there significant trends in the built environment – residential and/or commercial – that will impact future energy/emissions scenarios ? (eg online retail, sharing economy, circular economy, aging population, others?)

Abatement Options

This section summarises the technological solutions available for rapid decarbonisation of the building stock, along with the merits, opportunities and barriers associated with each. There are options for energy supply and there are options for end use technology with intendencies between them, something that is currently complicating decision making.

The scenarios are designed to allow analysis of combinations of energy source with combinations of end use technology with an emphasis on solutions that are available now, ready for rapid roll out.

Energy efficiency

All three scenarios will assume that energy efficiency of buildings continues to improve as a result of new, more efficient stock entering the market, the impact of better technology and better information being provided to consumers through expansion of labelling and benchmarking programs.

Behaviour

Behaviour change is necessary to achieve net zero. It might be as simple as changing temperature settings on air conditioning or accepting induction stoves are preferable to gas. Within the scenarios the assumption will be that effective communication and programs achieve result in the required behaviours.

Renewable energy sources

Growth in renewable electricity generation displacing fossil fuel is predicted to continue as per AEMO's planning forecasts including increasing penetration of solar PV on homes.

Renewable gas supplied via the grid is in the early stages of development and commercialization and it remains unclear if the grid can ever achieve a 100% renewable supply.

End use technology

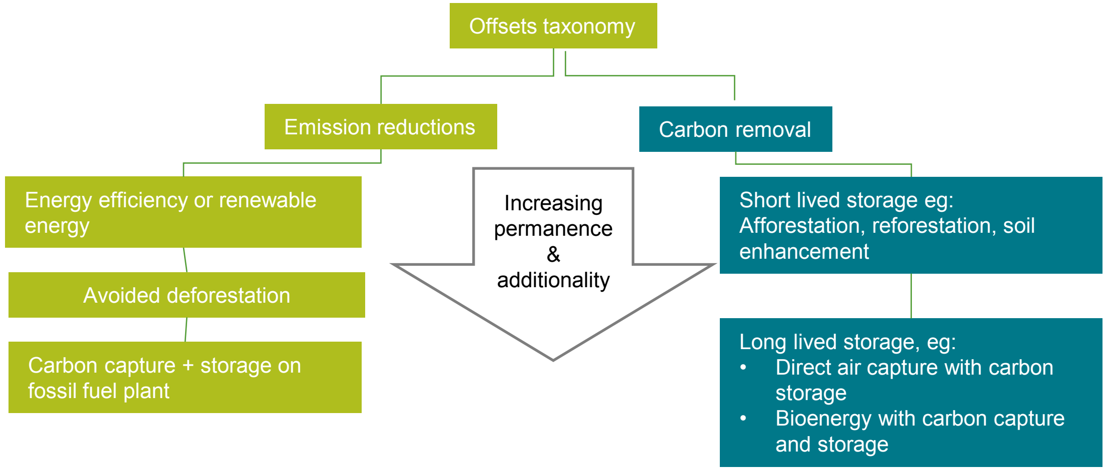
Key end technologies to provide space heating, hot water and cooking are detailed in the following pages, they may be supplemented with new forms of controls that will allow the whole energy system, generation to end-use to be optimised. Importantly, these technologies are available, off the shelf, now.

Time

Time is a considerable constraint in the development of future scenarios for net zero buildings. While 2050 is the national net zero target there are strong arguments for the built environment to achieve net zero earlier and the potential for international pressure to bring net zero forward. Then, under some scenarios, millions of appliances will need to be modified or replaced to accept a different energy source. There is a need to act with urgency to allow a managed transition.

Offsets

Offsets already feature in the strategy of some organisations striving to operate carbon neutrally today and they are acknowledged as part of a net zero strategy by the Australian Government. The market for offsets is rapidly evolving as the credibility of the different types of offsets are tested so where offsets are used in scenario modelling only long-term carbon removal offsets, nature based or otherwise, are considered. For example, the University of Oxford's The Oxford Principles for Net Zero Aligned Carbon Offsetting, September 2020, p. 9, recognise the need to move progressively towards more permanent carbon removals with long-lived storage and low risk of reversal (losses from storage).



Taxonomy of carbon offsets adapted from the The Oxford Principles for Net Zero Aligned Carbon Offsetting

The Role of Batteries and Smart Energy Management

The very significant economic opportunities to store low or negative cost electricity in batteries, for consumption at times of peak demand, are already being captured at utility scale.[19] However, they are not yet common at the building level due not only to high capital costs, but also to complex business cases that are affected energy market rules and regulation.

Opportunities for building owners could include:

- Enabling onsite renewable energy to be stored and used when needed, rather than exported at low feed-in tariffs or else curtailed.
- Helping system stability by importing energy for battery and thermal storage, and EV charging, at times of surplus renewable electricity generation,
- Participating in markets for frequency/voltage regulation, demand response and congestion management and, conversely, reducing demand at system peaks.

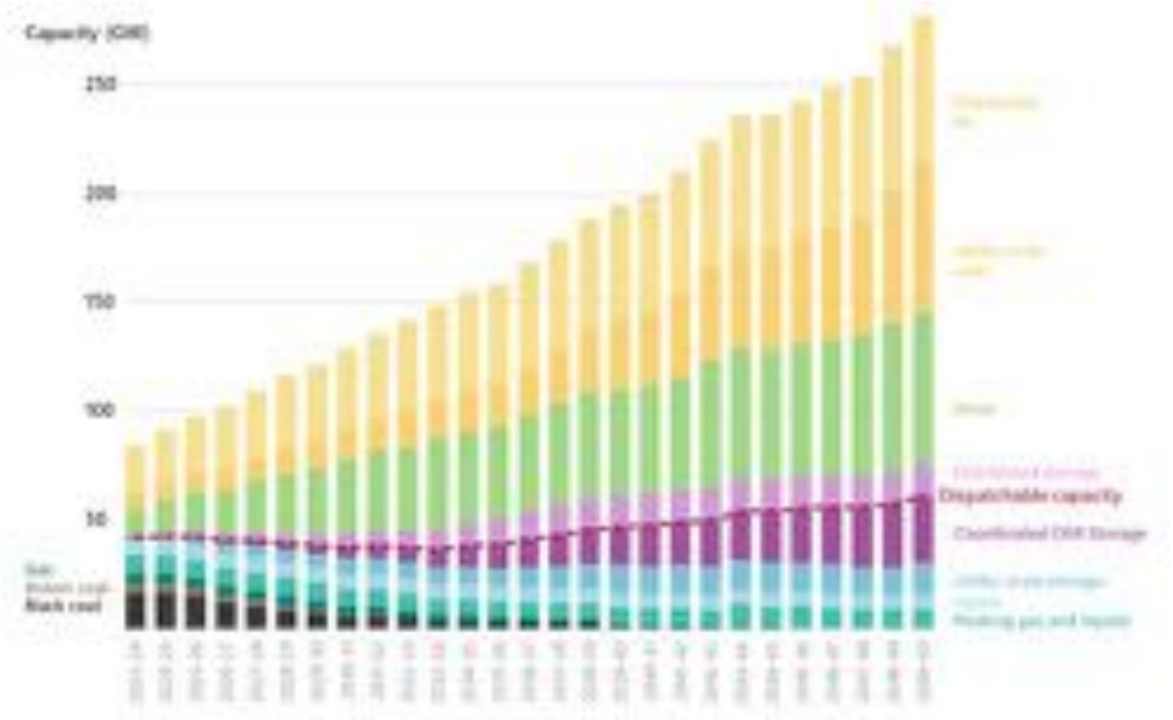
AEMO's Draft 2022 ISP envisages by 2050 (p. 8 - 9):

- Trebling the firming capacity…including utility-scale batteries, hydro storage, gas generation, and smart behind-the-meter batteries or "virtual power plants" (VPPs).
- Adapting networks and markets for two-way electricity flow and to provide essential power system services.
- 45 GW and 620 GWh of storage capacity, in all forms, will be required, including an important role for 'distributed' storage, embedded in distribution networks.

The ISP notes, p. 10, that "The most pressing need in the next decade (beyond what is already committed) is for batteries, hydro or viable alternative storage of up to eight hours' depth to manage daily variations in the fast-growing solar and wind output."

If building owners (residential and commercial) are to assist in meeting this pressing need, they must have access to these market opportunities on fair and reasonable terms, without the risk that changes in tariffs or market rules will strand their investments.

Since, in effect, building owners are competing with networks for the provision of these energy market services, it is critical that the playing field is level and that market access is not mediated by networks. The inherent imbalance of market power between monopoly network service providers and their customers must be recognised in this context.



Forecast NEM Capacity to 2050, Step Change Scenario, with transmission, being Figure 1, p. 9, from AEMO's Draft 2022 ISP.

In particular, we draw attention to the purple wedges of distributed storage (customer premises, not dispatched by AEMO) and coordinated (dispatchable) storage.

Residential energy end use net zero options

End Use	Net zero solutions	Description
Space heating	Heat pump Electric resistance heating	Heat pumps are widely available now, significantly more efficient than electric resistance heating and require no modification to run on renewable electricity. Resistance heaters remain common, often as portable, plug-in heaters. Less efficient and higher running costs than heat pumps but low capital cost.
	Gas heater	Where renewable gas blends exceed 10% - 20% hydrogen, gas heating systems are likely to require modification. This is not the case with biogases, if they can be supplied in the required quantity.
Domestic hot water	Solar hot water Heat pump Electric resistance	Solar hot water systems – notably evacuated tubes – are highly effective in most Australian climate zones but may capture less solar energy in very cold or cloudy locations. Since most solar hot water systems are electrically-boosted, they offer a zero-carbon solution for all climates when boosted with renewable electricity. As with heat pumps used for space heating, heat-pump based hot water systems offer very high energy efficiencies, up to 500%.[20,21] Households with rooftop PV systems can divert surplus solar energy into an electric storage hot water system, and solar diverter functionality is being included as standard in many new electric hot water systems, including heat pump-based systems. Hot water systems also offer some renewable energy storage potential.
	Gas hot water	Depending on the renewable gas blend, gas hot water systems may require modification.
Cooking	Induction cooking	Induction cooktops are an increasingly popular selection for clean, modern kitchens.
	Gas cooking	Depending on the renewable gas blend gas cooktops and ovens are likely to require modification.

Commercial building energy end use net zero options

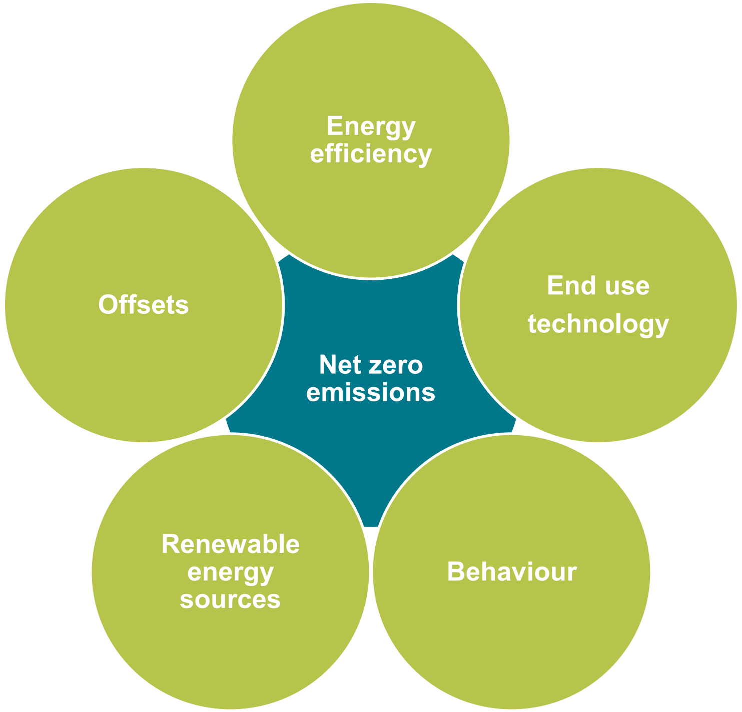
End Use	Net zero solutions	Description
Space heating	Heat pumps	Many different options suited to specific applications, including air-source, water-source, ground-source, ammonia heat pumps.
	Variable Refrigerant Flow (VRF) systems	Efficiency savings of over 30% of the electricity load compared to traditional HVAC systems have been reported for VRF systems.[22]
	Electric boilers	Models available in Australia generally offer lower capacity than gas boilers and higher running costs. Can be used in parallel with thermal storage to manage peak demands and recover heat from cooling systems.
	Radiative/resistance heating	Less energy efficient than heat pumps, but can be efficient solutions for spaces that have low utilization, or in outdoor settings. Electric duct heating can be efficient for reheat/supplementary heat, reducing the need to oversize centralized space heating facilities to meet occasional peak demand.
	Hydrogen/Biogas boilers	Hydrogen boilers are yet to be commercialised but may become available in future. Depending on the renewable gas blend, gas heating systems may require modification.[23]
Domestic hot water	Heat pump	As with heat pumps used for space heating, heat-pump based hot water systems offer very high energy efficiencies, up to 500%. Retrofits can be challenged by space/floor loading characteristics.
	Solar hot water	Solar pre-heat is widely used in apartment buildings and could be more widely used in applications where hot water demand is not too high.
	Electric resistance	
	Hydrogen/biogas hot water	As above, hydrogen boilers are yet to be commercialised but may become available in future while, depending upon the renewable gas blend, gas heating systems may require modification.
Cooking	Induction cooktops	Cooking is minor gas use overall, but induction cooktops offer a high-efficiency electrical alternative with technical characteristics that are favourable for commercial kitchens – but some may prefer gas.
	Gas cooktop	Depending on the renewable gas blend, gas cooktops and ovens may require modification.

Focus Questions – Residential abatement

- In developing future scenarios for comparison of cost and benefit what energy systems or technologies in residential buildings are going to play a key role in reducing emissions ?

Focus Questions – Commercial Buildings abatement options

- In developing future scenarios for comparison of cost and benefit what energy systems or technologies in commercial buildings are going to play a key role in reducing emissions ?



Scenario Framing

Phase 2 of the project – to commence in April 2022 – will quantify three plausible but divergent scenarios for rapid and least cost decarbonisation of building operations.

ASBEC is seeking stakeholder input into the framing of these scenarios.

The scenarios are intended to illustrate and explore broad options and decarbonisation pathways, along with their benefits and risks, both at the building level and at the level of the energy system.

By way of background, we note that the purpose of scenario analysis is not to predict the future but, as the International Energy Agency points out, "…to enable readers to compare different possible versions of the future, and the levers and actions that produce them, with the aim of stimulating insights…".[24]

Often, projections start from a 'business-as-usual' (BAU) base case which assumes no new technologies and no new policies. While this approach is useful for understanding the *incremental* impact of a single new policy or technology:

- BAU projections will be overly pessimistic, as they ignore the capacity of markets and governments to respond dynamically, thereby changing the incentives and the opportunities in future.
- They are often not consistent with political commitments – even if these are strongly supported in the community – or with international treaty obligations.

For these reasons, we propose not to model a BAU scenario. Instead, the aim is to propose three scenarios, all of which could *potentially* realise the outcome of net zero emissions (in building operations) by 2050, so the costs and benefits of each approach can be compared.

Scenarios will be modelled for five building archetypes in Brisbane, Sydney and Melbourne, as policy settings, fuel mixes and the emissions intensity of electricity all vary widely.

Offices, retail and hotels/accommodation are the commercial building types to be included in the modelling, while residential types includes stand alone dwellings (Class 1) and apartment buildings (Class 2).

For the purpose of the scenarios, it is planned to build on AEMO's Draft 2022 Integrated Systems Plan. These have resulted from extensive modelling inputs and also have involved extensive stakeholder engagement.

Scenario modelling will provide a clearer understanding of the mechanisms required to deliver decarbonisation earlier than net zero by 2050 especially when considering new buildings vs existing buildings. With most buildings lasting for multiple decades, it is critical that guidance impacting the design of new buildings is implemented at the earliest opportunity to manage risks of stranded investments.

Given these considerations the proposed scenarios, that are more fully described in the following pages, are:

- **Electrification with renewable electricity**: transitioning to fully electric buildings powered by renewables.
- **Renewable electricity/renewable gas**: renewable electricity is dominant with natural gas displaced with either biogas or green hydrogen.
- **Renewable electricity/blended gas/carbon offsets:** renewable electricity is dominant in the grid, some natural gas is displaced with renewable gas and credible offsets are used to achieve net zero.

Focus Questions

For each of the scenarios:

- What are the most important costs and benefits that should be taken into account when analysing each of the scenarios ?
- What are the consequences of each scenario that should be highlighted in analysis for policy makers to be aware of ?

Scenario 1: Electrification with renewable electricity

Many existing buildings are already fully electric and ready to be powered by renewable electricity. Under this scenario all new buildings would be delivered fully electric and those existing buildings that currently rely on gas for some services will require retrofitting.

Advantages	Challenges	Consequences
• Many residential and commercial buildings are already fully electric - but some jurisdictions have greater exposure to gas • Electrical technologies that are well-established, proven, and that offer low technical risk, are available now to meet all building operational requirements • Renewable electricity is readily available • Electricity is clean at point of use • The energy efficiency of PV panels, heat pumps and other electrical end-uses, is expected to continue to increase over time • The cost of PV installations has fallen dramatically over the last decade and is projected to fall further in future • Utility-scale renewables continue to set lower and lower price records • This strategy is applicable for most building types, residential and non-residential, existing and new • Renewable electricity generation avoids the combustion losses, and potentially the distribution losses (when generated onsite), associated with gaseous fuels • Electrification strategies may be enhanced with increasing uptake of electric vehicles	• Pace of decarbonisation of the electricity grid • 100% renewable electricity options exist today but may not be selected by building owners • Capacity of the electricity grid – generation, transmission and distribution, will be tested during periods of peak demand and reliability could suffer if this is not managed well • Capacity challenges could be amplified through the transition to electric vehicles • More extensive electrical demand management may be required to limit peak loads • At the building level, electrification of existing buildings could require upgrades to wiring or switchboard capacity • The time required to retrofit every building currently supplied with natural gas could delay net zero • Some larger PV retrofits require roof strengthening • At the electrical system level, electrification could require upgrades to local distribution substations, or other network capacity upgrades • Situations of existing energy poverty may be amplified where costs of transition; new appliances and rewiring, accumulate • Consumer fuel choice preferences need to be addressed	• Significant consequences for gas infrastructure and how it can be decommissioned over time • Millions of gas appliances to be replaced with an electric equivalent • Significant impact on businesses supporting gas systems, manufacturers, suppliers and installers of gas boilers and heaters • There may be social equity implications that justify government intervention • Building regulations and many other policy settings would need rapid change to avoid locking-in gas or other fossil fuels • A managed transition of existing buildings to fully electric demands careful management • Some buildings will be challenged spatially in accommodating technologies such as heat pumps

Scenario 2: Renewable electricity + renewable gas

This scenario is designed to explore the implications of changing to a fully renewable energy supply, renewable electricity plus 100% renewable gas supply using biogases and/or hydrogen.

Advantages	Challenges	Consequences
• Gas transmission and distribution systems can provide energy storage • Gas end uses are able to remain on the gas system and not add to electrical loads • Opportunity to utilise/repurpose existing gas distribution infrastructure • Gas option retained for consumers with a preference for this solution	• Changing the gas supply system to any significant degree (> 10% - 20%) will require modification of gas end use appliances and associated costs • Parts of gas networks may require upgrade to be compatible with 100% renewable gases • Gas appliances have lower energy efficiency than electric equivalents – relative cost effectiveness would depend on renewable gas pricing, which is uncertain • The availability of feedstocks for biogases may limit the feasibility of this approach and/or reduce its cost effectiveness • Transitioning gas networks to 100% renewable gases would take time and create uncertainties for users regarding the timing of appliance/end-use upgrades • There may be higher value applications for hydrogen and biogases	• To achieve zero emissions, millions of gas appliances require modification or change out • There may be social equity implications that justify government intervention • Risk of stranded investments if 100% renewable gas supply cannot be achieved and maintained or is not cost competitive with renewable electricity

Scenario 3: Renewable electricity + gas blend + offsets

This scenario causes the least disruption to end use equipment at the building level. Renewable dominate electricity generation and some renewable gases are blended with natural gas to reduce emissions intensity while high quality carbon removal offsets are applied to achieve net zero

Advantages	Challenges	Consequences
• No modification of building end use equipment is required • Existing energy infrastructure remains in use • Electricity and gas consumption can be balanced optimally recognising the storage capacity in the existing gas infrastructure	• Potential stranding of fossil fuel assets as investors seek lower carbon portfolios • Offsets that are credible (effective capture, permanent/reliable, biodiverse), are likely to become increasingly expensive with rising demand • Consumers may choose to move to electrification anyway leaving those remaining to pay higher gas/carbon prices	• International investors could preference investment in other countries if continued use of fossil fuel is judged an environmental risk • Risk of higher energy/carbon prices impacting on Australia's competitiveness • As other countries electrify, choice and availability of natural gas appliances could decline • The social equity consequences of this scenario are less clear and may depend where the costs associated with offsets are ultimately carried

Summary of focus questions:

- Are there significant trends in the built environment that will impact on future energy/emissions scenarios ? (eg online retail, sharing economy, circular economy, aging population)
- In developing future scenarios for decarbonisation, what energy systems or technologies in **residential** buildings are going to play a key role in reducing emissions ?
- In developing future scenarios for decarbonisation, what energy systems or technologies in **commercial** buildings are going to play a key role in reducing emissions ?
- What are the most important costs and benefits that should be taken into account when analysing each of the scenarios ?
- What are the risks and consequences of each scenario that should be highlighted in analysis for policy makers to be aware of ?

Please follow this link to provide your feedback:

https://www.surveymonkey.com/r/decarbonisationofbuildingoperationsdiscussionpaper

Further Reading

- *Australian Energy Markets Operator (2021), Draft Integrated System Plan 2022*
- *Infrastructure Victoria (2021), Towards 2050: Gas infrastructure in a zero emissions economy interim report*
- *COAG Energy Council (2019), Australia's National Hydrogen Strategy.*
- *Commonwealth of Australian (2021), Australia's whole-of-economy Long-Term Emissions Reduction Plan, Australian Government Department of Industry, Science, Energy and Resources.*
- *Energy Networks Australia (2017), Gas Vision 2050.*
- IRENA (2020), *Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5ºC Climate Goal*, International Renewable Energy Agency, Abu Dhabi.
- International Energy Agency (2020), *Energy Technology Perspectives 2020 – Special Report on Clean Energy Innovation*.
- HM Government (2021), *UK Hydrogen Strategy*, August.
- Allen, C., et al, (2021). *Modelling ambitious climate mitigation pathways for Australia's built environment*, Sustainable Cities and Society, https://doi.org/10.1016/j.scs.2021.103554
- Prasad. D.. Et al, (2021). *Race to Net Zero Carbon: A Climate Emergency Guide for New and Existing Buildings in Australia*, Low Carbon Institute
- London Energy Transformation Initiative (2021), *Hydrogen: a decarbonisation route for heat in buildings?*
- ClimateWorks Australia (2020), *Decarbonisation Futures: solutions, actions and benchmarks for a net zero emissions Australia – Technical Report*.
- Agora Energiewende, Agora Industry (2021), *12 Insights on Hydrogen*
- Australian Renewable Energy Agency (2021), *Australia's Bioenergy Roadmap*.
- Oakley Greenwood (2021), *Renewable Gas Economics*.
- Bruce, S., Temminghof, M., Hayward, J., Schmidt, E., Munnings, C., Palfreyman, D. and Hartley, P., (2018). *National hydrogen roadmap*, CSIRO.
- Longden, T., Beck, F, Jotzo, F, Andrews, R, Prasad, M., (2021). 'Clean' hydrogen? An analysis of the emissions and costs of fossil fuel based versus renewable electricity based hydrogen. ANU Centre for Climate and Energy Policy, Working Paper 21.
- Deloitte Access Economics, (2017). Decarbonising Australia's gas distribution networks Prepared for Energy Networks Australia.
- Australia Gas Infrastructure Group, (2018). *Using hydrogen to decarbonise natural gas consumption in Victoria is 40% less expensive than full electrification*.
- GPA Engineering for the Government of South Australia, in partnership with the Future Fuels CRC and the COAG Energy Council, (2019). *Hydrogen in the gas distribution networks*.

AUSTRALIAN SUSTAINABLE BUILT ENVIRONMENT COUNCIL

End-Notes

1. https://www.industry.gov.au/sites/default/files/October%202021/document/australias-long-term-emissions-reduction-plan.pdf, p. 48.
2. https://www.climateworksaustralia.org/resource/state-and-territory-climate-action-leading-policies-and-programs-in-australia/#:~:text=All%20Australian%20state%20and%20territory,also%20set%20interim%20emissions%20targets
3. https://www.betterbuildingspartnership.com.au/2020-bbp-annual-report-celebrating-ten-years-of-leadership/
4. https://gresb.com/nl-en/insights/australia-and-new-zealand-real-estate-sector-achieves-8-successive-years-of-sustainable-leadership/#:~:text=For%20a%20remarkable%20eight%20years,a%20global%20average%20of%2068.
5. https://www.energy.gov.au/households/solar-pv-and-batteries#:~:text=Australia%20has%20the%20highest%20uptake,have%20been%20installed%20across%20Australia.
6. https://reneweconomy.com.au/regulator-outlines-solar-tax-rules-says-onus-on-networks-to-prove-they-need-it/
7. https://www.yourinvestmentpropertymag.com.au/news/australia-has-the-third-most-expensive-housing-market-in-the-world-230330.aspx
8. https://www.accc.gov.au/speech/shining-a-light-australia%E2%80%99s-gas-and-electricity-affordability-problem
9. https://s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.vic-engage.files/7415/0267/4425/Retail_Energy_Review_-_Final_Report.pdf , p.6.
10. AEMO, Draft 2022 Forecasting Assumptions Update, December 2021, p. 9.
11. https://www.sciencedirect.com/topics/engineering/round-trip-efficiency
12. IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5ºC Climate Goal, International Renewable Energy Agency, Abu Dhabi.
13. Derived from *Australian Energy Statistics*, Table H.
14. Dept of Industry, Science, Energy & Resources, *Australian Energy Update 2021 – Energy Flows.*
15. Derived from *Australian Energy Statistics*, Table H, and Wood, T. and Dundas, G. (2020). *Flame out*. Grattan Institute.
16. Derived from *Australian Energy Statistics*, Table F
17. Derived from *Australian Energy Statistics*, Table F
18. Derived from NABERS online data.
19. https://reneweconomy.com.au/sa-batteries-paid-to-charge-over-two-months-as-solar-sends-prices-below-zero/
20. https://www.automaticheating.com.au/complete-guide-to-heat-pumps/co2-heat-pumps-in-practice/
21. https://ncc.abcb.gov.au/editions/2019-a1/ncc-2019-volume-three-amendment-1/section-b-water-services/part-b2-heated-water
22. Energy Efficiency Solutions for NYC Building Owners, n.d., The Variable Refrigerant Flow (VRF) Primer - Energy Efficiency Solutions for NYC Building Owners, https://www.eereports.com/the-variable-refrigerant-flow-vrf-primer/
23. CSIRO, NationalHydrogenRoadmap: pathways to an economically sustainable hydrogen industry in Australia, 2018.
24. https://www.iea.org/reports/world-energy-model/understanding-weo-scenarios

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