Greater South East Melbourne and South East Councils Climate Change Alliance – Roadmap to Net Zero Emissions

FINAL REPORT

Prepared for: GSEM and SECCCA

Date: July 2023

ACKNOWLEDGMENT OF COUNTRY

Greater South East Melbourne and South East Councils Climate Change Alliance respectfully acknowledge the Traditional Owners of the land on which we work, and pay respect to their Elders, past, present and future.

Disclaimer: This report is not intended to and does not provide any warranty with respect to emissions reduction investment opportunities. Those responsible for emissions within the region should source their own site-specific advice before making investment plans.

Revision History

Rev No.	Description	Prepared by	Reviewed by	Authorised by	Date
00	Draft Report	PH	MJ, HS	PH	21/12/2022
01	Second Draft Report	PH	MJ, HS	PH	2/3/2023
02	Final Report	PH	MJ	PH	24/05/2023

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EXECUTIVE SUMMARY

This study has been commissioned by Greater South East Melbourne (GSEM) and South East Councils Climate Change Alliance (SECCCA) in line with their mandates to undertake research and advocacy that help their member councils, and their communities, to respond and adapt to the challenges of climate change.[1]

In particular, this report identifies, sector by sector, the most important and the most cost-effective opportunities for achieving rapid and deep reductions in greenhouse gas emissions in the region. We cannot hope to cover all opportunities, and the degree to which certain solutions are cost-effective will vary from site to site and from application to application. This is why we specify that this report must not be taken as investment advice and that due diligence is required before any party makes significant investments.

Rather, the intention is to highlight the opportunities that are expected to do most of the heavy lifting in terms of reducing emissions, rapidly and to zero. By promoting, encouraging and advocating for the uptake of these opportunities, and demonstrating leadership in their members' operations, GSEM and SECCCA can actively support the rapid and least-cost transition to zero emissions in their regions.

We summarise the key abatement solutions in Table 1 at the end of this Executive Summary, including summarising known barriers to the uptake of these options, and opportunities for GSEM and SECCCA that would help to overcome these barriers and increase the uptake of the solutions.

It is the case now that significant reductions in emissions are expected through market-led change, together with the impacts of existing national, state and local policies. In particular, the Australian Energy Market Operator (AEMO) expects emissions associated with electricity use in Victoria to fall to very low levels by around FY2033. Since Victoria is the largest user of gas in most Australian sectors (Western Australia uses more in its industrial sector), electrification – or replacing gas use with electricity – now stands out as a key strategy. This is reinforced by key global trends:

- the increasing availability, model choice (including light and heavy trucks and SUVs) and affordability of electric vehicles
- the increasing capacity and performance of highly efficient electric heat pumps, available for use in the residential, commercial and industrial sectors
- the opportunity to save money as well as emissions by using renewable electricity, whether generated from rooftop solar photovoltaic (PV) or, for larger sites, secured from off-site generation through Power Purchase Agreements (PPAs).

The United Nations Intergovernmental Panel on Climate Change, in its Sixth Assessment Report Summary for Policymakers, warns that 'Limiting human-caused global warming requires net zero CO_2 emissions.' It also notes that to limit global warming to 1.5°C, 'rapid and deep and, in most cases, immediate greenhouse

1 Throughout this report, we refer to the GSEM region (comprising nine councils) and to the SECCCA region (comprising 11 councils, including the GSEM nine) as 'the region'. References to 'the region' should be understood as referring to both the GSEM and SECCCA regions.

gas emissions reductions [are required] in all sectors this decade.'[2]

This science-based advice puts the concept of an emissions pathway into a particular context. In the wake of the Paris Climate Agreement in 2015, with its focus on 2050 targets, there was an unfortunate tendency for governments around the world to defer abatement action until future decades – exactly the opposite of what was required. However, the science is crystal clear. The world is running extremely dangerous and irreversible risks by allowing emissions to continue to accumulate in the atmosphere. Our task is to reduce those emissions to zero as rapidly as is physically possible and economically feasible. Any pathway needs to be framed with this outcome as its objective.

Importantly, this report highlights that there are many solutions that are available today that have the potential to reduce emissions in virtually all sectors to zero in coming years. Most of these solutions will save businesses and households money, in addition to reducing emissions, but they require motivation and investment. While GSEM and SECCCA, and their members, cannot force the uptake of these solutions, they can support, encourage and assist their communities to do so.

We would discourage setting targets for the longer term, for fear of encouraging delay. However, we note that state and federal government targets will apply and provide guidance over the longer term in any case. All abatement opportunities that are available and cost-effective today should be implemented as rapidly as possible. There is an economic opportunity cost, as well additional climate damage, associated with any delay.
For example, if replacing a gas heater with an electric heat pump saves the householder money, as well as reducing greenhouse gas emissions, then failing to make this change imposes an opportunity cost on the household equal to the foregone savings, and that cost grows in magnitude every day. Of course, if the household can afford this cost, and is not focused on the climate damage associated with the gas use, then it may feel little pressure to change. This example can be extrapolated to countless situations in all sectors in the GSEM/SECCCA region.

Practically, the task must be to use all means to elevate the awareness of all sectors in the region to the dangers associated with continuing to use fossil fuels and other practices that cause greenhouse gas emissions, as well as to the opportunities and benefits associated with reducing those emissions to zero as rapidly as possible. In some cases, businesses or households will need targeted assistance to be able to do so. Our recommendation is that, in addition to raising awareness of the seriousness and urgency of the climate crisis, GSEM and SECCCA focus on those sectors, businesses and households that face particular barriers to change, whether that be:

- residential or business tenants not empowered to make necessary changes
- landlords who may perceive no economic or regulatory pressure to make changes

2 AR6 Synthesis Report: Headline Statements, IPCC, March 2023.

- low-income households and businesses with limited investment capacity
- those occupying apartments, other dwellings or buildings that have poor solar access.

In addition, member councils should ensure that they are offering leadership by reducing their own emissions to zero as rapidly as possible, as well as leveraging opportunities they have to nudge communities in the direction of zero emissions. As noted in Table 1, some opportunities might include participating in best-practice residential development schemes such as the Built Environment Sustainability Scorecard (BESS) which can be accessed through membership of The Council Alliance for a Sustainable Built Environment, and ensuring that planning schemes and development approval processes strongly support, and do not in any way impede, zero emissions outcomes.

Further, GSEM, SECCCA, and their members have considerable leverage as advocates for change on behalf of their communities. The focus of this advocacy may include national and state governments, but also companies and franchises in the region, and making use of other points of leverage, be that in schools, workplaces or community events.

It is the case that not all emissions in the region are amenable to immediate reduction. Aviation, agriculture and heavy transport face higher hurdles for the time being, but zero emission solutions are being developed and commercialised for these sectors too, generally involving electrification and/or hydrogen pathways.

There are already some effective abatement opportunities even in these sectors, and GSEM and SECCCA may be able to support, encourage and help leverage investment in zero carbon solutions.

Also, while the abatement opportunities highlighted in this report are generally cost-effective and available, this will not be the case in every instance. Solar will not always be available due to over-shading or unusual roof designs. PPAs that enable access to low-cost, off-site renewable energy are not yet available for residential buildings or for smaller businesses, even if this may change in the future. Electrification is generally feasible and cost-effective, but there will be cases where it is not, such as in some parts of the commercial and industrial sectors. Alternative feed sources for the livestock industry may attract a cost penalty.

The challenge in these cases is to look for innovative and effective solutions. For example, if individual buildings face barriers to solar uptake, then it may be that a community- or precinct-scale solution would be effective. These may require more co-ordination and effort, but may also be more cost-effective due to the shared nature of the investments involved. In other cases, support may be required for trials, demonstrations and commercialisation, and GSEM, SECCCA, and their members may be able to achieve the degree of co-ordination required for regional-scale investments in such innovative practices.

Table 1: Key opportunities by sector

Sector	Opportunity	Implementation timeline	Barriers	SECCCA/GSEM opportunities
Residential	Rooftop solar	Now. Adoption of PV is well underway, with systems already being highly cost-effective.	Rental properties, apartment buildings, low-income home-owners, and over-shaded properties face particular barriers, known as 'the solar divide'.	Ensure planning schemes and Development Applications require good solar orientation and solar access. Advocate for changes to strata title rules that present barriers to PV and for minimum rental standards that include PV. Advocate for improved access to solar for low-income households.
Residential	Electrification of space heating with heat pumps	Now. Heat pumps are already cost-effective and readily available. They are increasingly a preferred solution due to offering cooling as well as heating services.	Rental properties, some apartments (and potentially townhouses), and low-income households face the highest hurdles. Capital costs may be no higher than gas equivalents but higher than inefficient forms of electrical heating (such as bar radiators).	Encourage heat pumps through planning schemes, information and advisory schemes, and participate in best practice initiatives such as the BESS. Advocate for financial assistance for low-income households and for minimum rental standards that include heat pumps. Promote new rebates available for space heating and insulation.

Sector	Opportunity	Implementation timeline	Barriers	SECCCA/GSEM opportunities
Residential	Electrification of hot water with heat pumps (or electrically boosted solar)	Now. Technologies are available and cost-effective today.	Capital costs. May be noise barriers for apartments and townhouses.	Identify whether councils can assist in uptake of heat pump (or solar) hot water (e.g. via BESS). Advocate for financial assistance for low-income households and for minimum rental standards that include heat pumps.
Residential	Electrification of cooking via induction cooktops	Now. Technology is available and cost-effective today.	Attitudes/ preferences. Builder and developer-led choices, rather than consumers.	Build awareness of advantages of induction cooktops and that gas is a climate-damaging fossil fuel. Advocate for no new gas in new housing developments. Advocate for financial assistance for low-income households to electrify.
Commercial	Electrification with PPAs	Now. PPAs are available for larger businesses/ premises, at no premium and long term price certainty.	Low awareness. Commercial tenants and smaller premises may not be able to access, or may need to persuade landlord.	Build awareness of this solution in the business community. Advocate for solutions for smaller businesses/renters (similar to 'embedded network/retail' provisions in the National Energy Law. Council leadership in use of PPAs.

Sector	Opportunity	Implementation timeline	Barriers	SECCCA/GSEM opportunities
Commercial	Rooftop PV	Now. Rooftop PV is highly cost-effective and available now.	Significant barriers to larger systems imposed by networks (need for connection agreements, commercial terms). Renters may need to persuade landlord to invest (supported by embedded retain/network provisions in the National Energy Law).	Advocate for regulatory changes that reduce barriers to commercial investment in PV, such as automatic/non-discretionary connection agreements and pricing terms.
Commercial	Electrification of new buildings	Now. Avoids adding to the legacy of gas investments that will need electrification in the future. Electrification is easier and more cost-effective in new builds than in retrofits.	Developers take a 'least first cost' approach, which favours cheap gas equipment, rather than a least lifecycle cost approach.	Advocate with the development community to avoid putting gas into any new development. Seek commitments from major tenants/franchises to avoid using gas. Council leadership in avoiding gas use.
Commercial	Electrification of existing buildings	From now until (fossil) gas use is zero.	Can be higher and significant costs in some cases (particularly larger buildings).	Advocate for business community to commit to phasing out gas. Advocate for financial assistance, where required, to assist the process. Council leadership in avoiding gas use.

Sector	Opportunity	Implementation timeline	Barriers	SECCCA/GSEM opportunities
Industry	Electrification	Now. PPAs, industrial heat pumps and other electrical technologies are available and can be cost-effective now.	Some processes may be difficult to electrify. There may be a cost premium for heat pumps and other electrical solutions compared to gas.	Advocate with industrial sector to adopt this strategy. Advocate for financial assistance, where required, to assist the process.
Industry	Green hydrogen	Next 2–5 years. Technologies are evolving and costs are being reduced.	Not currently available as a commercial solution. Fuel likely required to be produced on-site, with associated costs, space requirements. Skill and knowledge barriers due to novelty of the solution.	Build awareness, including of the need for green rather than brown or blue hydrogen. Advocate for financial support, R&D, commercialisation assistance for pioneers.
Transport	Zero emissions vehicles (ZEVs)	Now to next 5 years. EVs are not yet available/ affordable in all market niches.	Capital cost, restricted model choice, lack of options at low end of price range.	Advocate for/ invest in recharging facilities, including in workplaces, commercial centres, carparks. Build awareness of EV benefits and options. Council leadership in electrifying as many classes as possible (mowers and leaf blowers through to garbage trucks and buses). Promote innovations such as micro-mobility freight hubs, ZEV-only zones.

Sector	Opportunity	Implementation timeline	Barriers	SECCCA/GSEM opportunities
Transport	Active and public transport	Now.	Societal preferences, COVID risk perceptions. Lack of infrastructure (e.g. for cycling, walking, secure bike storage) judged safe/ adequate by the community.	Use planning schemes and schemes such as BESS to promote appropriate development that facilitates active and public transport. Advocate for state and private sector investment in appropriate infrastructure.
Transport	Zero emissions aviation	Now to 2030. Cost premiums, model choice and range/capabilities all expected to improve over the decade.	Cost, limited model choice, limited range.	Advocate for change where feasible – e.g. starting with short-duration tasks (pilot training, sky-diving, short-haul transport)
Waste	Waste minimisation/ organics diversion.	Now. Technologies and models exist.	Limited awareness of or investment in innovation strategies. Requires co-ordination and communication, and consistent effort over time.	Show leadership by direct investment in waste minimisation, and/or leveraging outcomes through commercial/NFP service providers. Facilitate access to innovative options for time-poor businesses.
Waste	Methane capture and waste-to-energy	Now. Technologies exist and are applied in many sites.	Mainly commercial. Councils cannot sell large-scale generation certificates (LGCs) and claim zero emissions from waste at the same time but will need to forego offsets revenues.	To be investigated by more specialised service providers. Many opportunities will already be captured, but potentially not all.

Sector	Opportunity	Implementation timeline	Barriers	SECCCA/GSEM opportunities
Agriculture	Reducing emissions from grazing animals	Now to next 5 years. Options exist to substantially reduce emissions, such as supplements based on red algae and other sources are available but may require trials, support for commercialisation, etc.	Solutions are relatively novel, with limited awareness and likely cost premiums. Techniques ranging from ranging from tree-planting, shelter belts, soil carbon capture, strip grazing, biochar, to biodiverse plantings (eg, to help connect wider wildlife corridors), are all available.	Build awareness of solutions, advocate for their uptake, facilitate trials, R&D, commercialisation and upscaling of supply.
Agriculture	Carbon capture and sequestration	Now. Techniques ranging from tree-planting, shelter belts, soil carbon capture, strip grazing and biodiverse plantings are available.	Upfront costs, land-owner attitudes, limited awareness of benefits, risk-aversion.	Promote awareness of solutions, trials, demonstrations, state and federal government grants. Advocate for support for the same.

01 INTRODUCTION

1.1 Purpose

This report sets out the assessment of Strategy. Policy. Research. (SPR) of the major and most cost-effective opportunities to reduce greenhouse gas emissions in the GSEM/SECCCA regions (referred to as 'the region'). It presents our assessment of current emissions by sector – building on past analysis by Ironbark Pty Ltd (2019)[3] – and also expected future emissions out to FY2050.

For future emissions expectations and assumptions, we draw on AEMO's *Integrated System Plan* (ISP) 2022,[4] and in particular on the Step Change scenario from the ISP, as this is considered the most likely scenario by the majority of energy market stakeholders. We also draw on population projections by local government area (LGA) from the Australian Bureau of Statistics (ABS). Other key references and assumptions are detailed in Chapter 2.

We note, as per Figure 1, GSEM and SECCCA comprise the following council members:

- Bass Coast
- Bayside
- Cardinia
- Casey
- Frankston
- Greater Dandenong
- Kingston
- Mornington Peninsula
- Port Phillip
- Knox
- Monash

We acknowledge the support that the South East Melbourne Manufacturers Alliance (SEMMA) has provided to this project. SEMMA is a peak industry group representing more than 200 leading manufacturers based in South East Melbourne. SEMMA members play a critical role in the economic development of the South East. A group of SEMMA members contributed to the report through a workshop on fuel use and alternatives.

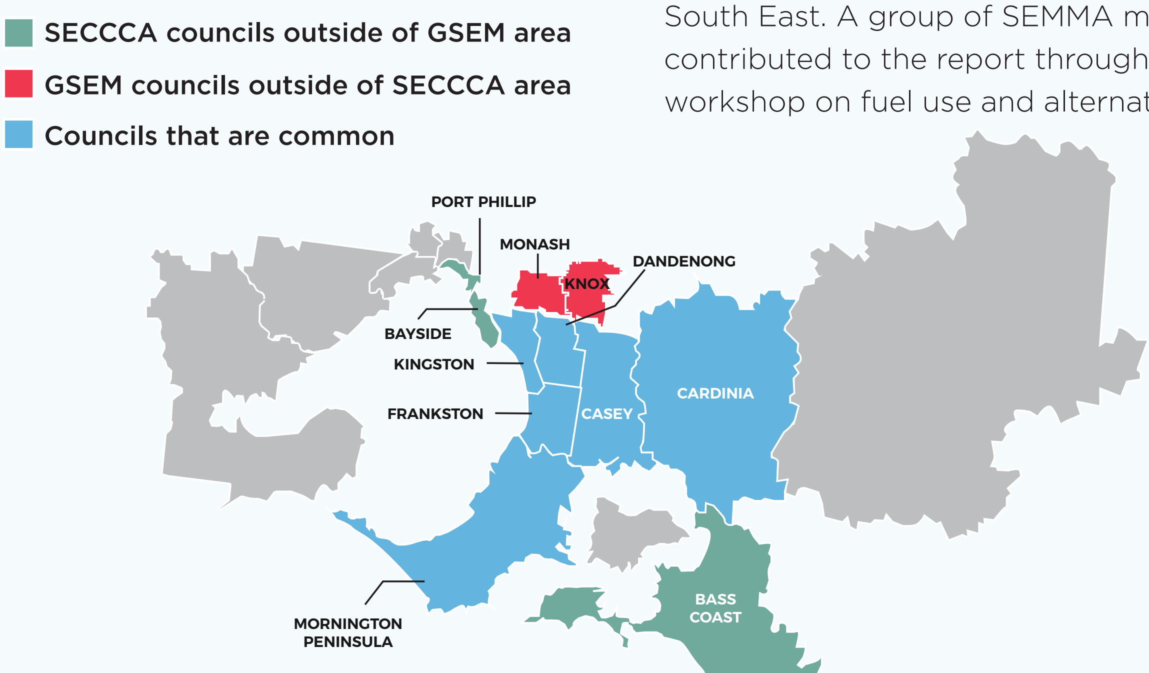

Figure 1: GSEM and SECCCA Members

3. Ironbark Sustainability, *Regional Opportunities Report – SECCCA Climate Action Planning Project*, 2021.

4. https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp, viewed online 23/05/2023.

1.2 BACKGROUND

This report has been commissioned by GSEM following a competitive selection process undertaken by SECCCA, following a competitive selection process in July 2022, with the project duly awarded to Strategy. Policy. Research. (SPR).

GSEM and SECCCA have already made significant progress in understanding and documenting community emissions (*inter alia*) in their regions, including via a (draft) *Regional Opportunities Report* prepared by Ironbark Sustainability, SECCCA has developed and published a *Strategic Plan 2021–2024*,[5] and also recently published a detailed Policy Platform (May 2022).[6] In October 2021, Nation Partners provided a *Zero Emissions South East Melbourne Roadmap Rationale*.[7] There has also been significant community engagement in the processes leading to these documents.

Against this background, it was agreed for this project that:

1. there is no need to formally review or recreate Ironbark's analysis of the regional emissions pie-chart, as this has been accepted as fit-for-purpose
2. the documents above provide a clear overall picture of preferred strategic directions and abatement opportunities
3. the gap that needs to be filled is a clear and robust analysis of:
   a. which options offer the most rapid and least-cost abatement for each of the major sectors in the region
   b. what costs and benefits are associated with each option
   c. how feasible rates of uptake of these options over time, across the main economic sectors, would lead to emissions outcomes at the regional level, including the achievement of net zero emissions by 2050 at the latest.

Thus, the project focuses primarily on point 3.

1.3 ABOUT SPR

SPR is an ecosystem of economic and other professionals that specialise in making the business case for sustainability. That is, our work is driven by research, objective and credible data, and our experience in working in and with most of the major industries and sectors that contribute to regional emissions. Among many hundreds of projects completed in recent years, we have prepared emissions roadmaps and related analyses for:

- Australian Government (*Trajectory for Low Energy Buildings*, with Energy Action Pty Ltd (2018) and with DeltaQ Pty Ltd (2022 Update))
- City of Sydney (*Energy Efficiency Master Plan* and four Sectoral Sustainability Strategies)
- Carbon Neutral Adelaide (*Foundation Report* and others)
- ACT Government (*Zero Emissions Strategy* and related projects over many years, with Beyond Zero Emissions)
- Grampians New Energy Taskforce, Roadmap to Net Zero Emissions (with Beyond Zero Emissions)

5. South East Councils Climate Change Alliance, *SECCCA Strategic Plan 2021 – 2024*, undated.
6. South East Councils Climate Change Alliance, *Policy Platform*, May 2022.
7. Nation Partners, Zero Emissions South East Melbourne Roadmap Rationale, Full Report, 15 October 2021.

02 OVERVIEW OF METHODOLOGY

SPR models greenhouse gas emissions on a bottom-up, top-down reconciliation basis, using an identity developed by the International Energy Agency in France, known an 'EASI'. This identity notes that change in (E)missions over time can be expressed as a function of changes in:

- (A)ctivity levels (e.g. numbers of cars, houses, etc.)
- (S)tructure (e.g. the distribution of the vehicle fleet and housing stock by type)
- (I)ntensity (e.g. L/100 km used by different vehicle types, GJ/dwelling).

This bottom-up approach – conducted by sector/sub-sector and fuel or emissions source – is then validated by capturing or estimating overall consumption of fuels, or other emission source totals, at a whole-of-region level, to ensure that the bottom-up processes match with known top-down data.

This enables a picture of emissions that is both detailed but also high-confidence, and where change in the component drivers (change in activity, structure and intensity) can be used to model change in emissions over time.

For this project, establishing the exact level of current/past greenhouse gas emissions was not prioritised by GSEM/SECCCA, as a study was undertaken by Ironbark Sustainability in 2021 which estimated this, at least for the SECCCA LGAs (see Figure 2). However, since this project requires annual emissions projections out to 2050, we commence with historical (FY2019) estimates to validate our models of emissions by sector.

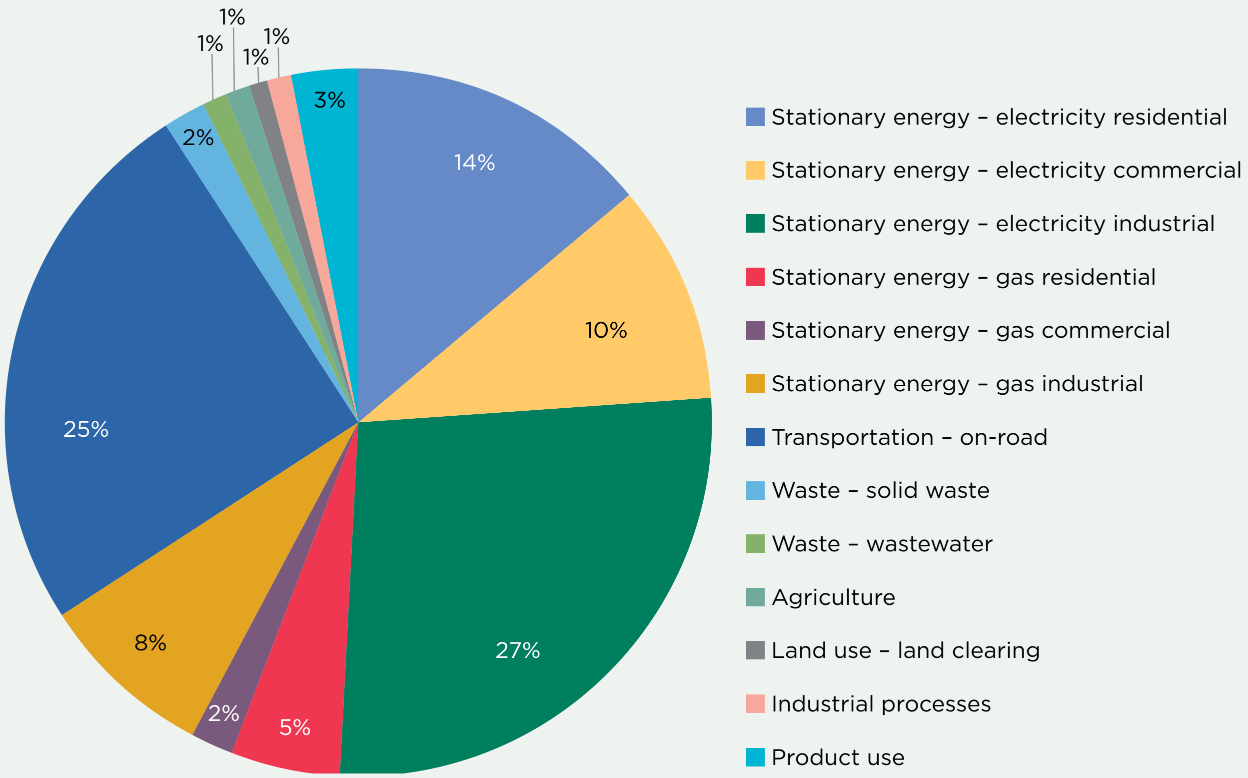

Figure 2: SECCCA regional emissions profile (Ironbark Sustainability, Regional Opportunities Report, 2021)

2.1 REFERENCE EMISSIONS PROJECTIONS

The reference emissions projections are intended to provide an indication of the emissions trajectory over time that is currently considered 'most likely'. This is based, as noted above, on AEMO's Step Change scenario, which around 80% of stakeholders in the ISP process nominated as 'most likely'. Note that Step Change is an ambitious scenario – not at all a 'business as usual scenario' – for example assuming that the share of renewable energy in electricity supply reaches 82% by 2030. We note that this target has now been adopted by the Australian Government,[8] lending credibility to the Step Change scenario assumptions.

For the reference projections, we construct emissions models for each of the major economic sectors – residential, commercial and services, industry, transport and waste.

These models draw on:

- ABS Census data (for dwelling numbers by type)
- ABS population projections (for housing growth over time)
- The Commercial Building Baseline Study 2022 (forthcoming, by SPR for the Australian Government) for estimates of commercial building numbers and gross floor area by building type, and for estimates of fuel intensities (fuel use per unit gross floor area) by building type
- Recent work by SPR and DeltaQ Pty Ltd for the Australian Sustainable Built Environment Council (ASBEC)[9]
- ABS enterprise counts by employment size and turnover range
- The *National Pollutant Inventory* for estimates of major gas users.

Energy use, activity and emissions are then projected out to FY2050, making use of AEMO's Step Change scenario for key data inputs, such as the degree of electrification expected in the future, electric vehicle uptake, growth in rooftop PV capacity, and the overall emissions outlook for the electricity market.

8. Australian Government Office of Financial Management, *Australian Government Climate Change commitments, policies and programs: a guide for AGS investors*, November 2022, p. 3.

9. See www.asbec.asn.au/publications, Unlocking the roadmap: Why electrification is the key to net zero buildings, December 2022, and supporting reports by SPR and DeltaQ Pty Ltd.

The ISP does not publish energy-related emissions projections by state (let alone by LGA), but only for the whole of the National Energy Market. However, we have used AEMO assumptions about the timing of phase-out of existing fossil fuel electricity generation units, and about the rate of investment in new renewable energy assets, to estimate the future emissions intensity of grid-average electricity consumption in the future. The ISP results include the annual shares of coal, gas and renewable generation supplying the Victorian grid, and total sent out generation over time.

Sent out emissions intensity[10] parameters for each coal and gas-fuelled power station in the state have been part of a large and detailed proprietary model of monthly National Electricity Market operations, built and maintained by Hugh Saddler, since 2001.

These enable the expected emissions intensity of the Victorian grid to be modelled in a manner that aligns with AEMO's Step Change assumptions (see Section 3.2).

Note that while we make use of AEMO's Step Change scenario, as a tested and plausible set of future expectations, this scenario assumes that significant investments in emissions reductions will be made in the future, and it also assumes future policy changes.

In the context of this study, we do not wish to gloss over the scale of investment required to reduce emissions in the region, therefore we use Step Change to illustrate expected or likely rates of change over time, but we quantify all of the investment required to reduce emissions (using the strategies documented in Chapter 4). This gives the reader a more complete picture of the scale of the task and of its expected cost-effectiveness.

10. The emissions intensity of electricity generation varies depending upon where in the electricity-using system it is measured. This variation is primarily caused by electrical losses that occur in different parts of the system. 'Sent out' emissions intensity is measured at the power station gate. As such, it reflects the emissions intensity of the electricity generation process itself, together with loads and losses within the power station, collectively known as 'parasite loads'. It does not include 'line losses' that occur in the transmission and distribution system.

2.2 ABATEMENT OPPORTUNITY ANALYSIS

The next step in this project was to document what we consider to be the most relevant, significant and likely abatement strategies for each sector. In practice, there are too many abatement options to fully map them all within the scope of this project, but we expect that the 3–5 options per sector documented represent the most important opportunities, applicable to the majority of households and businesses in the region. For each opportunity, we document:

- the average or typical investment cost involved (noting that this can vary quite widely from one enterprise or even house to the next)
- the expected yield (e.g. avoided energy costs and emissions)
- key indicators of cost-effectiveness such as:
  - net present values (NPV's) – this is the present value of all benefits (such as energy or fuel cost savings) over time, discounted back to a present value at an appropriate real discount rate (generally 7% real, but 4% real for transport infrastructure), minus the present value of all incremental costs (any additional costs required to be paid to achieve a certain outcome, such as higher costs for electric heat pumps than gas boilers in commercial buildings)
  - benefit cost ratios (BCRs) – these are the ratio of the present value of benefits (as defined above) to the present value of costs
  - internal rates of return (IRRs) – IRRs are equivalent to a real interest rate or rate of return on investment. The higher the percentage rate of return, the better the investment from a financial perspective. Any rate of return greater than the real discount rate is considered cost-effective.

2.3 ROADMAP MODELLING

We illustrate the impact on baseline emissions, overall and by sector – established as described in Section 2.1 – of the modelled rates of take-up or implementation of the specific abatement opportunities modelled. This illustrates the extent to which overall greenhouse gas emissions in the region would fall – beyond rates already expected under 'business as usual' conditions – towards zero by or before 2050.

2.4 SCOPE LIMITATIONS

Not all major/expected abatement opportunities are currently/always cost-effective. Key examples include electric vehicles (likely to be cost-effective for fleets but not households) and heat pump–based space heating for large existing buildings. In such cases we note expected 'learning rates', or expectations for future cost reductions, and also note that some uptake by early adopters will occur in any case.

Also, we note that some industrial emissions – related to chemical processes, for example – may require plant-wide investment to occur before they can be abated, and the timing of such investments will be unique to each plant and driven by factors unrelated to abatement, such as business expectations.

Overall, the intent of this project is not to pick winners, in terms of abatement opportunities, or to make specific recommendations for preferred abatement strategies. This is because, at the level of individual businesses, plants and households, site-specific factors need to be taken into account, and it is beyond our scope to anticipate all of these. Rather, the purpose is to illustrate that:

a) at least some attractive abatement solutions are available, but they require investments to be made – including in the normal course of events (e.g. with the turnover of vehicle, building, equipment and appliance stocks; and scheduled maintenance)
b) in other some cases, attractive solutions may not yet be available, and this may lead households/businesses to weigh up the costs vs risks of delaying abatement action, and it may point to areas where policy/program intervention may be required to accelerate abatement action.

Another scope limitation is that we consider only operational greenhouse gas emissions, rather than those 'embodied' in the built environment. This reflects the fact that embodied emissions are not reported at the point of use in most emissions reporting protocols, but rather at the point of production (e.g. emissions related to steel use are attributed to the steel mill (and its region), rather than to the user of the steel). To count both would be to double-count the emissions. In addition, there are no reliable statistics on embodied emissions, particularly at the local level. In practice, such emissions would be highly variable based on the 'provenance' (or source) of the materials used.

3.1 EMISSIONS INTENSITY OF GRID-SUPPLIED FUELS

3.1.1 Electricity

As noted above, we estimate the future emissions intensity of electricity in Victoria with reference to the expected generation types over time that are represented in AEMO's Step Change scenario projections for Victoria. Current projections are that the current coal-fired generation units in Victoria will be phased out by FY2033 – noting that these dates are estimates only and could in fact be earlier or later.

Small amounts of gas may continue to be used, generating some greenhouse gas emissions, and also inter-state trade in electricity may give rise to emissions that are imputed to Victoria (this could occur where there are net imports over a year from one or more jurisdictions that have higher emissions intensity than Victoria, for example). For this reason, even if fossil fuel–based generation is essentially phased out, there may be emissions in some years.

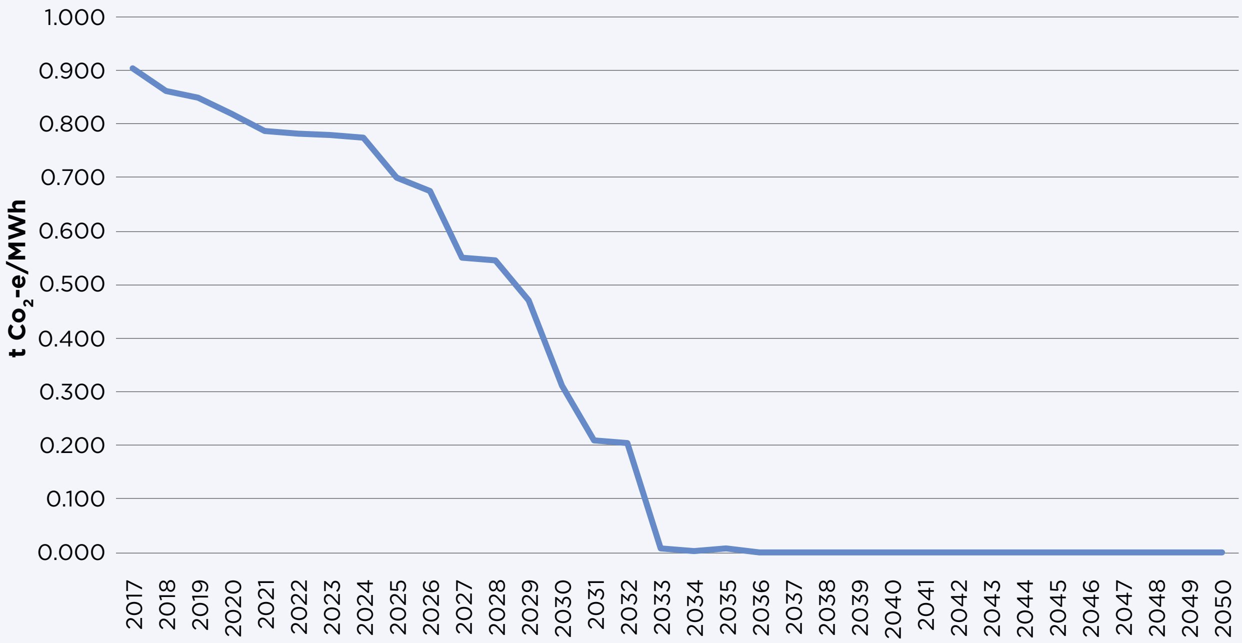

Figure 3: Projected average emissions Intensity of grid-supplied electricity consumption, Victoria

3.1.2 Gases

Emissions associated with pipeline-delivered natural gas (fossil methane) are assumed, in the context of Australia's official emissions reporting, to be constant over time. However, gas emissions intensity values[11] could change in the future, for example if renewable gases are blended with natural gas. While the gas industry in Australia has plans to market natural gas/biogas blends, with small-scale trials now underway in New South Wales, our view is that there are not sufficient organic feedstocks available to make a meaningful reduction in overall gas emissions. Also, the cost of biomethane is likely to be high due to the need to procure and process large quantities of biomass and/or waste. This would tend to push up the price of gas relative to electricity (where production costs are projected to continue to fall), making it less economic for consumers.

At the same time, there may well be viable applications for biogases or biofuels, which typically occur near to the feedstock source (to limit transport costs) in industries such as food and beverage production, waste processing and agriculture/horticulture.

As discussed further below in Section 4.3, it is increasingly likely that green hydrogen (produced from water and renewable electricity) could be generated in a manner that is cost-effective for large industrial consumers. The process is likely to involve production and consumption of hydrogen on the industrial site, to avoid the difficulties and costs associated with transporting hydrogen.[12] There is a very substantial research effort underway in Australia and elsewhere focused on reducing the production cost of green hydrogen (and indeed other forms of hydrogen that are not carbon neutral), and there are good prospects that future green hydrogen production costs could fall below the cost of natural gas over time.[13] However, since green hydrogen is produced from renewable electricity, its price must always be higher than that of renewable electricity, to cover the other production costs and margins.

The final element of the delivered hydrogen price would be the delivery cost itself – essentially the cost of infrastructure, including storage, transmission/distribution and point-of-delivery costs, such as metering. Since (pure) hydrogen is not yet distributed to customers via a distribution network anywhere around the world, so far as we know, it is not surprising that there are no estimates available of the cost of doing so.

11. Emissions intensity refers to units of emissions produced per unit of fuel/energy consumed. Different metrics can be used for this purpose. For gas, a common metric is tonnes of CO_2-e (carbon dioxide equivalent) per gigajoule (GJ) of gas consumption.

12. Hydrogen has very low density and is difficult to compress or liquify. The very small molecule size requires specialised storage and distribution materials, generally coated with personal protective equipment, as it will evaporate through steel.

13. See, for example, reneweconomy.com.au/integrated-wind-and-solar-still-the-cheapest-and-green-hydrogen-costs-falling-fast-csiro/

With respect to hydrogen storage, our consultations in the context of the *Rapid and Least-cost Decarbonisation* project, undertaken for ASBEC[14] revealed a view that underground storage would be both required and the least-cost solution. Line-pack (storage in transmission/distribution networks) would not be sufficient, while other storage solutions, such as liquefaction, would be energy-intensive and high-cost processes, more suited to hydrogen export than temporary storage as part of a domestic distribution system. Hydrogen can also be converted to other products such as ammonia for storage/transportation purposes, albeit with conversion costs and losses.

With respect to transportation via pipelines, the industry-led *Hydrogen Roadmap*[15] notes (p. 33) that steel and fibre reinforced plastic pipes are required to prevent embrittlement at higher pressures, while high-density polyethylene (PE) pipes are expected to be suitable for lower pressure (1–7 bar) distribution pipes. It also notes an expectation that fossil gas distribution networks will be refitted with PE pipes over the next decade, regardless of whether or not they are converted to hydrogen. Other potential incremental infrastructure costs, for example associated with meters, are not covered in the *Roadmap*.

We make the working assumption that there would be significant incremental infrastructure costs associated with a progressive conversion of the fossil gas transmission, storage and distribution network to enable it to deliver pure hydrogen to all current/future residential and commercial gas customers. Costs are likely to be incurred to prevent leakage of what are very small hydrogen molecules through pipes, fittings, connectors and meters; to compensate for relatively low density (compared to fossil gas); to upgrade transmission and distribution pipelines and pressurisation equipment; and for new meters.

The commercial acceptability and competitiveness of piped hydrogen as a fuel is, of course, also uncertain – as it is not currently a marketed product – and this presents significant risks. For example, if infrastructure costs must be recovered from a smaller eventual number of consumers than anticipated, then unit costs to those users will be higher than anticipated. However, to the extent that this occurs, customers would increasingly be discouraged from continuing to use hydrogen, as other fuels would be relatively less expensive. On these grounds, we assume here that green hydrogen is unlikely to be a viable solution for residential or commercial customers, even if it may be a solution for high-temperature industrial processes.

14. SPR, *Rapid and Least-cost Decarbonisation of Building Operations: final report, December* 2022.

15. Bruce S, Temminghoff M, Hayward J, Schmidt E, Munnings C, Palfreyman D, Hartley P (2018) National Hydrogen Roadmap. CSIRO, Australia

For further reading on green hydrogen, we note the following key references:

- *Australia's National Hydrogen Strategy* (www.dcceew.gov.au/energy/publications/australias-national-hydrogen-strategy#:~:text=Australia's%20National%20Hydrogen%20Strategy%20sets,explores%20Australia's%20clean%20hydrogen%20potential)
- *National Hydrogen Roadmap* (www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/csiro-futures/energy-and-resources/national-hydrogen-roadmap)
- *Australia's Hydrogen Production Potential* (www.ga.gov.au/scientific-topics/energy/resources/hydrogen/australias-hydrogen-production-potential)
- *State of Hydrogen 2021* (www.dcceew.gov.au/sites/default/files/documents/state-of-hydrogen-2021.pdf).

3.2 RESIDENTIAL SECTOR

The methodology used for projecting residential emissions and emissions abatement opportunities in the region is based on the approach used by SPR and DeltaQ Pty Ltd for a major national study for ASBEC[16]. This study identified complete electrification of energy use in residential buildings as the lowest cost option for decarbonising residential energy use.

Accordingly, we modelled complete decarbonisation of dwellings in the SECCCA LGAs. However, at the outset it was decided not to model decarbonisation of energy use in apartments (Class 2 dwellings) and only model decarbonisation of detached houses (Class 1(a) dwellings) and row and townhouses (Class 1(b) dwellings). These currently account for about 90% of all dwellings in the SECCCA LGAs as a whole, a share that has been remarkable stable over the past 20 years. The reasons for this exclusion are two-fold. Firstly, there is a wider range of options in the way that gas and electricity are used in apartment buildings and comprehensive data on the distribution of these options is almost non-existent. Secondly, options for replacing are, in consequence, also diverse and, furthermore, will often be constrained by structural features of the particular building.

As a result of this exclusion, all results of the modelling will be conservative, in the sense that the projected emission savings will be less, by an unknown amount, than potential savings achievable if apartment buildings were also included.

The first part of the modelling involved establishing changes in consumption of gas and electricity and in the purchase costs of new and replacement gas and electric appliances, relative to a case in which the mix of gas and electricity consumption remains unchanged from current, and past years.

16. SPR, *Rapid and Least-cost Decarbonisation of Building Operations: final report, December* 2022.

The second part involves integrating these changes into the reference case projections of future residential gas and electricity consumption. These are described further below.

3.2.1 Part 1

We established the current and recent past stock of occupied residential buildings in the SECCCA area, classified by the three main dwelling types:

- detached houses (Class 1(a))
- row and townhouses (Class 1(b))
- apartments (Class 2).

This was done by compiling occupied private dwelling stock data from each of the past five Censuses (2001, 2006, 2011, 2016, and 2021) in each of the 11 LGAs that are the subject of this study.

We then projected these numbers forward to 2050. The basis for the projections was the population and dwelling projections for Victoria and metropolitan Melbourne, issued in 2019 by the Department of Environment, Land, Planning and Water (now Department of Energy, Environment and Climate Action). In the absence of other data, it was assumed that the dwelling mix in the GSEM/SECCCA LGAs has the same proportions (share by dwelling type) as the total metropolitan Melbourne dwellings, based on the 2021 Census. It was also assumed that the shares of the three main dwelling types would be remain unchanged from the 2021 figures.

Interestingly, as noted above, these shares changed very little over the 20 years from 2001 to 2021, so this is a not unreasonable assumption.

We adjusted these projections downward to allow for the fact that, while gas distribution networks cover the areas where the great majority of dwellings are located, not all dwellings in Victoria have access to, and therefore make use of, gas. We made a further downward adjustment to allow for the fact that, while the great majority with access to gas are in fact connected to gas, a small proportion are not, i.e. they are already fully electrified.[17]

Drawing on the above, we then estimated total residential gas and electricity consumption in the region. This was done using annual residential gas consumption for the whole of Victoria, as reported by *Australian Energy Statistics*,[18] adjusted downward to allow for the factors described above on the basis of the total number of Class 1(a) and 1(b) dwellings in the region to total numbers in areas accessible to gas distribution networks (for gas), and total numbers in the whole of Victoria (for electricity).

We estimate gas consumption per gas-connected dwelling for each of the three main applications of gas – space heating, water heating and cooking – using the following assumptions for the proportion of gas connected dwellings using each application: space heating 97%, water heating 80%, cooking 100%.

17. LPG consumption is relatively small and not considered here. Abatement options for gas also apply for LPG, but the economics of electrification are more favourable, as LPG has a higher delivered cost than natural gas.

18. Department of Climate Change, Energy, the Environment and Water, Australian Energy Update 2022.

Using these figures, dwelling stock data from 2001, and assuming an average functional life of 20 years for all gas and electric appliances, we calculate the number of gas appliances expected to be replaced each year from 2022 onward and the number of new gas appliances installed each year. These figures provide the basis for modelling each of the two least-cost options for electrifying, which are no gas connections to new dwellings and no like-for-like replacement of gas appliances at end of life (20 years).

We then estimate the gas consumption savings, and electricity consumption increases, from electrification each year, on the basis of the dwelling and appliance numbers, assuming that gas space heaters are replaced by reverse cycle (heat pump) appliances and that both storage and instantaneous gas water heaters are replaced by electric heat pump water heaters. Both new appliance cost and appliance energy consumption figures are the same as used for the previously referenced study for ASBEC.[19]

Projected future residential retail prices for electricity and gas established for that study have also been used here. The full average cost, including the fixed annual network service access fee, is used for gas, because complete electrification will mean disconnection of gas supply. By contrast, only the marginal retail cost for grid-supplied electricity is used, because the network service fee is already being paid.

Note that it is assumed that all additional electricity consumption will be grid-supplied, but in practice, some additional consumption may be feasible from existing (or new) rooftop PV systems, with the consequence that less electricity would be exported to the grid. Given that feed-in tariffs for exports are much lower than the retail cost of electricity, it is more cost-effective for households to use self-generated power where available. However, additional consumption of electricity for space and water heating will be highest in winter when rooftop solar generation is at its lowest. Hence, it is more likely that this energy may need to be imported from the grid.

Using all these input data, gas consumption savings, electricity consumption increases, the cost of new electric appliances, and the avoided cost of new gas appliances were each calculated for each year out to 2050.

3.2.2 Part 2

The reference case projections of future demand for electricity and gas consumption are those defined by AEMO in its Step Change scenario from the 2022 ISP, which is noted to be the most likely of their scenarios. Step Change projections for residential electricity and gas consumption are much lower than extrapolations of recent annual consumption, due to two significant effects. The first of these is energy efficiency improvement, the relative size of which is assumed to be unaffected by electrification.

19. SPR, *Rapid and Least-cost Decarbonisation of Building Operations: final report, December* 2022.

The other and larger effect is electrification. We avoided the risk of double-counting these effects by subtracting the gas and electricity effects assumed in the Step Change scenario, (scaled down to represent the region only), from the total consumption changes (as calculated above), resulting from the modelled approach to electrification. The difference then represents the additional consumption changes resulting for the modelled approach. Total consumption is then calculated by adding this difference to the Step Change projection, with energy efficiency and a smaller quantity of electrification. This has the effect of bringing forward the year in which gas consumption is reduced to zero.

In the absence of any published information for AEMO about how it calculated its electrification, we have assumed that it represents what AEMO estimates to be the limit of cost-effectiveness (for the consumer). We have therefore calculated the additional costs and savings of electrification as modelled for this study but adjusted them to remove capital cost saving from avoided purchase of new gas appliances.

The reason for this change is that, on the basis of the modelling assumptions described above, additional or faster electrification can only occur if gas appliances are replaced when they still have some remaining useful life, i.e. the appliances are scrapped prematurely. From an economic point of view, past investments are 'sunk' and should not impact on the evaluation of new and current opportunities. Also, from a greenhouse gas emissions perspective, early retirement of gas appliances is warranted and encouraged, for example in *Rewiring Australia*.[20] However, gas users may need regulatory or financial incentives to do so.

Our reference case emissions projection for the residential sector – consistent with AEMO's Step Change – is shown in Figure 4. Emissions associated with electricity use are projected to fall rapidly and reach zero by FY2033, due to the expected rapid reduction in the emissions intensity of grid-based electricity supply. Note that AEMO also assumes, under Step Change, that gas consumption in the residential sector (in Victoria as a whole) will fall to zero by 2050, due largely to electrification.

20. See www.rewiringaustralia.org/

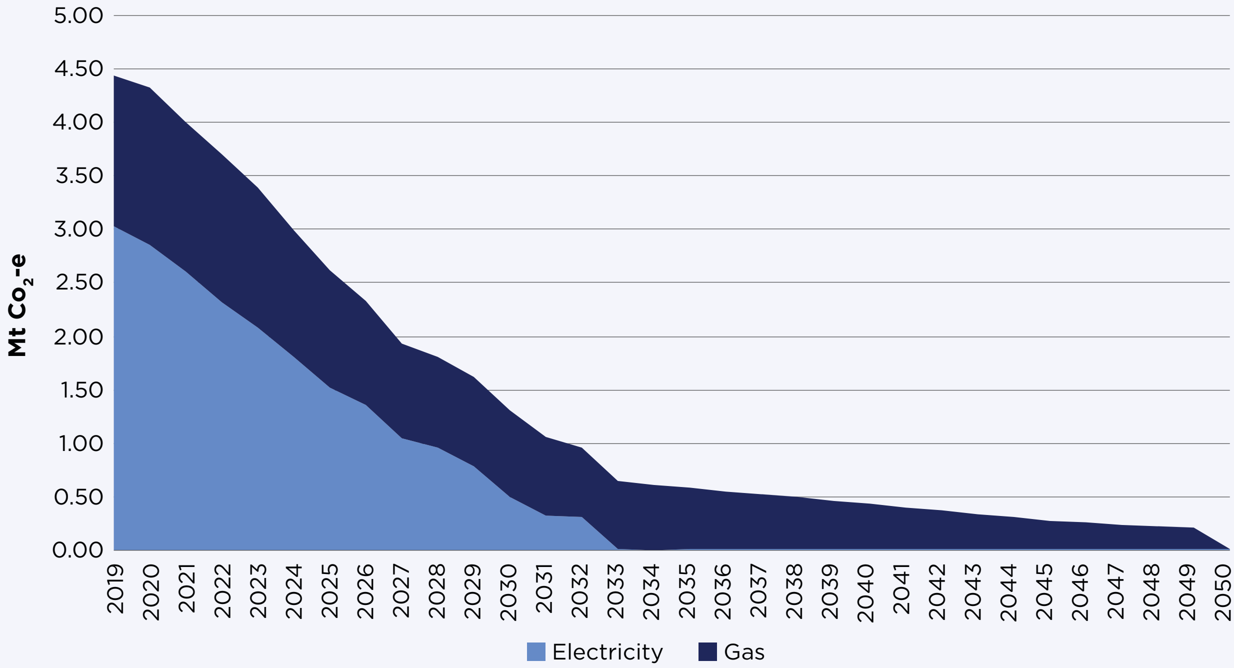

Figure 4: Reference case residential sector emissions, SECCCA region, step change scenario

3.3 COMMERCIAL SECTOR

3.3.1 Introduction

The commercial, or 'commercial and services', sector refers in this context to (operational) emissions attributable to energy use by buildings in the following economic sectors, as classified under the Australian and New Zealand Standard Industrial Classification (ANZSIC) system – see Table 2.

Table 2: Commercial and services divisions

Division	Name
F	Wholesale Trade
G	Retail Trade
H	Accommodation and Food Services
I	Transport, Postal and Warehousing
J	Information Media and Telecommunications
K	Financial and Insurance Services
L	Rental, Hiring and Real Estate Services
M	Professional, Scientific and Technical Services
N	Administrative and Support Services
O	Public Administration and Safety
P	Education and Training
Q	Health Care and Social Assistance
R	Arts and Recreation Services
S	Other Services

3.3.2 The Commercial Building Stock

First, we estimate the number and gross floor area of buildings involved in these sectors in the region. For this we draw on the 2022 *Commercial Buildings Energy Consumption Baseline Study*, prepared by SPR for the Australian Government Department of Climate Change, Energy, the Environment and Water.[21] In overview, this source estimates that, in FY2019, there were some 39,458 commercial buildings in the region, with a combined gross floor area (GFA) of 46.7 million square metres (sqm) – see Table 3.

As described in the 2022 *Commercial Buildings Energy Consumption Baseline Study*, there are some limitations imposed on the precision of these estimates by the nature of the underlying data sources. However, in the case of Victoria, the Baseline Study Update draws on detailed data supplied by the Victorian Valuer-General's office, and therefore the estimates are considered to be reliable.

Table 3: Estimate of FY2019 building count and gross floor area by Local Government Area

Local Government Area	Total building count (no. of whole non-residential buildings)	Total floor area (sqm GFA of primary purpose buildings)
Bass Coast (S)	1,834	756,324
Bayside (C)	1,500	919,612
Cardinia (S)	2,436	1,692,082
Casey (C)	3,906	3,518,137
Frankston (C)	3,040	3,198,531
Greater Dandenong (C)	6,699	12,417,218
Kingston (C) (Vic.)	4,616	6,871,844
Knox (C)	3,615	6,121,620
Monash (C)	3,941	5,026,488
Mornington Peninsula (S)	3,864	3,202,872
Port Phillip (C)	4,007	2,936,658
	39,458	**46,661,386**

(S): Shire (C): Council

21. SPR, *Commercial Buildings Energy Consumption Baseline Report*, December 2022.

For the expected growth in the commercial building stock (particularly in the GFA) we take into account differential rates of expected population growth for each LGA – drawn from *Victoria in Future 2019 Population and Household Projections* (DELWP 2019[22] – and the overall growth in Victorian state final demand, drawn from AEMO's Step Change scenario.[23] Note that the latter includes negative growth in FY2020 (–1.0%) and FY2021 (–0.6%) associated with the economic impacts of the global COVID-19 pandemic.

More generally, we note that forecasting growth rates at the LGA level is fraught, as the past may be little guide to the future, given that the rates and locations of new development can shift significantly over time, even within a given region. This project is not intended as a growth forecasting exercise for the region. However, some growth assumptions are required to model expected future greenhouse gas emissions. The basic principle employed is that the demand for commercial services (retail, health, education, etc.) is fundamentally linked to the underlying growth in population.

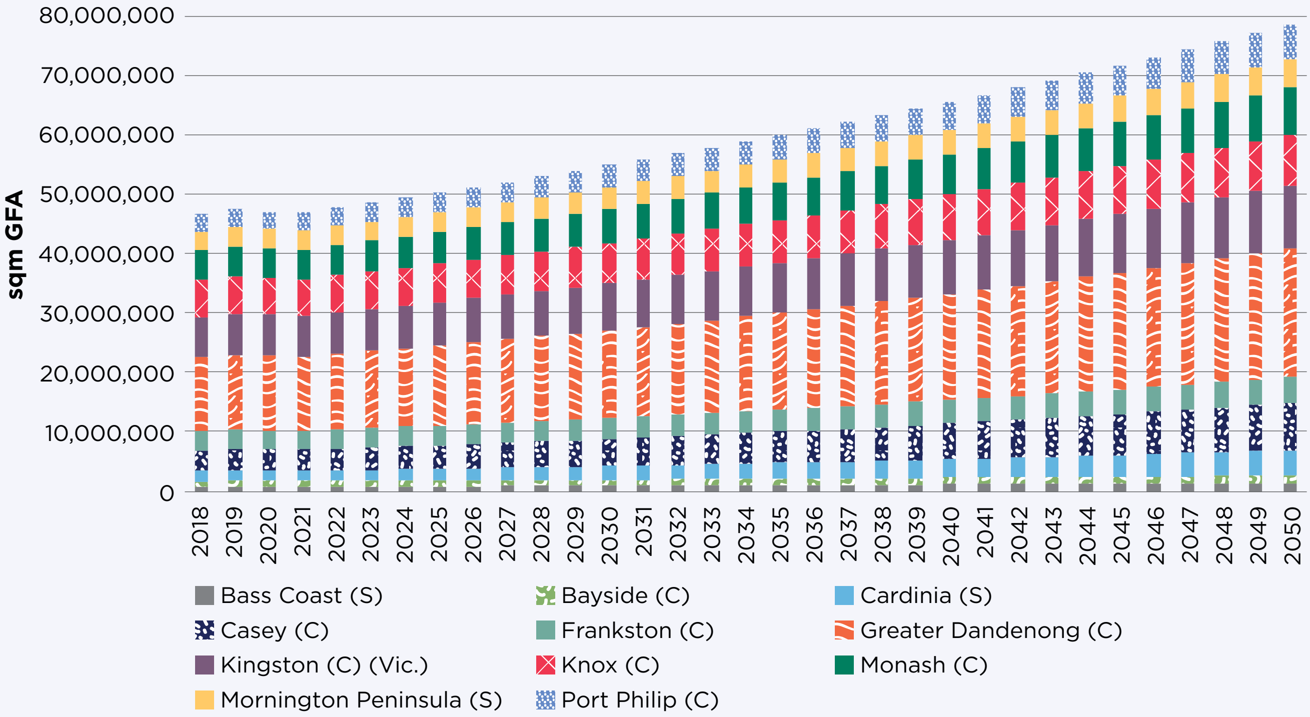

Figure 5: Total commercial floor area estimate and projection by LGA. (S): Shire (C): Council

22. See https://www.planning.vic.gov.au/guides-and-resources/data-and-insights/victoria-in-future#:~:text=VIF2019%20shows%20Victoria%20remains%20the,Total%20population

23. See aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios

As an overview of the commercial sectors in each LGA, Table 4 shows the total counts of businesses, and their break-down by employment size, derived from the ABS publication, *8165.0 Counts of Australian Businesses, including Entries and Exits, June 2017 to June 2021,*[24] compiling Divisions F–S (commercial and services) only. As noted in the table, the more than 127,000 businesses in the commercial sector represent, on average, nearly 74% of all business enterprises in the region. However, the majority of these enterprises are small to medium sized, with only 2.3% of commercial businesses employing 20 – 199 persons, and just 0.1% of commercial businesses employing 200+ persons in FY2021.

Table 4: Business counts by employment size range, FY2021

Local Government Areas	Non-employing	1–19 employees	20–199 employees	200+ employees	Total
Bass Coast	1,024	792	31	0	1,855
Bayside	6,822	3,920	162	6	10,907
Cardinia	3,399	2,188	91	9	5,677
Casey	12,441	6,558	251	11	19,269
Frankston	4,033	2,842	134	6	7,029
Greater Dandenong	8,089	4,765	385	15	13,269
Kingston	7,155	5,204	366	10	12,727
Knox	5,526	4,280	247	15	10,072
Monash	10,611	7,095	441	29	18,177
Mornington Peninsula	5,940	4,246	218	3	10,413
Port Phillip	10,867	6,580	586	11	18,047
Totals	**75,907**	**48,470**	**2,912**	**115**	**127,442**
% of all businesses in the region that are in commercial sectors	74.5%	73.3%	69.9%	68.5%	73.9%
% of all commercial sector businesses in region	59.6%	38.0%	2.3%	0.1%	100.0%

24. Australian Bureau of Statistics, 8165.0, Counts of Australian Businesses, including Entries and Exits, June 2017 to June 2021, 2022.

To estimate the number and floor area of commercial buildings by type, and also their average electricity and gas usage, we again draw on data tables prepared for the 2022 *Commercial Buildings Energy Consumption Baseline Study*. These data tables are freely available for download.[25] A limitation is that the Baseline Study Update is organised using a spatial unit known as 'SA2' rather than LGA. Therefore the study does not directly indicate the composition of the commercial building stock by building type at the LGA level. However, we use the average Victorian profile, as revealed in the Update, to estimate to count and GFA of buildings by type and LGA in the region. This methodology is a necessary simplification and it means that likely differences in the commercial stock composition between LGAs within the region are not able to be described.

Similarly, the methodology assumes that the composition (by type) of the commercial building stock (e.g. the share of offices or other building types as a percentage of the total) does not change over time – for want of a data source that indicates how it may be expected to change. In the context of this study, these simplifications are not considered material, as they do not affect the abatement strategies highlighted below. As noted above, however, each building is in some senses unique, and the optimal abatement strategies for an individual building should be considered on a case-by-case basis prior to investment.

Noting these qualifications, our estimate of the overall split of commercial building gross floor area within the region by building type is shown in Figure 6.

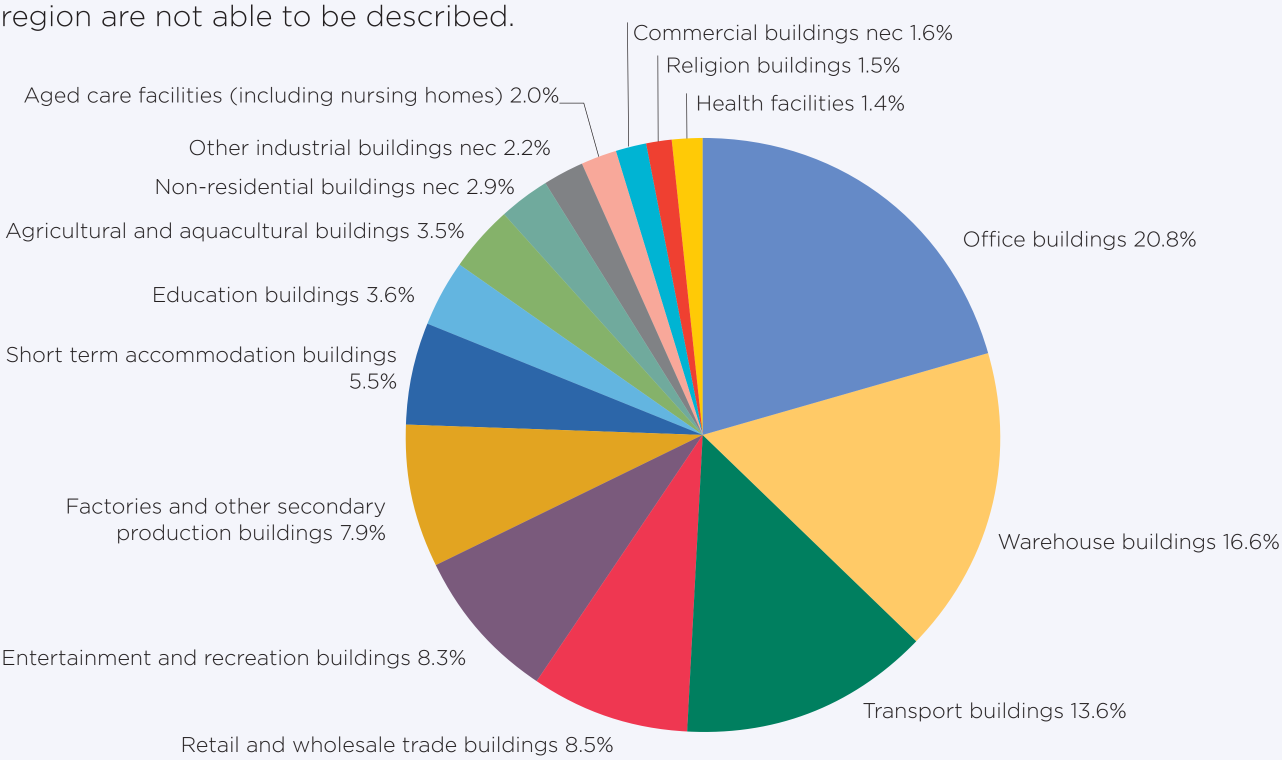

Figure 6: Estimated shares of commercial building gross floor area by building type, GSEM/SECCCA region, FY2022. nec: not elsewhere covered

25 See www.energy.gov.au/publications/commercial-buildings-energy-consumption-baseline-study-2022

3.3.3 Energy Use and Reference Case Emissions

We then estimate electricity and gas consumption associated with this floor area, drawing on analysis of average Victorian fuel intensities (fuel use per sqm GFA) by building type, drawn from the 2022 Update to the Commercial Building Baseline Study. This study assumes that there will be progressive reductions in the energy intensity of buildings, in line with historical trends. This assumption reflects the impact of national policies – such as the National Construction Code energy performance requirements, Commercial Building Disclosure, NABERS, Greenhouse and Energy Minimum Standards and others – on additional ongoing technical improvement, as witnessed most notably for lighting systems in recent years (wholesale adoption of LED lighting) and, to a lesser degree, in space conditioning and related systems. The effect of these efficiency improvements is somewhat offset by the underlying growth in the number and total floor area of commercial buildings expected within the region over the period to 2050 – see Figure 7. Gas consumption is projected to remain reasonably stable, or to reduce slightly, while electricity consumption grows. The decline in electricity and gas consumption in the historical period reflects a combination of efficiency improvement and the one-off effect of the global COVID-19 pandemic reducing occupancy and, to a lesser degree, fuel use in the commercial building stock (offset by higher consumption in the residential sector, due to many people working from home).

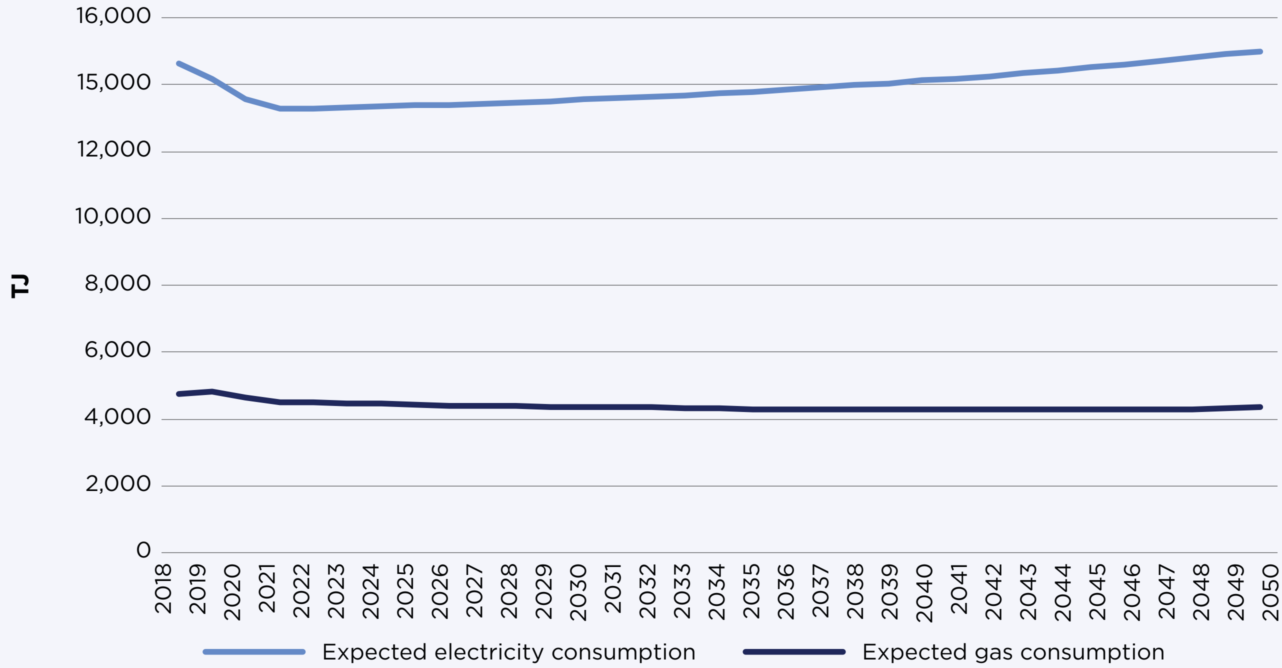

Figure 7: Commercial sector projected energy consumption by fuel, GSEM/SECCCA region, step change scenario

The final step in this 'reference case' projection is to convert the fuel use described above into greenhouse gas emissions units. The emissions intensity of pipeline-delivered gas is assumed to remain constant over time, although it is at least possible that there could be some blending of biogases and/or hydrogen into pipeline-delivered natural gas in the future. However, the likelihood and exact consequences for the emissions intensity of such possible developments are too uncertain at this time to predict with any confidence. With respect to electricity, Section 3.2 discusses our projection of emissions intensity (noting that this estimate is an average for the grid, while rooftop PV and PPAs are assumed to have zero operational emissions).

Figure 7 shows the reference case emissions projection for the commercial sector in the region to FY2050. It may be noted that, since electricity dominates energy consumption in this sector, the trace of projected emissions follows closely the trace for the projected emissions intensity of electricity consumption shown in Figure 3. To underscore the importance of declining emissions intensity of electricity consumption, we also show a dotted line representing what emissions would be expected if there were no reduction in the greenhouse gas emissions intensity of electricity in the future.

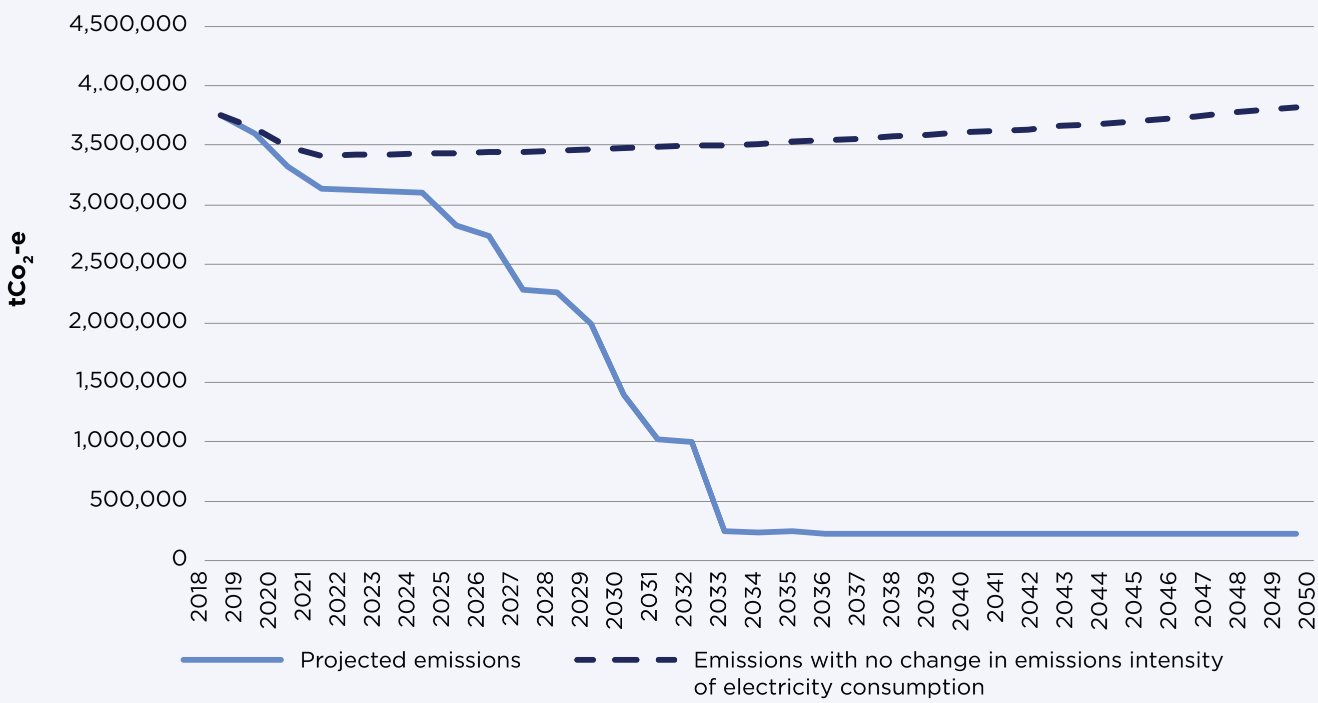

Figure 8: Reference greenhouse gas emissions, commercial sector, GSEM/SECCCA region, step change scenario

Figure 8 illustrates that:

- Significant reductions in commercial sector emissions in the region (and indeed elsewhere in Victoria) are expected in the future. By 2030, emissions are projected to be some 63% lower than in FY2018, while by FY2033 (when electricity emissions are expected to approach zero),[26] emissions are projected to have fallen by over 93% relative to FY2018.
- These reductions are largely attributable to the expected reduction in the greenhouse gas emissions intensity of electricity consumption in Victoria (and the region), as discussed in Section 3.2.
- On current expectations, all commercial sector emissions after FY2033 would be attributable exclusively to the consumption of natural gas.

These trends also clearly highlight the critical importance of electrification as an abatement strategy. With electricity consumption expected to be largely emissions-free after 2033, switching from natural gas to electricity (or potentially to other emissions-free sources, such as green hydrogen) is essential if the region is to become emissions-free.

3.4 INDUSTRIAL/ MANUFACTURING SECTOR

The major source of greenhouse gas emissions arising from industrial activities is combustion of fuels to supply thermal energy. By far the most important fuel used in the study area is natural gas. Of course, most manufacturing enterprises also use electricity, and some may use electricity only.

Gas use statistics in Australia are relatively poor – in part, for confidentiality reasons. The Australian Energy Regulator publishes annual summary operational data for each of the three gas networks operating in Victoria, including the two Multinet and Australian Gas Networks, which supply customers within the study area. However, for a variety of reasons, it is not possible to extract useful information from these data. Australian Gas Networks does provide information on its sales to larger industrial consumers, from which it can be calculated that in 2020 sales to the approximately 280 industrial customers, many of which are outside the study area, average 55 TJ/customer.

We can also gain an overview of the industrial sector in the region from statistical data sources. The ABS publication, *8165.0 Counts of Australian Businesses, including Entries and Exits, June 2017 to June 2021,* shows, for example, that at the end of FY2021, there were some 8,032 enterprises in the manufacturing and electricity, gas, water and waste services sectors in the region. While this represents less than 5% of all enterprises in the region,

26. Note that annual emissions may not be exactly zero, as they are affected by inter-state trade in electricity, as well as the emissions associated with generation in Victoria. This is likely to lead to minor variations from year to year.

industrial enterprises are typically larger than those in other sectors (measured here by employment ranges).

For example, there are 21 industrial enterprises with more than 200 employees, and over 700 enterprises employing between 20 and 199 employees. Still, it is worth noting that over 90% of industrial enterprises in the region employ less than 20 persons (Table 5).

It is challenging to establish past, let alone future, emissions for the industrial sector in the region – and we recall that doing so is not a core requirement of this project (which instead focuses on emissions reduction opportunities). The challenges arise for the following reasons:

Table 5: Count of industrial sector enterprises, GSEM/SECCCA region, end of FY2021, by employment size

LGA	Industry	Non-employing	1–19 employees	20–199 employees	200+ employees	Total
Bass Coast	Manufacturing	44	45	3	0	90
Bass Coast	Electricity, Gas, Water and Waste Services	7	4	0	0	19
Bayside	Manufacturing	148	111	12	0	272
Bayside	Electricity, Gas, Water and Waste Services	13	13	0	0	24
Cardinia	Manufacturing	193	175	15	3	387
Cardinia	Electricity, Gas, Water and Waste Services	17	21	0	0	43
Casey	Manufacturing	420	391	46	3	860
Casey	Electricity, Gas, Water and Waste Services	64	65	5	0	128
Frankston	Manufacturing	280	327	35	0	639
Frankston	Electricity, Gas, Water and Waste Services	22	26	0	0	46
Greater Dandenong	Manufacturing	403	762	225	3	1,395
Greater Dandenong	Electricity, Gas, Water and Waste Services	42	65	6	0	111
Kingston	Manufacturing	392	586	143	3	1,128

LGA	Industry	Non-employing	1–19 employees	20–199 employees	200+ employees	Total
Kingston	Electricity, Gas, Water and Waste Services	25	42	6	0	69
Knox	Manufacturing	329	461	95	3	881
Knox	Electricity, Gas, Water and Waste Services	10	27	4	0	44
Monash	Manufacturing	293	356	72	3	727
Monash	Electricity, Gas, Water and Waste Services	22	16	3	0	41
Mornington Peninsula	Manufacturing	323	292	20	0	639
Mornington Peninsula	Electricity, Gas, Water and Waste Services	29	27	3	0	63
Port Phillip	Manufacturing	204	143	18	3	365
Port Phillip	Electricity, Gas, Water and Waste Services	42	16	3	0	61
GSEM/ SECCCA Region	**Total Industrial Enterprise Counts**	**3,322**	**3,971**	**714**	**21**	**8,032**
GSEM/ SECCCA Region	Total Enterprise Counts	101,865	66,158	4,164	168	172,351
GSEM/ SECCCA Region	Industrial Share of all Enterprises	3.3%	6.0%	17.1%	12.5%	4.7%
GSEM/ SECCCA Region	Distribution of Industrial Enterprises by Employment range	41.4%	49.4%	8.9%	0.3%	100.0%

- Industrial output, energy use and emissions are all treated as confidential and commercially sensitive, and so there is little information in the public domain on these parameters.[27]
- The industrial sector in Australia – and also in the region – is highly diverse. While manufacturing in the region is primarily represented by elaborately-transformed products, where energy costs are typically a lower proportion of overall costs, there are also energy-intensive manufacturing enterprises such as Bluescope Steel, Oceania Glass, and the gas/fossil fuel processing plants at Lang Lang and Long Island Point.
- Much manufacturing output from Australia is either destined for export or else competes with imports.

  As a result, future production levels (and therefore energy consumption and emissions), depend primarily on global market trends, then on Australia's ability to produce products at prices that are globally competitive.

  For energy-intensive manufacturing, the cost of energy is an important influence on their overall competitiveness.
- Across Australia, manufacturing has tended to decline as a share of overall economic activity, yet at the same time, there has been considerable growth in certain segments, such as food and beverages, for example.

Ironbark Sustainability estimated FY2019 industrial sector emissions (not including those in Knox and Monash) at ~4.6 Mt CO_2-e for industrial electricity use, and ~1.4 Mt CO_2-e for industrial gas use.[28] Monash Council also provided data which noted that FY2020 industrial emissions in Knox LGA were 0.94 Mt CO_2-e, and 0.84 Mt CO_2-e, in Monash LGA, bring total industrial emissions in the region up to around 7.8 Mt CO_2-e.

Future industrial emissions in the region will therefore depend on at least two key drivers:

1. the rate of growth of industrial output by industry/product type
2. the fuel and emissions abatement choices made by manufacturing enterprises in the region.

The first driver is largely outside of local control, responding instead to global market conditions and considerations. The second driver is more amenable to local decision-making – although it is generally constrained by the first driver; that is, changing fuels or processes often requires very large-scale investment, for major industrial enterprises,

27. Data is, however, available to government via the National Energy and Greenhouse Reporting system, NGER, although this only covers a few hundred of the largest energy users in Australia – the vast majority of manufacturers do not report via this system.

28. Ironbark Sustainability, *Regional Opportunities Report – South East Councils Climate Change Alliance (SECCCA) Climate Action Planning Project*, 2021, p. 10.

and this is unlikely to occur unless the overall enterprise and local production units are profitable and expected to continue to be so in the future.

That said, both our workshop with SEMMA representatives, held on 22 November, and ABS statistical data presented in Table 5, highlight that:

- there are many smaller and less energy-intensive manufacturers in the region
- many of these enterprises primarily use electricity rather than gas, and/or use process that are more amendable to electrification.

While Figure 9 below was derived from ABS data only available for the whole of Victoria in FY2017, and is therefore not specific to the region, it nevertheless shows that there are a relatively small number of enterprises that use a large amount of non-electrical energy (notably those in the Petroleum and Coal Product Manufacturing sector and in the Primary Metal and Metal Product Manufacturing Sector). There is a much larger number of enterprises in diverse manufacturing sectors using much smaller (but not trivial) amounts of non-electrical energy per enterprise.

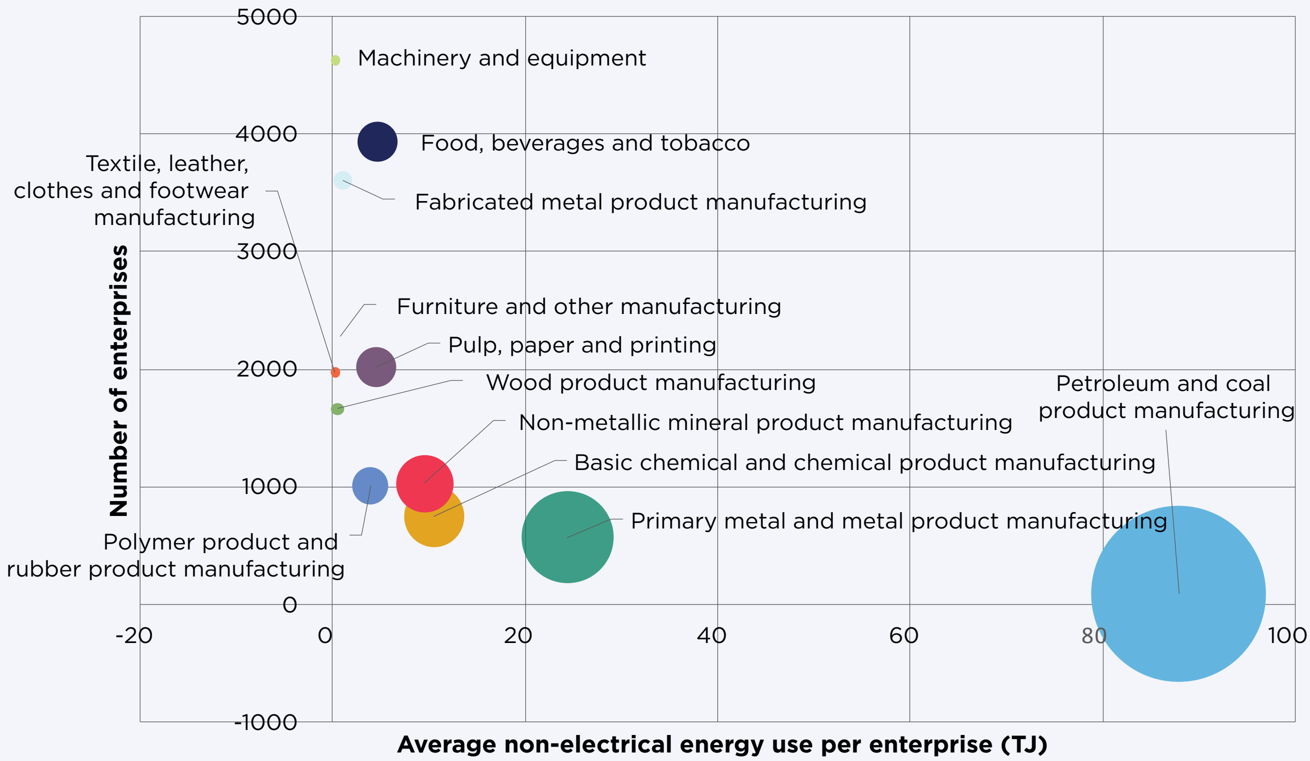

Figure 9: Average non-electrical energy consumption per enterprise, and no. of employees, Victoria, FY2017

3.5 TRANSPORT SECTOR

3.5.1 Introduction

Transport is fundamental to the region, underpinning countless economic and social activities.

Every business is reliant on transport – whether to send out products, take delivery of resources, or bring staff to work. Every community member needs to move – whether walking to school, catching a bus to work or driving to the medical centre.

The great challenge for any region is to retain the essential benefits of transport, while reducing greenhouse gas emissions and other negative impacts including air pollution, noise pollution and congestion.

This section provides an overview of transport activity and greenhouse gas emissions in the region.

The focus is on land transport as this is the dominant form of transport activity and emissions source. Aviation activity and emissions are considered separately.

3.5.2 The Land Transport Task

Transport involves the movement from place to place of people and products. This gives us the two task categories of passenger transport and freight transport.

Many passengers move in cars, light commercial vehicles (utes and vans) and public transport (buses and rail). This is termed the motorised vehicle passenger task.

Passengers also move under their own steam, by walking or cycling. This is termed active transport.

All passenger tasks are measured in passenger kilometres (passenger km or pkm), which is the number of kilometres moved by a single passenger. For example, a bus carrying 20 people for 10 km has performed a task of 200 passenger km.

The motorised passenger task is key, as internal combustion engine vehicles (ICEV) that burn petrol or diesel produce carbon dioxide emissions.

The vast bulk of land freight is moved by motorised vehicles, which are placed into the four sub-categories of heavy vehicles (articulated trucks), medium vehicles (rigid trucks), light commercial vehicles (LCVs) and rail.

Passenger transport

The total passenger transport task is rising as population increases, apart from the dip caused by COVID-19 impacts on travel.

Motorised passenger travel is increasing more slowly than population growth, as the annual amount of travel by motorised vehicle per person has been falling slightly.

This has occurred as people avoid or shorten some motorised trips by means such as public transport use, greater use of walking and cycling, and use of high quality and inexpensive information communications technology options for communication rather than travelling to work and meeting places.[29]

We expect these national and state-wide trends to also hold true for the region. The projected regional task is shown in Figure 10, with these estimates based on data and forecasts from ABS,[30] Bureau of Infrastructure, Transport and Regional Economics (BITRE),[31] National Transport Commission (NTC)[32] and the Victorian Government.[33]

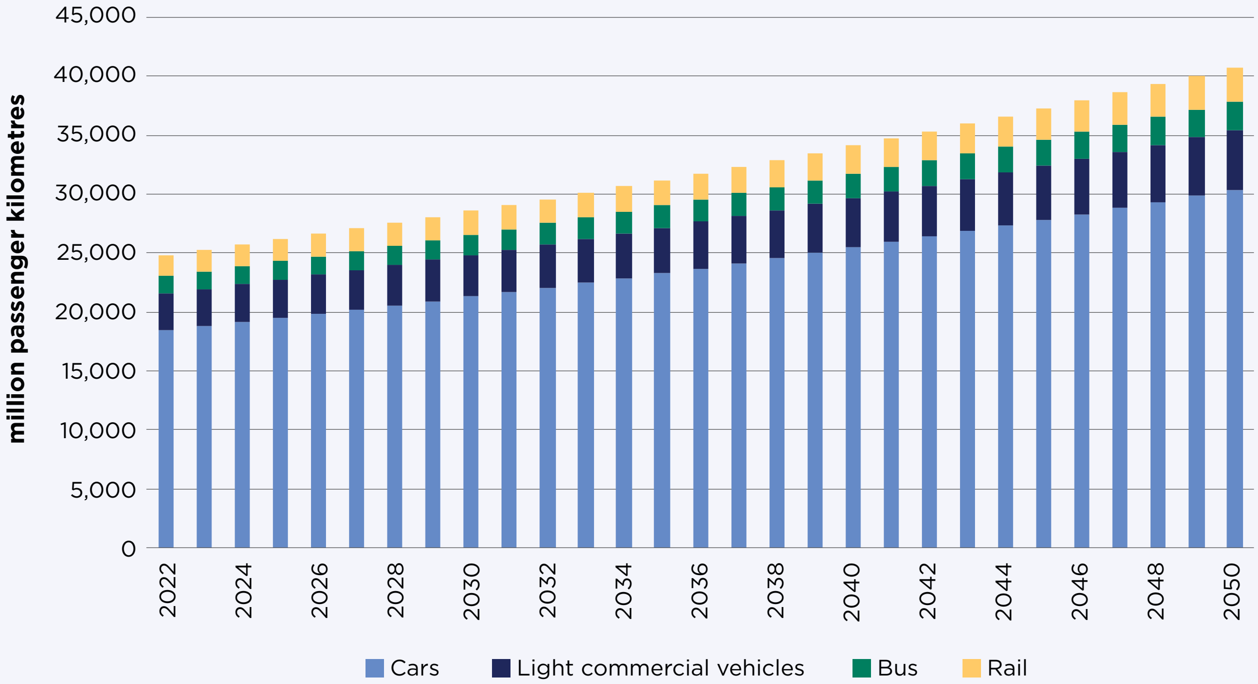

Figure 10: Projected annual passenger transport tasks – reference scenario

29. BITRE, 2014, *Long-term trends in urban public transport, Information Sheet 60*, BITRE, Canberra
30. ABS *Census 2021*, ABS *Survey of Motor Vehicle Use*
31. BITRE, *Australian Infrastructure Statistics Yearbook 2021*
32. NTC, 2016, *Who Moves What Where*
33. Victoria in Future, 2019 and Victorian Integrated Survey of Travel and Activity

These estimates are presented for the region as a whole, as many transport tasks span across LGAs.

However, it is important to note that the precise make-up of passenger travel will vary across the region. For instance, the inner-city areas will have a higher share of public transport use, given the much better availability of those services.

A good sense of the likely differences across LGAs between the use of private vehicles and public and active transport is provided by the Australian Urban Observatory scores for walkability and access to public transport.[34]

Walkability scores are based on land use mix and service/place availability (somewhere to walk to), connectivity (a way to walk there) and dwelling density (higher densities are correlated with better availability of nearby services). Zero is the average score.

The access to public transport score is the percentage of dwellings within 400 metres of public transport services with a least a regular 30-minute weekday service between 7am and 7pm.

The scores for each LGA are shown in Table 6. They show that inner city LGAs like Bayside and Port Philip have relatively good walkability and access to public transport, while less densely populated LGAs such as Cardinia and Mornington Peninsula have relatively poor walkability and access to public transport. Bass Coast has not yet been ranked. With its regional characteristics the Bass Coast LGA is likely to have low walkability and weak access to public transport – and a correspondingly high reliance on cars and LCVs.

Table 6: Walkability and access to public transport by LGA (Australian urban observatory scores)

LGA	Walkability score	Regular public transport access (%)
Bass Coast	no data	no data
Bayside	1.2	61.3
Cardinia	-2	8.9
Casey	-1.1	30.3
Frankston	-1.1	26.4
Greater Dandenong	0.4	43.2
Kingston	0.1	53.7
Knox	-0.6	37.8
Monash	0.6	59.7
Mornington Peninsula	-2	8.7
Port Phillip	5.9	88

34. Australian Urban Observatory auo.org.au

Freight transport

Freight activity is measured in tonne kilometres (tonne km or tkm), which is the movement of 1 tonne of freight over 1 kilometre. The freight transport task projected under the reference scenario is shown in Figure 11.

The estimate of the current task[35] for the region and splits by vehicle types are based on data from ABS,[36] BITRE,[37] and the NTC.[38]

Steady growth in freight out to 2050 is expected, driven by a growing population and rising economic growth.

Some sectors are reducing total tonnages of inputs and production, in response to technological change and structural shifts.

However other sectors (such as residential) are consuming greater quantities of goods, creating higher overall demand for freight transport. The trend of annual increases in the quantity of freight has been observed for some time. This is expected to continue in the region, in line with the Victorian Government forecast of 1.5% annual growth in freight demand.[39]

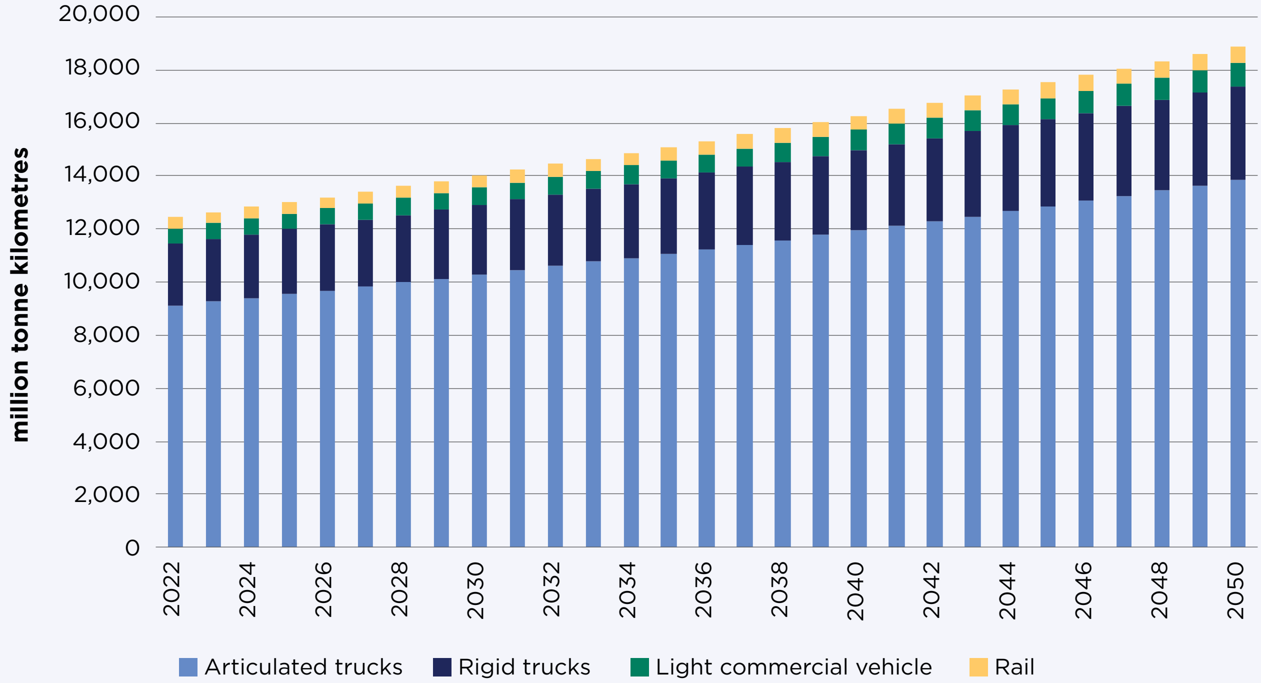

Figure 11: Annual land freight transport tasks by mode – reference scenario

35. Freight transport task' refers to the sumproduct of the tonnes (in this case, millions of tonnes) of freight moved, multiplied by the number of kilometres the tonnes are moved.

36. ABS, *Census 2021, Survey of Motor Vehicle Use and Census of Motor Vehicles*

37. BITRE, *Australian Infrastructure Handbook 2021* and *Australian aggregate freight forecasts – 2022 update*

38. NTC, 2016, *Who Moves What Where*

39. Victorian Government, 2018, *Delivering the Goods – Creating Victorian Jobs: Victorian Freight Plan*

3.5.3 Land transport reference case emissions

The reference scenario for land transport is shown in Figure 12. Under this scenario, passenger transport emissions fall to zero by 2050. Freight transport emissions are steady, and then slowly fall to 586 kilotonnes CO_2-e in 2050. This scenario for the region is in line with the projections for the switch to ZEVs produced by CSIRO[40] for AEMO's Step Change Scenario.

Transport emissions result from the combustion of liquid fossil fuels. The quantity of emissions depends on the size of the transport task (moving people and freight, as discussed earlier) and how much petrol and diesel is used to perform that task. It is worth noting here that inventories of emissions at state and national level only use fuel-use data to track emissions.

These inventories of past emissions do not track the nature or size of the transport task, as historical fuel-use data is sufficient for the inventory process. However, at a regional level, fuel use data is not readily available. Further, a focus on fuel use data alone cannot provide meaningful forecasts of future emissions.

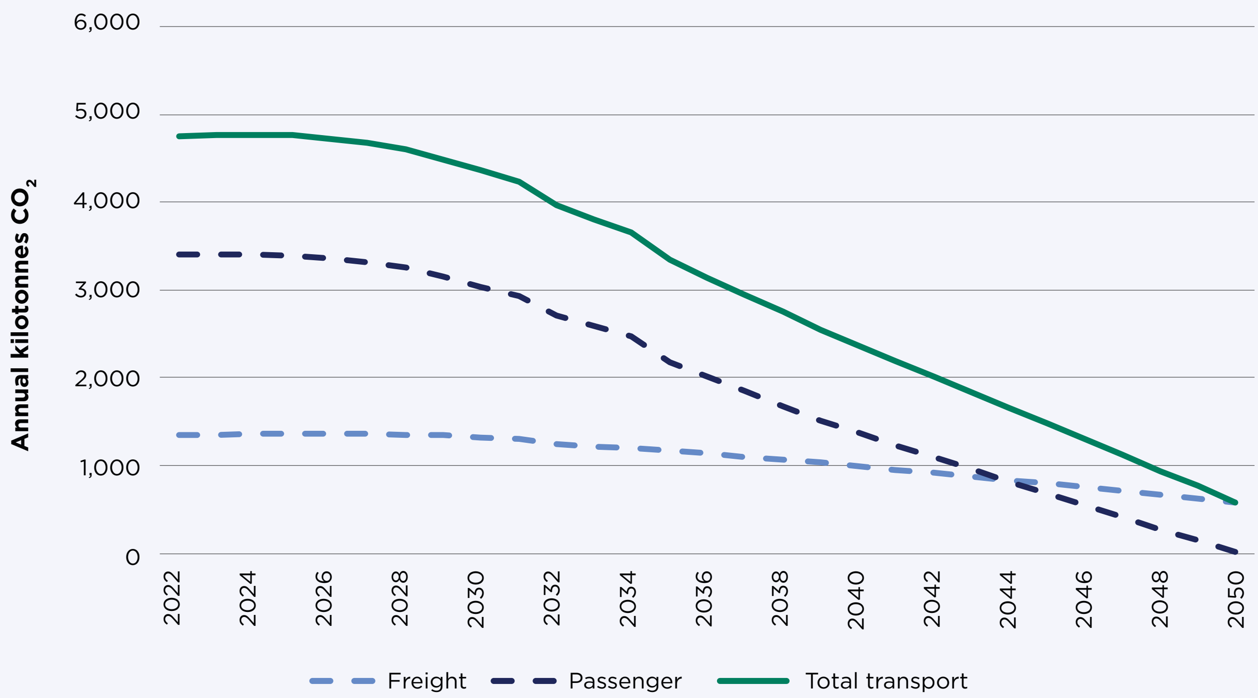

Figure 12: Annual land transport emissions – reference scenario

40. CSIRO, *Electric vehicle projections 2021*

The lack of data on liquid fuel use in the region, together with the need to estimate future emissions, requires the use of an alternative approach to the fuel-use method. The method used for this report first estimates the size of the transport task (as described earlier) and then examines the likely make-up and efficiency of the transport fleet performing the task.

Figure 8 and Figure 9 show that the transport task is expected to steadily increase out to 2050. However, emissions are expected to dramatically fall, as the consumption of diesel and petrol drops. This is due to three fundamental factors.

1. Electrification of vehicles

Petrol and diesel have been used to power cars, buses, trucks and long-distance trains for over 100 years. This paradigm is being disrupted, at a global scale, by a move to electric vehicles (EVs), which use an electric motor powered by electricity stored within a battery. When the electricity is supplied from renewable energy sources, the vehicle is emissions free. EV sales in Victoria are still very limited at present, trailing places like Norway and California, which have various government measures in place to speed the adoption of EVs. However, the shift to EVs has started in Australia. Once EV total ownerships costs (TOC), which are purchase plus running costs, achieve price parity or better with petrol/diesel vehicles, the uptake of EVs will accelerate. In some applications such as high mileage fleet cars, TOC is already at parity. This is likely already the case for segments in which EVs are currently marketed in Australia, which tends to be the more premium end of the market – where there is generally no premium for an EV compared to an internal combustion engine (ICE) equivalent. However, EVs are beginning to be marketed in Australia in the popular medium SUV category, with low premiums compared to ICE equivalents. At present, EVs are not available in Australia in the lower priced vehicle classes, but such vehicles are extremely numerous in both India and China, and likely will be marketed in Australia in the near future.

Electric/petrol hybrid technologies have been available for around 20 years in Australia. Their take-up has been slow, although it reached 7.1% of the light vehicle market in 2022.[41] There has been research that suggests that greenhouse gas emissions from plug-in hybrid cars may be as much as two and a half times higher than official tests indicate.[42] Our view is that while this technology has contributed to improved fuel efficiency for ICEVs, it does not offer a roadmap to zero-emissions transportation, while EVs do.

The shift to EVs is occurring slowly in Australia, compared to other countries such as Norway, where EVs accounted for 79.3% of new light vehicle sales in 2022.[43] This is indicative of the potential for EV uptake if, as in Norway, there is clear government support and leadership.

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41 www.westsideauto.com.au/news/the-rise-of-ev-and-hybrids-in-australia

42 www.bbc.com/news/science-environment-54170207

43 elbil.no/norway-celebrates-another-record-breaking-year-for-electric-vehicles/#:~:text=2022%3A%2079.3%20percent%20of%20all,in%20Norway%20were%20fully%20electric

In Australia, the transition to EVs has commenced with cars and LCVs, while early moves are underway also for rigid trucks, buses, and even heavy, articulated trucks. Under the reference scenario (Step Change), we expect the transition to EVs will be virtually complete by 2050. There will still be ICEVs in existence at that date, of course, but their share of the transport task (such as passenger kms) will be extremely small, with very few associated greenhouse gas emissions.

2. Efficiency improvements in petrol and diesel vehicles

The fuel and emissions efficiency of ICEVs has been slowly improving. The average annual rate of improvement in the average efficiency of the Australian car fleet from 2002 to 2017 is 1.75%.[44] This rate has been applied to the reference scenario as efficiency gains from engine technology improvements, use of hybrid technologies, as noted above, and reducing the weight of vehicles (improving energy efficiency) are expected to continue.

3. Shifts from cars to public transport, active transport and trip avoidance

Over the last decade, there has been a drop in the number of kilometres travelled annually by passengers in cars, on a per capita basis. Moving from cars to public transport is a shift to a more energy and emissions efficient form of transport.

When some journeys are taken by bike or on foot, the motorised transport task drops – and the associated emissions are eliminated.[45]

COVID-19 interrupted several transport trends. It greatly intensified trip avoidance causing a rapid drop in overall travel as people stayed at home. It also led to a shift away from public transport. The impacts of COVID are still playing out, but public transport patronage is returning, and various factors allowing people to avoid and reduce trip distance will continue, at a less intense level than during COVID's peak.

The effect of the factors pushing down emissions is strongest within passenger transport: we estimate a moderate fall in emissions to 2030 with stronger falls thereafter.

It is important to note that current government and vehicle industry policies are insufficient to achieve the emissions falls projected under the reference scenario. Under current policy settings at national and state levels, coupled with industry intentions to gradually (rather than quickly) shift away from petrol and diesel vehicles, there will still be some fossil fuel vehicles active in 2050.[46] The International Energy Agency (IEA) reports that transport globally is not on track to achieve zero emissions by 2050.[47]

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44. NTC, 2018, Carbon Dioxide Emissions Intensity for New Australian Light Vehicles 2017

45. Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2014, Long-term trends in urban public transport, Information Sheet 60, BITRE, Canberra

46. The world's largest car makers, including Toyota and Volkswagen have not committed to sell only zero emissions vehicles by 2035 and 2040 depending on market – which means ICEV stock will be active in 2050. See *Financial Times*, 13 Nov 2021, 'Car industry divided on road to zero emissions after climate deal snubbed'.

47. IEA (International Energy Agency), *Transport Tracking report – September 2022*

The CSIRO projections that we have adopted for the reference scenario assume that the current situation will rapidly evolve to one of intensive effort to shift passenger transport to zero emissions. This is consistent with AEMO's Step Change scenario.

In the case of freight, there is only a modest fall in emissions under the reference scenario. This is because the freight task steadily rises, while the shift to electric freight vehicles, or alternatives such as hydrogen vehicles, is expected to be slower than for passenger vehicles.

A note on hydrogen and biofuel vehicles and electric bikes

Like EVs, hydrogen fuel cell vehicles use an electric motor to drive the wheels. However, instead of a battery the motor is fuelled by hydrogen stored in a tank within the vehicle (rather than a battery). Such vehicles can be emissions free when using hydrogen produced using renewable electricity. Similarly, biofuel vehicles, where liquid biofuel powers a traditional internal combustion engine, have the potential to be emissions free but these are not explicitly included within the reference scenario.

At present, hydrogen vehicles are much more expensive than EVs and availability is very limited. Additionally, hydrogen production, distribution and re-fuelling infrastructure is also lagging far behind electric vehicle support infrastructure. So, from a 2022 perspective, EVs are expected to out-compete hydrogen vehicles. This situation may change.

If hydrogen technology improves drastically, by say 2035 or 2040, there could be many hydrogen vehicles on the road by 2050. Hydrogen may have strong uptake in the heavy vehicle segments. This is because under current battery technologies, the payloads for electric trucks are compromised by the heavy batteries needed to provide long-haul ranges of over 600 km.

On the biofuel front, first generation fuels only have niche applications where a specific, relatively small fleet has access to a biofuel source that would otherwise be wasted. First generation biofuels generally use feedstocks such as oilseeds, cereal crops and tallow. They cannot be sensibly produced in sufficient quantities to greatly lower overall transport emissions without having negative consequences such as driving up the cost of food and increasing the destruction of natural landscapes and biodiversity. Second or third generation fuels, from algae for instance, have potential, but these are scientific rather than commercial prospects at the current time.

The key point for the reference scenario is the assumption that any significant uptake of hydrogen or biofuel vehicles (or any other form of ZEV) would replace electric vehicle uptake, rather than petrol/diesel vehicles. The reference scenario is, in effect, showing the shift from fossil fuelled vehicles to non-fossil fuelled vehicles, whether they turn out to be electric or hydrogen or biofueled. In other words, the precise technology roadmap for the shift away from petrol/diesel vehicles has no effect on the emissions trajectory for transport under the reference scenario.

Electric bikes are becoming increasingly common due to their suitability for short to medium distance trips to work, schools, the shops and similar destinations. They are considered part of active transport, as they are speed limited and generally need to be pedalled most of the time. They are categorised as appliances rather than vehicles in terms of their power use. The small amounts of electricity that they draw is attributed to the residential and commercial sector rather than the transport sector.

3.5.4 Aviation Transport Activity and Emissions – Reference Case

Aviation emissions within the region are associated with aircraft movements from Moorabbin Airport, in the Kingston City Council LGA. There is also a small private airport at Tooradin, in Casey LGA. This airport hosts a sky-diving operation and flying school. The electrification of smaller passenger and recreational aircraft is already underway, and electric aircraft may be particularly suited to these operations, at this stage of their development.

Note that while the region does use aviation from other airports for interstate or international travel and airfreight, those emissions are attributed to the flight origin point – such as Tullamarine.

Moorabbin Airport is a busy airport, with around half a million flight movements annually. It is an important flight training centre and base for light aircraft including helicopters. King Island is linked to Victoria from Moorabbin.[48] Total emissions are relatively low as aircraft are light and flights are short.

The reference scenario for aviation emissions is shown in Figure 13.

Under this scenario, emissions will rise, with increased activity to 2030, then fall, as battery electric aircraft or zero emissions alternatives begin to replace the fleet utilising Moorabbin airport. From 2040 there is an acceleration in the adoption of zero emissions aircraft. This scenario is informed by analysis of the aviation sector by the IEA.[49]

Current emissions estimates are based on data on flight activity and fuel use. We used data from Moorabbin Airport on flight activity and aircraft types.[50] Various sources of data on fuel consumption by aircraft type were used.[51]

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48. See www.moorabbinairport.com.au/aviation/overview

49. IEA, *Aviation Tracking report – September 2022*

50. Moorabbin Airport Master Plan 2015

51. See bwifly.com/cessna-172-operating-cost, 2008 Beechcraft Baron G58 – Plane and Pilot Magazine (planeandpilotmag.com), Beechcraft King Air C90GTx Operating Costs – Fuel Burn | FlyRadius, www.rotorvation.com.au/robinson-R66

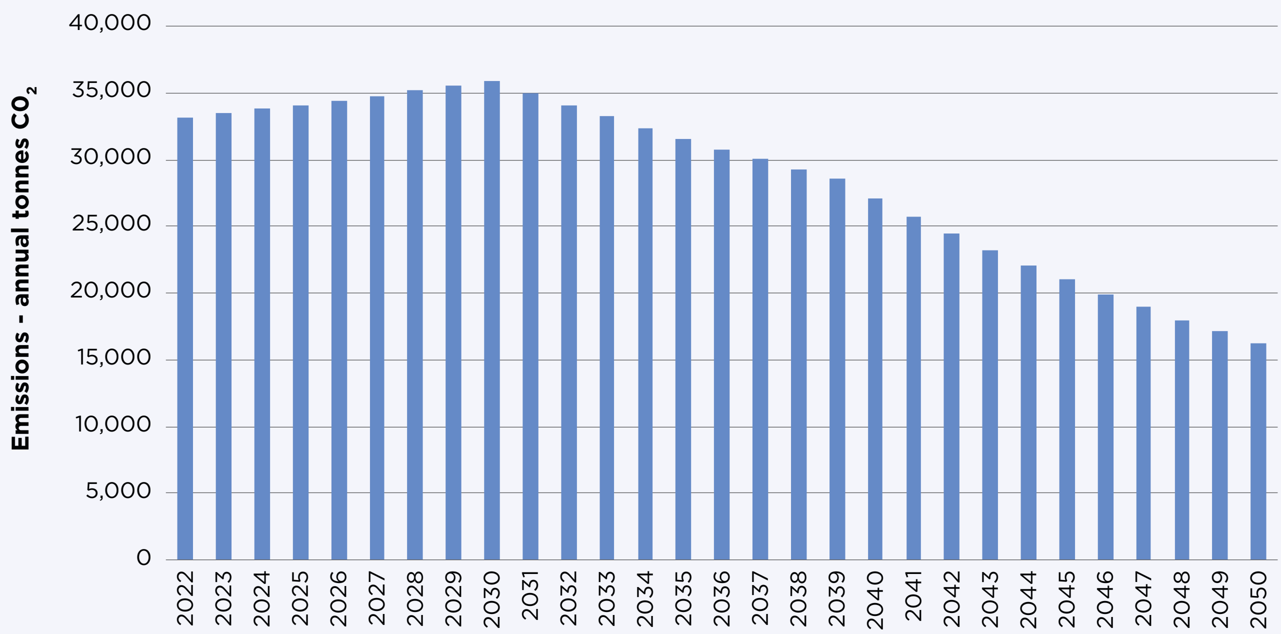

Figure 13: Aviation transport emissions – reference scenario

3.6 WASTE AND AGRICULTURE SECTOR

3.6.1 Introduction

Waste is a small but significant source of emissions for the region.

Agricultural emissions are smaller again on a regional basis, with many LGAs having no or very little agricultural emissions.

However, for Bass Coast agricultural emissions are 28% of emissions and 12% for Cardinia.

3.6.2 Waste Reference Case Emissions and Sources

Waste has two main sources of greenhouse gas emissions. Solid waste emits methane from the decomposition of organic materials in landfills. Wastewater treatment plants also emit methane and nitrous oxide (28%).

Current waste emissions data was taken from the Snapshot Climate tool, which provides waste emissions by LGA.[52]

52. See Snapshot Climate – Australian Emissions Profiles :: Snapshot

The recent trend has been for stable emissions from waste on a state-wide basis. This followed a long period of falling emissions from 1990 to around 2012. This was followed by a rise in emissions as the waste sector lost momentum in managing emissions with the end of the Carbon Price Reduction Scheme. More recently, emissions have been steady, as population growth and increased waste volumes have been offset by efforts to reduce waste to landfill.[53] This effort is set to increase, with a Victorian Government commitment to halve the amount of organic waste going to landfill by 2030.[54] The Victorian water sector has set an aggressive target, with a commitment to zero emissions by 2030.[55]

These trends and policy commitments are reflected in the reference scenario for waste emissions, which is displayed in Figure 14.

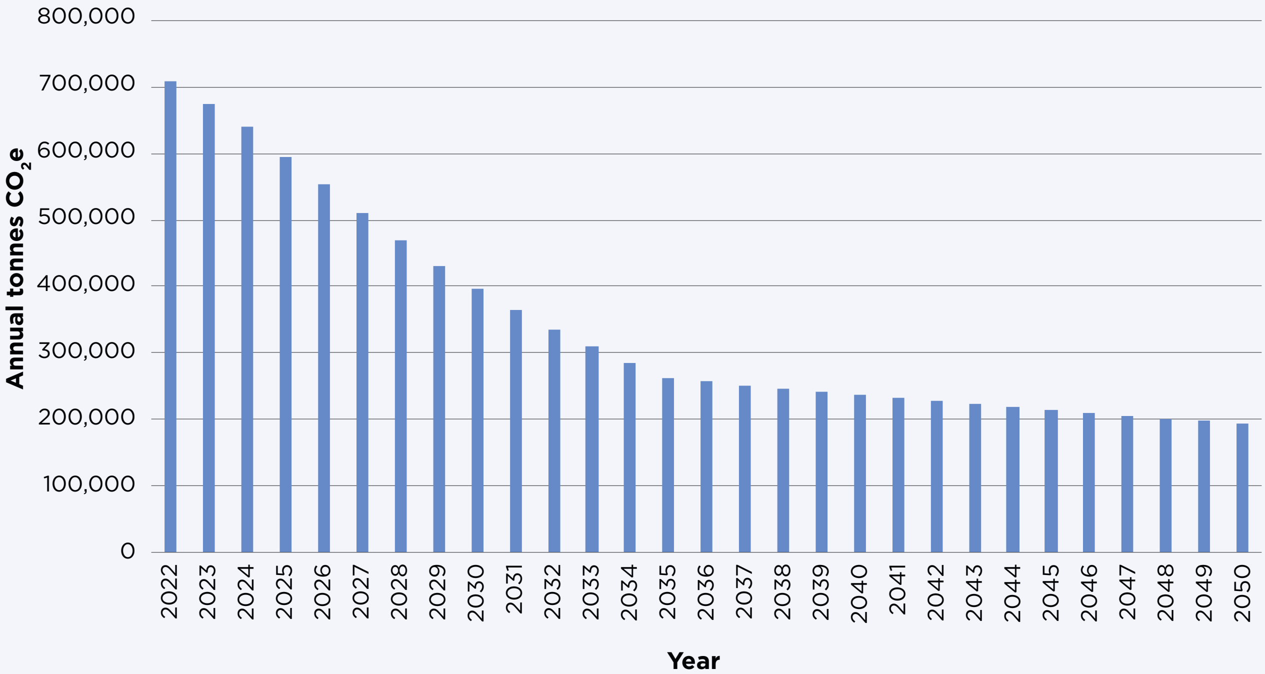

Figure 14: Waste emissions – reference scenario

53. Victorian Greenhouse Gas Emissions Report 2021

54. Victorian Government, *Victoria's Climate Change Strategy, 2022*

55. See www.water.vic.gov.au/climate-change/reduced-emissions-in-the-water-sector/net-zero-emissions-by-2050

3.6.3 Agriculture reference case emissions and sources

Agricultural emissions for the region are dominated by emissions from the Bass Coast and Cardinia LGAs.

These regions contain significant livestock industries, mainly cattle, with a roughly even split between meat and dairy cattle. Cattle produce methane (a greenhouse gas, with a tonne of methane roughly equivalent to 25 tonnes of carbon dioxide) through enteric fermentation as they digest grass.

The beef and dairy industries are well aware of the need to reduce emissions and there are feeds and other techniques being developed to lower methane emissions.[56] However, there is not yet united government and industry policy action to address agricultural emissions, therefore the reference scenario projects only a modest fall in emissions to 2050.

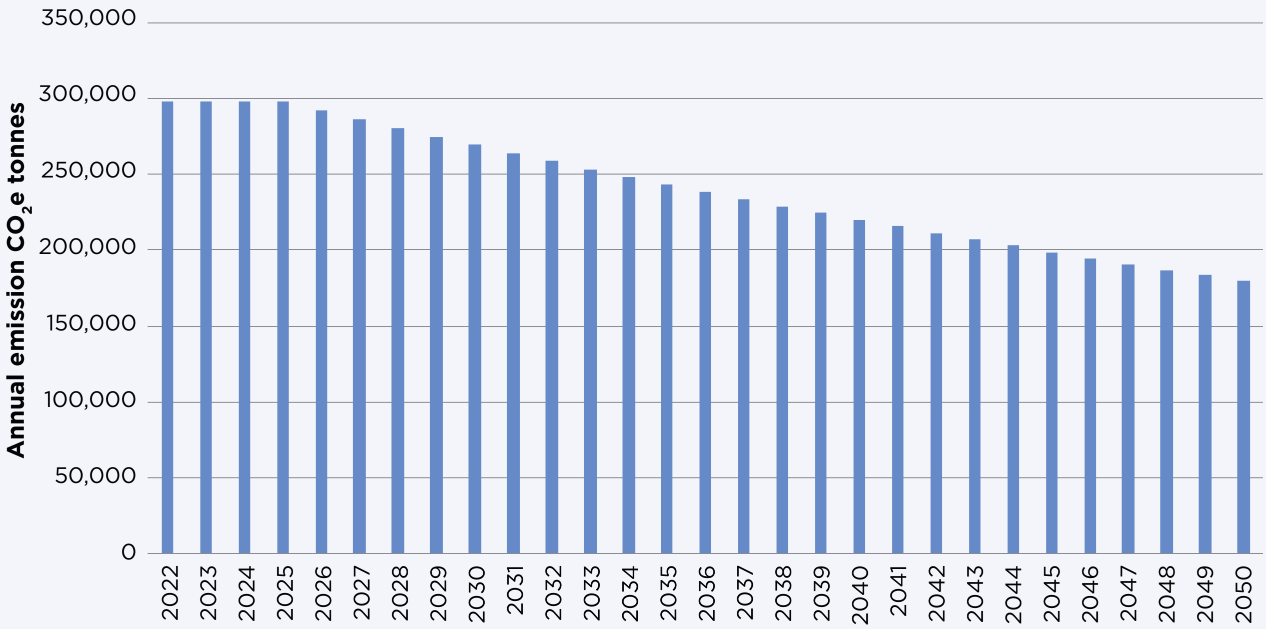

Figure 15: Agricultural emissions – reference scenario

56. See www.dairy.com.au/sustainability/reducing-environmental-impact/reducing-emissions and www.mla.com.au/research-and-development/Environment-sustainability/

04

EMISSIONS REDUCTION OPPORTUNITIES AND COST-EFFECTIVENESS

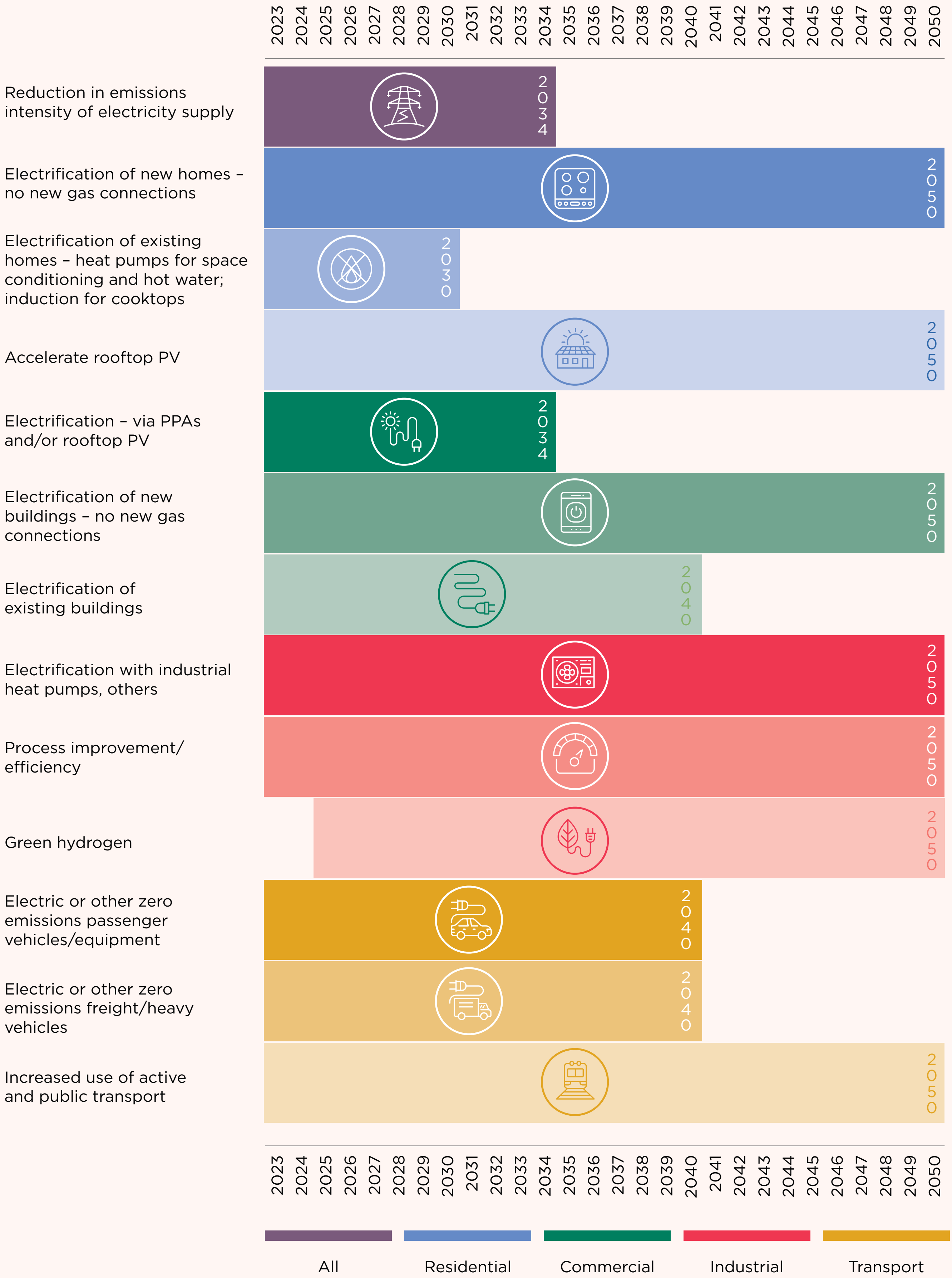

Figure 16: Emissions reduction cost-effective opportunities and timeframes roadmap

4.1 RESIDENTIAL SECTOR

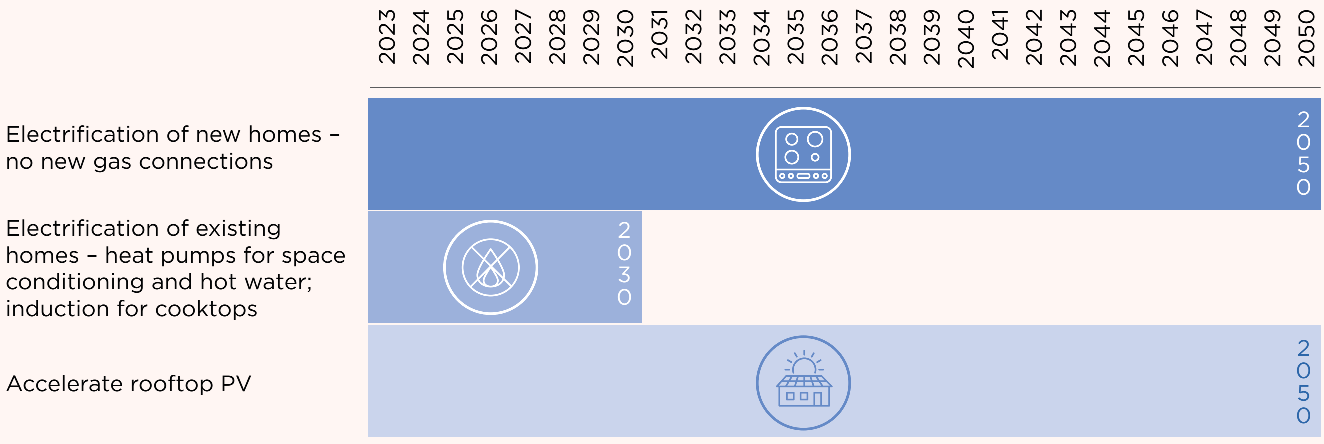

Figure 17: Emissions reduction cost-effective opportunities and timeframes: residential sector

In the residential sector, the most efficient and cost-effective electrical options to replace the main end-uses of gas are:

- for space heating, heat-pump units (reverse cycle air conditioners)
- for domestic hot water, heat pump water heaters
- for cooking, induction cooktops.

Note that we assume few choose gas ovens, and that most residential ovens are already electric.

Heat pumps are so named because rather than generating heat (by electric resistance, in the case of an electric heater, or by combustion of a fuel such as natural gas, heating oil or LPG), they pump heat from outside to inside a home (or vice versa in summer), using just a small fraction of the energy for the equivalent heat output.

The ratio of heat energy output to electricity energy consumed is referred to as the co-efficient of performance (COP), and many residential split systems can have a COP of 4 or more, equivalent to an energy efficiency of 400% or more, meaning that four times as much heat is generated as electrical energy consumed.

By contrast, a gas or other fossil fuel–based combustion heater may be only 80% – 85% efficient. This very high efficiency underpins the cost advantage that heat pumps hold in both space heating and water heating, despite higher upfront or purchase costs than for gas systems.

In addition, many people choose heat pumps for space heating because the same appliance can also provide space cooling in summer, which is not feasible using fossil fuels.

The *degree* of cost-effectiveness of the above options depends on a number of factors, and particularly on the starting-point efficiency of the gas-using equipment against which the electrical alternative is being compared.

In addition it will depend on the assumed price of the equipment, which in reality varies very widely indeed.[57]

However, indicative values from our own analysis are as follows:

- Heat pumps for space heating generally use no more than one-fifth, of the energy per year than a gas equivalent, while capital costs are comparable. This means that heat pumps can be around five times more cost-effective than gas heaters (although, as noted, this will vary depending upon the specific requirements of each dwelling).
- For domestic hot water, heat pumps have a higher purchase price than gas (instantaneous or gas storage systems) but also use a fraction of the energy each year for a given hot water consumption rate. For example, we recently compared the purchase price and running costs over 15 years of heat pump vs 5-star instantaneous gas. The instantaneous gas unit was priced at just over $1,000, but the 15-year running cost was over $13,000 (discounted at a 7% real discount rate). The heat pump had a much higher purchase price, at just over $2,700, but the 15-year running cost was only $2,800. Therefore the lifecycle cost of the heat pump was some $8,500 less than the gas unit. As above, the specifics will vary from dwelling to dwelling based on choice of hot water system and also on hot water consumption patterns.
- As noted above, induction cooktops and gas cooktops have prices that vary very widely, with that variation having little or nothing to do with their relative energy performances. Broadly their pricing falls within the same range and there is no premium that necessarily has to be paid for an induction cooktop. Running costs over a 15-year period, in a domestic setting, are also estimated to be similar. Induction cooktops cost less to run per hour, but they run for relatively few hours per year in a household kitchen. This is unlike a commercial kitchen where the hobs may run very long hours per day, giving the induction hob a distinct advantage. In a household setting, the two solutions are likely to be about cost-neutral, again depending upon the stylistic and brand preferences of the households.

Note that we assume in this study that few households will choose new gas ovens, and that most residential ovens are already electric.[58]

The policy or initiative/campaign that is modelled for residential has two components, both of which are assumed to commence in FY2024:

1. no new gas connections
2. no like-for-like replacement of gas appliances which reach the end of their operational life.

57. To illustrate, SPR found examples of four-burner gas hobs costing $203 or up to $4,995. Brand names and aesthetic characteristics appear to be the primary determinants of price, while energy performance appears to bear little or no relationship to price.

58. However, statistics in this area are not available, and it is likely that Victoria would have a higher share of legacy gas ovens that other states. Gas ovens are also still available for sale in Australia.

No new gas connections simply means that all new dwellings use only electricity, but that existing dwellings with gas connections can continue to use gas and can also replace a gas appliance with another gas appliance at end of life, should the owners wish to do so.

If every gas-using household did this, the number of gas appliances in use would remain constant at the level in 2024. In fact, the number would gradually decrease because each year a certain number of dwellings is removed (demolished) and replaced by new dwellings. No adequate data is available to estimate annual dwelling removal numbers, which means that the modelling of this scenario must rely on net, not gross new dwelling constructions. Hence the modelling somewhat under-estimates annual numbers of gas replacements, and hence the rate at which total numbers of gas appliances decrease.

No like-for-like replacement means the number of appliances replaced in 2024 is equal to the number installed as replacements in 2004 plus appliances installed in new dwellings in that year. The dwelling stock model used for this study extends back to 2001, meaning that it can be used to estimate the number of new gas appliances in each year from 2004 onward. In each modelled year, starting in 2024, the number of gas appliances replaced is the number installed in new dwellings in 2004, plus the number in older dwellings reaching the age of 20 years in 2004.

As a simplifying assumption, to avoid the need for further regress, the number of existing gas appliances replaced in each year from 2004 to 2023 is assumed to equal one-twentieth of 80% of the stock in that year.

For the entire modelled period, the share of dwellings with gas connections and the shares with each type of gas appliance in each state are assumed to equal the shares in 2014, and used for all the projection years, as defined above.

If the number of dwellings remained constant at the level in 2024, this policy by itself would not reduce gas consumption to zero by 2050, because gas appliances would continue to be installed in new dwellings. However, the two policies combined would reduce residential gas consumption close to zero some years before 2050, if both start in 2024.

The move to 7-star minimum dwellings from October 2023 will improve new housing energy efficiency but does not *directly* influence or determine the fuel choice for these dwellings. Also, we note that the National Construction Code does not encourage solar passive design or indeed other best practices, but only prescribes 'minimum necessary' standards. Councils have a critical role in the development planning and approval process, and could encourage appropriate solar orientation of building blocks, for example.

However, the inclusion of 'whole of home' energy budget provisions within National Construction Code 2022, which can be offset by rooftop PV, provides further encouragement for PV to be included as a standard feature on all new homes and, as a result, indirectly encourages electrification of those homes. Some houses/townhouses, and potentially a significant proportion of new apartments, however, may not be able to install sufficient PV to offset their whole-of-home energy budget requirements, due to poor solar access, poor orientation of new building blocks, or due to complications associated with strata-title apartment building management. Larger apartment buildings may also lack sufficient roof-space to provide sufficient installed PV capacity per dwelling, regardless of strata title considerations.

For these dwellings, our analysis is that heat pump hot water provides the largest and most cost-effective option for meeting the whole-of-home budget. As a result, we expect significant take-up of heat pump hot water systems in these dwellings, primarily displacing instantaneous gas systems. This too will encourage electrification of these homes.

In our model, for each year the total increase in electricity consumption and decrease in gas consumption is determined by the numbers of gas appliances of each type which are removed from the stock and replaced by an electric appliance. As time moves forward, the totals of capital costs incurred increase, until gas is no longer used, and the totals of avoided energy costs (from switching from gas to electricity) similarly increase.

Note that the avoided gas consumption cost in each year, starting from the year in which electrification incurred, includes the annual supply charge, since it is assumed that households changing either their space heating or water heating would find it more convenient to change any other gas appliance at the same time, and would also save the supply charge by doing so.

Average annual gas consumption per dwelling for space heating, in a dwelling which uses gas, is significantly larger than the corresponding average annual consumption for water heating, which is in turn significantly larger than the average for cooking.

The combination of consumption per dwelling per service and the proportion of dwellings using each service results in the following approximate estimates of the shares of total gas consumption for each service: space heating 75%, water heating 23%, cooking 2%. Clearly, space heating is the major use of gas in gas-connected dwellings. It is also worth noting that the potential, in both relative and absolute terms, for reducing gas consumption for space heating is much larger than the corresponding potential for the other gas services, because of the opportunities to upgrade the thermal performance of so many dwellings.

Figure 18 shows the reduction in emissions that would be expected over time with an accelerated campaign of electrification – for example over 15 years – compared with the reference case (AEMO Step Change), in which there is also electrification, but not as rapid. Emissions are shown to fall rapidly, reaching zero by around FY2037, as compared to FY2050 in the reference case.

At a 7% real discount rate, the NPV of the accelerated gas phase-out would be $74 million. We note that an accelerated phase-out of gas appliances, faster than their natural rate of attrition, means that costs (of electrification) that would otherwise occur later are instead brought forward in time. In present value terms, this means the cost of electrification is higher than it would otherwise be. However, the additional benefit is that greenhouse gas emissions fall faster.

The additional electrification reduces gas consumption to zero in 2035, compared with modest but continuing gas consumption in the Step Change scenario right out to 2050.

The projected more rapid closure of Victoria's three remaining brown coal power stations means that the emissions intensity of grid supplied electricity in the state falls almost to zero by 2035. Under Step Change, there is a very small continuing role for gas generation, which means that the state grid is about 99% renewable, rather than 100%.

As noted above, AEMO scenarios should not be taken as cast in stone. In fact, scenarios and forecasts are updated annually, reflecting the rapid pace of change in Australia's energy markets.

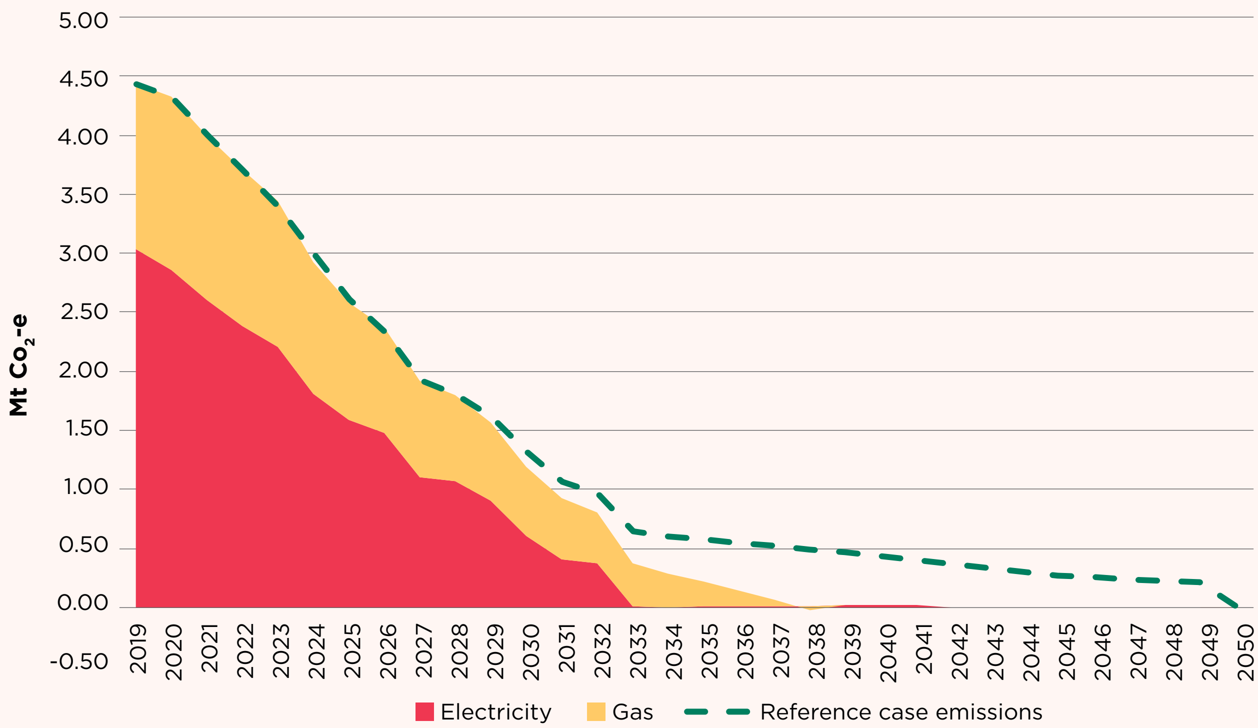

Figure 18: GSEM/SECCCA region residential sector emissions by fuel – with emission reduction measures modelled

4.2 COMMERCIAL SECTOR

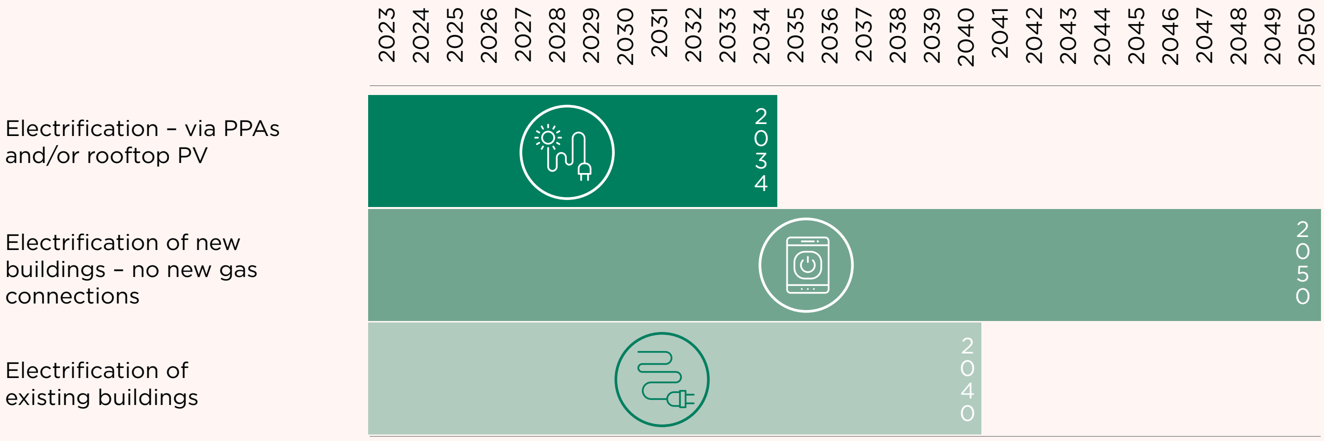

Figure 19: Emissions reduction cost-effective opportunities and timeframes: commercial sector

As noted in Chapter 3, the commercial sector in the region primarily uses electricity. Despite this, we estimate that in FY2022 some 25% of total energy consumption in this sector was natural gas. It was also noted in Chapter 3 that the emissions associated with grid-based electricity consumption are falling rapidly. As a counterpart to this, the share of greenhouse gas emissions from the sector that is attributable to gas is set to rise from around 25% in FY2022 to around 100% by FY2034. Therefore, reducing emissions associated with gas use is a critical focus for this sector, as it is for residential.

Broadly, there are two potential strategies for reducing emissions associated with natural gas use in the commercial sector. One would be to replace some or all of the fossil methane with renewably generated methane ('biomethane') or other 'green' gas (sourced from renewable energy), which may include 'green hydrogen'.

For complete emissions abatement, 100% of the fossil methane would need to be replaced by renewable alternatives. Small quantities of biogases,[59] including biomethane, are produced by the decomposition of waste organic materials, for example at landfill sites or sewage plants. Generally, such gases are flared, which converts the methane into carbon dioxide (a less powerful greenhouse gas than methane), or else they are used to generate electricity (again leading to the release of carbon dioxide – but the carbon dioxide is considered carbon neutral as it releases carbon previously sequestered in the organic materials that are now in landfill/waste processing). Green hydrogen can be generated from dissociating water into hydrogen and oxygen using renewable electricity.

59. Biogas is a generic term for gases generated from organic materials – such as the raw feedstock emerging from a landfill site, for example. Different biogases may contain differing mixtures of a range of gases. One of these gases may be biomethane. Biomethane refers to a 'cleaned' or pure methane of 100% renewable origin, not containing any CO_2 or other gases. As such, biomethane is a value-added and more expensive product.

However, as discussed in Section 3.2 above, this solution is expected to be cost-effective primarily in large industrial establishments, where the fuel consumption is large enough to justify manufacturing the green hydrogen on-site. Major investments of this kind are being announced regularly, although we are not aware that any plants are operating as yet. We consider it much less likely that green hydrogen could ever be cost-effectively distributed through the natural gas distribution network to residential or commercial customers of natural gas. For more background on this issue, see SPR's report for ASBEC.[60]

The second major approach to reducing emissions associated with natural gas use is electrification. This term refers to fuel switching from gas to electricity by replacing the gas-using equipment with a suitable electrical alternative. Where emissions reduction is the aim (or one of the aims) of electrification, the electricity must be sourced from renewable electricity, with options discussed further below.

However, noting the major transition that is now underway in the electricity market – which in Victoria's case is expected to reach close to 100% renewable electricity by around FY2033 (see Section 2.3) – electrification even using normal grid-supplied electricity is very likely to reduce emissions over time. By specifying 100% renewable electricity, the emission abatement is both accelerated and made certain.

Against this background, we consider five abatement options for the commercial sector:

1. electrification with PPAs
2. roof-top solar PV
3. electrification of new buildings
4. partial electrification of existing buildings (space conditioning only)
5. full electrification of existing buildings.

We note that we do not include amongst these options the many different opportunities to improve the efficiency of gas or electricity use. Such options are too numerous to study in this context, but also, and increasingly, their 'yield' of emissions reduction is set to fall, particularly for electricity, as the emissions intensity of electricity falls. Gas efficiency improvement opportunities are far fewer and smaller than those for electrical equipment, due to the faster rate of improvement in electricity-using technologies such as heat pumps, lamps, cooking equipment and others.

While we do not highlight these efficiency opportunities here, there are many that will be cost-effective and that will lead to at least some emissions reductions as well. More generally, the business- and policy-case for energy efficiency is changing over time.

60. SPR, *Rapid and Least-cost Roadmaps for Decarbonising Building Operations – Final Report*, October 2022.

As the climate warms, and heatwaves become more frequent, severe and longer-lasting, improving the thermal performance of housing and other buildings may be a key strategy to protecting human life, well-being and productivity, for example. Also, efficiency investments generally reduce the quantity of energy required to be consumed and, most often therefore, reduce the cost of energy consumption. Some investments can also change the time of use of energy, and of peak demand, and therefore again reduce energy costs, although this depends on the nature of the tariffs that households and businesses are exposed to.

Thermal energy sharing – for example through district heating and/or cooling systems – is common-place in Europe but almost never used in Australia. Partly this reflects our less severe climate but also a different approach to infrastructure provision and pricing. In many parts of Europe, district heating systems are supplied as a matter of course to new housing developments.

In Australia, energy market contestability rules would significantly impede such an approach, and this in turn would increase commercial risk for potential service providers. Overall, we consider it unlikely that this approach will contribute significantly to emissions abatement in Australia.

On the other hand, systems for sharing PV output and for storage of that output – such as virtual power plants (VPPs) and community-scale batteries – have better prospects, within the overall 'sharing economy'.

We note that there *could* be opportunities for more co-ordinated electrification, whether through planning for optimal electrification, strengthening limited existing provisions for customer energy sharing (such as embedded networks/retailing provisions), or – more generally – embracing a more consumer- and community-orientation, as distinct from our existing centralised, network-controlled approach. However, there are at present major barriers to these outcomes in Australia.

First, there is as yet no national policy agreement around electrification. The National Energy Law, and much energy policy, is framed around the concept of 'fuel neutrality' – the idea all fuels are effectively equivalent and should be treated equally, notwithstanding their very different consequences for the environment and climate change in particular. This – together with abolition of carbon pricing in Australia in 2014 – stands as a major barrier to recognition of the fundamental difference between clean and zero carbon fuels, on the one hand, and fossil fuels on the other.

Further, even though AEMO's Step Change scenario assumes significant customer side investment and participation in energy systems, this stands at odds with current regulatory and pricing frameworks. We acknowledge that there are some minor provisions within the National Energy Law that, for example, allow embedded networks under defined circumstances, and that require networks to at least investigate non-network solutions prior to investing in more 'poles and wires'. However, this is far from the policy environment that will be required to bring about the kind of energy system that Step Change envisages. While these issues are well beyond the scope of the current project, nevertheless the policy environment conditions behaviour and incentives in the region as well as nationally. We expect that there will be greater focus on these issues within the energy market in coming years, but note that energy market law and rules have been painfully slow to change to this point. Realistically, it may be some time before policy settings actively encourage the transition to a Step Change world.

In the following sections, therefore, we focus on the five major opportunities above – each of which is available now and not contingent on policy change.

4.2.1 Power Purchase Agreements (PPAs)

Power purchase agreements (better-know, as 'PPAs') refer to generally longer-term supply agreements made between a (renewable energy) generator and a customer (or a retailer on behalf of a customer). They can be secured on commercial terms that are negotiated, rather than transparent, so we cannot be definitive about their costs. However, intelligence from the commercial property sector indicates that PPAs are often able to be secured at no premium (even in the short term) to the alternative retail cost of electricity and, in many cases, significant price discounts have been reported. At worst, smaller commercial players may need to pay a small premium for a PPA in the short term.

PPAs offer numerous advantages over conventional electricity procurement strategies including:

- the ability to achieve zero emissions immediately
- the potential to hedge future electricity cost risks over 10 years or more, replacing that with a simple CPI-linked or other indexation basis, removing cost volatility for consumers
- the potential to *reduce* electricity costs in the short term, as well as longer term – as noted below, PPAs are being reported at costs well below current pool prices – noting that use of network costs and retail costs are likely to be incurred in addition to the energy cost

- PPAs ensure new and additional investments are made in renewable energy supply, and they can be selected to ensure that the investments and associated job creation occur in regional economies, creating local economic benefits.

In terms of PPA costs, CSIRO estimates that the levelised cost of electricity using solar PV currently sits within the range of $44 to $65 per MWh, while wind power costs range from $45 to $57 per MWh, depending on size and location. This compares to the estimated levelised cost of a *new* black coal generator of between $87 and $118 per MWh and *new* gas generation costs between $65 and $111 per MWh. These costs reflected a 'baseload' use case and a 40–80% capacity factor, with costs for peaking generators even higher due to lower utilisation.[61]

These levelised costs for utility scale, or offsite, PV/wind are generally lower than (energy) prices available from retailers, as these reflect the mix of existing generators, which in Victoria is dominated by brown coal. Thus, by purchasing a PPA, a buyer can both secure 100% new renewable energy to operate their facilities at zero emissions, and potentially pay *less* than they would otherwise have to pay.

When the value of longer-term contracts is taken into account (conventional electricity contracts are only 1–2 years in duration, preventing effective hedging of electricity price risks), then PPAs may have a negative incremental cost, and therefore a negative cost of abatement.

PPAs are not without risks or costs. PPAs can take many forms, and due diligence would be required to ensure that individual commercial customers achieve value for money, as well as meeting their emissions reduction and/or other goals. However, this strategy is proven, cost-effective and widely used in the property industry. For example, the Better Buildings Partnership (BBP) – which comprises AMP Capital Investors, Brookfield Office Properties Australia, Charter Hall, City of Sydney, Colonial First State Global Asset Management, DEXUS Property Group, Frasers Property, The GPT Group, Investa Property Group, Lend Lease, Mirvac, Stockland, JLL, CBRE, Knight Frank and Colliers International, amongst others – has a collective target of achieving zero emissions (or, in some cases, being carbon positive)[62] by 2030. BBP members are almost exclusively relying on electrification with renewable electricity (see below), as well as energy efficiency, to achieve this goal (some may also use offsets). PPAs are the primary form of renewable electricity used by BBP members, but some also use on-site renewables.

61. reneweconomy.com.au/csiro-gencost-wind-and-solar-still-reign-supreme-as-cheapest-energy-sources/

62. That is, generating a surplus of renewable energy, relative to consumption, so as to avoid their own emissions and to reduce emissions elsewhere.

This initiative on its own is significant, as BBP represents over 50% of the office floor space in Sydney's CBD and in the ACT; however, Energetics' Corporate Renewable PPA Deal Tracker notes that 'Since 2017, corporate PPAs have supported projects with a combined capacity of nearly 9,500MW, of which approximately 8,000MW enabled investment in new projects'.[63]

Thus, PPAs represent a mainstream, immediately available, highly effective and financially attractive abatement strategy.

An excellent overview of the PPA market is published annually by the Business Renewables Centre Australia.[64] The Green Building Council of Australia offers training and awareness courses with respect to PPAs.

Since there may be no cost associated with this strategy, we do not undertake any benefit–cost analysis. Rather, we recommend that commercial parties may wish to explore PPAs alongside other options as part of an optimised energy procurement and emissions-abatement strategy.

In this context, we note that SECCCA has previously explored a South East Melbourne Renewable Energy Project (SEMREP), which is documented in a *SEMREP PPA Options Discussion Paper*.[65] This project aimed to procure a PPA for participating councils within the region, with the potential for multiple financial, environmental and community benefits. There is now a completed feasibility study for this project, and the option of progressing it further remains in place.

4.2.2 Rooftop PV

The business case for onsite renewables is different from that for PPAs. On the benefit side, generation 'behind-the-meter' can displace consumption that would otherwise have to be imported from the grid, at costs that will vary according to the tariff arrangement in place. Some sites also earn generous feed-in tariffs for exports off-site, but these are generally legacy arrangements, with new contract feed-in prices being much lower.[66] Some organisations also value on-site (as compared to off-site) renewables as a visible demonstration of their commitment to environmental values. PV systems may have economic lives of 40 years or more, albeit with some degradation of output over time. However, where a building is scheduled for retirement, or may be sold, such an investment may not be warranted.

On the negative side, it can be difficult to secure network agreements for systems that are large enough to export (and, for this reason, some organisations deliberately undersize PV systems to avoid or minimise exports).

Also, where tariffs include a significant maximum demand component, the presence of PV systems onsite, on its own, may offer no or little assistance with

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63. www.energetics.com.au/insights/knowledge-centres/corporate-renewable-ppa-deal-tracker

64. See https://arena.gov.au/assets/2021/12/corporate-renewable-power-purchase-agreements-in-australia-state-of-the-market.pdf

65. Supplied by SECCCA.

66. Our analysis suggests a typical or average feed-in tariff in Victoria is around 8 c/kWh, but rates up to 20 c/kWh may be available (for limited quantities of exports).

these costs. However, it can do when combined with battery or other energy storage systems, and/or smart demand management. Some sites will not be suitable for solar, due to limited roof space availability, poor orientation, and/or over-shading, while other sites, for example in urban locations, may face future over-shading risks due to future commercial development. Commercial tenants may not be able to access the benefits of rooftop PV, except by negotiation with building owners.

The economics of onsite renewable energy systems vary, depending primarily on site-specific factors (mounting costs, suitable façade area). In some cases, older roofs may need to be reinforced to meet the extra weight of PV systems. Also, in some cases – typically with older buildings – wiring, switchboard or local distribution transformer capacity may need to be upgraded.

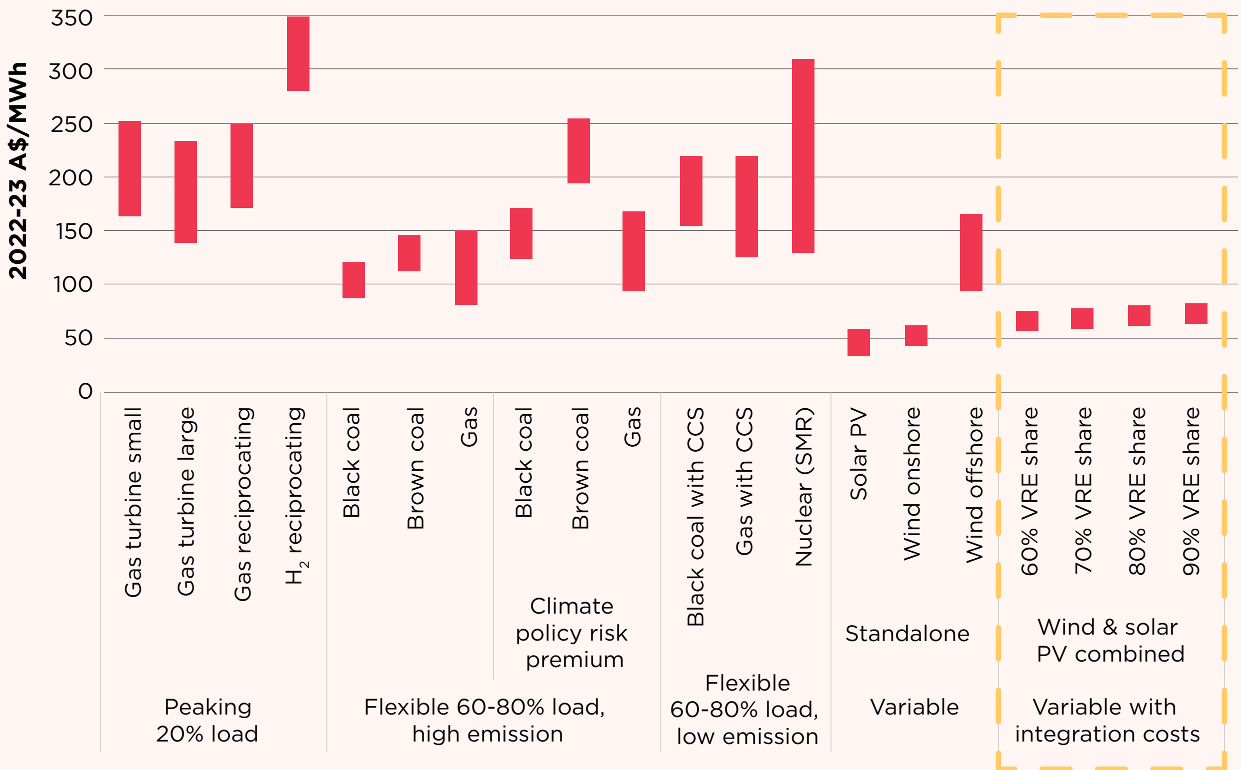

Figure 20: Levelised cost of generation by technology and category. SMR: steam methane reforming. CCS: Carbon capture and storage. VRE: variable renewable energy

However, the real costs of generation from PV systems have fallen by a remarkable extent, notably in the last decade, and PV now represents the lowest-cost form of power generation – see Figure 7, sourced from CSIRO's current *GenCost 2022–23 Consultation Draft*, December 2022, p. 33.[67] This is despite costs of all forms of new generation rising in the short term due to the global supply situation and widespread cost inflation, in Australia and elsewhere. Installation costs can be higher on commercial than residential buildings, but this effect can be offset by economies of scale for larger systems.

For this study, we model a scenario in which a goal is set and achieved of reaching (and maintaining over time) 100% of the expected maximum potential for rooftop PV on non-residential buildings in the region. Such a target may be ambitious, and we are not suggesting it should be set or achieved, but rather illustrating the costs and benefits of doing so. The maximum potential is significantly less than 100% of the roof area, as PV can compete with air conditioning plant and other rooftop uses, and some roofs are partially or wholly over-shaded.

We estimate that between 50% and 80% of buildings such as factories and warehouses could potentially be used for PV generation, depending on the building type.

First, we estimate the *total* rooftop area based on the building footprint size (area at ground level), which is generally, but not always, similar to the roof area, with footprint sizes estimated from data compiled for the 2022 *Commercial Building Baseline Study*. For the region, this is estimated at around 20.3 million sqm. Applying limits based on the likely maximum roof area available for PV, this figure diminishes to around 13.8 million sqm.

The next factor to consider is the current uptake of solar on these roofs. This is not known with precision from any readily available data sources.[68] Therefore we estimate this quantity at between 5% and 10% of the maximum available roof area, depending upon the building type, and validate these estimates with reference to AEMO's Step Change *total* rooftop PV capacity in Victoria in 2022.

This source notes that there was a total installed capacity of rooftop PV in Victoria in 2022 of 3,444 MW. Of this, some 2,040 MW is estimated to be on residential buildings – in line with Solar Victoria noting that 510,000 homes in Victoria have rooftop solar,[69] combined with an average size estimate of 4 kW for residential systems.

This implies that installed capacity on all non-residential buildings in Victoria as a whole in 2022 was around 1,404 MW.

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67. Figure 7: Commercial sector projected energy consumption by fuel, GSEM/SECCCA region, step change scenario

68. But could be established using a commercial data source, such as Geoscape Solar.

69. www.solar.vic.gov.au/victorians-embracing-solar-record-levels

Of this, we estimate that some 187 MW is installed in the region. Statistically, the AEMO data equates to an average of 5.8 kW per building across Victoria, which would imply an average for the region of around 234 MW, which makes our estimate of 187 MW slightly conservative.

Estimating the current and the maximum potential installed PV capacity means that we can then model the impact of a hypothetical measure, or campaign, that encouraged the maximum feasible degree of PV uptake on commercial buildings across the region, to be achieved in 10 years. This would see the total installed capacity in the region rising from around 187 MW to close to 1,800 MW by end of FY2032 (or FY2033, if the initiative commenced in FY2024). Annual generation from this capacity would rise from around 270,000 MWh in FY2022 to around 2.5 million MWh (2.5 TWh) by the end of the period. Annual investment over the 10-year period would increase from around $107 million in FY2024 (or year 1) to just over $140 million by year 10, as there is projected to be an increase in roof area over this period. The NPV of this investment, at a 7% real discount rate, is $888 million.

The total value of the PV output would rise from just over $34 million in year 1 to around $359 million by year 10. This assumes:

- a 0.5% degradation in PV output per year, in line with estimates from the US National Renewable Energy Laboratory (NREL)[70]
- on average, 80% of the power is used on-site and 20% is exported at an average feed-in tariff of 8.1 c/kWh
- initial installed cost of PV is $900/kW, but this is assumed to fall over time at an average of 1% per annum. Note that this arises from an increase in the expected efficiency of panels over time, in addition to the trend reduction in costs per panel or sqm of panels.

On this basis, the present value of output over the life of the installed systems is some $3,464 million. Thus, without considering any benefits for the climate, and purely on the basis of private costs and benefits, such a program would generate an NPV of just over $2.6 billion, with a BCR of 3.9. In investment terms, this would represent an IRR of 36% per annum.

Of course, there is uncertainty about the value of the PV output in the distant future, and other factors such as the rate of change in average installation costs.

70 www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html#:~:text=NREL%20research%20has%20shown%20that,climates%20and%20for%20rooftop%20systems.

Such uncertainties apply to all future forms of generation, and values can also turn out to be more favourable, rather than less favourable, than expected.

However, the economics of rooftop PV are so attractive that even if such values are less favourable in the future than anticipated, the investment economics would still be extremely attractive. The resulting emissions reductions would occur at a negative cost of abatement, since the investments required to achieve the emissions reductions create a net economic benefit, rather than a net economic cost.

Note that the above analysis does not take into account the potential to install PV on the vertical façades of buildings, as this is – currently – less cost-effective than rooftop PV. However, if façade-mounted PV becomes more cost-effective over time, this could add to the maximum PV generation potential of non-residential buildings in the region.

4.2.3 Electrification of new buildings

This analysis of the cost-effectiveness of electrification of new (and existing) commercial buildings is based on very recent and detailed analysis by SPR and DeltaQ Pty Ltd, published by ASBEC.[71] For additional background on this option, the separate SPR and DeltaQ reports[72] are recommended reading.

We first estimate the share of non-residential buildings that are currently connected to gas.

This apparently simple statistic is in fact not well established. Using Regulation Information Notices (RIN) data published by the Australian Energy Regulator, we estimate that just under 25% of non-residential buildings in Victoria are connected to gas, and so we assume the same percentage in the region. On this basis, some 12 million sqm GFA in the region would be connected to gas, rising to over 19 million sqm GFA by 2050 on a 'business as usual' basis.

The Australian Energy Regulator RIN data also suggests an average annual consumption per non-residential customer in Victoria of 327 GJ. Allowing for the share of new buildings using gas being more efficient than the older stock, and based on the Commercial Buildings Energy Consumption Baseline Study 2022[73] (CBBS 2022) study, we estimate FY2023 gas consumption would be around 382 MJ/sqm per year on average for the gas-connected sqm, although this value would be much higher for certain building types such as hospitals and major hotels. On this basis, for each annual cohort of buildings we add over 65 TJ of gas consumption to the region. By FY2050 at this rate, over 2,300 additional TJ of gas would be being consumed, assuming the same rate of usage as in the past. The present value of the cost of this gas consumption is some $316 million.

With this as a baseline, we can then test the economics and impact of hypothetical policies or scenarios.

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71 ASBEC, *Unlocking the roadmap: Why electrification is the key to net zero buildings* – www.asbec.asn.au/publications/

72. Strategy Policy Research, *Rapid and Least Cost Pathways for Decarbonising Building Operations – final report*, 14 October 2022; and DeltaQ Pty Ltd, ASBEC – *Rapid and least cost pathways for decarbonising building operations, Building-Level Technical Report*, 27 October 2022.

73 https://www.energy.gov.au/publications/commercial-buildings-energy-consumption-baseline-study-2022

For example, a scenario could be that there are no new connections permitted (or that new gas connections are strongly discouraged). In such a case, all new buildings in the region would be assumed to use electricity only. The quantity of additional electricity consumption is estimated to rise from around 4,500 MWh in FY2023 to 157,000 MWh in FY2050, assuming an average co-efficient of performance for heat pumps (replacing gas boilers) of 4. The present value of the cost of this additional electricity (assuming it is purchased on grid-average prices, as compared to PPAs or self-generation) is $188 million, with the NPV of net energy cost savings (that is, the present value of gas savings less the present value of additional electricity consumption) valued at $128 million ($316 million less $188 million).

In terms of the capital cost of electrifying these new builds, DeltaQ estimate a per-sqm cost of $33.40, but this is based on large (10,000 sqm) hotels and offices, where the average gas consumption intensity is much higher than estimated for the region on average. We therefore factor down both the average gas consumption intensity and the incremental cost by 382/588 MJ/sqm per year (the difference in the two gas intensity estimates), resulting in an average incremental cost estimate of $17.38/sqm to avoid the average of 108 MJ/sqm per year of gas consumption.

These incremental costs are assumed – based on the DeltaQ advice – to fall over time, primarily as heat pump efficiency rises and costs (per unit performance) fall.

On this basis, the incremental capital costs have a NPV of a little over $35 million. This would mean an NPV for the measure or scenario of just under $93 million ($128 million less $35 million) at a BCR of 3.6, equivalent to an IRR of 27%.

The qualifications that apply to this analysis are primarily that it is based on averages which will vary considerably in individual cases. For example, for the more gas-intensive and larger non-residential buildings, DeltaQ found that electrification may not be cost-effective, or only marginally so. If we assume the full 588 MJ/sqm per year of gas intensity, and the full incremental cost of $33.40/sqm, as estimated by DeltaQ as a Victorian average for such large buildings, our analysis is only just above a break-even – that is, a BCR of 1.0. The better economics found above for this measure or scenario reflect the fact that gas usage in reality is more mixed – some buildings use it for cooking only, some for hot water only, some for space-heating, or supplemental space heating, or for a mixture of the above, and other minor end-uses. If the average gas intensity in commercial buildings is lower, as the Commercial Buildings Energy Consumption Baseline Study 2022[74] (CBBS 2022) study suggests, then the scale of the investment required for electrification is proportionately smaller.

74 https://www.energy.gov.au/publications/commercial-buildings-energy-consumption-baseline-study-2022

DeltaQ note that electrification of new buildings at the design stage is invariably much more cost-effective than electrifying existing buildings, as incremental changes (such as the diameter of piping, which will typically be larger for heat pump–based systems than for gas-based systems, can be priced at just the marginal cost of the thicker pipe.

By contrast, if an existing building requires heat distribution pipes to be replaced post-construction, the cost of doing so is likely to be prohibitive. Similar considerations apply with plant room sizing and configuration, which can readily be adjusted at the design phase, but which may be expensive or (in some cases) impractical post-construction, due to physical space limitations in existing plant rooms.

Overall, we conclude that a policy (or initiative) that aimed to encourage 100% electric new commercial buildings in the region would be cost-effective, as noted above, even if that may not be the case for every building. In terms of emissions reductions, this measure would lead to net emissions savings (that is, avoided gas emissions less additional electricity emissions) that would be negative in the first two years, but quickly turn positive as the emissions intensity of electricity falls, reaching 116,000 t CO_2-e by FY2050. Cumulative emissions savings over the period to FY2050 are estimated at just over 1.4 Mt CO_2-e.

4.2.4 Partial electrification of existing buildings

This analysis again draws on the ASBEC reports by DeltaQ and SPR, this time focusing on the electrification of space heating only in existing non-residential buildings. This topic is dealt with at much greater length in the DeltaQ report[75] for those wishing to explore this option in more detail.

We also note that the DeltaQ analysis was limited to certain building types, and individual builder owners will need to undertake their own site-specific analysis to determine expected costs and benefits in their own cases.

In this analysis, we assume that in addition to a policy (or campaign) of 'no new gas' (no gas used in new buildings), a policy or campaign is introduced that aims to see gas use in existing non-residential buildings phased out over 20 years. The choice of 20 years reflects the idea that the policy could be 'no like-for-like replacement' of gas-using equipment in existing buildings at the end of the economic life of existing gas-using equipment. This means that no existing investments in gas would be stranded ahead of full depreciation of the equipment in question. This means that only any incremental cost associated with electrification *at the time of scheduled replacement* would be incurred. Of course, it would be possible to encourage faster phase-out of gas, and this could occur in any case due to market forces and preferences, for example if the price of gas rises rapidly over time.

75 Strategy Policy Research, *Rapid and Least Cost Pathways for Decarbonising Building Operations – final report*, 14 October 2022; and DeltaQ Pty Ltd, ASBEC – *Rapid and least cost pathways for decarbonising building operations, Building-Level Technical Report*, 27 October 2022.

For this analysis, we again start from the estimate of a little under 12 million sqm of non-residential buildings in the region using gas in 2022, as discussed in the previous section. Assuming no new gas buildings, the task modelled is to electrify this floor area over 20 years; that is, just under 600,000 sqm GFA on average each year.

The cost per sqm of this task, as estimated by DeltaQ, is higher than for new builds, with their original estimate averaging $222/sqm over the building forms analysed. However, as above, these modelled forms were much more gas-intensive than the average (gas-using) building in the region. Therefore we again factor down both gas intensity and capital costs, resulting in an estimate of $125.96/sqm on average. We note that the DeltaQ report referenced highlights that costs will vary widely from building to building, and so again we stress that building owners need to prepare individual site business cases. The present value of the incremental capital costs would total around $75 million in year 1, falling over time due to the 4%/year assumed learning rate or real cost reduction), equating to an NPV of $535 million.

In the Business As Usual (BAU) case, if the 12 million sqm continued to use gas at historical levels, close to 4 PJ of gas would be used per year (space conditioning only), with an annual cost (in FY2024) of around $123 million, although current AEMO input assumptions (which are likely to be revised soon, most likely upwards) show falling real gas prices over time, and therefore a lower cost of gas consumption. On those assumptions, the present value of gas consumption under BAU conditions (but assuming a policy of no new gas) would be around $1,365 million (but higher if gas prices increase over time).

The assumed 20-year phase-out of gas leads to both gas consumption and cost savings, but also to additional electricity use and associated costs. Based on the BAU level of gas use, and assuming an average electricity-to-gas conversion ratio (or co-efficient of performance) of 4, this additional electricity consumption would be around 278,000 MWh per year. The cost of this additional electricity consumption would be over $59 million in the first year, falling over time in line with the projection of falling electricity prices. The present value of these additional electricity costs is around $790 million. Deducting the additional electricity costs from the avoided gas costs, the present value of net energy savings would be $575 million ($1,365 million less $790 million). The NPV of this policy or initiative would thus be around $40 million ($575 million less $535 million), with a BCR of 1.1 and an IRR of 8.4%. That is, the measure is estimated to be cost-effective (IRR = 7%), but modestly so. This result implies that some buildings will be cost-effective to electrify and others not, which is consistent with DeltaQ's findings for ASBEC, and it underscores the need for due diligence by individual building owners.

However, the measure if implemented would yield important greenhouse gas emission reductions of just under 2 Mt CO_2-e over the period to FY2050. Importantly, by focusing on gas emissions (which were noted to comprise 100% of the sector's emissions post-FY2033), it would contribute materially to achieve zero emissions for the sector by 2050.

Of course, neither GSEM nor SECCCA can determine the extent to which existing buildings in the region are electrified. However, they could encourage building owners to explore the economics of the option, and it could also campaign for state and/or federal government policy and/or funding support for such an outcome.

4.2.5 Full electrification of existing buildings

In this context, full electrification refers to electrification of space heating, hot water and cooking end-uses of gas in non-residential buildings in the region. An additional advantage of full electrification for the building owner is that they avoid the annual gas connection fee, which otherwise continues to apply in the case of partial electrification.

This analysis is very similar to the above, again drawing on the DeltaQ[76] analysis for ASBEC,[77] and factoring their modelled values for gas intensity and incremental cost down to reflect the average gas intensity for the region based on the Commercial Buildings Energy Consumption Baseline Study 2022[78] (CBBS 2022). However, the factored down average incremental cost of electrification is a little higher, at $140 per sqm – due to the additional end-uses to electrify – and the average gas use intensity is also a little higher (at 382 MJ/sqm per year). This leads to an incremental capital cost of electrification of close to $84 million in year 1, but again falling over time, with an NPV of just under $598 million.

In this full electrification version, the avoided present value of gas consumption is also higher at $1,567 million, with additional electricity consumption costs having a present value of $907 million. This means that the present value of net fuel cost savings is $660 million ($1,567 million less $907 million). Deducting away the present value of incremental costs (just under $598 million, as above), then the full electrification initiative would be cost-effective, with an NPV of $62 million ($660 million less $598 million), a BCR of 1.1 and an IRR of 9.1%. While these results are still modest, we find that full electrification is, on average, likely to be both cost-effective and more cost-effective than partial electrification. The yield of emissions abatement would also be higher than for partial electrification, with a cumulative total of just under 2.2 Mt CO_2-e. Perhaps more importantly, this measure, in combination with no new gas, would have the potential to reduce commercial sector emissions to zero by 2050.

76. Strategy Policy Research, *Rapid and Least Cost Pathways for Decarbonising Building Operations – final report*, 14 October 2022; and DeltaQ Pty Ltd, ASBEC – *Rapid and least cost pathways for decarbonising building operations, Building-Level Technical Report*, 27 October 2022.

77. See www.asbec.asn.au/publications, Unlocking the roadmap: Why electrification is the key to net zero buildings, December 2022, and supporting reports by SPR and DeltaQ Pty Ltd.

78. https://www.energy.gov.au/publications/commercial-buildings-energy-consumption-baseline-study-2022

4.2.6 Commercial sector emissions trajectory with measures

Figure 8 in Chapter 3 set out the reference case emissions trajectory expected for the commercial sector in the region under AEMO Step Change assumptions. Figure 16 below shows the cumulative effect of the following measures, modelled above, in reducing reference emissions:

1. Maximum rooftop PV
2. No new gas (no gas in new buildings)
3. Full electrification of existing buildings over 20 years.

As discussed in Section 3.2.1, the overwhelming factor driving down emissions in the reference case is the expected rapid reduction in the emissions associated with the consumption of electricity in Victoria. Traditionally, Victoria has had the highest greenhouse gas emissions intensity of electricity consumption of any state in Australia, due to its extensive use of brown coal as a power generation fuel. However, following the assumptions in AEMO's ISP,[79] all of these plants – which are already very old – are expected to be completely phased out by around FY2033. In practice, it might be a little earlier or later, but the overall trajectory is clear. This capacity is expected to be replaced primarily by renewable energy supported by additional energy storage and strengthened interstate transmission systems. It is possible that some additional gas peaking capacity could be added to the mix. However, even if this does occur, such a plant is extremely expensive to run per hour and is generally only run for a small number of hours per year when pool prices are sufficiently high to justify this. Generally in the future, we expect the grid in Victoria and other states to operate at close to 100% renewable energy share, but gas may be called on to support the grid from time to time.

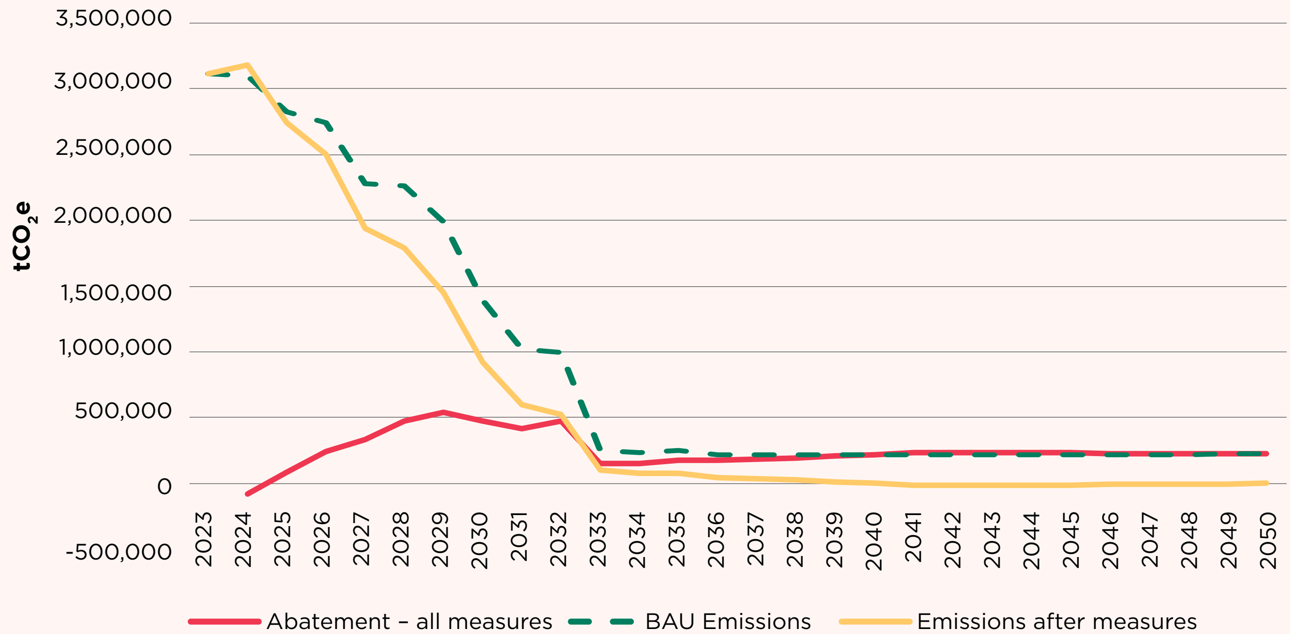

Figure 21: Commercial sector emissions trajectory with emission reduction measures modelled

79. https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp, viewed online 23/05/2023.

It may be noted that these measures would create abatement additional to that expected under the reference scenario, with earlier reduction in electricity-related emissions, due to extra PV uptake, and with a steady reduction in gas emissions, due to electrification in new and existing buildings.

If the measures or initiatives rolled out as modelled, then commercial sector emissions could reach zero by around FY2041. This reflects both the reduction in the emissions intensity of electricity consumption, and also that a planned 20-year phase-out of gas could in fact occur in less than 20 years, as some of the gas-using buildings are likely to be retired (demolished or converted) at the end of their economic lives during this period in any case.

Taking the three initiatives shown above together, total annual investments of around $200 million are modelled across the region in the first 10 years (due to rapid PV uptake), which then fall significantly thereafter (for progressive electrification of new and existing buildings). The resulting energy savings (and PV output) have a value rising to around $400 million per year by around FY2033.

The net cash flow would be positive by FY2028, with the NPV (or net benefit) of the package being some $2.6 billion, with an overall BCR of 2.8 and an IRR of 33%.

Thus while elements of the investments are only marginally cost-effective on average (notably, electrification of some existing buildings) – implying that not all buildings will be cost-effective to electrify – overall, the investments required to achieve zero emissions in the region's commercial sector are cost-effective and financially attractive. It is, however, likely that some policy support will be required to induce owners to electrify buildings in the cases where the return on investment for that activity is poor.

4.3 INDUSTRIAL/MANUFACTURING SECTOR

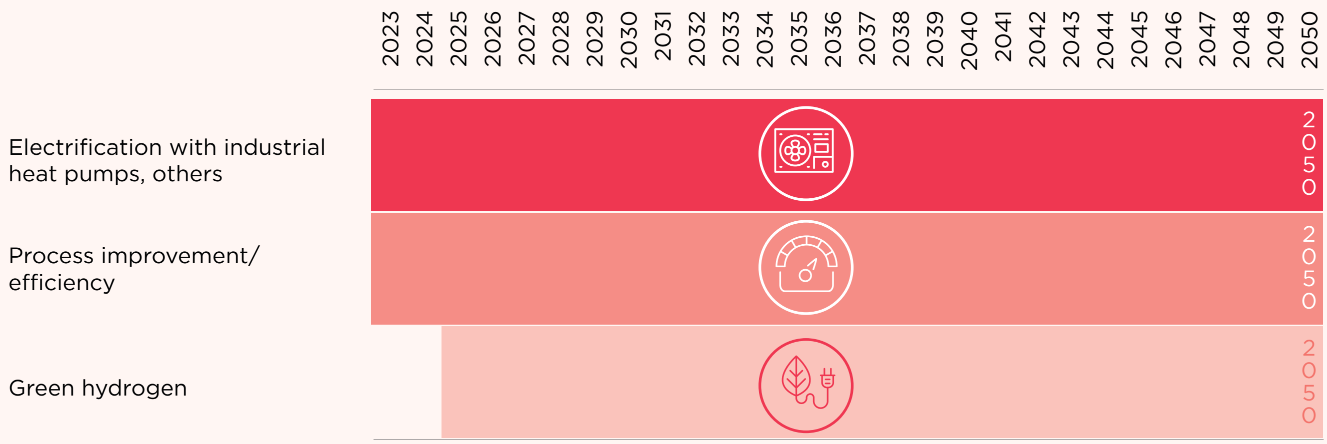

Figure 22: Emissions reduction cost-effective opportunities and timeframes: industrial sector

Chapter 3 noted that the future path of industrial sector emissions in the region is difficult to predict, at least without a far more detailed study than this one. However, the absolute size of current or even future emissions in the region from this sector may be less important than:

- the availability of cost-effective and high-impact emissions reduction measures that are relevant to industrial enterprises in the region
- the incentives for investing in these measures over time, whether they arise from relative changes in fuel prices, technology costs, competitiveness pressures, government incentives and policies, corporate emissions policies/ disclosure commitments, or some combination of the above.

Broadly, we can categorise the abatement opportunities by fuel type and process type (or end-use). Most manufacturing processes require some use of thermal energy (heat); many require very large quantities of heat. Thermal energy used directly or indirectly in an enormous variety of manufacturing processes is the major use of natural gas by the manufacturing sector.

Natural gas is a fuel which can be very easily controlled in combustion equipment and is much cleaner than alternative fossil fuels to store, handle and burn. It is for these reasons that once natural gas became widely available in Australia, during the 1970s, it replaced the fossil fuels previously used (fuel oil, heating oil, coal and coal briquettes) almost as quickly as gas distribution networks could be built.

This was particularly the case in Victoria, where natural gas was cheaper and more abundant than anywhere else in Australia. Use of coal is now confined to a relatively small number of mostly large manufacturing establishments, in situations where it still has a cost advantage and where its more demanding handling and pollution control requirements can be accommodated.

Gas is primarily used for steam raising in boilers – although there are many other applications such as 'direct firing' (heating) with gas – with the steam then distributed for use in a range of applications, at different temperatures, sometimes with heat recovery. Such plants are highly integrated and designed for 'cascading' use of progressively lower temperature heat in a series of processes. The overall energy efficiency of such a system can be low, with boilers generating steam at higher temperatures than actually required for end-uses, and with significant losses in heat distribution and recovery processes.

A report by the Australian Alliance for Energy Productivity (A2EP) notes:[80]

> Steam systems are notoriously inefficient. They have excessive losses in most cases due to poor insulation of lines, failure to recover all available condensate, condensate heat losses, boiler blowdown losses, leaking steam traps and steam leaks. Boilers themselves typically have 15%+ losses in flue gases and radiation losses, unless they have installed condensing economisers and are kept in very good tuning with flue gas monitoring and control systems. They also suffer turndown and cycling losses at lower loads and respond slowly to changed operating conditions. Standby losses are also typically significant. So, few centralised boiler systems are much more than 60% efficient, and some barely achieve 25% efficiency overall, though this is seldom recognised due to lack of gas and steam monitoring and data.

At the same time, the integrated nature of many industrial plants can present a barrier to electrification, unless new investments or major reinvestments in existing plants are occurring.

80. A2EP, *High Temperature Heat Pumps for the Australia Food Industry – Opportunities Assessment*, August 2017.

4.3.1 Electrification with industrial heat pumps

Until recently, large scale use of electricity to provide heat (or, more precisely, non-motive energy) for manufacturing has been confined to a few specialist applications. These include electrolysis, for some chemical and metallurgical processes, notably aluminium smelting, and electric arc furnaces, for secondary steel making and a few other metallurgical processes.

Recent years, however, have seen a rapid development of industrial heat pump technology, capable of heating water in small/medium industrial scale volumes to temperatures up to 180°C.[81] There have also been significant developments in other technologies capable of delivering process heat at higher temperatures. For example, a major report by Beyond Zero Emissions, *Electrifying Industry* (2018),[82] surveys five categories of electrical heating technologies:

- industrial heat pumps
- electromagnetic heating – infrared, induction and microwaves
- electric furnaces – resistance, arc and plasma
- renewable hydrogen produced by electrolysis
- heat storage – storing electricity as heat.

While there may be specialised applications for all of these, the most readily available option today is industrial heat pumps. The A2EP report[83] cited above noted that industrial heat pumps were developing rapidly – as indicated by the maximum reported temperature 5 years ago being 150°C, cf. 180°C today.[84] It also noted that the economics of industrial heat pumps were being aided by rising natural gas prices, and this is even more the case today. It found that the most economically attractive applications occur where heat pumps can be used to upgrade heat from waste streams and/or capture latent heat (like wastewater, hot humid air (e.g. from dryers), condenser heat from refrigeration systems), and where simultaneous heating and cooling duties can be delivered. Typical applications of high temperature heat pumps (in the food industry) include:

- food drying and washing processes, where the heat pump cool side captures latent heat in exhaust stream, as well as sensible heat to provide hot, dry inlet air, water or steam at the required temperature
- heating process or cleaning water by upgrading waste heat from a waste heat stream or a refrigeration system
- pasteurisation where the heat pump may provide heating and cooling duties to displace steam.

81. www.pv-magazine.com/2021/08/19/the-worlds-hottest-heat-pump/

82. Beyond Zero Emissions, Electrifying Industry, 2018.

83. A2EP, *High Temperature Heat Pumps for the Australia Food Industry – Opportunities Assessment*, August 2017.

84. www.airah.org.au/Content_Files/Industryresearch/19-09-17_A2EP_HT_Heat_pump_report.pdf

Increasingly, however, a key benefit is the fact that these devices can be supplied with 100% renewable electricity (for example, via a low-cost and predictable PPA), enabling zero-emissions operations as well as insulation from unpredictable fuel cost changes as discussed on pp 61–62 above.

The economics of industrial heat pumps are highly dependent upon the process requirements, such as the required temperature lift relative to a waste heat stream, as well as relative gas and electricity prices. However, an example included in the AIRAH report (p. 25)[85] indicates cost savings of between 50% and 75% per kWh of hot water requirement – see Table 7.

4.3.2 Green Hydrogen

Green hydrogen refers to hydrogen produced by hydrolysis of water using renewable electricity. Such a fuel would be considered zero carbon – as distinct from ‘blue’ or ‘brown’ hydrogen (produced by steam reforming of natural gas or brown coal, respectively) where emissions are likely to be higher than from use of the input fuels.

Table 7: Industrial heat pump vs gas boiler cost-effectiveness for water heating

Hot water requirement	Energy source	Efficiency: avg COP	Energy consumption	Cost of source	Cost of hot water requirement	Heat pump savings
1 KWh	Natural Gas Boiler	0.33-0.8 delivered	1 KWh / 0.8 = 1.25-3 KWh	$12/GJ = $0.0432 /KWh	1.25-3 KWh x $0.0432 / KWh = $0.054-0.13	
1 KWh	Water Cooled Heat Pump	6.0	1 KWh / 6.0 = 0.167 KWh	$0.15-$0.18 / KWh	0167 KWh x $0.15-$0.18 / KWh = $0.025 – $0.03	44 – 75+% At COP 4, 17-50+%

85. www.airah.org.au/Content_Files/Industryresearch/19-09-17_A2EP_HT_Heat_pump_report.pdf

While our study for ASBEC[86] found that green hydrogen is not likely to be competitive with other fuels if distributed through the natural gas transmission/distribution network, it also found that it is likely to become competitive with – and potentially cheaper than – natural gas in terms of production cost. This reflects:

- the extensive research, development and commercialisation efforts being undertaken in Australia and elsewhere, with a key focus on cost reduction
- the expected (continued) reduction in the levelised cost of (new) renewable electricity generation, which is a key input into the production process.

CSIRO's *National Hydrogen Roadmap*,[87] for example, sets out technical roadmaps that would support the achievement of the Australian Government's target of $2/kg production cost in coming years. That said, there are no commercial-scale green hydrogen plants yet operating in Australia. However, the Australian Renewable Energy Agency (ARENA) has committed funding to the first such plant, to be built in the Pilbara region of Western Australia. Hydrogen from this facility will be used to make ammonia for production into nitrogenous fertilisers.[88] Mining entrepreneur Andrew Forrest is investing in green hydrogen for the production of 'green metals', and targets manufacturing 15 million tonnes a year of green hydrogen by 2030.[89]

A technical advantage of hydrogen for the manufacturing sector is that it can be combusted at very high temperatures.[90]

This may then provide an option to replace natural gas combustion in high-temperature applications. Research by DeltaQ Pty Ltd for ASBEC[91] confirmed the gas industry's expectation that hydrogen-using equipment, or 'hydrogen-ready' equipment, is not likely to attract a cost premium compared to natural gas versions of the same equipment. The practical and economic questions are:

- When will this solution be commercially available?
- What will be the levelised cost of production at that time – vis-à-vis the cost of natural gas?

These questions are, as noted, the subject of intense research and development, and the answers are likely to emerge in coming years. While this option may not, therefore, be available to manufacturers in the region in the short term, it is an option that may be suitable and cost-effective for larger sites and high-temperature applications. In the meantime, electrification of all feasible end-uses, with industrial heat pumps and/or other approaches (as set out in the BZE study reference)[92] provides an immediately available emissions reduction approach, which, subject to site-specific due diligence, could also be cost-effective today, particularly when combined with low-cost PPA-sourced electricity.

Self-generation of electricity from PV (or wind) may be an option for some manufacturers, but these solutions are generally more feasible in more remote and less densely populated locations.

86.ASBEC, *Unlocking the roadmap: Why electrification is the key to net zero buildings* – www.asbec.asn.au/publications/

87. www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/csiro-futures/energy-and-resources/national-hydrogen-roadmap, viewed online 24 July 2022.

88. arena.gov.au/blog/australias-first-large-scale-renewable-hydrogen-plant-to-be-built-in-pilbara/

89. www.washingtonpost.com/climate-solutions/2022/11/24/twiggy-forrest-green-hydrogen/

90. A stoichiometric adiabatic flame temperature of 2,182°C, compared to natural gas which has an adiabatic flame temperature of 1,937°C – cea.org.uk/practical-considerations-for-firing-hydrogen-versus-natural-gas/

91. ASBEC, *Unlocking the roadmap: Why electrification is the key to net zero buildings* – www.asbec.asn.au/publications/

92. Beyond Zero Emissions, Electrifying Industry, 2018.

4.4 TRANSPORT SECTOR

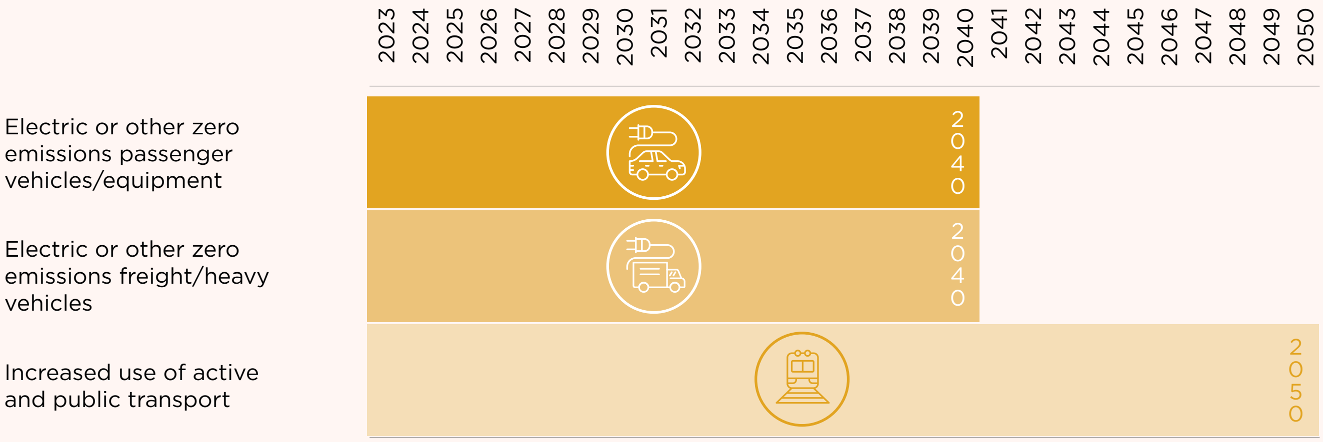

Figure 23: Emissions reduction cost-effective opportunities and timeframes: transport sector

4.4.1 Land Transport – cost-effectiveness under the reference scenario

Emissions are expected to reach zero for passenger transport and fall significantly for freight transport under the reference scenario. This is largely driven by a switch from ICEVs to ZEVs.

Initially, the transition to ZEVs will come at a cost, as electric vehicles generally have a purchase price premium over their ICEV counterparts. The upfront price premium is partially offset by lower running costs. For some buyers of EVs there will already be parity in TOC terms, particularly at the luxury end of the market, where a Tesla has a roughly similar price to a Lexus for instance or where annual kilometres travelled is very high.

TOC parity between ICE and ZEV cars, on a fleet average basis, is expected by around 2028 by CSIRO.[93] We project LCVs to reach TOC parity by 2028, with parity in Europe expected from 2025.[94]

For medium trucks, TOC parity is projected to occur in 2032, with parity expected in Europe before 2030. Heavy trucks are projected to hit price parity by 2035 with no payload penalty.[95]

The net effect across the motorised transport task for the region is that by 2035, ZEVs will be cheaper to own than ICEVs. Thereafter considerable savings will be available through ownership of ZEVs.

The present value of the cost to the owners and managers of ZEVs up to 2035 is estimated to be around $205 million. This is the additional cost of undertaking the region's transport task with the projected fleet make-up of ZEVs rather than ICEVs.

93. CSIRO, *Electric Vehicle Projections, 2021*

94. International Council on Clean Transportation (ICCT), *Electrifying Last-Mile Delivery: A total costs of ownership comparison of battery electric and diesel trucks in Europe*, June 2022

95. ICCT, *Long-haul battery electric trucks in Europe*, 2022 and ICCT, *The role of hydrogen in decarbonizing the heavy-duty vehicle sector in Europe*, 2022

The take-up of ZEVs will avoid large quantities of carbon dioxide. This benefit is valued at $370 million. The further benefit of avoided air pollution is valued at $502 million. Air pollution values are sourced from Transport for NSW.[96] Greenhouse gas values per tonne are based on valuations from the Climate Change Authority.[97]

The NPV of the reference scenario out to 2034 is $667 million at a discount rate of 7%. The BCR is 4.3. Annual costs and savings to 2034 are shown in Figure 24.

The projected reference case shift to ZEVs by 2035 is therefore highly cost-effective from a community perspective. The continuing shift from 2035 will deliver net cost savings to vehicle owners and avoid increasing quantities of air pollution and carbon dioxide.

4.4.2 Land transport – opportunities for further emissions reductions

Land transport emissions could be reduced further and faster than the reference scenario.

The key opportunities and their outcomes are:

- a faster shift to light ZEVs to hit zero emissions earlier than 2050 for passenger transport.
- a faster shift to medium and heavy ZEVs to achieve zero emissions for all freight transport by 2050.
- increased uptake of active and public transport to improve the overall sustainability and cost-effectiveness of the region's transport system.

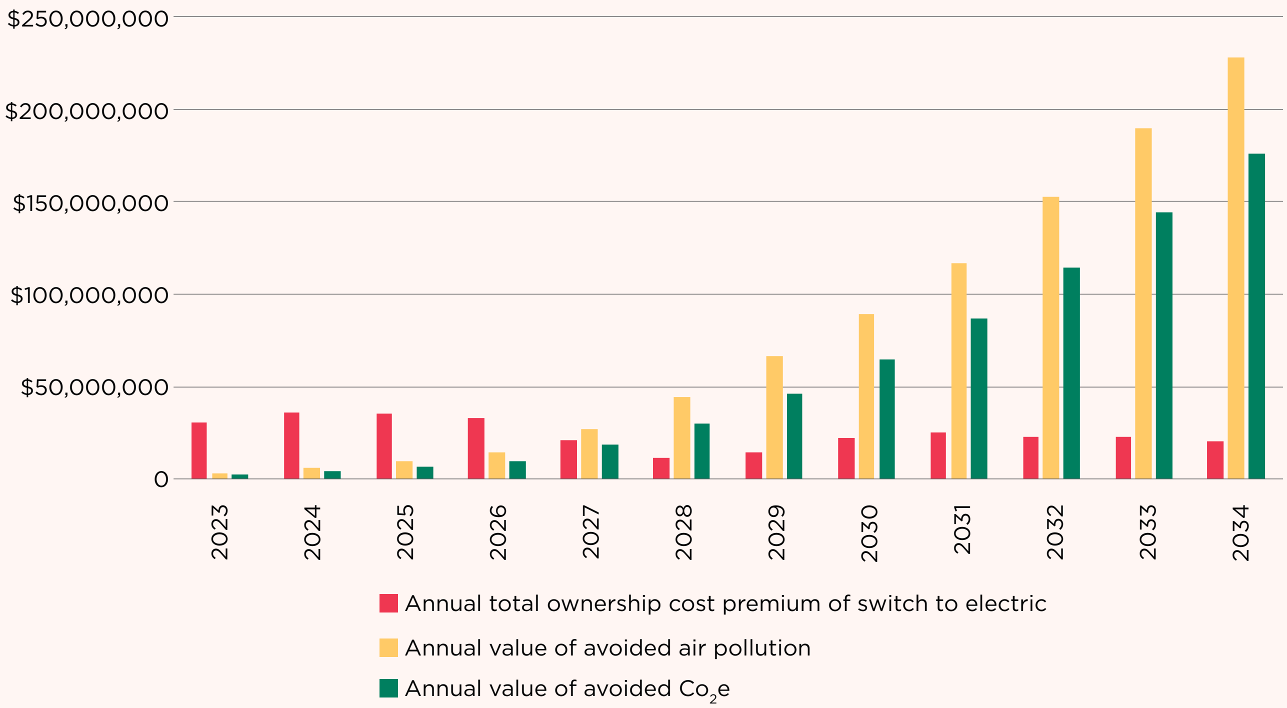

Figure 24: Transition to zero emissions transport – ownership costs vs avoided CO_2 emissions and air pollution

96. TrNSw, *Economic Parameter Values 2022*

97. Targets and Progress Review | Climate Change Authority

The trajectory of transport emissions under a scenario where these broad opportunities are taken is shown in Figure 25.

Speeding the shift from ICEVs to ZEVs

Given that the transport of both passengers and freight is almost entirely reliant on ICEVs at present, the scale of the challenge to transition to zero emissions is considerable.

The technology needed for the transition is already available – or is very likely to be available by 2030.[98] However, the vehicle industry is global and on this global level we are still very far from a point where ICEVs are no longer built, and ZEVs are manufactured in sufficient quantities to perform all motorised transport tasks. This has three major implications for Australia and for the region.

Firstly, governments in Australia need to join global efforts to push the international vehicle industry to phase out manufacture of ICEVs in favour of ZEVs. At present, even if there was a collective decision among vehicle buyers in the region to shift to ZEVs, there would not be enough ZEVs available to meet transport demand.

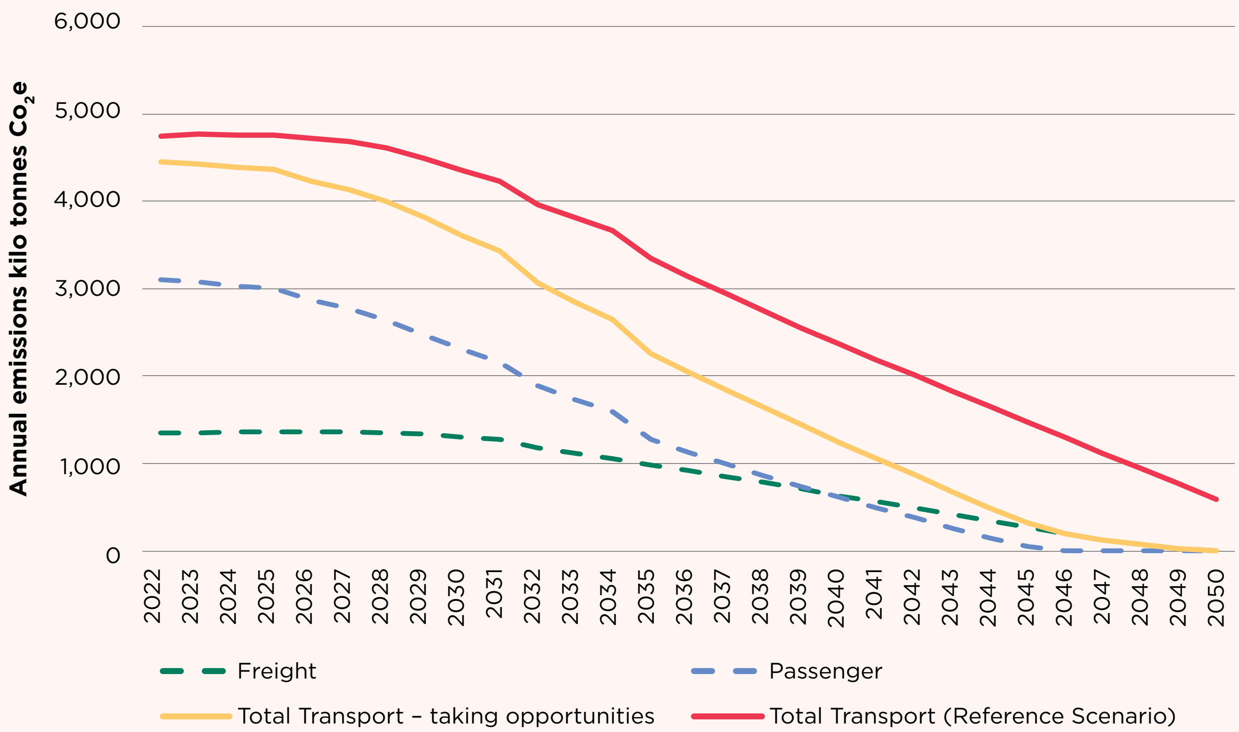

Figure 25: Emissions from freight, passenger and total transport – reference vs further opportunities scenarios

98. IEA 2022

Secondly, governments and vehicle buyers in Australia must introduce policies that ensure that global production of ZEVs is diverted to the Australian market. At present, the lion's share of ZEVs goes to markets like Norway and California where policies favour the purchase of ZEVs. This is stalling the uptake of ZEVs in Australia, simply because vehicle availability is short of demand.

Thirdly, GSEM/SECCCA councils, households and businesses need to introduce policies and make purchase decisions that ensure that the region is proactively moving to zero emissions transport.

While the CSIRO has developed a scenario for Australia (adopted here as the reference scenario) whereby passenger transport is zero emissions and freight transport well on the way by 2050, the probability of this occurring is not high. At present, vehicles in Australia are on the road for an average of 15 years – and some operate for over 40 years.[99]

It follows that zero emissions in 2050 will only be reached if new ICEVs cease being available for sale by 2035. Even then it is likely that some buyback/scrapping measures, or the banning of liquid fossil fuel sales, will be needed to get ICEVs off the road by 2050.

Given the likelihood that Australia as a whole will not have zero emissions transport by 2050, the region will have to make additional effort to ensure that this target is hit.

Within and beyond the major points discussed above, there are numerous issues and barriers involved in the shift from ICEVs to ZEVs. These, along with the main players involved in addressing these issues, and the ways to overcome barriers are summarised in Table 8.

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99. Grattan Institute 2022, *The Grattan truck plan: practical policies for cleaner freight*

Table 8: Barriers and routes to a swift adoption of zero emission vehicles

What (barrier or issue)	Who (has control over the issue)	How (can the issue be addressed)
Insufficient supply of ZEVs	Industry	Change production from ICEVs to EVs.
	National Governments	Force change through emissions standards or similar regulatory measures.
	Governments	Incentivise change by creating ZEV demand – introducing policies that favour private purchases of ZEVs over ICEVs.
Upfront cost premium of ZEVs	Vehicle industry	Scaling up production/achieving economies of scale along with continued innovation and refinement.
	State and Federal Government	Reduce government-imposed costs (taxes/fees) on ZEVS.
	Local Government	Provide incentives that compensate for higher cost – e.g favourable parking access, lower parking costs, access to low emissions zones.
Driving Range	Vehicle industry	Continued innovation and refinement to supply a wider range of vehicles with appropriate range – from 200 to 600 km+.
Recharging infrastructure	Federal and State Government	Provide consistent policy and standards to support industry investment, and provide charging where no commercial case is likely.
	Charging/ refuelling Industry	Supply services to meet growing demand.
	Local Government	SECCCA has the excellent *Electric Vehicle Charging Roadmap*[100] – its suggestions and recommendations should be adopted.
Availability of ZEVs for every transport task	Vehicle industry	Continued innovation and refinement to supply a wider range of vehicles for a variety of purposes. Light vehicle types that currently lack a ZE version include an inexpensive hatchback, a ute that combines towing ability and range. Medium trucks are being introduced, but cost and range need to improve. Heavy ZE trucks are being developed and introduced, but range/ payload issues have not yet been solved.

100. Institute for Sensible Transport, May 2022, *Electric Vehicle Charging Roadmap: Prepared for SECCCA*

What (barrier or issue)	Who (has control over the issue)	How (can the issue be addressed)
	Government	Use procurement processes to set specifications and demand for vehicle types not yet available on the Australian market
	Business	As above – large logistics firms can set specifications and create demand for vehicle types not yet available with the use of long-term contracts.

Examples of specific policy measures targeting passenger transport that could be developed by GSEM/SECCCA (ideally in concert with the Victorian Government) in in Table 9.

Table 9: Regional measures for a faster transition to zero emissions passenger vehicles

Actions	Timing	Comment/cost-effectiveness
Implement the SECCCA Electric Vehicle Roadmap	Between 2025 and 2035 (after that the high share of EVs in the fleet will ensure charging points are provided by multiple commercial entities	Costs will be administrative or borne by commercial players who will recoup their investment. Community benefits from reduced emissions and air pollution will deliver a positive BCR.
Optimise parking fees for ZEVs until 2030	Apply until 2030 (with an option to continue)	Cost neutral to councils, as car parking fees should be increased for non-ZEVs. Positive BCR.
Switch by councils to EV light vehicle fleets	By 2026	This will demonstrate leadership and astute procurement practice (e.g. joint purchases across councils) and choices should achieve cost neutrality.
Introduce Zero Emissions zones – excluding access to certain areas to non ZEVs	Gradual – pilot in 2025, with 1 to 2 zones in each LGA by 2030	This is recommended by the Climate Council.[101] Councils in the UK and France have introduced areas and streets where ICEVs (or sometimes any cars) are not permitted. The cost of this measure is the inconvenience to drivers of ICEVs – and makes such change politically challenging. The benefits include improved places and faster take-up of ZEVs – delivering a positive BCR.

101. Climate Council of Australia, 2022, *Are we there yet? Clean Transport Scorecard for Australian States and Territories*

Freight transport is lagging passenger transport in the transition to net zero due to the lower availability of zero emissions vans and trucks. However, this is changing with the release of electric vans. Heavy trucks remain a challenge, but Tesla and Volvo have released electric heavy trucks in the US/Europe and Volvo will be constructing both medium and heavy electric trucks at their Brisbane facility in the near future. The challenge, for both industry and government, is to provide the policies and factories needed to supply zero emissions trucks for every freight task at TOC parity to diesel trucks. Much of this work will take place at the national and international level, but measures are available to GSEM/SECCCA to encourage uptake of zero emissions freight vehicles. Examples are shown in Table 10.

Table 10: Local measures to speed the adoption of zero emissions freight vehicles

Actions	Timing	Comment/cost-effectiveness
GSEM/SECCCA councils adopt a joint labelling and recognition system for freight vehicles.	From 2024 to 2035	Zero emissions freight vehicles can carry a label, for instance 'THIS IS A ZERO EMISSIONS VEHICLE – supporting the health of Southeast Victorians'. The program would likely be supported (or adopted) by Victorian Government, keeping admin costs low to councils. BCR would be strong.
Introduce Zero Emissions zones – excluding access to certain areas to non ZEVs	Gradual – pilot in 2025, with 1 to 2 zones in each LGA by 2030	As per the passenger transport measure. The benefits include improved places (less noise and air pollution) and faster take-up of ZEVs – delivering a positive BCR.
Establish micro mobility freight hubs	By 2025	In dense commercial precincts, establish micro-mobility hubs where micro e-vans and e-motorbikes have privileged access. Transport for NSW has established a pilot near Central Station in Sydney.[102] Benefits include lower emissions, pollution and congestion.

102. NSW Government 2022, *Net Zero Cities Action Plan*

Reducing reliance on private vehicles – boost uptake of active and public transport

Motorised vehicles are essential for many tasks. However, some tasks, particularly passenger travel, can be accomplished on public transport (buses, trains and trams) or by walking or cycling (termed active transport).

Public transport can be quickly made zero emissions. Governments can take out renewable energy PPAs to power the passenger rail system. Electric buses are fast becoming available and will reach TOC parity with diesel buses in the near term.

Shifting people out of private cars onto buses, bikes and feet dramatically cuts air pollution and noise.

Even when the private vehicles used are zero emissions, there are huge benefits from limiting their use in favour of increased public and active transport.

Reducing car use eases congestion, which has considerable economic benefit. The Victorian Government values decongestion highly as shown in Table 11.

Table 11: Decongestion values, Victoria

Time period and congestion level	$/vehicle-km, mid-2019 prices
Peak Heavy	1.30
Peak Moderate	0.92
Peak Light	0.24
Off-peak	0.24

Source: Australian Transport Assessment and Planning, M1 Public Transport, 2021

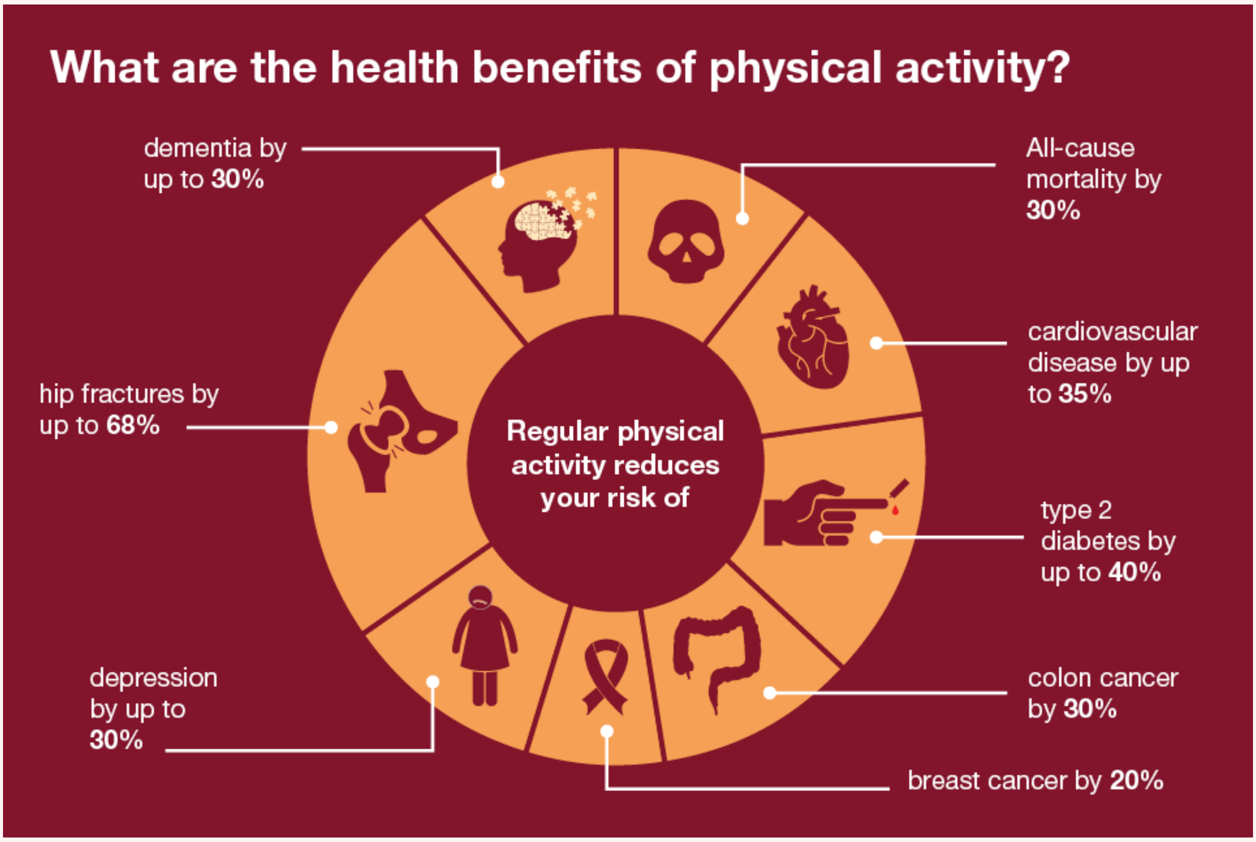

Figure 26: The health benefits of physical activity[103]

The other major benefit of getting people out of cars is boosted wellbeing. People are healthier when they are physically active by walking or cycling, in numerous ways, as illustrated in Figure 26.

Australian, state and territory governments have developed values for the health benefits of walking and cycling – and they are considerable.[104]

Health benefits (savings in health system costs) are:

- $2.77 per km per person for walking
- 1.40 per km per person for cycling

Examples of measures to encourage the uptake of public and active transport in the region are summarised in Table 12.

103. Public Health England, 2018, Physical activity: applying All Our Heath

104. Australian Transport Assessment and Planning: M4 Active travel

Table 12: Local measures to boost walking, cycling and public transport

Actions	Timing	Comment/cost-effectiveness
Investment in active transport infrastructure (green space and paths)	Ongoing	Projects can be developed and those with the highest NPVs and BCRs can be selected. Benefit streams include avoided emissions, pollution, congestion and improved health. A major barrier is perceived safety risks from walking and cycling – good infrastructure makes public and active transport safer and more desirable.
No-car period/ areas around schools	Gradual – pilot in 2024, most schools in each LGA covered by 2030	This encourages walking or cycling to schools. Even when vehicles are used for the majority of the trip, a short walk of say 5 minutes becomes necessary and beneficial. Exemptions can be provided as needed.
Speed limits reduced to 15 km/ hour in selected areas	By 2025	This makes areas more walking and cycling friendly. In addition to benefits cited above, there are safety benefits. Note that Australian Transport Assessment and Planning value a fatality at approximately $7 million.
Planning and urban design that promotes active and public transport	Ongoing	Wide paths, leafy areas, pleasant and safe bus stops are all part of good urban design that promotes public and active travel. Particular measures/projects can be assessed by cost-benefit analysis and selected on the basis of strong NPVs and BCRs.

4.4.3 Aviation transport – opportunities for lower emissions

The outlook for aviation emissions is uncertain at present. While government and the aviation industry accept the need to shift to zero emissions, the technologies that will allow this to occur are only in their infancy.

Also, there is the possibility of a second airport being constructed in the region, and this would induce additional emissions, both directly and indirectly via induced traffic, at least for as long as fossil fuels are used in these tasks.

The challenges are not as great for light aviation. The smaller range requirements present opportunities for electric aircraft as battery weight is less of an impediment. Accordingly, the reference scenario projects falling emissions.

The elimination of emissions at Moorabbin Airport should be possible if opportunities to introduce electric aircraft or biofuels are introduced earlier.

There are industry led moves to develop zero emissions aircraft, by established players including Airbus and Rolls Royce, as well as smaller initiatives.[105]

A major obstacle to wide-spread adoption of zero emissions aircraft will be the upfront cost. The light aircraft industry does not have the sales volumes needed to achieve impressive economies of scale. Aircraft are therefore expensive and are kept operational for decades.

National and state governments and industry will need to develop a comprehensive action plan including regulatory settings and compensation/subsidies if the potential to reach zero emissions aviation is to be reached. GSEM/SECCCA will need to advocate for the development of such a plan.

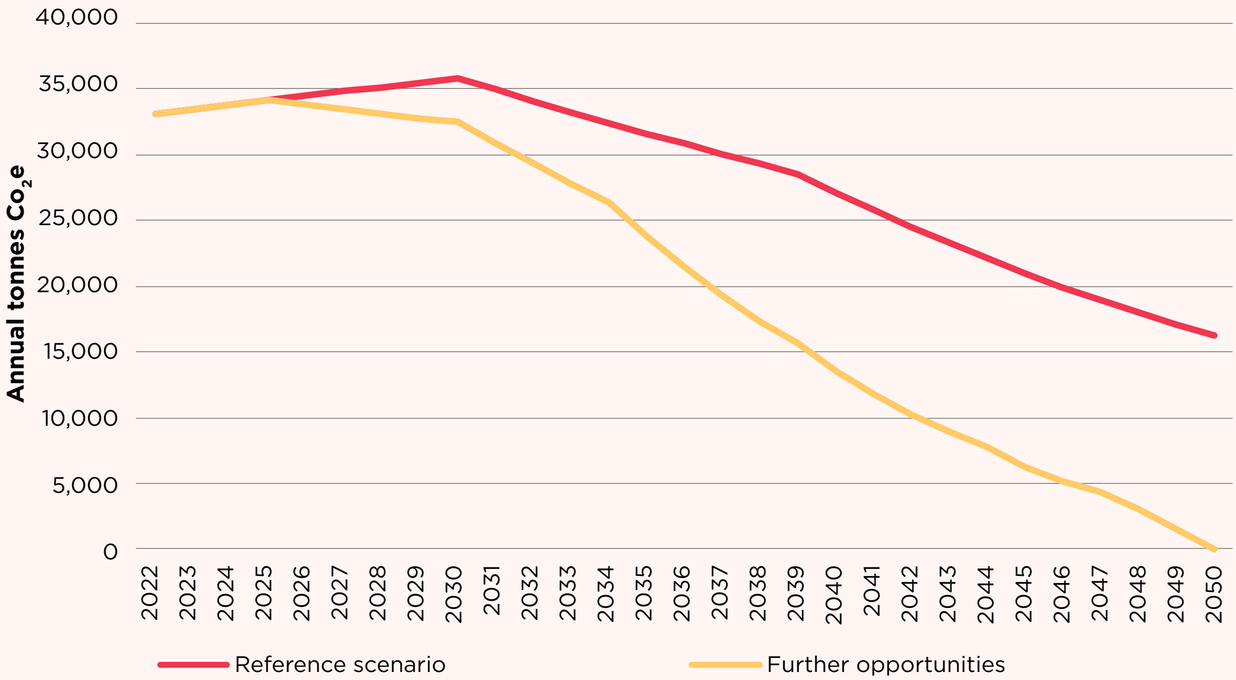

Figure 27: Aviation emissions – reference and further opportunities scenarios

105. See cleantechnica.com/2022/11/17/electric-helicopter-makes-historic-flight/

4.5 WASTE AND AGRICULTURE SECTOR

4.5.1 Waste – opportunities for further emissions reductions

Under the reference scenario, waste emissions will reduce but not fall to zero by 2050. Actions driving emissions reductions are the commitment by the Victorian water sector to reduce wastewater treatment emissions to zero by 2035. There is also a Victorian Government commitment to reduce organic waste to landfill by 50%.

The opportunities to transition waste management to a zero-emission footing therefore lie in two areas:

1. further reductions in the quantity of organic waste to landfill
2. improved management of landfills so that methane is captured, rather than released into the atmosphere.

Organic waste is generated by households, the food industry and other sectors that generate food-related waste and other wastes including plant materials and paper. Ideally waste is prevented, or recovered, rather than disposed of, as shown in Figure 28, which has a food focus, but the same principles apply to all organic waste.

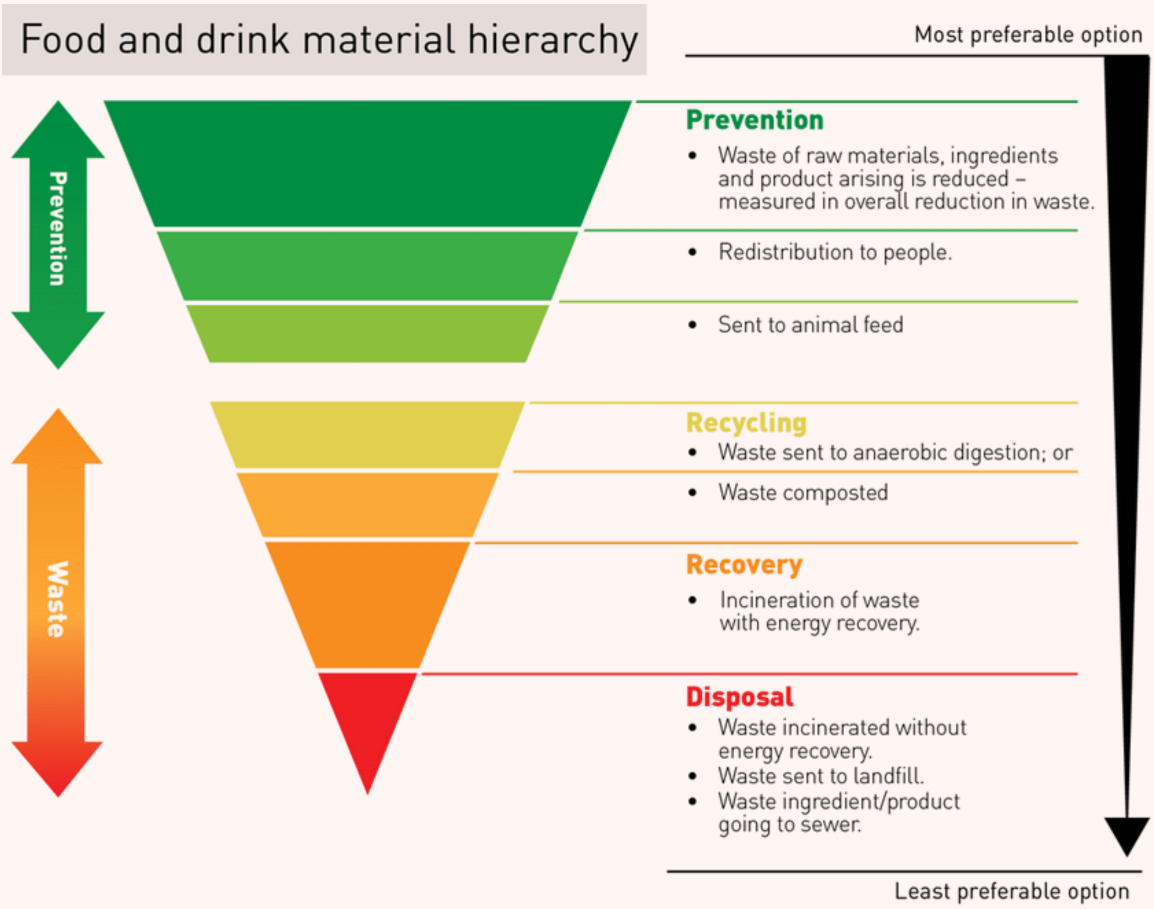

Figure 28: The WRAP food and drink material hierarchy[106]

106. WRAP Website (The Waste and Resources Action Programme), WRAP UK. Why take action: legal/policy case. Available at: www.wrap.org.uk/content/why-take-action-legalpolicy-case

Examples of local measures to reduce waste could include the development of circular economy organic hubs and connections.

The region has a large food and drink manufacturing presence, as well as a thriving garden and landscape sector. GSEM/SECCCA could launch a joint program to map production, input needs, waste generation and flows to identify ways to prevent, recycle and recover organic waste.

A good UK circular economy example is Kellogg's Salford factory's management of cornflakes which fail quality control standards but are still edible. These are supplied to a neighbouring brewer which substitutes the flakes for grain, resulting in 'Throw Away IPA'.[107] A more basic example is ensuring that organic kitchen waste is used to create compost for use by the landscaping and garden sector rather than going to landfill.

Inevitably, some waste will end up in landfill. Some landfills in the region have methane capture systems, but some systems are not fully comprehensive or effective, and some landfills don't capture methane. The opportunity here is to ensure that all landfills in the region have adequate methane capture systems in place before 2050.

When methane is captured, there is the opportunity to convert that energy into electricity, and this already occurs, at small scales, at many waste facilities around Australia. It is not clear what percentage of active and legacy waste sites in the GSEM/SECCCA region are fitted with methane capture and conversion devices.

Waste-to-energy facilities are considered to be renewable energy, as the release of carbon (e.g. CO_2) from combustion of gases or other materials produced from biological sources returns to the atmosphere carbon that was previously sequestered, e.g. via photosynthesis, with no net emissions of carbon. However, councils should be aware that where such activities are used to generate large generation certificates (LGCs), and these are sold as 'offsets', these offsets permit another party to release the exact quantity of emissions sold, meaning that these facilities are no longer carbon neutral but instead are causing, or enabling, net emissions. If councils wish such facilities to be carbon neutral, LGCs must be cancelled, not sold. The trajectories under the two scenarios are shown in Figure 29, detailing the reference scenarios vs the two waste management opportunities discussed above.

107. See environmentjournal.online/articles/waste-kelloggs-corn-flakes-to-beer-turned-into-beer/

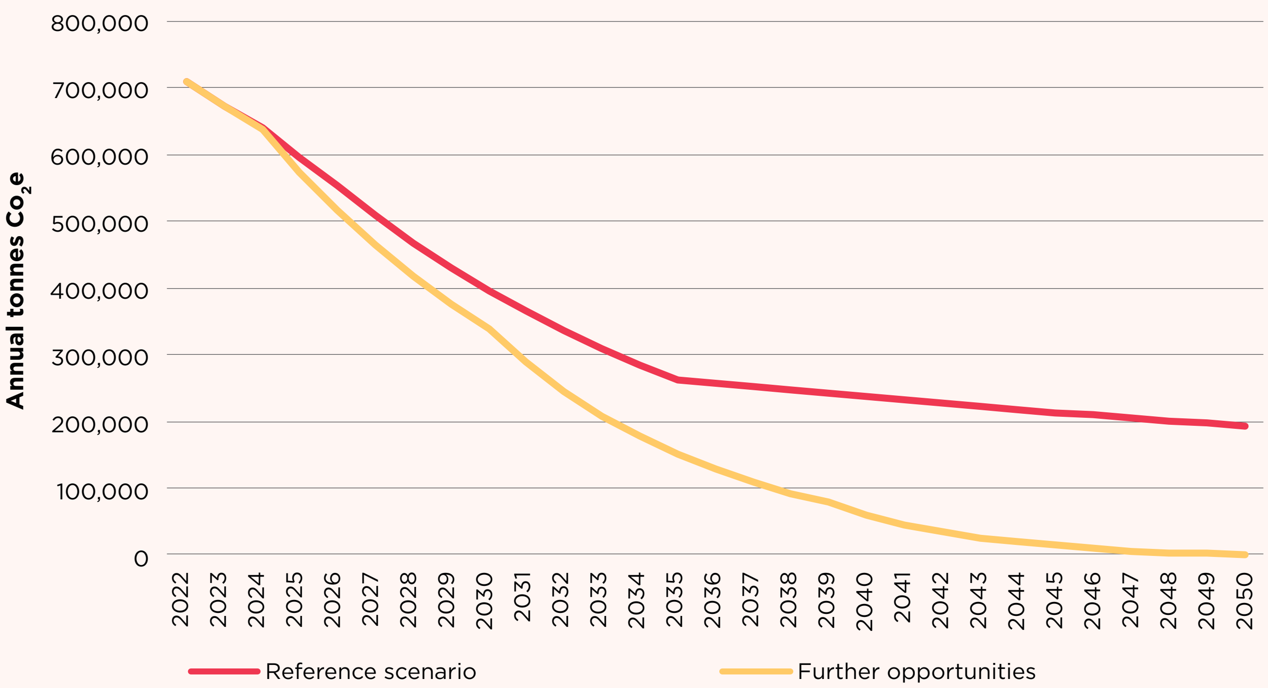

Figure 29: Waste emissions to 2050 – reference vs further opportunities scenarios

4.5.2 Agriculture – opportunities for further emissions reductions

Under the reference scenario, emissions from agriculture in those LGAS with agricultural activity will only fall slightly by 2050.

The opportunities to reduce agricultural emissions to zero by 2050 fall into two main types, as explained in the following sections.

Reduce the quantity of methane produced by the region's cattle

Research to identify cost-effective and high impact dietary supplements and/or vaccines to reduce methane emissions in ruminants is ongoing. Supplements based on red algae have potential to reduce methane by 99% in feedlot environments.

Supplements including bioactive compounds from leptospermum and melaleuca plants have potential for 25% reductions. The first commercial sale of asparagopsis feed supplement occurred this year from CH4 Global to a beef feedlot in South Australia.[108]

Importantly, there is strong potential for Victoria to develop a seaweed industry, to meet the needs of the region and state's cattle herd. There are suitable sites adjacent to the Bass Coast region.[109]

Dairy is well suited to feed additives, with the cattle being milked twice a day at a central point. The region's beef cattle industry is also relatively intensive, with smaller paddocks making the provision of feed additives feasible.

108. www.beefcentral.com/news/methane-reducing-seaweed-additive-now-commercially-available-for-beef-producers/

109. Bursic and Fulton et al, 2022, *Assessing the potential for seaweed aquaculture in Gippsland: guidance in selecting species and locations*, Deakin University

Introduce carbon capture techniques to offset remaining methane emissions

CSIRO has conducted considerable research into soil carbon (whereby carbon capture is increased in the soil by boosting the organic matter) and into establishing permanent shrubs and trees to sequester carbon. The establishment of permanent groves of trees and shrubs shows the most promise in terms of permanence and in boosting the environmental and commercial sustainability of agricultural enterprises.

Under such systems, land use is carefully allocated according to profitability, sustainability and suitability. This would see the most productive land (fertile soils in flat areas of at least medium rainfall) used for intensive agriculture (horticulture, orchards, cropping). Livestock would be the main product in areas of medium-productivity land (low to high rainfall on moderately fertile soils). The least productive land – poorer soils, shallow soils, steep slopes and waterways/gullies – would support a mix of carbon and biodiversity plantings.

This would commonly occur in a mosaic pattern, both from a regional and farm by farm basis. The basic CSIRO land use mosaic is shown in Figure 30.

1. Trees planted to sequester carbon

2. Biodiverse plantings

3. Grazing perennial pastures

4. Cropping enterprise

5. Streambank / gully remediation planting

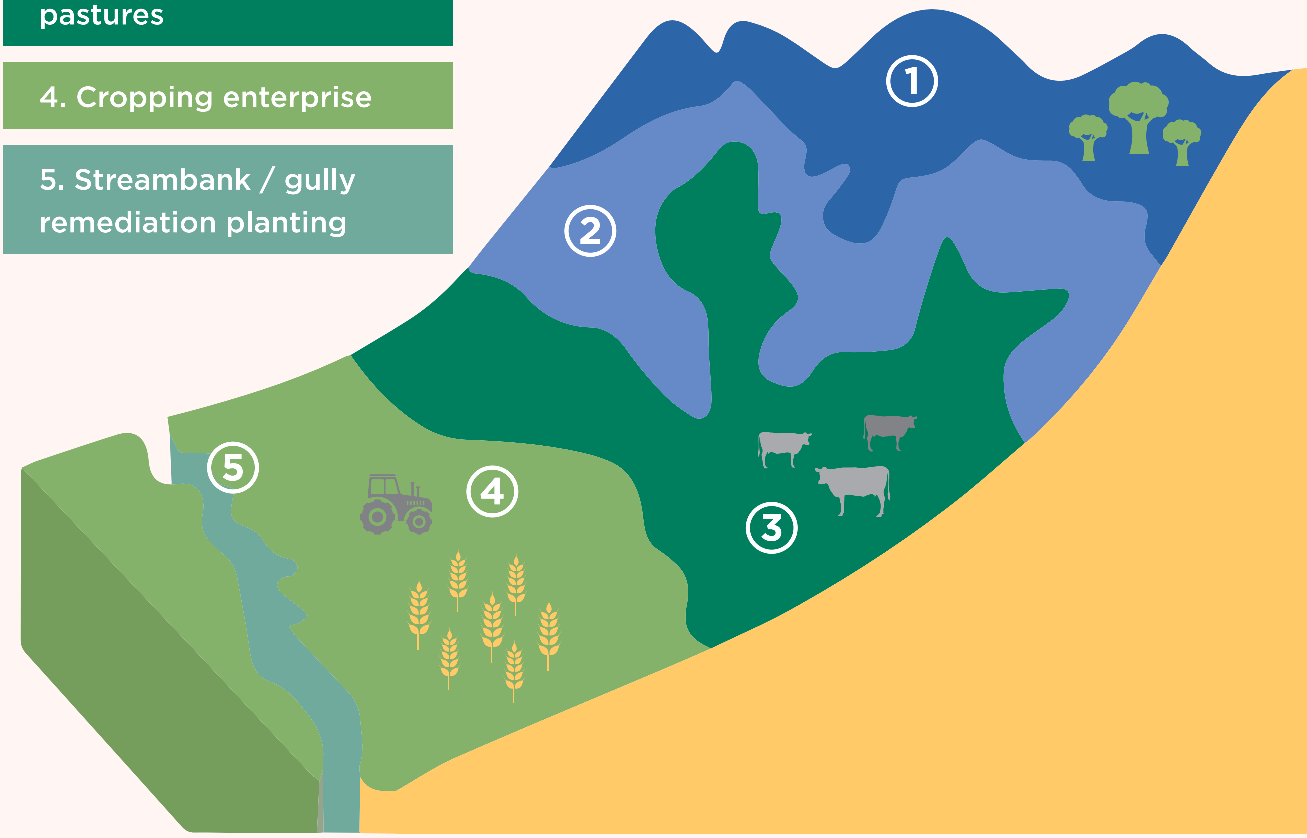

Figure 30: A mosaic of land use balancing agricultural production with carbon sinks and ecosystem health. Source: CSIRO 2019

The impact on emissions if these opportunity types were comprehensively rolled out across the region's agricultural enterprises would be substantial, as illustrated in Figure 31.

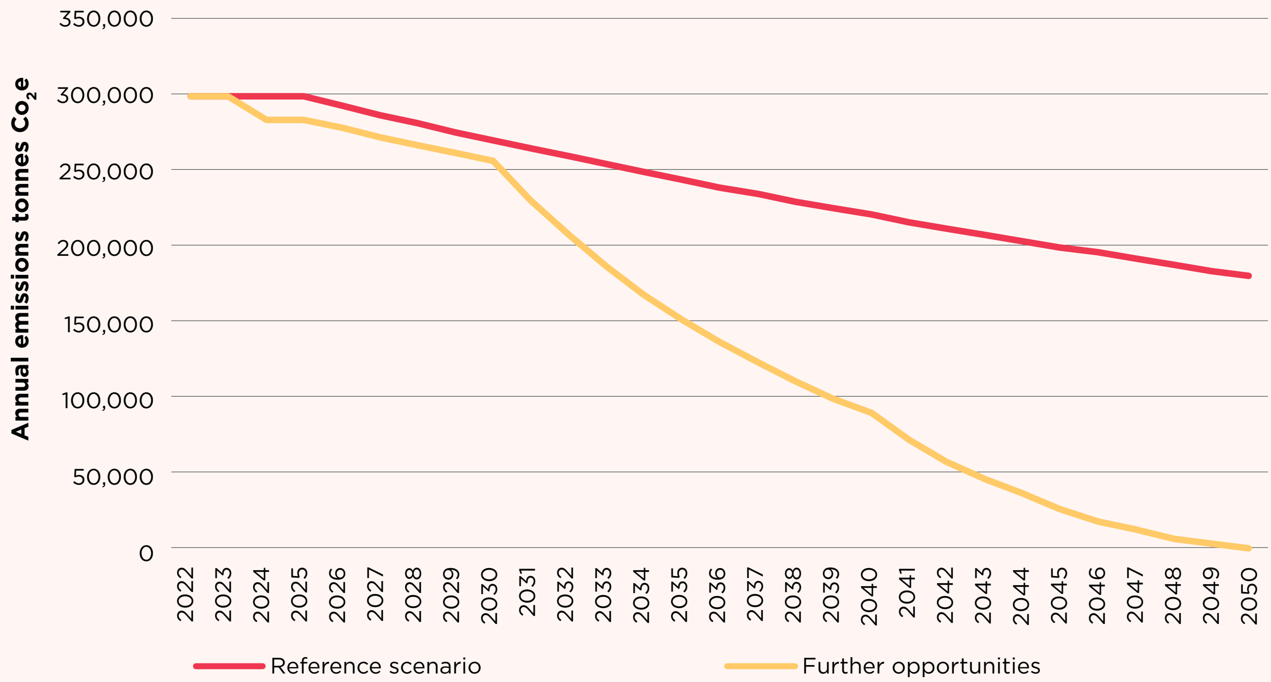

Figure 31: Agricultural emissions – reference vs further opportunities scenarios

4.6 GSEM/SECCCA OPPORTUNITIES

GSEM represents eight councils and has a primary function of advocacy for jobs, infrastructure, investment, liveabililty, sustainability and wellbeing for everyone who lives and works in the region. GSEM has a particular focus on future-proofing the community and ensuring liveability and sustainability.

SECCCA is a network of nine councils in the South East Melbourne area, where over 1 million people live. Its core functions include education, advocacy and project delivery in support of its mission to support member councils and their communities to respond and adapt to the impacts of climate change.

There are 11 councils in the region in total, with some being members of both GSEM and SECCCA.

Climate change represents a common thread between these two initiatives. It represents a very real threat to the community and businesses in the region in the form of increasing risks of violent climatic events such as floods, storms, inundation from sea-level rise (combined with storms), and wildfire. Climate changes also presents risks from heat stress and other medical conditions, as well as eroding natural values in the region, with impacts on species viability and biodiversity.

While we consider it unethical to regard climate change as an opportunity, it is the case that many climate change solutions and responses create multiple benefits, well beyond contributing equitably to reducing climate change related threats including:

- reducing household and business operating costs
- improving the quality and resilience of the built environment and of the power system
- reducing exposure to fossil-fuel price cycles and unpredictable energy costs
- reducing noise and air pollution not only in the transport system but also from power generation.

Australia's history with respect to climate change policy has been unfortunate, with a legacy being that many householders and businesses are very likely to carry misunderstandings and attitudes that may impede the realisation of these opportunities, as well as the reduction of threats.

Therefore, the first opportunity for GSEM and SECCCA – and their member councils – is to communicate the core messages from this project (and others) to households and businesses in the region. Engaging actively with individuals and businesses can provide the opportunity for two-way dialogue, testing of ideas, and weighing of evidence, ultimately encouraging more investment in emissions reductions, which is the first and most critical step in combatting climate change.

Second, GSEM and SECCCA both have advocacy as a core mission, and it is clear that advocacy is required in many domains to change policies, programs, budgets, regulations and laws that either encourage or subsidise fossil fuel use, or which fail to actively encourage and enable the use of sustainable alternatives. Of course, it is a time of active change in policies at all levels of government in Australia, and it is fair to say that there is now more hope than ever before that major policy barriers may be removed in the near future, while there are increasing numbers of programs and policies – at local, state and national levels – that already actively support climate action.

However, it is clear that there is more work to be done. Some aspects highlighted by the project are listed below.

1. Many of the financial benefits for households and businesses are associated with, and/or enabled by, the uptake of rooftop solar. However, not all households or business have a clear roadmap to accessing these benefits. Barriers most notably affect:
    a. those renting homes or business premises[110]
    b. those on lower incomes.

Initiatives to require or encourage landlords to install, or to enable to be installed on fair terms, PV systems in rental premises would make the benefits of solar more widely available as well as encourage additional investment and emissions abatement.

Further, the regulatory environment for investment in behind-the-meter PV systems (and indeed in larger systems) is fraught with barriers and disincentives, and some of these barriers are being raised rather than lowered. For example, not only have feed-in tariffs for exported solar power been reduced, there are active plans in some networks to seek to tax exports of solar power (apply a 'sun tax').[111] This and other features of the National Energy Market that discourage investment in PV and other clean energy solutions are a legacy of past governments and may change in the future. However, active advocacy will help to bring about these changes, and more rapidly.

2. Commercial businesses are required to seek connection agreements with their local electricity networks when they install PV systems, yet these systems are perceived by many network businesses as a direct threat to their (current) business model. This means they are directly conflicted in making fair and reasonable terms for connection agreements, and indeed for other policies that affect the attractiveness of clean energy, distributed storage and other solutions that are required and which are being actively encouraged by other energy institutions, such as AEMO in its ISP.[112] Networks are regulated monopolies, meaning that their business models and incentive structures are entirely created by government laws and regulations. If they are leading to outcomes that are dysfunctional from the perspective of a sustainable future, it is clear that it is the laws and regulations that must change if market outcomes are to change. This is a key opportunity for advocacy.
3. Incentives and infrastructure to support the electrification of transport remain relatively weak in Australia, particularly when compared to leading markets in Europe, Asia and North America. Affordability of EVs will improve with time and economies of scale, but there is clear evidence that EV manufacturers take into account the degree of support – or otherwise – afforded to EVs when

110. We note that the SolShare model is becoming more popular, particularly for apartment buildings. See allumeenergy.com/au/

111. reneweconomy.com.au/here-comes-the-sun-tax-the-export-tariffs-proposed-for-households-with-rooftop-pv/

112. https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp, viewed online 23/05/2023.

making decisions about where to ship their limited stocks.[113] Advocacy is required not only to overcome the capital cost penalty that applies, particularly at the more affordable end of the car market, but also to ensure that fuel efficiency and vehicle emissions standards, infrastructure investment, registration and stamp duty policies and other measures actively encourage, and do not discourage, business and household investment in EVs and recharging infrastructure.

We acknowledge that there is extensive and rapid change underway in the private sector, with many businesses leading change and providing demonstrations for their staff, customers and competitors. Initiatives such as the Better Buildings Partnership (under which institutional building owners are targeting zero emissions by FY2030, and are well on the way to its achievement);

- the Climate-Related Financial Disclosures Project (which is encouraging very many larger businesses to become aware of, and to disclosure to investors, their specific climate-related risks);
- voluntary initiatives such as the Green Building Council of Australia, and many more have already changed the attitudes and behaviours of many in business, with this impact set to grow in the future. At the same time, not all businesses offer such leadership, and there are also businesses for which cost-effective and large-scale emissions abatement may not be feasible or cost-effective in the short term, at least without government support. Another role for GSEM/SECCCA advocacy, then, would be to seek state and federal government support for highly targeted and highly effective interventions that would help businesses facing such conditions to make attractive business cases for emissions reductions, and to invest in realising them.

SECCCA's third role, of project and research delivery, is well-illustrated in this project. Research and evidence provides the solid ground for both education and advocacy.

113. 'Volkswagen Australia says a mix of limited supply and high demand means ID electric cars were prioritised for markets like Europe, where car makers face financial penalties for missing strict emissions targets – regulations which do not yet exist in Australia.' – www.drive.com.au/news/volkswagen-id-electric-car-rollout-australia/

05 CONCLUSIONS

5.1 SUMMARY

This study highlights that there are immediately available and cost-effective – in some cases, highly cost-effective – emissions reduction opportunities for each of the residential and commercial sectors in the region, and there are similar opportunities available today for at least parts of the region's transport and industry. Aviation and heavy transport face higher hurdles but also have solutions that are being developed and commercialised, generally involving electrification and/or hydrogen roadmaps. Waste and wastewater are sectors where there are existing commitments to reach zero emissions, and plans are well underway to achieve them. Agriculture also faces significant challenges, but again is developing solutions such as alternative feed regimes and pasture management systems, while electrification also offers opportunities for parts of the agricultural supply chain.

Our modelling of the residential and commercial sectors in the region shows that emissions associated with electricity use are falling and are set to reach zero in Victoria by around FY2033. Thus, electrification is an immediately available and highly effective solution for emissions reduction. We note that electrification is generally cost-effective, but may not be in certain instances, such as in the conversion of space heating systems in larger existing non-residential buildings. Individual business cases are required to determine the least-cost abatement and optimal investment choices for larger and more complex buildings/facilities. These conclusions also apply in industry, where specific processes, often involving high temperatures, may await the commercialisation of green hydrogen to achieve zero carbon emissions. Similarly, the road-based passenger transport task in the region is likely to reach zero emissions by or before 2050, but that is less certain for heavy vehicles and aviation – even if the early stages of electrification and/or other abatement roadmaps are already in evidence.

5.2 LIMITATIONS OF THE ANALYSIS

This study does not have the scope to consider all emissions reduction options for all sectors that might be relevant and cost-effective in the region. In particular, we have noted the diversity of the industrial sector in the region, and the challenges that accompany forecasting emissions and identifying optimal investment opportunities. While we have highlighted some of the largest and most attractive options, there will be many more that we have not highlighted. For some businesses, these missing options may include those that are most appropriate and least-cost for them.

Also, we note that not only Australia but much of the world economy is currently facing supply constraints and cost-price pressures. This means that generic analyses of cost-effectiveness, such as those presented here, can be rapidly overtaken by market developments.

Of course, these price and cost pressures are not limited to emissions abatement investments but are widespread throughout product and services markets.

These realities only highlight that there are many emissions abatement options, and that site or company-specific due diligence is the strategy to ensure that the best opportunities are identified and implemented. In particular, the diverse nature of manufacturing plants, and of the products they produce and the markets in which they operate, mean that investment economics will vary from one application to the next in the industrial sector in particular.

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