Final Report

AMPC Decarbonisation pathways update

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1.0 Executive Summary

This research report was commissioned by the Australian Meat Processor Corporation (AMPC) to update the 2019 report "*Emission reduction pathways and opportunities for the Australian red meat processing (RMP) sector"* (AMPC report 2019-1059). This update includes a review of the 2022 Environment Performance Report (EPR) results, the status of decarbonisation in the international red meat processing industry, decarbonisation technologies, Australian government policies, and the outputs from updated domestic decarbonisation pathway analysis.

As discussed in the previous report, Australia is already taking steps towards market leadership in red meat decarbonisation. In 2017, the Australian red meat and livestock industry set a target to be carbon neutral by 2030 (CN30). The AMPC has a similar ambition to achieve CN30. The results from the EPR project over the last 13 years (see Table 1) indicate that Australian red meat processors (RMP) have achieved about 15% to 20% energy intensity and greenhouse gas emissions reduction. The recent increases in both energy intensity and carbon intensity can be attributed to lower production levels in 2022, which resulted from limited animal supply, China's imports ban, and staff shortages due to COVID-19 at several meat processing plants. Lower production output has reduced estimated annual total RMP industry emissions from 1,300,000 tCO_2e/year in 2018 to 1,139,850 tCO_2e/year in 2022[1].

Table 1 Australian red meat processing 2022 EPR results

Resource	2008/9	2013/14	2019/20	2021/22
Energy intensity (MJ/tHSCW)	4108	3005	3316	3435
Carbon emissions intensity* (kgCO_2e/tHSCW)	554	432	397	447

*Includes an estimate of carbon emissions from wastewater treatment

Major international RMP companies are also making efforts to reduce carbon emissions. They have set energy and carbon emissions targets, with differences in ambition (e.g., 10% versus 30% reduction by 2030), scope (energy use emissions only, versus emissions scopes 1, 2, and 3), and timeframes (net zero by 2030 to 2050). The decarbonisation strategies for Australian companies owned or in partnership with international groups follow the targets set by their international owners or partners. These targets are not as ambitious as the CN30 target set by AMPC and MLA.

A review of the carbon intensity for international companies shows the key differentiating factor for emissions intensity per tonne of meat processed in each country is the emissions intensity of the grid electricity in that country or region. A summary of the estimated emissions intensities for each country shows that most of our key competing countries have lower emissions intensity per tonne of meat processed, specifically Brazil, UK, and New Zealand (see Table 2). These countries have an average grid electricity carbon intensity of 0.10 to 0.15 tCO_{2}-e/MWh, which is lower than the most ambitious forecast for Australian electricity decarbonisation, which projects grid intensity of 0.20 tCO_{2}-e/MWh by 2030.

[1] Data provided by AMPC

Table 2 Country electricity grid carbon emissions intensity and estimated RMP production carbon emissions intensity

Country	Average grid electricity carbon emissions intensity tCO_{2}-e/MWh	Estimated RMP carbon emissions intensity $kgCO_2$-e/tHSCW
Australia	0.68 (0.85 in Victoria and 0.17 in Tasmania)	447 (100 to over 600)
Brazil	0.12	220
New Zealand	0.15	240
United States	0.40	330
United Kingdom	0.10	>200
India	0.82	500
Mexico	0.43	350

The speed at which each country reduces its grid electricity emission intensity will impact red meat processing decarbonisation pathways. This holds true for RMP businesses in Australia where the carbon intensity of the grid in 2022 varies from 0.17 tCO_{2}-e/MWh in Tasmania to 0.85 tCO_{2}-e/MWh in Victoria. Aside from the carbon intensity of grid electricity, the decarbonisation paths for thermal energy used in each country are very similar, and feature the replacement of fossil fuels (coal, LPG, fuel oil and natural gas) with biomass- and biogas-fired boilers and electrification using heat pumps and electric boilers.

The key technologies for decarbonisation have not changed significantly since the 2019 report, but heat pumps have become more available and competitive for hot water generation (75ºC to 90ºC). The rapid decarbonisation of Australia's electricity grid, high and volatile natural gas prices, and rapid progress in heat pump technology development have led to increased interest in heat pumps for the electrification of natural gas and other fossil fuel-reliant processes. This is demonstrated by the recent implementation of a heat pump, solar PV, and battery project for the Hardwick Meats plant in Gippsland with funding support from the Australian Renewable Energy Authority (ARENA)[2].

Steam boilers are still the most cost-effective solution for the higher temperatures required for rendering operations, although high temperature (up to 160ºC) heat pumps are under development and could be available in the next three to five years. Subject to cost constraints and renewable electricity availability, high temperature heat pumps and electric boilers could eliminate the need for fossil fuel-fired steam boilers in the RMP industry. However, renewable fuels such as biomass boilers are gaining interest on the back of pilot test unit results showing that paunch and wood chip can be combusted successfully for steam generation.

There has been rapid growth in the implementation of on-site solar PV systems. In the last two years, AMPC has funded projects which have helped to increase the RMP solar PV adoption pipeline by 150%, commenced a hydrogen pilot project and assisted in the development of industry heat pump assessment tools with Australian Alliance for Energy Productivity (A2EP). All these projects are important steps for the development of the RMP decarbonisation pathway (see Appendix 8.6 for a list of recent decarbonisation related projects).

Two key factors which have changed since the 2019 emissions pathway report are:

[2] Hardwick Meatworks Heat Pump Installation and Power Upgrade Demonstration - Australian Renewable Energy Agency (ARENA)

- The change in government in 2022 has produced a significant change in Australian climate change policy. The Labour government has set new national targets for emissions reduction of 43% below a 2005 baseline by 2030 and net zero by 2050. (In 2020, under the Coalition, the national target was 26-28% reduction from 2005 levels, which, by counting Kyoto Protocol carryover credits toward the target, resulted in an effective target of 16%).
- Based on recent electricity grid decarbonisation forecasts[3], RMP facility's emissions from grid electricity use could fall by 40% to nearly 90% by 2030 solely through grid decarbonisation. By 2050 all states converge on zero-emissions grid electricity.

It is important to note that the decarbonisation pathway for each RMP plant may differ considerably due to location-based factors such as grid electricity carbon intensity variations and the source of fuel for thermal systems. For those plants with cogeneration systems using natural gas as the primary fuel, the carbon intensity of the cogeneration generated electricity can range from 0.3 to 0.35 tCO_2e/MWh depending on power generator efficiency. Therefore, plants using cogeneration located in Tasmania and South Australia where grid carbon intensity in 2022 was 0.17 and 0.25 tCO_2e/MWh respectively (see Appendix 1), need to consider the use of renewable fuels or electrification for further decarbonisation.

If grid electricity does not decarbonise at the projected rate, this may also require RMP plants to move more quickly on replacement of fossil fuels with renewable energy sources to achieve the Australian government target of 43% by 2030 and entail larger efforts to achieve the Paris target of 63% by 2030.

To reach CN30, the RMP will need to decarbonise all scope 1 and 2 emissions. This would require the use of renewable energy for all electrical equipment including heat pumps, renewable fuels such as biomass and biogas boilers, and most likely the purchase of carbon offsets to address wastewater carbon emissions and Greenpower or renewable energy certificates to abate any residual emissions in electricity supply.

Carbon offset prices differ significantly, depending on the type of project they represent, the certification scheme they adhere to, and the time they are purchased. In general, offset prices are increasing, reflecting greater demand as companies and governments around the world establish carbon reduction targets. However, prices can be highly volatile. For example, the Australian Carbon Credit Unit (ACCU) price has varied significantly in the last couple of years due to government policy and Safeguard Mechanism program changes. In August 2023, the price of an ACCU was around $30/certificate, but it was as high as $56/certificate in 2022.

The business case for decarbonisation can be challenging, especially when available grid electricity has a significant carbon intensity. A good method to improve the business case for a decarbonisation opportunity is to include a shadow carbon price, to account for the effective cost of emissions over the life of the opportunity. The recent ACCU price of $30/$tCO_2e$ provides a reasonable starting value for the shadow carbon price.

Further pressure for decarbonisation in the RMP industry is growing. In recent times, Australian food retailer Woolworths has a commitment of a 19% reduction in value chain emissions by 2030[4] and Walmart, one of the world's largest international retailers, has committed to a goal to reduce or avoid one billion metric tonnes of Scope 3 CO_2e in the global value chain by 2030 (Project Gigaton)[5]. These major businesses are asking suppliers to demonstrate their commitment to reducing climate change through decarbonisation plans and activities. As part of red meat supply chain for major food retailers, the RMP industry will need to decarbonise to help reduce the retailers' scope 3 emissions. In the years to come this could become a strong differentiation factor for food purchases.

[3] https://www.dcceew.gov.au/sites/default/files/documents/australias-emissions-projections-2022.pdf
[4] Net positive carbon emissions by 2050 (woolworthsgroup.com.au)
[5] Climate Change (walmart.com)

Recommendations resulting from this analysis are:

- AMPC should develop guidelines for AMPC members to respond to the food retailers looking for scope 3 decarbonisation in the food supply chain. The Australian RMP industry supported by AMPC has a strong history in decarbonisation demonstrated by the improvements in energy intensity and water intensity over the last 10 to 15 years.
- Each RMP plant should develop a site carbon footprint using the state-based grid electricity carbon intensity and appropriate carbon multipliers for other fuels and emissions. This work should also include an initial look at decarbonisation opportunities required to achieve the carbon reduction targets.
- Continued AMPC support for decarbonisation research and pilot projects is recommended, especially for those opportunities that will be critical for future decarbonisation including heat pumps, biomass boiler and other renewable energy supplies.
- Those companies with international partners or ownership may wish to review the carbon emissions reduction targets required for your business. Several of the international company carbon emissions reduction targets are 30% by 2030 which does not align with the Australian government target of 43% by 2030.

2.0 Introduction

The purpose of this project is to review the emissions reduction pathways for the Australian RMP and update the work conducted in 2020.

This research report was commissioned by the Australian Meat Processor Corporation (AMPC) to update the Emission reduction pathways and opportunities for the Australian red meat processing (RMP) sector (AMPC report 2019-1059). This update includes a review of the 2022 Environment Performance Report (EPR) results, international status for decarbonisation in the red meat processing industry, decarbonisation technologies, Australian government policies, and the outputs from updated decarbonisation pathway analysis.

3.0 Project Objectives

3.1 Research objectives

The objectives of this research are:

1. Review the previous emissions reduction pathway analysis conducted in 2020.
2. Update the previous research with new decarbonisation technologies, changes in Australian government policy and recalculate the decarbonisation pathway based on the updated situation.
3. Provide an overview of international RMP industry carbon emissions intensity and the types of decarbonisation technologies for comparison with the Australian RMP.
4. Assess the impact of retailer carbon emissions goals on RMP.
5. Conduct a brief assessment of fugitive emissions.
6. Review the use of Power Purchase Agreements (PPAs) for RMP.
7. Review the status of carbon offsets.
8. Update the status and forecast of the electricity grid decarbonisation.

3.1 Methodology

This project is a desktop analysis which draws on the data and research in the Environmental Performance Report (EPR) 2022 report and a wide range of reports and web site information. The phases of the projects are as follows:

1. Kick-off meeting with AMPC
2. Review of EPR results and discussion with AMPC and CSIRO (authors of the 2022 EPR report). Discussions with AMPC members occurred during the energy and water benchmarking workshops (Project 2023-1008) helped to determine the types of decarbonisation opportunities and assess reasons for changes in carbon intensity.
3. Market research for new technologies using A2EP/ARENA work on heat pumps, electric boiler research, and improvements in alternative energy systems.
4. Desktop market research for international decarbonisation of the red meat processing industry.
5. Desktop review of Australian federal and state government policies and programs will an assessment of the impacts on red meat processing businesses

6. Workshop with AMPC to review the findings of the market research and discuss next steps.
7. Prepare a report on revised decarbonisation pathways based on market research and workshop discussions. Include a shadow carbon price to help assess the value of decarbonisation projects when compared to carbon offsets or under a carbon tax regime.
8. Prepare a final report and assist graphics provider to complete their report.
9. Hold a final presentation with AMPC.

4.0 Project Outcomes

4.1 2022 EPR results

As discussed in the previous report, Australia is already taking steps towards market leadership in red meat decarbonisation. In 2017, the Australian red meat and livestock industry set a target to be carbon neutral by 2030 (CN30). The AMPC has a similar ambition to achieve CN30. The results from the Environmental Performance Report (EPR) project over the last 13 years (see Table 3) indicate that Australian red meat processors (RMP) have already taken steps to improve energy intensity and reduce their emissions. The recent increases in both the energy intensity and the carbon intensity indicator can be attributed to lower production levels in 2022, which resulted from limited animal supply, China imports ban and staff shortages due to COVID-19 at several of the meat processing plants. The lower production output has reduced the annual total RMP industry emissions from 1,300,000 tCO_2e/year in 2018 to 1,139,850 tCO_2e/year in 2022[6].

Table 3 Australian red meat processing 2022 EPR results[7]

Resource	2008/9	2013/14	2019/20	2021/22
Energy intensity (MJ/tHSCW)	4108	3005	3316	3435
Carbon emissions intensity* ($kgCO_2e$/tHSCW)	554	432	397	447

4.2 International red meat processing decarbonisation

Major RMP companies in key countries (see Appendix 8.2 for more details) are making efforts to reduce carbon emissions. They have set energy and carbon emissions targets, with differences in ambition (e.g., 10% to 30% reduction by 2030), scope (energy use emissions only, emissions scope 1, 2, and 3), and timeframes (Net Zero by 2030 out to 2050).

Many of the major RMP companies are part of large international food groups with a significant portion of red meat production and red meat processing. Some groups include pork and chicken production and processing. Several of these companies own or have interests in red meat processing companies operating in Australia, including JBS, Cargill (partnership with Teys) and Minerva, which recently procured Australian Lamb Company and two Western Australian lamb processing plants. The decarbonisation strategies for the Australian companies in which these groups have an interest are similar to the strategies set by their international owners or partners.

[6] Data provided by AMPC
[7] 2022 Environmental Performance Review for the red meat processing industry (ampc.com.au)

A key factor in the differences between the emissions intensity of production in each country is the emissions intensity of the country's grid electricity. A summary of the estimated emissions intensities for each country shows that most competing countries have lower emissions intensity per tonne of meat processed, particularly Brazil, UK, and New Zealand (see Table 4). These countries have an average grid electricity carbon intensity of 0.10 to 0.15 $kgCO_2$-e/kWh, which lower than projected by the Australian Energy Market Operator in the "Step Change" scenario, which reaches 0.20 $kgCO_2$-e/kWh in 2030[8]. The step change scenario is becoming less likely due to delays in transmission line upgrades and new renewable energy projects.

Table 4 Country electricity grid carbon emissions intensity and estimated RMP production carbon emissions intensity

Country	Average grid electricity carbon emissions intensity tCO_2-e/MWh	Estimated RMP carbon emissions intensity $kgCO_2$-e/tHSCW
Australia	0.68 (0.85 in Victoria and 0.17 in Tasmania)	447 (100 to over 600)
Brazil	0.12	220
New Zealand	0.15	240
United States	0.40	330
United Kingdom	0.10	>200
India	0.82	500
Mexico	0.43	350

Aside from carbon intensity of the grid electricity, the decarbonisation path for the thermal energy used in each country is very similar, where fossil fuels (coal, LPG, fuel oil and natural gas) are being replaced by biomass and biogas fired boilers and electrification using heat pumps and electric boilers.

4.3 Australian decarbonisation

Key changes in decarbonisation since 2019 for the Australian RMP industry are:

- Rapid decarbonisation of Australia's electricity grid
- High and volatile natural gas prices
- Accelerated progress in heat pump technologies.
- Stronger national emissions targets
- Demand from major grocery retailers for scope 3 emissions reduction.

Together these factors provide impetus for the RMP sector to advance the electrification of gas reliant processes as part of a decarbonisation strategy.

4.3.1 Grid decarbonisation

The emissions intensity of Australian grid electricity in the eastern states under the National Electricity Market (NEM) and in Western Australia under the South West Interconnect System (SWIS) is projected to decline. Under the AEMO's "most likely" scenario, a RMP facility's emissions from grid electricity use could fall by 40% to nearly 90% by 2030 through grid decarbonisation (see Table 5).

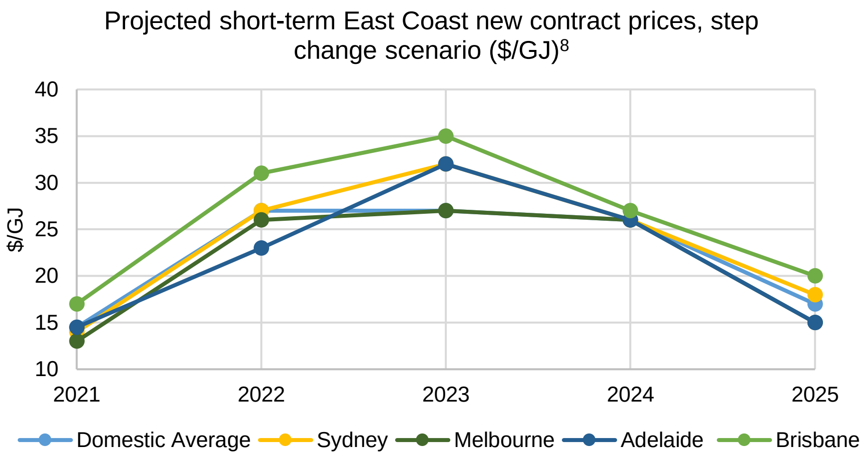
Table 5 Australian electricity grid carbon intensity forecasts[9]

State (grid)	2022 Grid electricity carbon intensity (tCO_2e/MWh)	2030 Grid electricity carbon intensity (tCO_2e/MWh)	% carbon intensity reduction by 2030
NSW & ACT (NEM)	0.73	0.12	84%
Queensland (NEM)	0.73	0.38	48%
Victoria (NEM)	0.85	0.37	56%
South Australia (NEM)	0.25	0.02	92%
Western Australia (SWIS)	0.51	0.24	53%
Tasmania (NEM)	0.17	0.02	88%
Northern Territory	0.54	0.34	37%
Australian Average	0.68	0.26	62%

4.3.2 Natural gas prices

Gas prices have risen six-fold over the past decade. This has been driven by Russia's invasion of Ukraine, which has led to sanctions on Russia and Australian LNG exporters increasing spot export sales, combined with unscheduled outages at coal-fired power stations and increased power demands.

Contract natural gas prices are projected to remain above $20/GJ until 2025, reaching $35/GJ for Brisbane in 2023 (as they are closer to LNG export terminals)[10].



[9] Table 38, https://www.dcceew.gov.au/sites/default/files/documents/australias-emissions-projections-2022.pdf
[10] Gas Price Projections for Eastern Australia, 2023 Update Australian Energy Market Operator by Lewis Grey Advisory

These factors in combination make it evident that the electrification of gas-using processes will be paramount in the industrial decarbonisation of RMP.

When integrated with low emissions electricity, the replacement of natural gas-fired equipment with electrically powered equipment will lead to significant emissions savings. The electrification of natural gas also provides the benefit of reducing reliance of natural gas lessening financial risks associated with current price volatility.

4.3.3 Key decarbonisation technologies

The key technologies for decarbonisation have not changed significantly since the 2020 report, however heat pumps have become more available and competitive for hot water generation (75ºC to 90ºC). Steam boilers are still the most feasible solution for the higher temperatures required for rendering operations, although high temperature (up to 160ºC) heat pumps are under development and could be commercially available in the next three to five years (see Appendix 8.3). There has been rapid growth in the implementation of on-site solar PV systems, and biomass boilers are gaining interest on the back of pilot test unit results showing that paunch and wood chip can be combusted successfully for steam generation.

A review of the AMPC energy and water benchmarking report (Project no: 2023-1008) provides an indicative list of decarbonisation projects implemented and under investigation by AMPC members.

- Entering a renewable electricity PPA.
- Purchasing ACCUs / carbon credits.
- Investigating refrigeration energy efficiency opportunities.
- Heat pump installation.
- Investigating heat recovery opportunities to reduce the quantity of steam required for hot water generation such as heat pump heat recovery from refrigeration.
- Installing biomass boilers, including the use of paunch as a fuel source.
- Using of biogas for boiler fuel.
- Installing covered anaerobic lagoons (CALs) and capture biogas for boiler fuel.
- Improving boiler blowdown.
- Improving condensate return to boilers to a target of 80-85%.
- Installing economisers to preheat boiler feedwater.
- Installing rooftop and ground mounted solar PV.
- Installing of batteries to store renewable energy and to potentially provide electricity supply security, demand response and load shifting capacity.
- Utilising mechanical vapour recompression (MVR).
- Utilising cogeneration.
- Considering absorption chillers as part of the cogeneration systems to fully utilise heat recovery.
- Conducting steam trap surveys.
- Replacing older burners with new VSD controlled units.
- Installing VSDs on chiller and freezer fans or replace with electronically commutated fan motors.
- Optimising staging of refrigeration compressors, to use the most efficient first and to use VSDs over slide valves for part load.
- Replacing old lighting with LEDs.

Many of these decarbonisation options have been available for many years, such as LEDs to replace old lighting, variable speed drives (VSD) for pumps, fans and compressors, advanced refrigeration controls including floating head pressure control and optimal compressors selection, and hot water optimisation in sterilisers. The implementation of these more common decarbonisation projects has become a business-as-usual process for most sites. The most commonly investigated decarbonisation opportunities mentioned during the energy and water benchmarking project (2023-1008) were:

- Solar PV and batteries - Many sites showed an interest in solar PV and battery combinations, in order to store solar energy for later use or demand response. Demand response, where the local electricity retailer or demand response aggregator will pay industrial facilities to reduce load during high spot price periods, has grown in the last few years to become a viable option for many sites. The Hardwicks meat heat pump, solar PV and battery project provides a good example[11].
- Biomass boilers - The development of the pilot biomass project recently run at the JBS Riverina site[12] provides a good opportunity for sites to test the biomass boiler opportunity. The pilot will test biomass combinations in a portable multi-fuel biomass boiler. The objective is to build confidence and capability when members consider renewable solid fuels for thermal energy, and help processors to make more informed decisions about the costs and benefits of adopting biomass boilers.
- Heat pumps for water heating – Many sites are exploring the potential of heat pumps. The recovery of waste energy from refrigeration condensers by a heat pump to boost water temperatures from 30ºC to as much as 75ºC has become a very viable option with many installations going ahead in the commercial and industrial sectors in Australia and across the world. (See Appendix 8.3 for case studies and examples of heat pump projects). The development of higher temperature units is also gaining pace, and in the next few years heat pumps able to heat water above 100ºC and generate steam at up to 160ºC are predicted to become commercial options.

4.3.4 Australian government policy and programs

The change in government in 2022 has produced a significant change in Australian climate change policy. The Labour government has set new national targets for emissions reduction of 43% below a 2005 baseline by 2030 and net zero by 2050. (In 2020, under the Coalition, the national target was 26-28% reduction from 2005 levels, which, by counting Kyoto Protocol carryover credits toward the target, resulted in an effective target of 16%).

In response to the new more aggressive carbon emissions reduction target, there are several energy and decarbonisation programs under development. A recent source of financial assistance for RMP decarbonisation is the Australian Renewable Energy Agency (ARENA). This agency was established by the Australian Government in 2012 to accelerate the pace of pre-commercial innovation in renewable energy[13]. Some recent studies and projects relevant to the RMP industry are:

- In 2021, ARENA released a Bioenergy Roadmap to inform policy decisions by the private and public sectors in the bioenergy industry in Australia[14]. Identified priorities of relevance to the RMP industry are enabling the use of bioenergy in industrial heat generation and injecting renewable gas into gas pipelines.
- Recent support for Hardwick Meats in Gippsland for solar PV, heat pump and battery project with ARENA funding of $838,000.

There are several support and information programs at state level which can be categorised as grid decarbonisation, natural gas replacement with alternative fuels, electrification, and energy efficiency including:

[11] Hardwick Meatworks Heat Pump Installation and Power Upgrade Demonstration - Australian Renewable Energy Agency (ARENA)
[12] First biomass boiler trial results are in (ampc.com.au)
[13] ARENA | About ARENA
[14] ARENA | Australia's Bioenergy Roadmap

- The Victorian Government released a Gas Substitution Roadmap in 2022[15].
- The Federal government Small Business Energy Incentive provides businesses with annual turnover of less than $50 million an additional 20% deduction on spending that supports electrification and more efficient use of energy.
- Energy saving certificates can be used to help fund energy savings projects under the NSW Government Energy Savings Scheme. Additional benefits are available through the Peak Demand Reduction Scheme. Both schemes are part of the Energy Security Safeguard.
- The Victorian Energy Upgrades (VEU) program provides Victorian energy efficiency certificates (VEECs) for decarbonisation projects.

In the last 2 years, AMPC has funded projects (see Appendix 8.6) which have:

- Increased RMP solar PV adoption pipeline by 150%.
- Commenced a hydrogen pilot project.
- Assisted in the development of industry heat pump assessment tools with Australian Alliance for Energy Productivity (A2EP).
- Carbon Active demonstration (Carbon neutral product certification)
- ERF Handbook to how to register, develop, create ACCUs, audit and management process.
- Studied various energy efficiency and heat integration opportunities.
- Reviewed anerobic co-digestion opportunities

4.3.5 Food retailer scope 3 carbon emissions commitments

In recent times, Australian food retailer Woolworths has a commitment of a 19% reduction in value chain emissions by 2030[16] and international large retailers such as Walmart have committed to a goal to reduce or avoid one billion metric tonnes of Scope 3 CO_2e in the global value chain by 2030 (Project Gigaton)[17]. These major businesses are asking suppliers to demonstrate their commitment to reducing climate change through decarbonisation plans and activities. As part of red meat supply chain for major food retailers, the RMP industry will need to decarbonise to help reduce scope 3 emissions for the retailers. In the years to come this could become a strong differentiation factor for food purchases.

4.5 Decarbonisation pathway

The decarbonisation pathway for Australian RMP facilities will vary considerably depending on the grid electricity supply and fuel types. The following examples show the variation in decarbonisation required to reach the following targets:

- Scenario 1 – 43% carbon emissions reduction by 2030 (Australian government target)
- Scenario 2 – 65% carbon emissions reduction target by 2030 (2015 Paris climate agreement, to try to hold global temperatures to no higher than 1.5C above pre-industrial level).

In Victoria, the 2022 grid carbon intensity of 0.85 tCO2e/MWh is predicted to decrease to 0.37 tCO2e/MWh by 2030 (see Table 5, above). To reach the 43% carbon emissions reduction target, a large RMP plant (see Figure 1) will only need to implement plant wide energy efficiency activities. The story is even better for a small plant without

[15] Victoria State Government | Victoria's Gas Substitution Roadmap
[16] Net positive carbon emissions by 2050 (woolworthsgroup.com.au)
[17] Climate Change (walmart.com)

rendering where electricity is the major source energy for the site: this plant will achieve more than the 43% target by 2030 (see Figure 2) through grid decarbonisation alone.

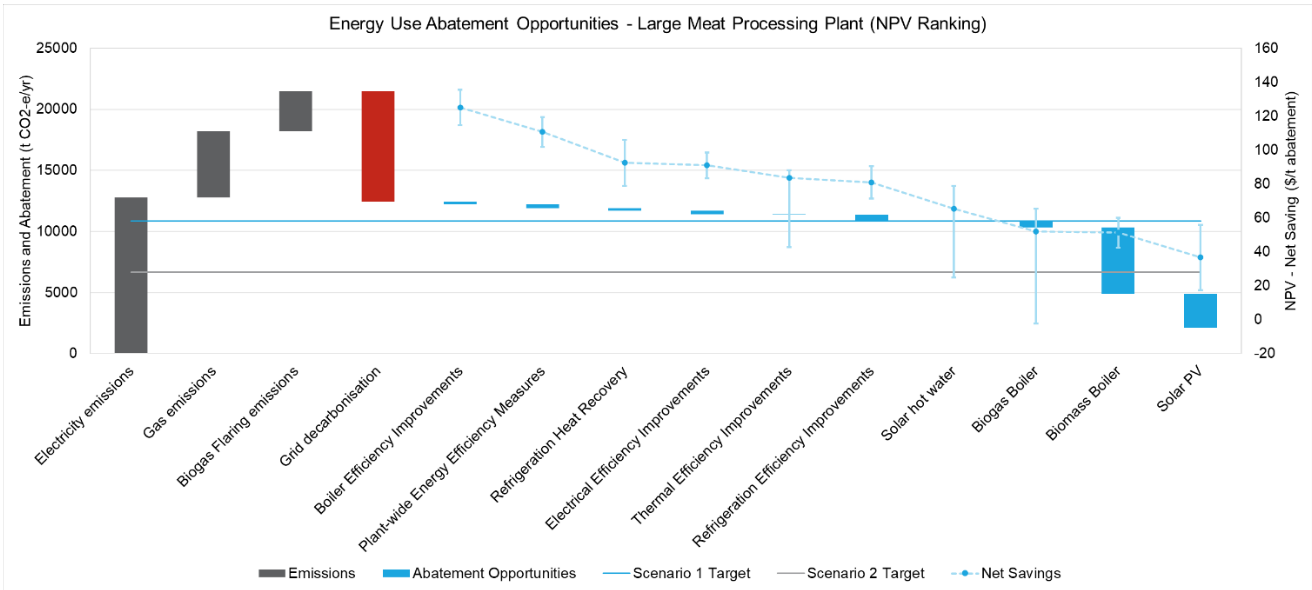


Figure 1 Victorian large RMP plant decarbonisation pathway

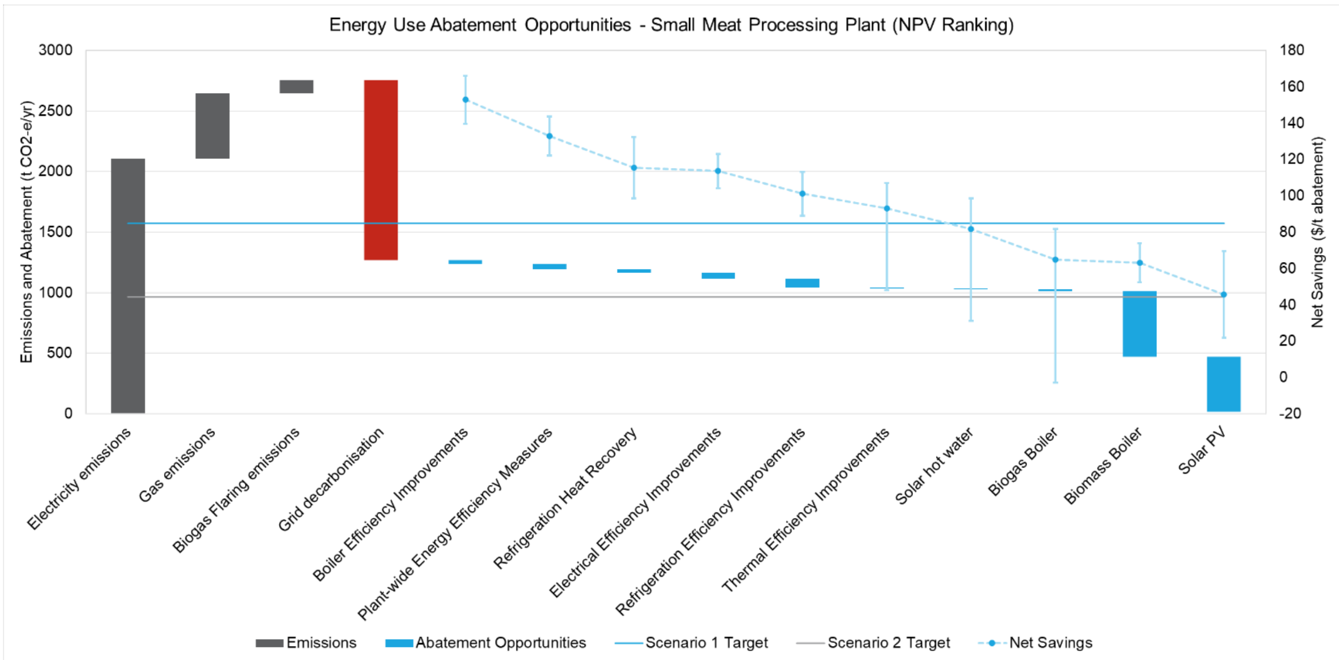


Figure 2 Victorian small RMP plant decarbonisation pathway

A large RMP plant in Tasmania has a much lower carbon footprint than the Victorian plant due to lower grid carbon intensity of 0.17 tCO_2e/MWh in 2022 and reaching 0.02 tCO_2e/MWh in 2030. However, to meet the 43% reduction target (scenario 1), this plant will need to implement a range of energy efficiency projects including solar PV (see Figure 3).

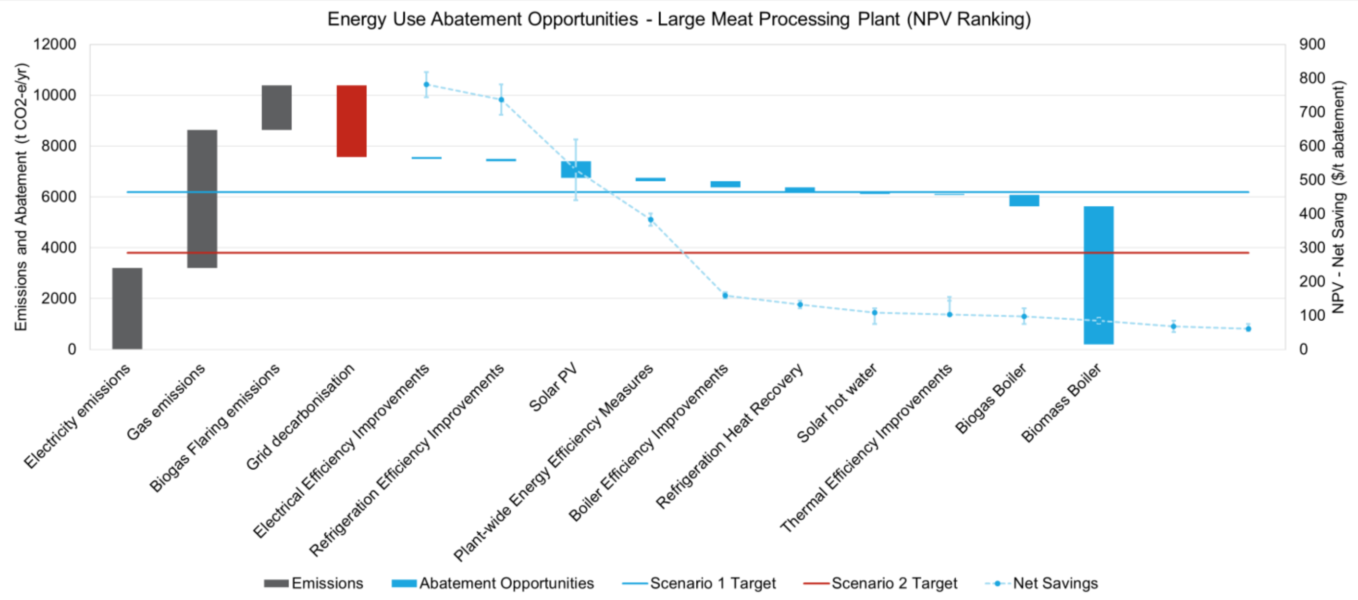


Figure 3 Tasmanian large RMP plant decarbonisation pathway

This amount of plant decarbonisation required to meet targets relies on the grid decarbonising at the predicted rate (see red bar in each figure above). There are many factors that can slow the grid decarbonisation including time to install new transmission lines to bring renewable energy from remote regions to the high energy users located in major cities and on the coast line, permission to build large scale solar and wind farms in regions such as off-shore or in farming regions where access may be an issue and for large battery installations to help balance energy use across the day and night. If the grid does not decarbonise at the forecasted rate, this may require RMP plants to move more quickly on replacement of fossil fuels and the use of on-site renewable energy sources to achieve the decarbonisation targets.

4.6 Other decarbonisation opportunities

The decarbonisation pathway for RMP plants can reach a point where there is not a good business case for further equipment replacement or renewable energy sourcing. In this case, carbon offsets or the purchase of renewable energy certificates can be used to abate the residual emissions.

4.6.1 Carbon offsets

The Australian Carbon Credit Unit (ACCU) is a possible source of carbon offsets. The unit price has varied significantly in the last couple of years due to government policy and Safeguard Mechanism program changes. In August 2023, the price of an ACCU was around $30/certificate however it has been as high as $56/certificate in 2022.

ACCUs can be purchased for voluntary offsetting but are also used for compliance by entities covered by the Safeguard Mechanism. Australian companies can use some types of international offsets for voluntary activity, such as VERs and Gold Standard credits[18].

Carbon offset prices can vary significantly, there is expected upward pressure over the next few years as companies look for decarbonisation options to reach their 2030 carbon reduction target.

[18] About Carbon Markets (cleanenergyregulator.gov.au)

4.6.2 PPAs

Power Purchase Agreements (PPAs) offer flexibility in reducing emissions associated with electricity consumption and can be accessed in a range of ways. One option is for an external business to build, own, and operate an on-site energy supply system such as a solar PV system or a cogeneration plant and sell the renewable energy at an agreed price.

Alternatively, renewable electricity and/or certificates can be purchased from an energy supplier operating a large-scale solar PV or wind farm. Individual RMP plants do not use sufficient electricity at site level or have sufficient sites in a state region for an individual PPA and would need to join a PPA buying group to obtain a competitive price.

4.6.3 Carbon shadow price

The business case for decarbonisation can be challenging, especially when available grid electricity has a significant carbon intensity. A good method to improve the business case for a decarbonisation opportunity is to include a shadow carbon price, to account for the effective cost of emissions over the life of the opportunity. The recent ACCU price of \$30/tCO_2e provides a reasonable starting value for the shadow carbon price.

5.0 Discussion

5.1 International red meat processing decarbonisation targets

International red meat processing companies have set widely varying targets, ranging from 10% to 50% by 2030 and 100% by 2035 to 2050 (see Table 6). The baseline dates can vary from 2017 to 2020 and some of the targets do not have a publicly stated baseline date. The high degree of variability in targets and baseline dates indicates that most companies are still trying to align with what is feasible with what is expected by stakeholders. The food producers around the world are looking at their supply chain as food retailers and the public are asking for sustainably produced products.

Table 6 International red meat processing decarbonisation targets

Country	Company	Scope 1 and 2 Target dates					Baseline date	Scope 3 targets
		2025	2030	2035	2040	2050		
Brazil	JBS		30%		100%		2019	
	BRF		35%					12.3% by 2030
	Marfrig			68%			2019	33% by 2035
	Minerva		30%	100%			2020	
New Zealand	ANZO		25%			100%	2020	
	Silver Fern Farm		42%				2020	
	Alliance Group		No coal					
USA	Cargill	10%					2017	Reduce emissions intensity from extended supply chain by 30tCO2-e/tonne of product sold by 2030
	Tyson Foods		30%			100%		100% reduction by 2050
	National Beef							
UK	Cranswick PLC		50%		100%			100% by 2040
	ABP Food Group		20%					
	Dunbia (UK)		30%		100%			

Minerva has set a target of net zero emissions (scopes 1 and 2) by 2035 (see Brazilian companies in Table 6). This company is now operating in Australia, having recently procured Australian Lamb Company and two Western Australian lamb processing plants. JBS is also a major player in the Australian RMP industry and has set a 2040 net zero target. This may influence other RMP businesses in Australia to take a more aggressive approach due to market pressures.

5.2 Decarbonisation technology

Heat pump technology has been accelerated by recent events in Europe, where natural gas supply has been reduced due to the Russian invasion of Ukraine. Many European countries are encouraging the use of heat pumps to replace space heating and process heating. As demonstrated by the 2022 REPowerEU plan to reduce dependence on Russian fossil fuels, the European Union (EU) aims to deploy 10 million hydronic heat pumps in the next five years and 30 million by 2030[19]. According to the European Heat Pump Association, this aim is on track. In 2022 heat pump sales grew by 38%, increasing the number of heat pumps in the EU to 20 million, representing both residential and industrial buildings[20].

Table 7 Heat pump technology readiness level (TRL)

Temperature range	2019 TRL[21,22,23]	2023 TRL[24,25]	Temperature related needs in an abattoir
<80°C	TRL 10: Commercial and competitive, but large-scale deployment not yet achieved	TRL 11: Proof of market stability	Scalding
80°C – 100°C	TRL 8-9: First-of-a-kind commercial applications in relevant environment	TRL 10: Commercial and competitive, but large-scale deployment not yet achieved	Sterilisation
100°C – 140°C	TRL 4: Early prototype	TRL 8-9: First-of-a-kind commercial applications in relevant environment	Cooking and Rendering
140°C – 160°C		TRL 6-7: Pre-commercial demonstration	
160°C – 200°C	TRL 1-3: Basic technology research	TRL 4-5: Early to large prototype	

Most RMP plants utilise a fossil fuel-fired boiler to produce steam at temperatures of around 160°C. The development of heat pumps that can produce temperatures of 140°C – 160°C has reached the early pre-commercialisation stage (see Table 7) and could be available for the international market within three to five years.

Industrial heat pumps can be very efficient, with a coefficient of performance (COP) of more than three, when the difference between the input and output temperatures ("temperature lift"), is in the 30°C - 50°C range. For higher

[19] REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition
[20] Heat pump record: 3 million units sold in 2022, contributing to REPowerEU targets
[21] Arpagaus, Cordin; Bless, Frédéric; Uhlmann, Michael; Schiffmann, Jürg; and Bertsch, Stefan, "High Temperature Heat Pumps: Market Overview, State of the Art, Research Status, Refrigerants, and Application Potentials" (2018). International Refrigeration and Air Conditioning Conference. Paper 1876. https://docs.lib.purdue.edu/iracc/1876
[22] Guido Francesco Frate, Lorenzo Ferrari, Umberto Desideri, Analysis of suitability ranges of high temperature heat pump working fluids, Applied Thermal Engineering, Volume 150, 2019, https://doi.org/10.1016/j.applthermaleng.2019.01.034**.**
[23] HSBC, Lending to Low Carbon Technologies, 2019
[24] Maruf, N. et al. (2022), Classification, potential role, and modelling of power-to-heat and thermal energy storage in energy systems: A review, Sustainable Energy Technologies and Assessments, Vol. 53(B), https://doi.org/10.1016/j.seta.2022.102553
[25] 2022 The Future of Heat Pumps IEA

temperature lifts, the COP can be lower, though the system can be configured with multi-level cycles to improve its efficiency. However, this comes with increased equipment costs.

The replacement of fossil-fuel-fired boilers with high temperature heat pumps may be a few years away, but lower temperature heat pumps with high COP can provide a cost-effective solution. The business case to replace a natural gas fired water heater with an efficiency of 76% with a heat pump with a COP of three and natural gas price of $25/GJ and electricity price of $200/MWh (see Table 8). Note that the electricity intensity is 0.73 tCO_2e/MWh (Queensland grid electricity carbon intensity in 2022). The decarbonisation level will vary for other states with the greatest savings in Tasmania (see Table 9). Complete decarbonisation of the thermal process through electrification will require renewable electricity.

Table 8 Example of natural gas fired water heater replacement with a heat pump using Queensland electricity grid carbon intensity .

Items	Amount	Units
Heat pump COP	3	
Efficiency of fossil fuel combustion	76%	
Electricity used	500	MWh
Natural gas used	1973.7	MWh
Cost of natural gas	25	$/GJ
Cost of electricity	200	$/MWh
Natural gas carbon intensity	0.05153	tCO_2e/GJ
Electricity carbon intensity	0.73	tCO_2e/MWh
Electricity carbon emissions	365	tCO_2e
Gas carbon emissions	366.1	tCO_2e
Carbon emissions savings	1.1	tCO_2e
Installed cost heat pump multiplier	3000	$/kW
Operating hours	5280	hrs
Heat pump size	94.7	kW
Cost of heat pump	$284,091	
Cost savings	$77,632	
Simple payback	3.7	years

Table 9 Example - heat pump carbon emission savings

Electricity grid	2022 Carbon emissions intensity (tCO2e/MWh)	Heat pump carbon emissions savings (tCO2e per year)
Grid electricity (NSW & ACT)	0.73	1.1
Grid electricity (QLD)	0.73	1.1
Grid electricity (VIC)	0.85	-58.9

Grid electricity (SA)	0.25	241.1
Grid electricity (WA average)	0.51	111.1
Grid electricity (TAS)	0.17	281.1
Grid electricity (NT average)	0.54	96.1
Grid electricity (Average)	0.68	26.1

5.3 Decarbonisation pathways

The decarbonisation pathway for each plant will differ depending on the current electricity grid carbon intensity, the expected rate of electricity decarbonisation, and the fuels used for thermal energy generation.

Analysis of possible decarbonisation pathways found that plants using cogeneration from fossil fuels reached a point where the electricity produced by the cogeneration system had an equal carbon intensity to the grid electricity carbon intensity. However, several cogeneration systems in Australian RMP plants use a mix of biogas and natural gas for power generation.

Based on the modelling shown in Table 10, a natural gas-fired cogeneration system using an engine with 35% efficiency, 62% thermal efficiency and achieving an overall system efficiency of 75%, will have an electricity carbon intensity of 0.32 tCO_2e/MWh. If the power generation efficiency is lower as found in a gas turbine, say 28% efficiency, then the electricity carbon intensity becomes 0.35 tCO_2e/MWh and for 40% engine efficiency the carbon intensity drops to 0.30 tCO_2e/MWh.

Table 10 Example of cogeneration electricity carbon intensity

Items	Amount	Units	Amount	Units
Engine/Turbine efficiency	35%			
Overall cogeneration efficiency	75%			
Electricity produced	18795	MWh		
Natural gas used to produce electricity	193320	GJ	**11411.22**	tCO_2e
Heat available after electricity produced	125658	GJ		
Cogeneration energy used	144990	GJ		
Cogeneration energy after electricity used	77328	GJ		
Thermal efficiency	62%			
Extra natural gas needed at 80% efficiency	28128	GJ		
Electricity	18795	MWh	5977.068	tCO_2e
Natural gas	105456	GJ	5434.148	tCO_2e

Totals	173118	GJ	**11411.22**	tCO_2e

Cogeneration equivalent to grid intensity	**0.32**	tCO_2e/MWh

In 2022, the grid carbon intensity was lower than 0.3 tCO_2e/MWh in Tasmania and South Australia, and by 2026 to 2032 many states in Australia could have electricity grid carbon intensities below 0.3 tCO_2e/MWh.

However, if the cogeneration system uses biogas, lower carbon intensities can be achieved. Assuming fully renewable biogas is used in a system with a 50%/50% mix of biogas and natural gas, the electricity produced will have an intensity of only 0.15 tCO_2e/MWh.

6.0 Conclusions / Recommendations

6.1 Conclusions

The Australian RMP has an opportunity to accelerate its decarbonisation. The key drivers for decarbonisation are:

- There is a growing pressure/expectation across the Australian market that all businesses will strive to meet a carbon emissions reduction target. In response, AMPC and MLA announced an ambition to achieve a carbon neutral target by 2030.
- Australian RMP plants have a similar challenge to decarbonise as international plants. The major RMP companies in Australia are either partnered with or owned by international companies which have carbon reduction targets.
- The technologies required for decarbonisation are the same however the rate of decarbonisation for the RMP industry depends on the rate of electricity grid carbon intensity and level of government support within that region and/or country for electrification and fossil fuel replacement.
- Australian government policies and funding programs to support decarbonisation in commercial and industrial sectors are growing at State and Federal levels. ARENA and CEFC have developed industrial programs which are being used to support RMP research and pilot decarbonisation projects.
- Large food retailers are committing to decarbonisation of the food supply chain and setting scope 3 carbo emissions targets. This will increase the pressure for decarbonisation in the RMP industry.
- The decarbonisation pathway for Australian RMP plants can vary considerably depending on the electricity grid connection, the use of fossil fuels and level of modern energy efficiency equipment and advanced control already in place. The pathway for each plant needs to be assessed at a site level. It is important to note that the modelled pathways start with energy efficiency improvements which are usually more cost effective than buying renewable electricity and replacing fossil fuel-fired equipment.

6.2 Recommendations

Key recommendations from this report are:

- The Australian RMP industry supported by AMPC has a strong history in decarbonisation demonstrated by the improvements in energy intensity and water intensity over the last 10 to 15 years. This history and the plans for further decarbonisation provide an excellent platform for response to the food retailers looking for scope 3 decarbonisation in the food supply chain. This report along with other decarbonisation project reports could be used to develop guidelines/presentations for each RMP business for discussions with the food retailers and other interested businesses.
- Each RMP plant should develop a site carbon footprint using the state-based grid electricity carbon intensity and appropriate carbon multipliers for other fuels and emissions. This work should also include an initial look at decarbonisation opportunities required to achieve the carbon reduction targets.
- Continued AMPC support for decarbonisation research and pilot projects especially those opportunities that will be critical for future decarbonisation including heat pumps, biomass boiler and renewable energy supplies.
- Those companies with international partners or ownership may wish to review the carbon emissions reduction targets required for your business. Several of the international company carbon emissions reduction targets are 30% by 2030 which does not align with the Australian government target of 43% by 2030.

7.0 Bibliography

References are provided as footnotes.

8.0 Appendices

8.1 National Greenhouse Accounts Factors for grid electricity

The following table is an extract from the 2022 National Greenhouse Accounts Factors report. We have used the Scope 2 emissions intensities in this report. Scope 3 emissions are a recent addition to the Australian grid emissions intensity reflecting the losses of the grid transmission and network distribution systems, not used in the grid emissions intensity forecasting and not used in this report.

Table 1 Indirect (Scope 2 and Scope 3) emissions from consumption of purchased electricity from a grid

State, Territory or grid description	Scope 2 Emission Factors		Scope 3 Emission Factors	
	kg CO_2-e/kWh	kg CO_2-e/GJ	kg CO_2-e/kWh	kg CO_2-e/GJ
New South Wales and Australian Capital Territory	0.73	202	0.06	15
Victoria	0.85	238	0.07	20
Queensland	0.73	202	0.15	41
South Australia	0.25	72	0.08	23
Western Australia - South West Interconnected System (SWIS)	0.51	164	0.04	12
Tasmania	0.17	47	0.01	3
Northern territory - Darwin Katherine Interconnected System (DKIS)	0.54	152	0.07	19
Western Australia - North Western Interconnected System (NWIS)	0.58	160	NE	NE
National	0.68	189	0.09	25

Sources: Primary data sources comprise National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Schedule 1), Australian Energy Statistics, Clean Energy Regulator, and AEMO data and Department of Climate Change, Energy, the Environment and Water.

Notes:

- Data are for financial years ending in June.
- An adjustment has been made to include methane emissions from hydro dams. This adjustment impacts Tasmania and the Snowy Hydro (NSW and VIC).
- For the purposes of calculating electricity emission factors, all small scale solar generation is assumed to be exported to the grid.
- Depending on the intended use, the publication of these revised factors does not necessarily imply any need to revise past estimates of emissions. Previously published emission factor estimates available in previous NGA Factors Workbooks.
- NE = not estimated. No data available to support the provision for a scope 3 factor for this grid.
- For further information see Appendix 4 Methodology for calculating electricity

8.2 International Red Meat Processor industry decarbonisation

8.2.1 Red meat processor markets and competitors

Australia is positioned as one of the key exporters in the global red meat market. In 2021, Australia was the largest sheep and goat meat exporter (see Table 11) and the fourth largest beef exporter[26].

Table 11 Top red meat exporters in 2021

Exporter ranking	Beef*	Sheep	Goat
1st	Brazil	Australia	Australia
2nd	United States	New Zealand	New Zealand
3rd	India	United Kingdom	Mexico

*Australia was the fourth largest beef exporter in 2021

To retain Australia's positioning in the global red meat industry it is essential that Australia performs as well as or better than its counterparts in terms of international decarbonisation frameworks and policies.

Australia is already taking steps towards market leadership in red meat decarbonisation. In 2017, the Australian red meat and livestock industry set a target to be carbon neutral by 2030 (CN30). The AMPC has a similar ambition to achieve CN30. Australian red meat processors have already taken steps to reduce their emissions, and RMP emissions intensity have been trending down for over a decade (see **Error! Reference source not found.**). The r ecent increase in the carbon intensity indicator is due to lower production levels in 2022, which resulted from limited animal supply, China import bans and COVID-19 at several of the meat processing plants.

Table 12 Environmental Performance Report trends

Resource	2008/9	2013/14	2019/20	2021/22
Energy intensity (MJ/tHSCW)	4108	3005	3316	3435
Carbon intensity (kg CO_2e/tHSCW)	554	432	397	447

Major red meat processing companies offshore are also making efforts to reduce emissions. They have set energy and emissions targets, with differences in ambition (e.g.,10% to 30% reduction, net zero), scope (energy only, emissions scope 1,2, and 3), and timeframes (2030, 2050). The following sections detail the international decarbonisation of the red meat processing industry, focusing on the top three exporters of each red meat type (apart from Australia) .

Most publicly available information on the sector's emissions and decarbonisation efforts focuses on red meat production, processing and distribution as a whole, or on production only. There is very limited research specific to red meat processing emissions internationally. Many research papers refer to previous Australian reports conducted by MLA and AMPC.

Many of the major companies shown in the following sections are large international food groups with a significant portion of red meat production and red meat processing. Some groups include pork and chicken production and

[26] State of the industry report MLA, 2022

processing. These companies own or have interests in red meat processing companies operating in Australia, including JBS, Cargill (50%/50% partners with Teys) and Minerva, who recently procured Australian Lamb Company and two Western Australian lamb processing plants. The decarbonisation strategies for Australian companies with part or full ownership by these international groups are based on the targets set by their international partners.

A key factor in the differences between emissions intensity per tonne of meat processed in each country is the emissions intensity of the grid electricity in that country. A summary of the estimated emissions intensities for each country shows that Australia is competing with three countries characterised by very low-emissions grid electricity, specifically Brazil, UK, and New Zealand (see Table 13).

Table 13 Countries' electricity grid and production carbon emissions intensities

Country	Average grid electricity carbon emissions intensity tCO_2-e/MWh	Estimated RMP carbon emissions intensity $kgCO_2$-e/tHSCW
Australia	0.68 (0.85 in Victoria and 0.17 in Tasmania)	447 (100 to over 600)
Brazil	0.12	220
New Zealand	0.15	240
United States	0.40	330
United Kingdom	0.10	>200
India	0.82	500
Mexico	0.43	350

The speed with which each country reduces the emission intensity of its electricity system will directly reduce red meat processing emissions in that country. Aside from grid electricity, the decarbonisation path for the thermal energy used in each country is very similar, where fossil fuels (coal and oil and natural gas) are being replaced by biomass and biogas fired boilers and electrification.

8.2.2 International decarbonisation targets

8.2.2.1 Brazil - #1 beef exporter

In Brazil, land clearing and changes to land use dominate the discussion of greenhouse gas emissions from red meat production. If direct land use and deforestation emissions are annualised over 20 years, the carbon footprint of Brazilian beef is estimated at more than 700 $kgCO_2$-e/tonne product. However, the emissions intensity of red meat processing is relatively low due to the low emissions intensity of Brazilian electricity, which is generated primarily by renewables (in 2020, 66% of generation came from hydropower, 11% from solar and wind, 8% from biomass). Fossil fuels – natural gas – only contribute 12% of generation.[27] Emissions from Brazilian electricity average 97-128 tCO_2-e/MWh[28] compared with Australia's average of about 680 tCO_2-e/MWh[29] . This means that the processing component of Brazilian red meat emissions is likely to be significantly lower than in Australia. No specific emissions intensity values for Brazilian meat processors were found in this research, but assuming a similar production process

[27] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis
[28] Understand low-carbon energy in Brazil through Data | Low-Carbon Power (lowcarbonpower.org)
[29] Australian National Greenhouse Accounts Factors (dcceew.gov.au)

to that of a typical Australian plant suggests that Brazilian red meat processing emissions intensity is likely to be around 220 $kgCO_2$-e/tHSCW product, compared with AMPC's latest EPR benchmark of 447 $kgCO_2$-e/tHSCW [30].

The high emissions intensity of Brazilian beef production is reflected in the emissions goals of Brazil's top four largest red meat companies; all have goals that address processing emissions but also extend upstream to production emissions, as detailed in the Table 14 below. The largest companies, JBS and BRF, have integrated animal production, transport and processing businesses which include a range of products such as pork and chicken as well as red meat.

The decarbonisation initiatives planned and underway for the Brazilian red meat processors are like those implemented by Australian RMP companies, including biogas generation, biomass boilers, solar PV and renewable energy certificates. In addition to these actions, there are several Scope 3 initiatives to reduce methane emissions from animals, to reduce forest clearing, and improve cattle husbandry practices. Most of these companies also set emissions targets with reference to the Science Based Targets Initiative (SBTi), an entity that defines criteria for decarbonisation targets to be considered in line with the 1.5°C goal of the Paris Agreement.[31]

Table 14 Emissions goals and initiatives of the largest red meat companies in Brazil

Brazil Largest RMP companies[32]	Emissions and related goals	Key activities
JBS Foods Group.[33,34 35] Integrated production and processing	Reduce emission intensity in all JBS facilities by 30% by 2030 from a 2019 baseline. Achieve Net zero emissions by 2040. Use 100% renewable electricity by 2040. Eliminate illegal Amazon deforestation from its supply chain by 2025, and in other Brazilian biomes by 2030. zero deforestation across its global supply chain by 2035	Seeking target verification from the Science Based Targets Initiative Monitors and reports emissions across scopes 1, 2, 3 Uses 90% renewable energy in production units in Brazil. A bioenergy plan using sugarcane bagasse and other biomass generates energy equivalent to 20% of the total used by all Brazilian JBS units. Planning to invest more than $1 billion capex over the next decade in emission reduction projects globally, and $100 million by 2030 in R&D regenerative farming practices, including carbon sequestration and on-farm emission mitigation technologies.
BRF[36,37, 38]	Achieve Net zero by 2040. Reduce Scope 1 and 3 emissions by 35% by 2030.	Seeking target verification from the Science Based Targets Initiative

[30] https://www.academia.edu/24286239/Including_Carbon_Emissions_from_Deforestation_in_the_Carbon_Footprint_of_Brazilian_Beef
[31] Ambitious corporate climate action - Science Based Targets
[32] https://www.iatp.org/documents/rise-big-meat-brazils-extractive-industry-executive-summary
[33] https://jbsfoodsgroup.com/our-purpose/sustainability
[34] https://jbsfoodsgroup.com/our-purpose/net-zero
[35] Net Zero 2040 | JBS
[36] https://www.imarcgroup.com/meat-companies
[37] https://www.brf-global.com/en/sustainability/net-zero/
[38] BRF 2021 Integrated Report ace75f6a-3a48-7fe7-ffb7-c9ecab0c1a16 (mziq.com)

Integrated production and processing	Reduce Scope 3 emissions by 12.3% by 2030. Ensure 100% traceability of grains acquired from the Amazon and Cerrado	Established the Net Zero Committee and implemented a digital and global system for the management of Scope 1 and 2 emissions. Using 90% renewable energy Achieved 75% of traceability of grains acquired from direct suppliers in the Amazon and Cerrado.
Marfrig[39] Processing	Reduce Scope 1 and 2 emissions by 68% by 2035 form a 2019 baseline. Reduce Scope 3 tCO2-e/head by 33% (2019 base year) by 2035 Increase the use of renewable energy from 27% in 2019, to 100% by 2030	Achieved target verification from the SBTi Protocol for low emissions cattle husbandry against which suppliers report compliance Monitor and report scope 1,2, 3 emissions
Minerva[40,41] Processing	Reduce Scope 1 and 2 emissions intensity by 30% by 2030 from a 2020 baseline. Achieve net zero emissions by 2035 Maintain net zero emissions in the operational energy matrix (Scope 2) with 100% of energy coming from renewable sources.	Implemented emissions reduction projects such as biogas fuels for boilers, solar PV panels, renewable energy certificates to achieve 2030 target. “Renove” program - engagement and collaboration with cattle suppliers adopting low-carbon practices, internationally recognized technologies, and methodologies to measure net carbon emissions from ranch properties.

8.2.2.2 New Zealand - #2 sheep and goat exporter

The New Zealand electricity supply has heavily dominated by renewable energy: 82% of power generation comes from geothermal, hydro and wind. As a result, electricity emissions are about 149 tCO_2e/MWh[42]. No specific emissions intensity values for New Zealand meat processors were found in researching this report, but assuming the New Zealand production process is similar to that a typical Australian processor equates to New Zealand red meat emissions of 240 $kgCO_2e/tHSCW$, compared with AMPC’s latest EPR benchmark of 447 $kgCO_2e/tHSCW$ [43]. Further investigation indicates that coal is still a major source of thermal energy for New Zealand plants, which could increase emissions intensity to over 300 $kgCO_2e/tHSCW$.

New Zealand red meat processors are strongly focused on eliminating the use of coal and switching to biogas generation, biomass boilers, solar PV, heat pumps and electrode boilers (see Table 15). They have also set initiatives to reduce scope 3 emissions, including reducing methane emissions from cattle and creating carbon neutral products. The New Zealand government released plans in October 2022 to begin taxing methane emissions from livestock in 2025.[44]

[39] https://www.marfrig.com.br/en/Paginas/metas-marfrig-aprovadas-science-based-targets.aspx#
[40] https://minervafoods.com/en/sustainability
[41] https://www.minervafoods.com/wp-content/uploads/2021/04/Minerva-Foods-Commitment-to-Sustainability.pdf
[42] New Zealand: emissions intensity from electricity generation | Statista
[43] https://www.academia.edu/24286239/Including_Carbon_Emissions_from_Deforestation_in_the_Carbon_Footprint_of_Brazilian_Beef
[44] https://www.usmef.org/export-resources/exporter-alert-archive/new-zealand-unveils-livestock-methane-tax-plan/

Table 15 Emissions goals and initiatives of the three largest red meat companies in New Zealand

NZ Largest RMP companies[45]	Emissions goals	Initiatives
ANZCO Processor 100% owned by Japan's Itoham Yonekyu Holdings, a top 10 global meat company based in Japan.	Reduce Scope 1 and Scope 2 emissions by 25% by 2030 from a 2020 baseline. Achieve Net Zero by 2050[46]	Scope 1 emissions projects - Canterbury site reduced use of coal fired boilers and reinstated electric boilers and high temperature heat pumps. Other projects include methane inhibition research, solar panel application, biodiversity development at Five Star Beef, Natural Energy group biodigester and Kokiri boiler replacement
Silver Fern Farms	Reduce Scope 1 and Scope 2 emissions by 42% by 2030[47] Achieve zero coal usage by 2030 and halve emissions from coal over the next two years.	Launching Toitū Net Carbon Zero Certified Beef in the United States Achieved 9.2% reduction in energy use per kilo of product from 2016 baseline. Achieved 20% reduction in processing emissions from 2018 baseline.
Alliance Group Limited	End the use of coal in all plants by 2029[48]	Absolute emissions have reduced 22% and emission intensity has improved 27% since 2000. Installed an electrode boiler to reduce the use of existing coal-fired boilers at Lorneville, saving 11,739 tonnes of carbon per annum Replaced the coal-fired boiler at Mataura with a high temperature heat pump system and small diesel unit for peak loads only. Captured waste heat from the refrigeration plant at Smithfield to replace coal use for process heat, saving 3,811 tonnes of carbon per annum Plans for biogas and heat pumps installations in all plants for implementation in 2023 to 2025.

8.2.2.3 United States - #2 beef exporter

On average, the emissions intensity of grid electricity in the United States is around 0.4 tCO_2e/MWh; however, as there are multiple separate grids, each with its own generation mix, this can vary by location from 0.1 tCO2-e/MWh

[45] https://beeflambnz.com/sites/default/files/Meat%20processors%20in%20NZ%20-%20May%202019.pdf
[46] https://anzcofoods.com/assets/Documents/ANZCO-Foods-Climate-Change-and-Sustainability-Report-2022.pdf
[47] https://silverfernfarms.com/nz/en/our-company/sustainability#:~:text=We%20have%20committed%20to%20a%201.5%2Ddegree%20science%2Daligned%20reduction,target%20inclusive%20of%20livestock%20emissions.
[48] https://www.alliance.co.nz/co-op/environment/

to 1.0 tCO_2e/MWh. Based on a processing plant similar to Australia, the intensity of American RMP is expected to be about 330 $kgCO_2e/tHSCW$ using the average grid electricity intensity.

Several large RMP businesses in the USA have set emissions targets (see Table 16) and are undertaking decarbonisation initiatives, mostly similar to those of businesses in Brazil and New Zealand. Cargill is also reducing emissions by diversifying into bio-based products and alternative protein options to cater to a growing demand for non-animal-based products.

Table 16 Emissions goals and activities of some largest red meat companies in the USA

USA Largest RMP companies [49]	Emissions goals	Initiatives
Cargill Meat Solutions Large food producer with red meat processing operations 50%/50% partners in Teys Australia.	Reduce emissions intensity from extended supply chain by 30tCO_2-e/tonne of product sold by 2030 Reduce absolute emissions by 10% by 2025 from a 2017 baseline.[50]	Cargill has science-based targets covering scope 1, 2, and 3 emissions In 2022, Cargill invested more than $70 million in emissions reducing technology and renewable energy projects. Pursuing electrification opportunities Switching to renewable electricity, Installing onsite generation of renewable electricity. Engage in several pre-competitive initiatives to reduce emissions across supply chains, such as the Ecosystem Services Market Consortium (ESMC) and the Global Maritime Forum's Decarbonization Task Force. Expand the market for bio-based products and alternative protein options, such as investments in PURIS, the largest North American producer of pea protein.
Tyson Foods Large food producer with red meat processing operations (140 countries)	Achieve 30% absolute GHG emissions reduction by 2030, for Scopes 1 and 2. Achieve Net Zero across our global operations and supply chain by 2050[51], including Scopes 1, 2 and 3. Increase our domestic use of renewable energy—both purchased and self-generated—to 50% by 2030.	Plans for renewable energy and reducing transportation-based emissions Reduced Scope 2 emissions per pound of product from 2.77 in 2018 to 1.96 in 2022. Developing a beef-focused emissions accounting framework to capture cradle-to-gate emissions. Plan to verify sustainable beef production practices on more than 5 million acres of U.S. cattle-grazing land by 2025

[49] https://www.zippia.com/advice/largest-meat-companies/
[50] https://www.cargill.com/sustainability/priorities/climate
[51] https://www.tysonsustainability.com/downloads/Tyson_2021_Sustainability_Report.pdf

National Beef Packaging company US meat packing group	General policy to reduce emissions however no specific targets found	Invest high-efficiency lighting, low-energy computer monitors, and auto-shutoff technology in our coolers, storage areas, and warehouses to reduce energy use. At Liberal, Kansas facility, biogas replaces approximately 20% of natural gas requirements and rendering systems heat recovery to produce hot water for processing
JBS USA Large multi-national business	Reduce emission intensity in all JBS facilities by 30% by 2030 from a 2019 baseline. Achieve Net Zero by 2040. Achieve 100% renewable electricity by 2040.	Prioritise investments in clean renewable sources and energy efficiency projects, See **Error! Reference source not found.** for m ore examples of JBS global initiatives.

8.2.2.4 United Kingdom - #3 sheep exporter

The emissions intensity of British electricity is about 0.1 tCO2e/MWh; around 60% of electricity comes from renewables and nuclear, with gas accounting for the remaining 40%. Assuming a similar production profile to the typical Australian red meat processor, a British processor would produce less than 200 kgCO_2e/tHSCW.

The UK also has incentives for RMP to reduce carbon emissions and energy use. The British Meat Processors Association (BMPA) administers a climate change levy discount scheme whereby a business can claim an energy cost discount if they can demonstrate they have achieved energy reduction targets in a two-year program52.

The 5 largest companies in the meat processing sector in the UK industry are Dunbia (UK), ABP Food Group, Hilton Food Group plc, Cranswick plc and Wm Morrison Supermarkets Ltd.

Table 17 Emissions goals and activities of three of the largest red meat companies in the UK

UK Largest RMP companies[53]	Emissions goals	Initiatives
Cranswick PLC & Cranswick Country Foods PLC	Reduce Scope 1, 2 and 3 by 50% across its entire value chain by 2030. Achieve Net-zero by 2040[54]	14 of UK sites are now certified carbon neutral. Achieved 100% renewable grid electricity in 2018 Refrigeration systems to use ammonia rather than F-Gas – reduce carbon footprint by over 10,000 tonnes CO_2 Installed Combined Heat & Power (CHP) in various forms using both biomass and gas-fired systems.
ABP Food Group	Achieve 20% emissions reduction.	Achieved quadruple certification from The Carbon Trust.

[52] Climate Change Levy Discount Scheme - BMPA (britishmeatindustry.org)
[53] https://www.dnb.com/business-directory/company-information.animal_slaughtering_and_processing.gb.html
[54] https://cranswick.plc.uk/news/cranswick-delivers-carbon-neutral-manufacturing

	Reduce 40% electricity usage.	Founding member of the Origin Green programme in Ireland ABP Nenagh has installed Escopod[55] - tri-generation systems to eliminate use of coal Full ISO 50001 accreditation
Dunbia (UK)	Achieve 30% reduction in Scope 1 and 2 emissions by 2030 from a 2016 baseline.[56] Achieve 40% emissions reduction by 2025 Achieve Net-zero by 2040[57]	Procuring 100% of electricity requirements in the UK and Ireland from renewable sources Continuously improving the efficient use of thermal energy and water on our sites Employing lean management principles in daily operations Transitioning to lower emission fossil fuels Reducing fugitive emissions from refrigeration systems

8.2.2.5 India - #3 beef exporter

The average carbon intensity for grid electricity in India is 0.82 tCO_2e/MWh. This is higher than the Australian average of 0.68 tCO_2e/MWh and very much higher than Brazil and New Zealand. Based on a similar production process as found in Australia, India's red meat processing will have an estimated emissions intensity of 500 $kgCO_2e/tHSCW$.

The largest RMP companies in India are Allanasons Private Limited, Al-hamd Food Products Pvt Ltd, Mirha Exports Pvt Ltd, none of which has a publicly available emissions reduction goal.

8.2.2.6 Mexico - #3 goat exporter

Mexico's average emissions intensity is 0.43 tCO_2e/MWh[58] which is very like the US grid electricity and lower than Australia's grid electricity intensity of 0.68 tCO_2e/MWh. Based on a similar production process as found in Australia, Mexico's red meat processing will have an estimated emissions intensity of 350 $kgCO_2e/tHSCW$.

The largest RMP companies in Mexico are SuKarne[59], Grupo Kuo SAB de CV[60], Sigma Alimentos SAB de CV[61], none of which has a publicly available emissions reduction goal.

[55] https://esco-pod.squarespace.com/escopod
[56] https://dunbia.com/dawn-meats-cuts-science-based-target-emissions-by-248000-tons-in-2020/
[57] https://www.farmersjournal.ie/dunbia-collabs-with-climate-tech-company-in-emissions-reduction-drive-755081
[58] CT2021Mexico.pdf (climate-transparency.org)
[59] https://www.sukarne.com/en/sustentabilidad/
[60] https://kuo.com.mx/informe-anual/2021/en/descargas
[61] https://sustainability.sigma-alimentos.com/wp-content/uploads/2021/07/Sustainability-Report-2020.pdf

8.2.3 Glossary

Term	Definition
AMPC	Australian Meat Processor Corporation
CO_2e	Carbon dioxide equivalent. All non-CO_2 greenhouse gases are converted to CO_2-e to account for their different atmospheric properties within a consistent framework
Decarbonisation	Reduction in emissions and/or emissions intensity.
$MtCO_2e$	Million tonnes of carbon dioxide equivalent.
RMP	Red Meat Processing
SBTi	Science based target initiative
tCO_2e	Tonnes of carbon dioxide equivalent.

8.3 Decarbonisation technologies

8.3.1 Summary

In Energetics' 2019 report for the AMPC, the electrification of process heat was identified as potential route for decarbonisation. However, at the time, it was excluded as a viable abatement opportunity as efficiency gains could only be achieved for low-temperature heat. In addition, the environmental credentials of heat pumps are dependent on those of the electricity which powers it, and only minor grid decarbonisation was forecast.

Key changes in decarbonisation since 2019 for the RMP industry are:

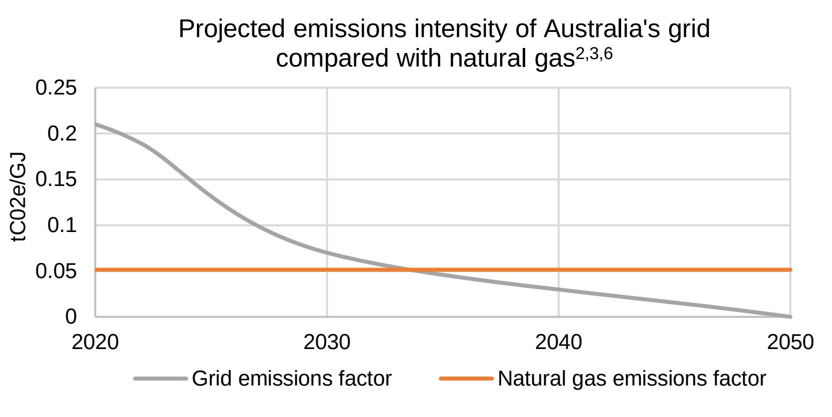
- Rapid decarbonisation of Australia's electricity grid
- High and volatile natural gas prices
- Accelerated progress in heat pump technologies.

Together these factors enable the RMP sector to advance the electrification of gas reliant processes.

8.3.2 Rapid decarbonisation of Australia's electricity grid

Since 2019, the average emissions intensity of the grid electricity has fallen from 0.218 to 0.189 tCO2e/GJ[62,63,] 0.02 tCO2e/GJ[64] (0.785 tCO2e/MWh to 0.68 tCO2e/MWh) more than was forecast in 2020.

The federal government has projected that the intensity of the electricity grid will reach 0.07 tCO2e/GJ (0.26 tCO2e/MWh) by 2030[65] and net zero by 2050. As the emissions intensity of natural gas combustion is 0.0514 tCO2e/GJ[66] and this is not projected to change, a GJ from grid will have a lower emissions factor than gas from 2035 onwards.

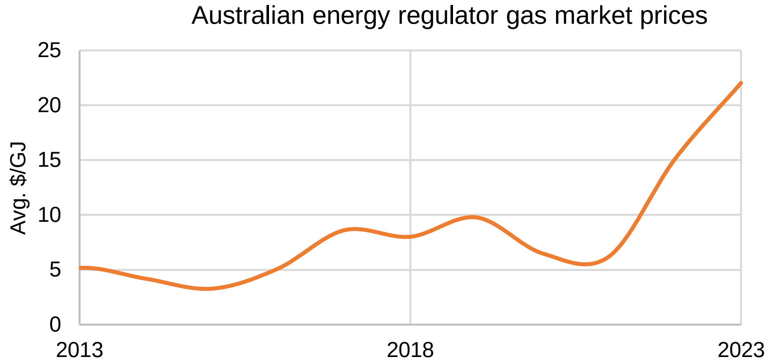


8.3.3 High and volatile natural gas prices

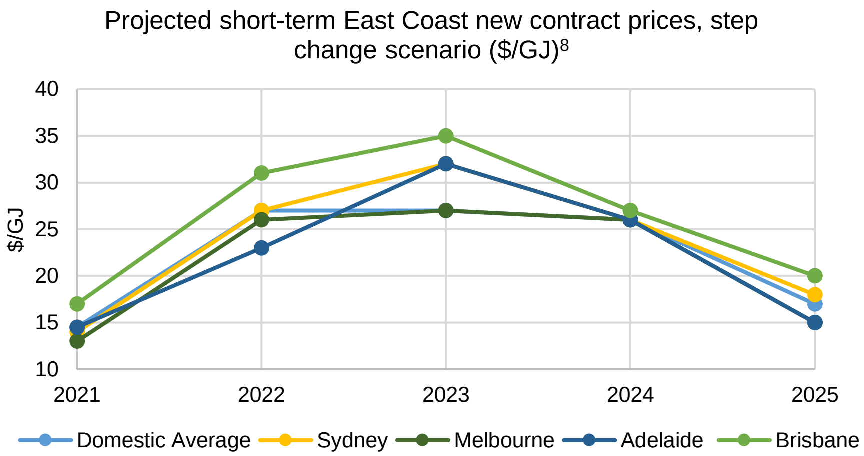
Gas prices have risen six-fold over the past decade. This has been driven by Russia's invasion of Ukraine leading to sanctions on Russia, Australian LNG exporters response to these sanctions by increasing spot export sales,

[62] 2019 National Greenhouse Accounts Factors Table 44, page 79
[63] 2022 National Greenhouse Accounts Factors Table 1, page 8
[64] Department of Climate Change, Energy, the Environment and Water, Australia's emissions projections 2022, DISER, Australian Government, 2020, Appendix C, page 74
[65] Department of Climate Change, Energy, the Environment and Water, Australia's emissions projections 2022, DISER, Australian Government, 2022, Appendix C, page 80
[66] National greenhouse accounts factor Australian National Greenhouse Accounts August 2022, Table 4, page 13

combined with unscheduled outages at coal-fired power stations and increased power demands. The 2022/23 YTD average wholesale price of gas is $22.04/GJ[67].



Gas prices are projected to remain above $20/GJ until 2025, reaching $35/GJ for Brisbane in 2023 (as they are closer to LNG export terminals)[68].



These factors in combination make it evident that the electrification of gas will be paramount in the industrial decarbonisation of RMP in an efficient and cost-effective matter.

When integrated with low emissions electricity, the replacement of natural gas appliances with electrically powered appliances will lead to significant emissions savings. The electrification of gas also provides the benefit of reducing reliance of natural gas lessening financial risks associated with current price volatility.

8.3.4 Advances in key decarbonisation technologies

In recent years, technologies for the electrification of gas-fired heating and cooling have advanced in technology readiness levels (TRLs), making them a viable abatement opportunity.

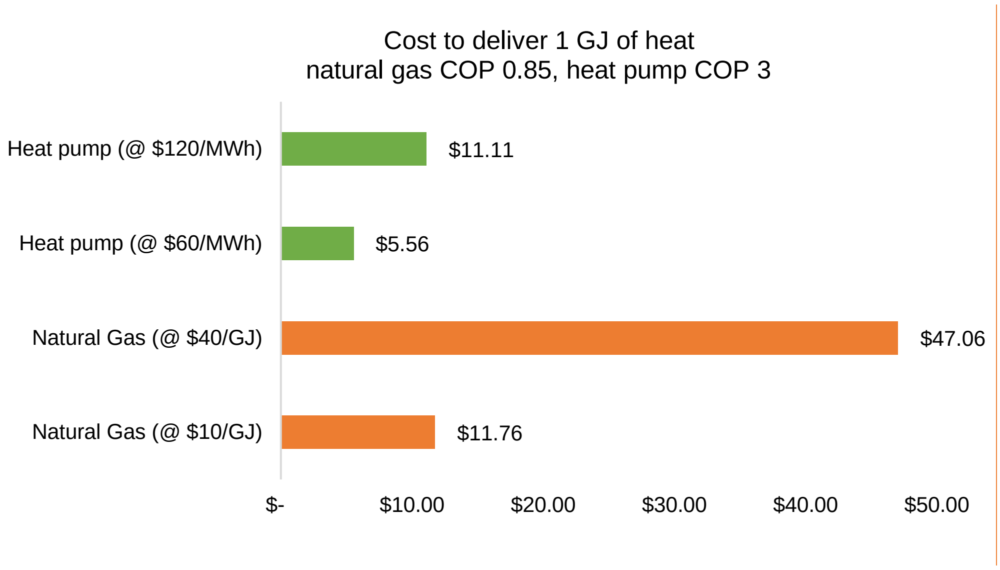
A recent study by the Energy Efficiency Council (EEC) & Australian Alliance for Energy Productivity (A2EP) found that costs associated with energy use can be reduced utilising the high coefficient of performance (COP) of heat pumps and mechanical vapour recompression (MVR)[69].

MVR is a heat pump variant that is typically used for low-temperature evaporation processes requiring temperature lifts of less than 15°C. MVR heat pumps commonly deliver COPs greater than 10. While MVR is generally used for

[67] Australian Energy Regulator gas market prices
[68] Gas Price Projections for Eastern Australia, 2023 Update Australian Energy Market Operator by Lewis Grey Advisory
[69] Hardwick Meatworks Heat Pump Installation and Power Upgrade Demonstration

processes below 100ºC, they can deliver heat up to 250°C. A2EP is currently working on a project examine how MVR improve energy efficiency in meat rendering[70].

Given the high COP of heat pumps, indicative gas prices between $12–24/GJ[71] and electricity tariffs ranging from $70/MWh to $128/MWh[72], the cost to deliver 1 GJ of heat is lower than that of gas at a variety of market metrics.



The replacement of gas with heat pump technology may enable further cost savings if the pump is set up to use waste heat from refrigerators to preheat water, improving the efficiency of the cooling process. Given refrigeration (including chilling and freezing) is the largest consumer of electrical energy on most meat processing plants, this refrigeration efficiency improvement would result in significant energy savings.

8.3.5 Heat pump technology

Since 2019, industrial heat pump systems for heating up to 110°C have become common, and higher temperature applications are likely to be available in the next 3 years[73]. Table 18 summarises the TRL of heat pumps in relation to their applications in abattoir processes.

Table 18 TRL advancements of heat pumps, in relation to different abattoir processes

Temperature range	2019 TRL[74,75,76]	2023 TRL[77,78]	Temperature related needs in an abattoir
<80°C	TRL 10: Commercial and competitive, but large-	TRL 11: Proof of market stability	Scalding

[70] Techno-economic feasibility study of Mechanical Vapour Recompression for improving Energy Efficiency in Meat Rendering
[71] Commercial and industrial air source heat pump water heaters, A2EP 2022
[72] Australian Energy Regulator, wholesale statistics electricity Q4 2022
[73] Energy Efficiency Council and A2EP, 2023 harnessing heat pumps for net zero
[74] Arpagaus, Cordin; Bless, Frédéric; Uhlmann, Michael; Schiffmann, Jürg; and Bertsch, Stefan, "High Temperature Heat Pumps: Market Overview, State of the Art, Research Status, Refrigerants, and Application Potentials" (2018). International Refrigeration and Air Conditioning Conference. Paper 1876. https://docs.lib.purdue.edu/iracc/1876
[75] Guido Francesco Frate, Lorenzo Ferrari, Umberto Desideri, Analysis of suitability ranges of high temperature heat pump working fluids, Applied Thermal Engineering, Volume 150, 2019, https://doi.org/10.1016/j.applthermaleng.2019.01.034.
[76] HSBC, Lending to Low Carbon Technologies, 2019
[77] Maruf, N. et al. (2022), Classification, potential role, and modelling of power-to-heat and thermal energy storage in energy systems: A review, Sustainable Energy Technologies and Assessments, Vol. 53(B), https://doi.org/10.1016/j.seta.2022.102553
[78] 2022 The Future of Heat Pumps IEA

	scale deployment not yet achieved		
80°C – 100°C	TRL 8-9: First-of-a-kind commercial applications in relevant environment	TRL 10: Commercial and competitive, but large-scale deployment not yet achieved	Sterilisation
100°C – 140°C	TRL 4: Early prototype	TRL 8-9: First-of-a-kind commercial applications in relevant environment	
140°C – 160°C		TRL 6-7: Pre-commercial demonstration	Cooking and Rendering
160°C – 200°C	TRL 1-3: Basic technology research	TRL 4-5: Early to large prototype	

Considering these technology advancements, heat pumps can replace the majority of RMP thermal needs. With several examples of this being seen in Europe [79,80].

Case study 1: Snellman Meat Refinement in Pietarsaari was one of the first companies to employ industrial heat pumps for waste heat recovery. In 2007 Snellman installed a 1 MW heat pump to recover waste heat and to heat up washing water to 55°C. In 2009, the meat refinement company procured further heat pumps, this time utilising heat from cooling machines and produce 75°C water for heating the plant. Finally in January 2019, the company invested in additional heat pumps producing temperatures of +95 °C. According to Snellman "Last year we saved 580 000 Euro. And we save it every year!"[20]

Case study 2: A leading Belgian retail group recently installed a 1 MW heat pump unit at their meat processing plant Fine Food Meat. The heat pump consists of 3 piston compressors combined with heat exchangers producing hot water with temperatures up to 78°C achieving high COPs[20].

Case study 3: Hutten slaughterhouse in the Netherlands has utilised heat pumps to electrify their low temperature, gas-reliant processes. The low temperature process heat is delivered by a heat pump utilising the heat rejected from the refrigeration plant of the facility. The remaining high temperature heat demand is produced from an electric boiler. The combination of the technologies has eliminated the use of gas[19].

As part of the 2022 REPowerEU plan to reduce dependence on Russian fossil fuels, the European Union (EU) aims to deploy 10 million hydronic heat pumps in the next five years and 30 million by 2030[81].

According to the European Heat Pump Association, this aim is on track. In 2022 heat pump sales grew by 38%, increasing the number of heat pumps in the EU to 20 million, representing both residential and industrial buildings[82].

[79] Strengthening Industrial Heat Pump Innovation Decarbonizing Industrial Heat, SINTEF 2020
[80] Large scale heat pumps in Europe, Real examples of heat pump applications in several industrial sectors EPHA
[81] REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition
[82] Heat pump record: 3 million units sold in 2022, contributing to REPowerEU targets

Hardwick Meatworks provides an example of Australia adopting heat pumps in RMP.

Case study 4: Hardwick Meatworks, a red meat processor in rural Victoria, is piloting Australia's heat pump adoption in the red meat sector. With the support of the Australian Renewable Energy Agency (ARENA), Hardwick's is switching to a heat pump-driven water heating system.

According to ARENA, the heat pump will deliver hot water at a planned 75°C, utilising existing on-site 2.5 MW solar PV and a 2 MWh battery energy storage system. The project will make use of existing thermal energy storage in the form of approximately 150,000L hot water storage tanks. The project will also upgrade the Hardwick Meatworks electrical supply system[9].

8.3.6 Other abatement technologies

To address remaining emissions, opportunities exist to integrate heat pumps with solar photovoltaics (PV). Additionally, high heat processes left unabated by low temperature heat pumps – such as rendering – can be addressed utilising electric boilers and MVR.

While solar PV capital is high, this abatement opportunity typically pays back in three to six years[83] and can additionally generate significant, positive publicity. Power purchase agreements (PPAs) are an option for facilities to source on-site or off-site renewable energy, such as solar PV, without the need of upfront capital.

Biogas cogeneration can also be used to generate power or hot water and steam. Biogas is a readily available by-product from wastewater produced from anaerobic ponds and lagoons. The technology is inexpensive and significantly reduces wastewater organic loading.

In both the 2019 report and now, Energetics did not recommend on-site wind as an abatement opportunity for the RMP sector as wind is a capital-intensive venture which requires significant land space, also wind generation is intermittent and wind farms are prone to poor performance if not sited appropriately.

Multi-fuel biomass boilers are also a viable option for those areas with a reliable long-term supply of biomass (see case study 6 below). Multi-fuel biomass boilers are suitable for combusting the paunch produced in red meat processing after blending with dryer and higher calorific value biomass or after multi-stage mechanical dewatering. Currently, paunch / woodchip blend at supply cost is ~$2/GJ with a blend of up to 80% paunch, 20% woodchip[84].

8.3.7 Recent uptake of abatement technologies

There has been significant uptake of renewable technologies by RMP businesses as shown in the recent Environmental Performance Report (EPR)[85] including:

Solar PV pipeline for the red meat processor sector has increased by 150% in the last 18 months. A recent example of solar PV installation is shown below.

Case study 5: G&K O'Connor commissioned the 1.26 MW rooftop solar system at their Pakenham site, in January 2023, on time and on budget. The solar system is producing more electricity than forecast. The solar project will reduce the site's emissions by 1,390 tCO_2e/annum. or roughly 10% of total Scope 1 & 2 emissions. The project will provide annual cost savings of more than $200,000 and will generate Victorian Energy Efficiency Certificates (VEECs) that will cover 40% of the capex investment, providing an expected payback period of just

[83] Depending on cost of energy, system size, typical energy produced and feed-in electricity tariff.
[84] Data from AMPC
[85] 2022 Environmental Performance Review for the red meat processing industry

Bioenergy consumption by red meat processor sector is 3rd largest energy source and has surpassed on-site coal consumption for first time ever. A pilot program to test the viability of biomass boilers has shown positive results.

Case study 6: Results from AMPC's first biomass boiler trial site are in. Late last year AMPC delivered a biomass boiler to a JBS Riverina meat processing facility as part of its investment into sustainable fuel options. The pilot demonstrated how different types of biomass, sourced through a circular economy approach, contributed to lowering energy costs, energy emissions, and achieving energy reliability.

JBS Sustainability Engineer Michael Lang said, "During the trial we monitored the feasibility of various blends of available biomass. We successfully used paunch materials (usually identified as a waste stream) in multi-fuel biomass blends of up to 80% paunch, 20% woodchip.

"The ability to use this site generated biomass together with externally sourced biomass such as wood chips has provided energy to the plant at sub $2/GJ. Costs to supply thermal energy to the site have substantially increased with both natural gas and coal prices rising sharply over the last 12–18 months. The ability to replace these fossil fuels with a lower carbon emission biomass alternative, using purpose-built boilers is now a genuine possibility."

AMPC Program Manager Matthew Deegan said, "Using locally sourced and on-site sustainable biomass fuels can include paunch, sludges, unrecyclable wood, woodchip, nut shells, saw dust, or agri-wastes, as long as the final fuel blend meets the boiler fuel specifications.

"Australian red meat processors are serious about their transition to clean energy. Since we started this project, processor use of bioenergy has overtaken on-site coal use as the sectors third largest source of energy, behind grid gas and grid electricity."

8.3.8 Glossary

Term	Definition
A2EP	Australian Alliance for Energy Productivity
Abatement	Reduction in net greenhouse gas emissions (through reduction or offsetting)
AMPC	Australian Meat Processor Corporation
ARENA	Australian Renewable Energy Agency
CO_2e	Carbon dioxide equivalent. All non-CO_2 greenhouse gases are converted to CO_2e to account for their different atmospheric properties within a consistent framework
COP	Coefficient of performance
Decarbonisation	Reduction in emissions and/or emissions intensity.
EEC	Energy Efficiency Council
EU	European Union
LULUCF	Land use, land use change, and forestry

$MtCO_2e$	Million tonnes of carbon dioxide equivalent.
MVR	Mechanical Vapour Recompression.
PPAs	Power purchase agreements
PV	Photovoltaics
RMP	Red Meat Processing
$tC0_2e$	Tonnes of carbon dioxide equivalent.
TRL	Technology Readiness Level
VEECs	Victorian Energy Efficiency Certificates

8.4 Australian Government Policies and programs

8.4.1 Red meat processing emissions in the context of national emissions reduction policy

Red meat processing carbon emissions result from energy consumption and wastewater treatment. In 2022, the RMP industry generated 1,139,850 tonnes of carbon dioxide equivalent (tCO_2e). Over half (53%) derive from electricity from the grid (scope 2) and 27% from scope 1 energy sources, such as natural gas, diesel, and petrol[86], and 20% from wastewater carbon emissions (

Figure 4).

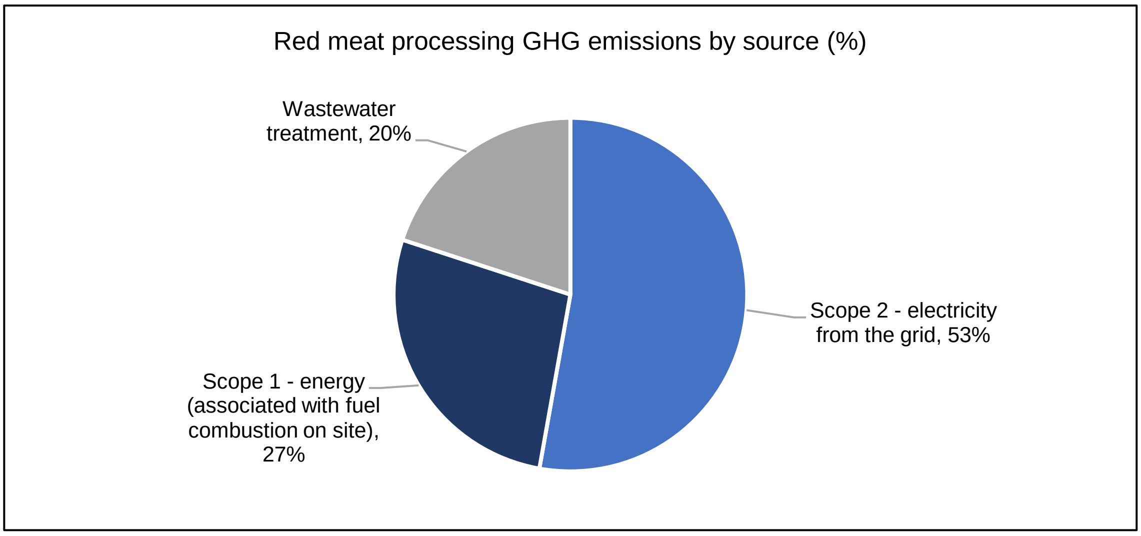


Figure 4: RMP GHG emissions, data from AMPC's 2022 Environmental Performance Review

The Australian Government has legislated a national emissions reduction target of 43% by 2030 on 2005 levels and net zero emissions by 2050[87]. Policies to achieve these goals are still in development. The most significant decarbonisation policy instrument is the Safeguard Mechanism, which the Government has strengthened, but as this currently applies only to facilities that emit over 100,000 tCO_2e (scope 1) annually, it is not directly relevant to the RMP industry, whose largest facilities fall below this level. However, there are multiple smaller federal and state policies that address opportunities to reduce red meat processing emissions. These opportunities can be broadly categorised as grid decarbonisation, natural gas replacement with alternative fuels, electrification, and energy efficiency.

Below we note the role of the Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC) in supporting all these opportunities; this is followed by an overview of relevant Government policy and programs within each opportunity category.

8.4.2 Federal support for multiple opportunities: ARENA and CEFC

ARENA was established by the Australian Government in 2012 to accelerate the pace of pre-commercial innovation in renewable energy[88]. ARENA's strategic priorities include "optimising the transition to renewable energy", which includes, bioenergy / energy from waste, renewables for industry, battery storage and hybrid technologies[89]. ARENA

[86] AMPC | Environmental Performance Review 2022
[87] Australian Government, Department of Climate Change, Energy, the Environment and Water | Australia's energy strategies and frameworks
[88] ARENA | About ARENA
[89] ARENA | Projects

provides grants to projects that can provide demonstration of the feasibility of new technologies or support business models that are new to the Australian context. Its "Renewables for industry" funding is aimed at:

- Feasibility studies and demonstration projects that may enable substantial energy end uses to shift to renewable energy, either individually or in aggregate across multiple sites and sectors.
- Innovative projects using technologies such as bioenergy, solar thermal, renewable hydrogen, and renewably powered electrification technologies and processes.
- Enabling technologies such as energy efficiency, energy storage, demand side flexibility to match renewable energy supply, and mechanical alternatives to process heating[90].

ARENA has funded decarbonisation project specific to the meat processing industry is included in section 5 below.

The CEFC was established in 2012 as a public provider of concessional finance for near-commercial decarbonisation opportunities. Its mission is to help achieve Australia's national goal of net zero emissions by 2050[91]. The CEFC may provide debt or equity finance to innovative companies or investors to implement clean energy, energy efficiency or low emissions technologies. For small businesses, the CEFC has partnered with Australian private sector lenders to develop discounted finance for clean energy equipment and systems for projects up to $5 million[92]. An example of support provided by the CEFC to a red meat processor study is provided in section 6 below[93].

8.4.3 Decarbonisation of the electricity grid

The largest current driver of national emissions reduction (and emissions reduction within the red meat processing industry) is the decarbonisation of the electricity grid[94]. Since 2019, Australia's electricity emissions have fallen by more than 10 $MtCO_2e$ / year.

This trend was started by the Renewable Energy Target and is still supported by Government policy but is now driven primarily by market forces. The rapid decline in renewable energy generation costs over the past decade has reduced the competitiveness of coal fired power generation, and ageing coal generators are continuing to exit the market.

In early 2022 the Australian Energy Market Operator (AEMO) released analysis projecting the withdrawal of 14 gigawatts (GW) of coal capacity in the National Electricity Market (NEM) by 2030 (under the Step Change scenario) (Figure 5). This represented potential closure of nearly two-thirds of total coal capacity in the NEM and almost double the amount of capacity that had been announced to be retired (8 GW)[95]. Since then, retirement dates for 16 coal generators have been brought forward, bringing announced (installed) capacity withdrawal by 2030 to 12.8 GW (Figure 6).

[90] ARENA | Renewables for industry
[91] CEFC | Mission and values
[92] CEFC | Asset finance
[93] CEFC | Finance for Bindaree Beef biogas and rendering upgrade
[94] Technically, Australia's electricity comprises several major grids: the National Electricity Market (NEM) is the grid serving Qld, NSW, ACT, Vic, SA, Tas. In WA there are the Southwest Interconnected System, the Northwest Interconnected System and smaller regional grids. The NT has five regional grids. The discussion of grid decarbonisation is applicable primarily to the NEM and SWIS, although all grids will transition to varying degrees to a greater use of renewable power generation.

[95] AEMO | 2022 Integrated System Plan (ISP)

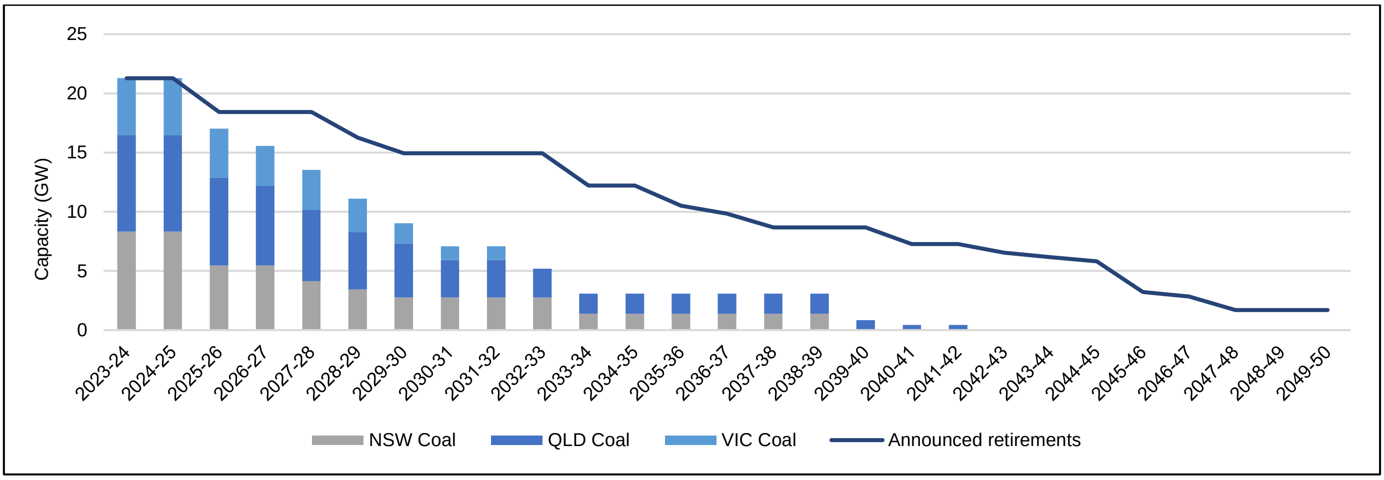


Figure 5: Projected coal retirements, Step Change technology and regional outlook, Extract from AEMO's Integrated System Plan 2022

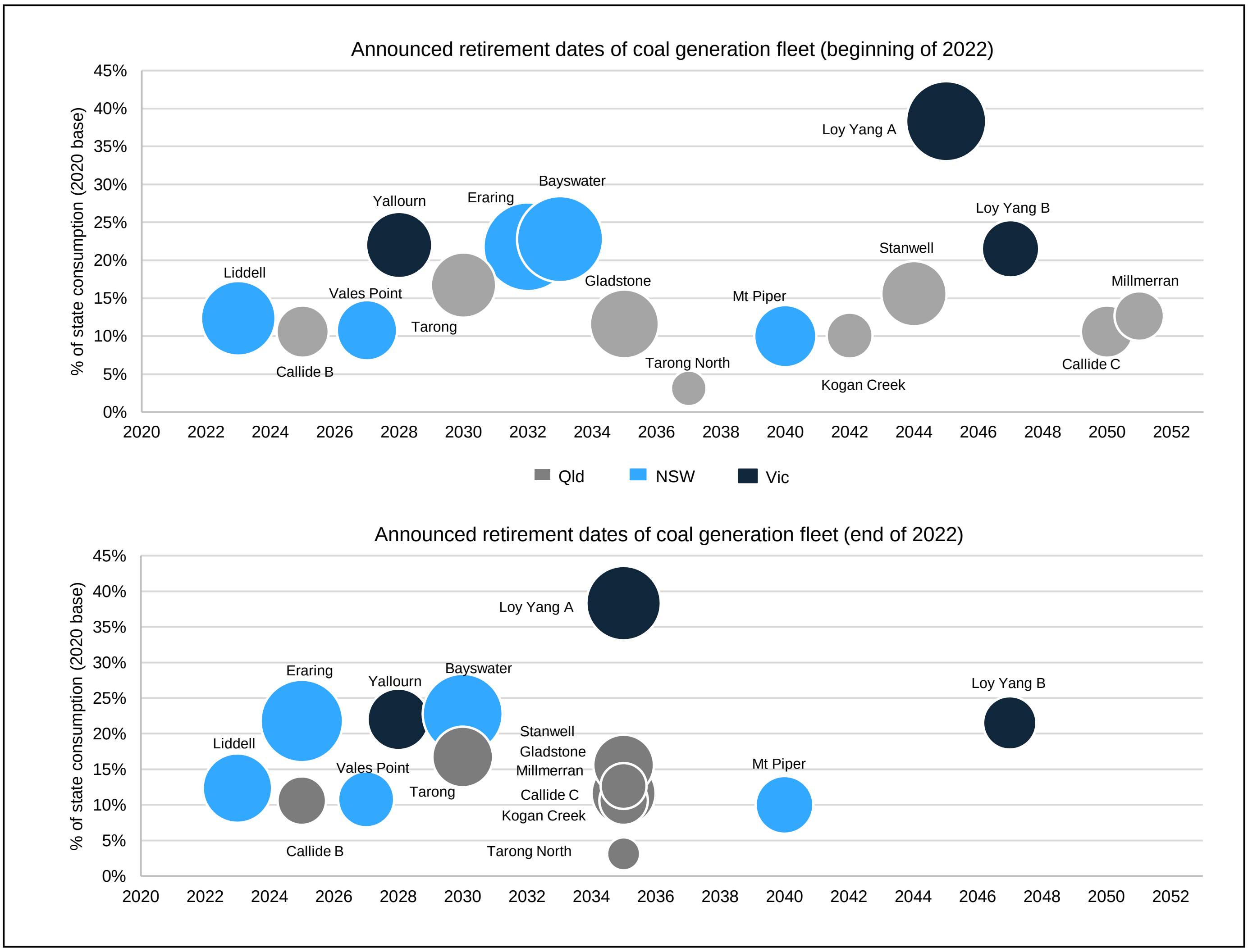


Figure 6: Coal fired generation announced retirement dates, start of 2022 vs. end of 2022, bubble size representing % of state consumption.

Although AEMO and electricity market stakeholders consider Step Change the "most likely" scenario, there is significant uncertainty as to whether sufficient replacement capacity will be available in time to offset expected retirements over the next 10 – 15 years[96]. The AEMO's Progressive Change scenario, for example, shows a slower rate of coal retirement, which could reflect a situation where coal generators are supported to remain in the market for longer to preserve grid stability. However Progressive Change and AEMO's other scenarios follow the same general trend to near-full decarbonisation of the electricity system by the 2040s.

This means that by 2030, the emissions intensity of grid electricity used by red meat processors could decline from a NEM average of 0.63 tCO_2e / MWh at present[97] to 0.20 tCO_2e / MWh in a Step Change scenario and 0.41 tCO_2e / MWh in a Progressive Change scenario (Figure 7). (Note: The grid emissions intensity will vary from state to state). In other words, a facility's emissions from electricity use could fall by 30-65% by 2030 just as a function of grid decarbonisation. By 2050 both scenarios converge on zero-emissions electricity. Electrification of other energy-consuming processes would allow processors to reduce emissions further and earlier (see electrification section below).

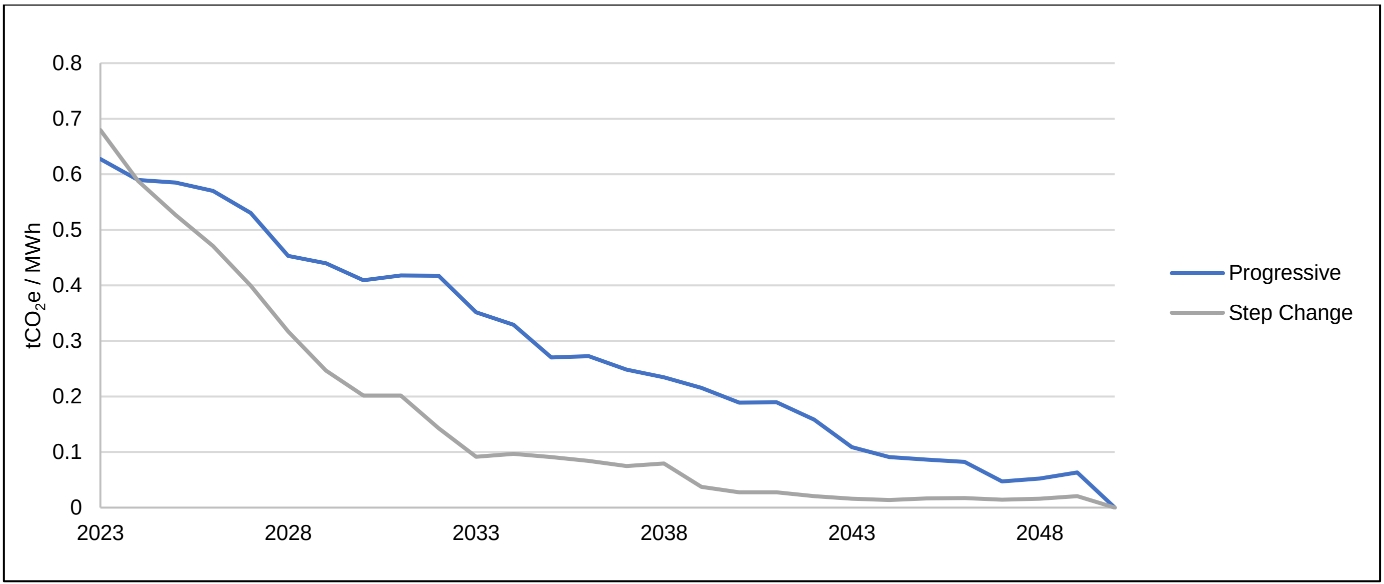


Figure 7: Annual emissions intensity projection for Progressive and Step Change AEMO scenarios

Federal and state Governments are taking varying approaches to supporting grid decarbonisation. The federal Government is focusing on expanding transmission capacity to enable renewable energy integration through its Rewiring the Nation policy. This was established in the 2022-23 Budget with $20 billion in low-cost finance to expand and modernise Australia's electricity grids, including the Marinus Link between Tasmania and Victoria, offshore wind projects and Renewable Energy Zones (REZs) in Victoria, and the Victoria-NSW Interconnector (VNI West)[98]. This policy should also increase access to remote renewable generation. ARENA's Advancing Renewables Program supports the transition to renewable electricity through a range of development, demonstration, and pre-commercial deployment projects[99]. Additionally, the federal Government is supporting grid decarbonisation through funding the expansion of the Snowy Hydro Scheme with Snowy 2.0. Once built, Snowy 2.0 will provide an additional 2,000 MW of generating capacity and 350,000 MWh of large-scale storage to the NEM[100].

Victoria and Queensland are funding large-scale renewable energy projects, though, respectively, the Victorian Renewable Energy Target (VRET) and the Queensland Energy and Jobs Plan (QJEP). To achieve the VRET, which

[96] See, for example, Australia's energy transition: Snowy Hydro 2.0 faces further cost increases.
[97] DCCEEW | Australia's emissions projections 2022
[98] Australian Government, Department of Climate Change, Energy, the Environment and Water | Powering Australia
[99] ARENA | Advancing Renewables Program
[100] Snowy Hydro | About

targets 50% of Victoria' power generation to come from renewable sources by 2030, the state is running reverse auctions for generation and storage capacity[101].

The QEJP is targeting 70% of Queensland's generation to be renewably sourced by 2032, through direct funding for solar, storage and transmission capacity projects, and a transformation of the state-owned coal generators into clean power hubs[102]. NSW is focused on enabling renewable energy through Renewable Energy Zones (REZs). REZs are high-quality resource areas where clusters of large-scale renewable energy projects can be developed using economies of scale[103]. WA's Energy Transformation Strategy[104] includes development of a Whole System Plan to help shape the most appropriate generation mix and network configuration into the future and planning for the orderly retirement of coal-fired generation.

8.4.4 Electrification

There is relatively little Government policy focused specifically on enabling industrial users of natural gas to switch to electricity. The Victorian Government released a Gas Substitution Roadmap in 2022[105]. This considered industrial desires and concerns regarding switching from gas to electricity but contains no new initiatives for this sector, although it notes that the Victorian Energy Upgrades (VEU) scheme (see section 7, Energy Efficiency below) now includes a new commercial and industrial heat pump hot water activity and that electrification opportunities may be supported through the bespoke project-based efficiency activity. ARENA's Industrial Energy Transformation Studies (IETS) Program has enabled a demonstration electrification opportunity at a red meat processor (see case study below)[106].

Case study: Electrification of water heating and reduction of gas consumption at Hardwick Processors

In 2022, ARENA announced $838,000 in funding to Hardwick Processors to install a 1 MW (thermal) demonstration scale heat pump and upgrade the electrical supply system at its meat processing plant in Kyneton, Victoria. The heat pump upgrade will enable the site to produce enough hot water to operate at levels to improve shelf life and access further export market growth, while helping to reduce the site's reliance on natural gas by over 75%. The project will also be able to benefit from Hardwick Processors' previous commitments to reducing emissions by utilising existing on-site renewable energy supply infrastructure of 2.5 MW solar PV and a 2 MWh battery storage system.

Key lessons / recommendations from this project, identified by Hardwick Processors, included[107]:

- Employing more effective stakeholder communication to reduce delays. The power upgrade caused delays in renewable assets coming back online,
- Checking compliance with all regulatory or code obligations. The requirement for ammonia detection in the plant room was overlooked at the design phase,
- Achieving effective sizing of plant to match all operational requirements and variables. The initial analysis for this heat pump project was carried out over in 2019 and was carried out largely due to the availability of funding to support the investigation. In designing a system, it is very important to consider what flexibility is required to allow for operational variabilities of the processing facility.

[101] Victoria State Government | Victorian renewable energy and storage targets
[102] Queensland Government | Queensland Energy and Jobs Plan
[103] AEMO | Appendix 3. Renewable energy zones Appendix to 2022 ISP for the National Electricity Market
[104] The Government of Western Australia | Energy Transformation Strategy
[105] Victoria State Government | Victoria's Gas Substitution Roadmap
[106] ARENA | Hardwick Meatworks Heat Pump Installation and Power Upgrade Demonstration
[107] ARENA & Hardwick Processors Proprietary Limited | Lessons learnt report number 2

In April 2023, an energy incentive for small businesses has been announced. The Small Business Energy Incentive provides businesses with annual turnover of less than $50 million an additional 20% deduction on spending that supports electrification and more efficient use of energy. Examples of investments include the electrification of heating and cooling systems, upgrading to more efficient fridges, and installing batteries and heat pumps[108].

8.4.5 Switching from Natural Gas to Alternative Fuels

8.4.5.1 Development of Bioenergy Production and Use

In 2021, ARENA released a Bioenergy Roadmap to inform policy decisions by the private and public sectors in the bioenergy industry in Australia[109]. Identified priorities of relevance to the RMP industry are enabling the use of bioenergy in industrial heat generation and injecting renewable gas into gas pipelines. It notes that "industries that generate organic waste as a by-product, such as the food and wood processing industries, could viably integrate bioenergy within existing operations. This is because their production processes generate feedstocks, thus providing direct access to them." Modelling of a 'Targeted Deployment' scenario finds that supportive Government policy could enable:

- Bioenergy to provide 244 PJ / annum of renewable industrial heat, which would represent about 33% of the total industrial heat market.
- Gas pipelines to incorporate 105 PJ / annum of renewable gas, about 23% of the pipeline gas market.

To aid in the implementation of the Bioenergy Roadmap, in 2021 the Government committed an additional $33.5 million to ARENA to support Australia's bioenergy sector. Over the past decade, ARENA has provided over $131 million in funding towards bioenergy projects across Australia. ARENA's investments have spanned electricity and biogas production, biofuels, efficient feedstock harvesting technology and projects that aim to capture energy from a range of waste materials[110]. An example of ARENA assisting the commercialisation of bioenergy in the RMP sector is seen in a case study below[111].

Case study: Goulburn Bioenergy Project, Southern Meats Abattoir

This ARENA funded project, finalised in 2018, helped ReNu Energy to build an anaerobic digester. ReNu Energy's digester is supplied with wastewater from Southern Meats biogas treatment plant. The anaerobic digester consists of two 800 kW dual fuel Caterpillar generators that are electrically connected to Southern Meats.

ReNu Energy operates the anaerobic digester under a Build Own Operate Maintain (BOOM) model, whereby ReNu Energy sells the electricity generated to Southern Meats under a 20 year power purchase agreement (PPA). This project also enables ReNu Energy to generate Large Scale Renewable Energy Certificates (LGCs) and Australian Carbon Credit Units (ACCUs), that they can supply to the Clean Energy Regulator (CER).

The Managing Director of ReNu Energy, Chris Murray, said, "The commercial operation of the Goulburn Bioenergy Project is a significant milestone for ReNu Energy and for the bioenergy sector in Australia. The project will supply approximately 4,000 MWh of energy annually, representing over 50% of the facility's power consumption and a significant reduction in energy costs and carbon emissions for our customer, Southern Meats." [112]

The CEFC has also supported bioenergy production and use. According to a report released by CEFC in March 2021, Australia-wide, they estimate a potential infrastructure pipeline of $4–$7.8 billion in investment opportunities in bioenergy, recycling and resource recovery. The CEFC's investment pipeline is focused on anaerobic digestion for behind-the meter energy applications in intensive agriculture, food processing and wastewater treatment. The CEFC

[108] Treasury portfolio | Small Business Energy Incentive
[109] ARENA | Australia's Bioenergy Roadmap
[110] ARENA | Paving the way for Australia's bioenergy industry
[111] ARENA | Goulburn Bioenergy Project, Southern Meats Abattoir
[112] Energy Magazine | NSW bioenergy project begins commercial operation

noted that the project pipeline is constrained by the lack of policy support and that active Government support to overcome these barriers could unlock significant expansions in bioenergy projects[113].

8.4.5.2 Hydrogen Production and Use

Recent advancements in hydrogen fuel cell technology enable the following hydrogen opportunities for red meat processors[114.115]:

- Hydrogen as a transport fuel for refrigerated trucks (Mercedes Econic platform), hook bins (Mercedes Econic platform), and other heavy vehicles (Kenworth with Toyota FC Mercedes Econic platform).
- Hydrogen forklifts (Hyster) and light vehicles (Toyota MIRAI, Hyundai, NEXO FWD SUV).
- Power generation for off-grid, peak shaving, and emergency power applications (Ballard's stationary power generation).

To enable increased hydrogen penetration, in 2019 Australia formed a National Hydrogen Strategy which includes development of a Guarantee of Origin scheme, regional Hydrogen Hubs, and direct funding of more than $1.3 billion. There is now a $127 billion pipeline of announced hydrogen investment in Australia. This includes 80 renewable hydrogen projects, 15 of which have passed the final investment decision[116].

Additional to this, at the 2023-24 Federal Budget, the Australian Government announced the establishment of the $2 billion Hydrogen Headstart initiative to underwrite the biggest green hydrogen projects to be built in Australia[117]. Hydrogen may be blended into gas distribution networks at concentrations of less than 10%, but it is unlikely to be commercially available at scale before the mid-2030s.

8.4.6 Energy efficiency

Australia's state governments have variable policies and grants with slightly different parameters addressing energy efficiency.

Victoria, NSW and the ACT have energy efficiency certificate schemes, each with slightly different parameters. These schemes lower the costs of energy efficiency opportunities to households and business. RMP businesses have accessed the schemes for electricity and gas saving projects, refrigeration upgrades, biogas use in boilers, and VSD air compressors. Additional eligible activities include lighting upgrades, air conditioner replacement, installation of air source heat pump water heater systems, replacement of boilers and compressed air system activities[118,119 120.] Businesses can also earn credits for bespoke 'project based' energy efficiency, electrification and fuel switching activities that cut emissions in NSW and Victoria.

NSW has also introduced a Peak Demand Reduction Scheme (PDRS), to incentivise installation of appliances that use less electricity during peak times, such as air conditioners, refrigerated cabinets, heat pump hot water systems and motors for ventilation or refrigeration[121].The next stages of this program will include industrial demand reduction which may be suitable for RMP.

[113] CEFC | Energising resource recovery: the Australian opportunity
[114] AMPC | Renewable hydrogen (H2) cost-benefit analysis for Australian red meat processors
[115] AMPC | Renewable Hydrogen (H2) Cost-Benefit Analysis for Australian Red Meat Processors
[116] DCCEEW | Growing Australia's hydrogen industry - DCCEEW
[117] ARENA | $2 billion for scaling up green hydrogen production in Australia
[118] A2EP | Energy grants & funding
[119] Australian Government | Financial incentives for NSW businesses to improve their energy efficiency
[120] Victoria State Government | Victorian Energy Upgrades for businesses
[121] IPART | Reducing peak demand with PDRS

Several energy efficiency grant programs, such as NSW's Metering and Monitoring Planning Offer and Implementation Grants, SA's Assess-Implement-Monitor (AIM) Grants and ACT's Business Energy and Water Program.

The Metering and Monitoring Planning Offer and Implementation provides $12 million to support businesses to get the most out of energy metering and monitoring. Applicants for grants to implement recommended metering and monitoring plans will open in the first half of 2023[122,123]. RMP businesses could take advantage of this grant to monitor electricity and water usage.

Up to $15,000 is available for businesses to AIM grants provide a subsidy for businesses to assess ways to implement more economically and environmentally sustainable practices. "Funding is available for businesses and not-for-profits to: Assess materials and resource efficiency, waste management, and / or other options to support a more sustainable and circular economy for South Australia. Implement recommendations made through a GISA-funded, independent, and impartial assessment. Projects should enable participants to monitor progress and report outcomes, using it as a base for continuous improvement" [124].

Under the ACT's Business Energy and Water Program, small-to-medium business can apply for a rebate of up to $5,000 to upgrade technologies to be more energy efficient technologies, including cooling or heating, hot water, insulation, lighting, refrigeration, tapware, and toilets[125].

8.4.7 Policies in development

The Government has announced a National Reconstruction Fund (NRF), to be modelled on the CEFC but for "projects that diversify and transform Australia's industry and economy"[126]. Priority areas for the fund include renewables and low emissions technologies (up to $3 billion) and value-add in the agriculture, forestry, food, and fibre ($500 million). Given the agriculture focus, RMP businesses may be able to use this fund to install renewable technology and invest in low emissions technologies such as heat pumps. Consultation on the implementation of the NRF recently closed, and the NRF is expected to be operational following the finalisation of co-investment plans with industry in late 2023[127].

The Australian Government is also supporting the decarbonisation of existing industries and creation of new clean energy industries through the $1.9 billion Powering the Regions Fund (PRF)[128]. The PRF will provide funding to help in the transition towards net zero emissions by focusing on four key areas, the first area being the most pertinent to RMP:

1. Decarbonising Existing Industries
2. Developing New Clean Energy Industries
3. Workforce Development
4. Purchasing Carbon Credits

8.4.8 Glossary

Term	Definition
AEMO	Australian Energy Market Operator

[122] NSW Climate and Energy Action | Metering and monitoring
[123] A2EP | Energy grants & funding
[124] Government of South Australia | Green Industries SA Assess-Implement-Monitor (AIM) Grants
[125] ACT Government | Business Energy and Water Program
[126] Department of Industry, Science and Resources | National Reconstruction Fund: diversifying and transforming Australia's industry and economy | Department of Industry, Science and Resources
[127] Department of Industry, Science and Resources | National Reconstruction Fund consultation paper (storage.googleapis.com)
[128] DCCEEW | Powering the Regions Fund: Consultation Update

AMPC	Australian Meat Processor Corporation
ARENA	Australian Renewable Energy Agency
CEFC	Clean Energy Finance Corporation
CO_2e	Carbon dioxide equivalent. All non-CO_2 greenhouse gases are converted to CO_2e to account for their different atmospheric properties within a consistent framework.
ISP	Integrated System Plan
NEM	National Electricity Market
NRF	National Reconstruction Fund
PDRS	Peak Demand Reduction Scheme
PRF	Powering the Regions Fund
REZs	Renewable Energy Zones
RMP	Red Meat Processing
VNI West	Victoria-NSW Interconnector
VRET	Victorian Renewable Energy Target
QJEP	Queensland Energy and Jobs Plan

8.5 Decarbonisation pathways

8.5.1 Decarbonisation pathway model

The following graphs have been updated to include heat pumps and the new Australian carbon reduction target of 43% by 2030. The decarbonisation pathways have been modelled using a generic large plant with rendering and small RMP plant without rendering.

Decarbonisation model parameters

Financial Model		
Project Life	30	years
Discount Rate	5.00%	
Annual maintenance cost	5.00%	Percent of CAPEX
Electricity price escalation	2.50%	Annual price increase
Gas price escalation	1.00%	Annual price increase

Facility Data	Large Plant	Small Plant	
Description	Large animals, full facility with rendering. 55,208 tHSCW/yr throughput	Small animals, no rendering. 11,600 tHSCW/yr throughput	
Electricity price	220	280	$/MWh
Electricity price (marginal)	140	200	$/MWh
Gas price	17	25	$/GJ
Gas price (marginal)	15	22	$/GJ
Annual electricity consumption	18795	3097	MWh/yr
Annual gas consumption	105456	10482	GJ/yr
Alternative fuel (biomass) cost	5	7	$/GJ

Emission Factors	2022	2030 (BAU Forecast)	2030 (Paris Forecast)	
Natural gas	51.53	51.53		kg CO2-e/GJ
Grid electricity (NSW & ACT)	0.73	0.12		kg CO2-e/kWh
Grid electricity (QLD)	0.73	0.38		kg CO2-e/kWh
Grid electricity (VIC)	0.85	0.37		kg CO2-e/kWh
Grid electricity (SA)	0.25	0.02		kg CO2-e/kWh
Grid electricity (WA average)	0.51	0.24		kg CO2-e/kWh
Grid electricity (TAS)	0.17	0.02		kg CO2-e/kWh
Grid electricity (NT average)	0.54	0.34		kg CO2-e/kWh
Grid electricity (Average)	0.68	0.26	0.20	kg CO2-e/kWh, weighted by no. facilities
Source: National Greenhouse Accounts (2022)		Australia's emissions projections 2022 (dcceew.gov.au)		

State	Member Facilities	Average Throughput 2008-2018 (tHSCW)
NSW	21	1,580,141
QLD	35	1,675,305
VIC	25	2,133,452
SA	9	799,932
WA	8	525,755
TAS	2	131,257
NT	0	0

Abatement Parameters

Facility Baselines	Large Plant	Small Plant		
Electricity emissions	12849.70	2117.35	t CO2-e/yr	
Gas emissions	5434.15	540.14	t CO2-e/yr	
Biogas Flaring emissions	1766.10	70.22	t CO2-e/yr	
Total emissions	20049.95	2727.70	t CO2-e/yr	
2005 Baseline	20915.41	2845.44	t CO2-e/yr	Scaled using historical industry-wide emissions

Abatement Targets	Large Plant	Small Plant	
Scenario 1 (BAU - 43%)	8993.63	1223.54	t CO2-e/yr
Scenario 2 (1.5C - 65%)	13595.02	1849.54	t CO2-e/yr
Scenario 3 (100%)	20915.41	2845.44	t CO2-e/yr

8.5.2 RMP decarbonisation pathway – Victoria and Tasmania

The average NEM electricity grid carbon intensity will decrease from 0.68 tCO_2e/MWh to 0.26 tCO_2e/MWh under the Step Change forecast scenario. However, this average decrease in emissions does not apply to any specific plant because the grid decarbonisation forecast varies for each state (see yellow highlighted area in the modelling above).

To test the actual impact of grid decarbonisation, Victoria and Tasmania have been selected to test the impact of the variation of grid decarbonisation.

8.5.2.1 RMP decarbonisation pathways in Victoria

In Victoria, the 2022 grid carbon intensity of 0.85 tCO_2e/MWh is forecasted to decrease to 0.37 tCO_2e/MWh by 2030. To reach the Australian government carbon emissions reduction target of 43% by 2030, the large RMP plant (see Figure 8) will only need to implement a few energy efficiency activities or small energy projects and the small plant (see Figure 9) will achieve more than the 43% target through grid decarbonisation alone.

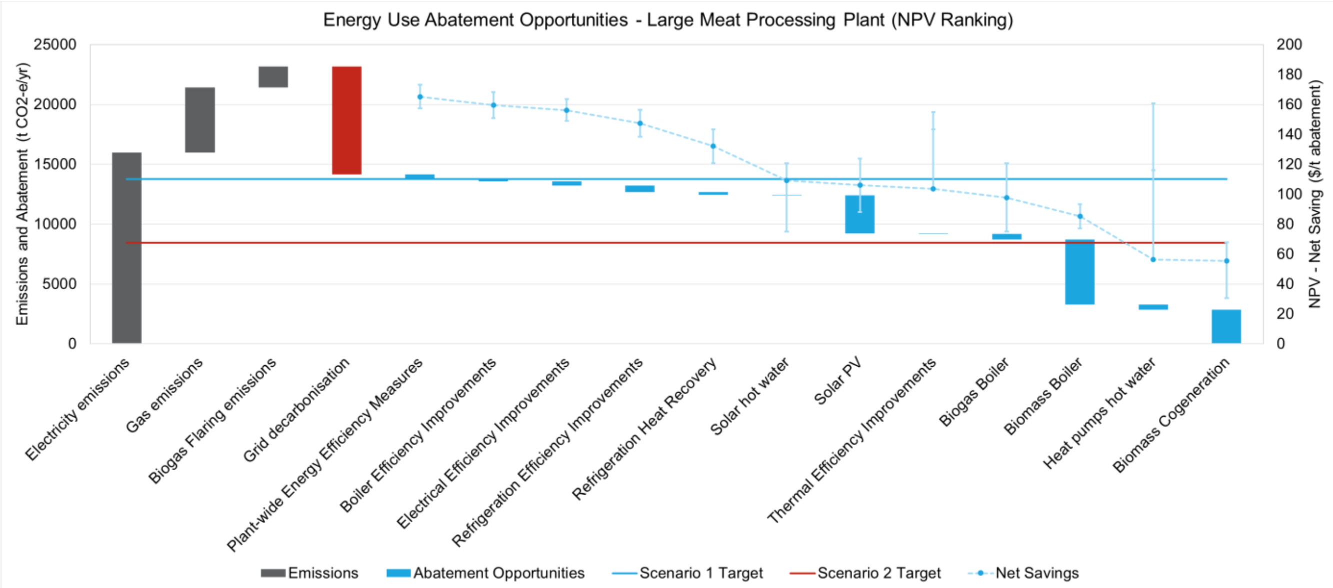


Figure 8 Victorian RMP large plant decarbonisation pathway.

However, further decarbonisation to reach the Paris carbon reduction target of 65% by 2030 will require a Victorian plant to implement all feasible energy efficiency, biogas boiler and solar PV projects. To reach Net Zero, the plant will need to implement renewable fuels and/or electrification. Where the business case for renewable fuels and electrification is not feasible and this will vary for each plant, there may be a need to purchase carbon off-sets to reach Net Zero.

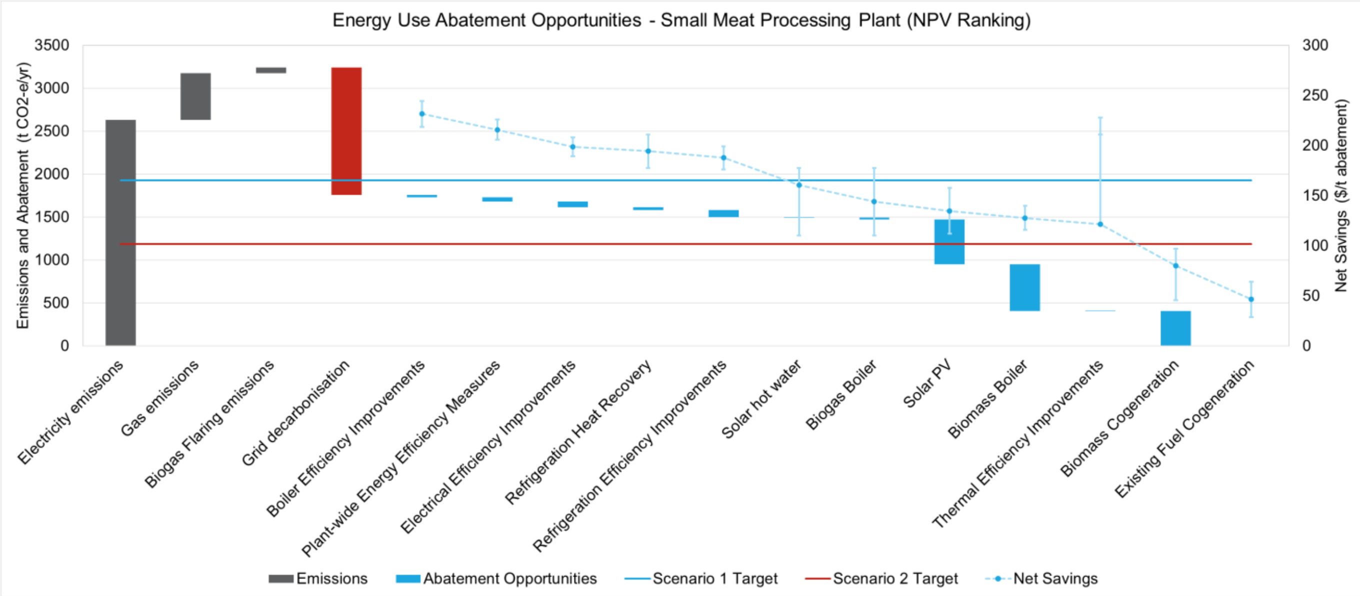


Figure 9 Victorian small RMP plant decarbonisation pathway

8.5.3 RMP decarbonisation pathway – Tasmania

The decarbonisation pathway for a large RMP plant located in Tasmania where the grid electricity is forecasted to decrease from 0.17 tCO_2e/MWh to 0.02 tCO_2e/MWh by 2030, has a carbon footprint dominated by fossil fuel use.

To meet the 43% target, the Tasmanian plant will need to implement energy efficiency projects and solar PV. To meet Net Zero the plant will need to replace fossil fuels with renewable fuels or electrification. There will be very little residual carbon emissions due to low carbon intensity of grid electricity.

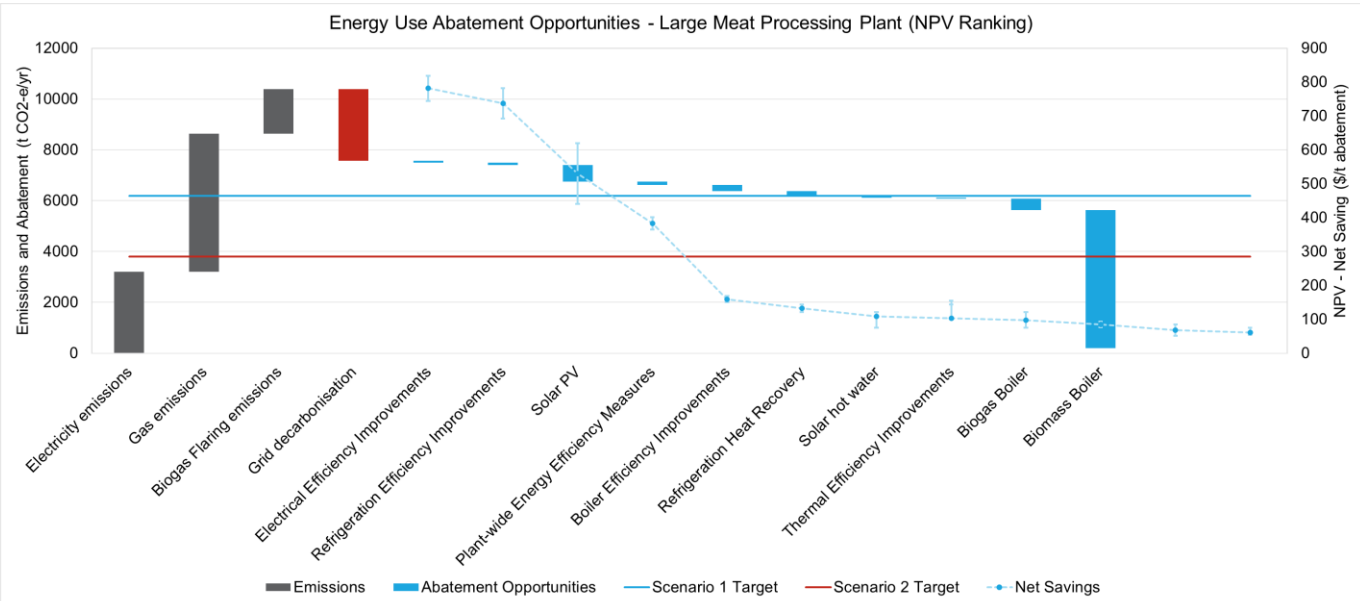


Figure 10 Tasmanian large RMP plant decarbonisation pathway

8.6 AMPC Decarbonisation projects

The following table provides a list of AMPC projects which involve decarbonisation.

Program Stream	Code	Project Title
2.1 Communities	2023-1017	CN Certifcation - Climate Active demonstration for members
2.1 Communities	2023-1049	ERF – Handbook on how to Register, develop, create ACCUs, audit & management process
2.1 Communities	2024-1005	Science Based Target initiative (SBTi) to demonstrate processor carbon abatement
2.2 Energy	2021-1047	Assess & arrange Solar PV opportunities – increased Solar PV development pipeline by 150% over 2 years
2.2 Energy	2021-1150	“Waterless Sterilisation” – Stage 3 spray & UV sterilizer knife options to reduce energy and water on slaughter floor
2.2 Energy	2021-1167	AMPC Helpline – 2 year project to help find grant funding for energy efficiency and renewables adoption
2.2 Energy	2021-1211	Multifuel Biomass Boiler Pilot
2.2 Energy	2022-1056	RACE for 2030. 1. Refrigeration Load shedding 2.MVR 3.Heat Pump studies
2.2 Energy	2022-1071	RaaS Stage 1, pathway to superior energy efficient refrigeration
2.2 Energy	2022-1096	EnMS for better integration of hybrid renewable energy systems at Greenham Tongala
2.2 Energy	2023-1005	Transport Emissions, Efficiency and Sustainability Roadmap – baseline & opportunities
2.2 Energy	2023-1008	Emissions, Energy & Water benchmark calculations & improvement workshops by Energetics
2.2 Energy	2023-1011	Working with H2 – application for stationary energy & energy storage
2.2 Energy	2024-1011	Closing the loop on integrated renewable process heat. A techo-economic feasibility study for integration of plant energy efficiency, process heat, bioenergy & renewables
2.4 Waste	2021-1142	Tool to self-assess & design integrated WWT & resource recovery
2.4 Waste	2023-1013	Bio-resource Recovery - Centres of Excellence
2.4 Waste	2024-1003	Mapping Anaerobic Co-digestion opportunities. A grant by Sustainability Victoria – Dairy Australia, AMPC, APL, and Agrifutures