EMISSION REDUCTION PATHWAYS AND OPPORTUNITIES FOR THE AUSTRALIAN RED MEAT PROCESSING SECTOR

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1.0 EXECUTIVE SUMMARY

This research report was commissioned by the Australian Meat Processor Corporation (AMPC). It investigates the risks and opportunities for the red meat processing (RMP) sector associated with climate change policy, and actions that red meat processors can take to reduce their climate policy-related risks and costs and maximise the benefits of reducing emissions.

The report shows what red meat processors can do under three scenarios for sector-wide emissions reduction and provides recommendations to red meat processors and policymakers.

Red meat processors have already taken steps to reduce their emissions, and the sector's emissions have been trending down for over a decade. However, the combination of prolonged domestic policy uncertainty, new opportunities to access low emissions technologies, and the emerging international framework of the Paris Agreement all indicate that the sector cannot simply rely on maintaining its past performance to avoid future emissions reduction pressures that could be extremely costly and disruptive.

At an emissions intensity of 432 kg CO_2e/t HSCW and annual production of 3,071,000 tonnes in 2018, the red meat processing sector's emissions are estimated at approximately 1,330,000 tCO_2e per year.[1] About 44 per cent of emissions are scope 1 (emissions directly produced on site) and 56 per cent are scope 2 (emissions indirectly generated through the purchase and use of electricity).

The red meat processing sector is a vital part of Australia's red meat industry, which contributes over $18 billion to annual GDP[2] and produces around 8 per cent of national emissions.[3] Although the sector produces only a small fraction of total red meat industry emissions (about 2 per cent), its emissions are more easily reduced than those of other parts of the red meat industry. This is because meat processing emissions primarily result from energy consumption, for which low-carbon alternatives are commercially available, while the broader industry's emissions footprint is dominated by enteric fermentation in livestock, which is significantly more difficult to address. This makes the red meat processing sector's contribution to the broader industry goal of carbon neutrality by 2030 a small but essential component.

Several illustrative emission trajectories provide insights into plausible pathways for red meat processing sector emissions. In Figure 3 we outline three trajectories that meet different emissions targets in 2030 but keep within the industry's <2°C carbon budget.

1) "Current Policy" – this trajectory is based on Australia's current national emission reduction target for 2030 (a headline reduction in emissions of 26-28 per cent from 2005 levels, which, by counting Kyoto Protocol carryover credits toward the target, results in an effective target of 16 percent[4]).

[1] Production figures provided by AMPC; remaining data from AMPC, 2015. Environmental Performance Review: Red Meat Processing Sector 2015.
[2] Meat and Livestock Australia, 2019. The red meat industry. https://www.mla.com.au/about-mla/the-red-meat-industry/
[3] National Greenhouse Gas Inventory, based on categories specified in CSIRO, Greenhouse Gas mitigation potential of the Australian red meat production and processing. Report for Meat and Livestock Australia, 2018.
[4] Investor Group on Climate Change, 2019. The Coalition Climate Policy: Too Little Too Late? IGCC, Melbourne.

2) "Paris Goals" - this is based on the 1.5-2°C temperature range referenced in the Paris Agreement[5]; this targets a 63 per cent reduction from 2005 levels[6].

3) "Carbon Neutral 2030" is based on the broader industry goal of carbon neutrality by 2030 (100 per cent reduction from 2005 levels). These scenarios are discussed in more detail in section 5.2.

In the Current Policy scenario, the red meat processing sector will have expended over 90 percent of its <2°C carbon budget by 2030 (and blown its 1.5°C budget by 2026), resulting in the need for drastic emissions cuts over the following decade. In Paris Goals, rapid emission reductions before 2030 defer the need for the sector to reach net zero emissions until after 2050. In Carbon Neutral 2030 (CN2030), a straight pathway to carbon neutrality by 2030 means the industry expends only half of its <2°C carbon budget and three-quarters of its 1.5°C budget.

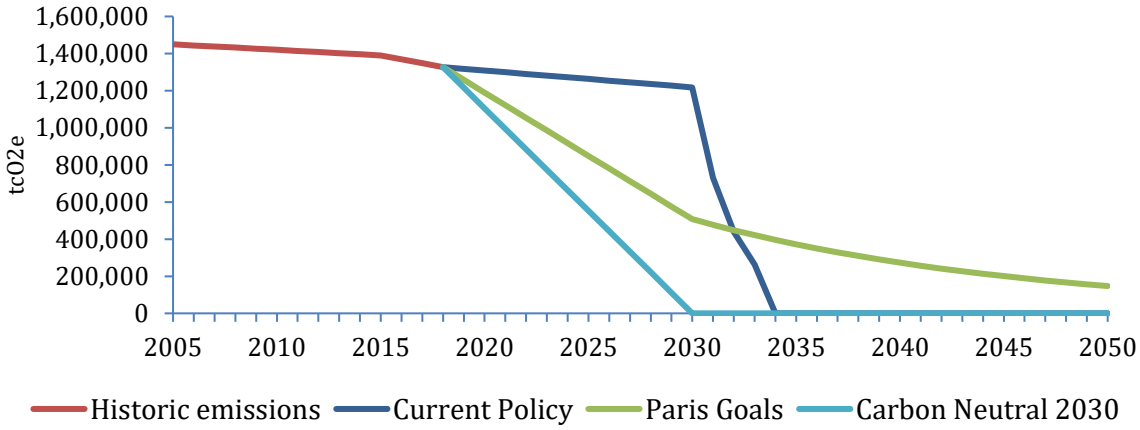


Figure 1: Implications of a <2°C carbon budget for different 2030 emission targets

Table 1 shows a summary of the industry-wide expenditure required to achieve each scenario's abatement target, assuming a 90%-10% split between large and small facilities across the industry.

Based on this analysis, the RMP sector will need to implement mostly energy efficiency to achieve the emissions targets under Current Policy, however far more action is required to achieve the Paris Goals and Carbon Neutral by 2030 scenarios. The options for reducing emissions after implementing energy efficiency are limited to renewable thermal and electricity generation projects. The cost of the projects needed to meet these targets shows multi-million expenditure for most AMPC members, with higher costs incurred by the larger operations. The net present value (NPV), based on a discount rate of 7 per cent, for these projects is low, with average payback periods over 5 years for most scenarios.

[5] Paris Agreement, Article 2.1.(a), https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_.pdf

[6] Climate Change Authority, 2014. Targets and Progress Review: Final Report, Appendix C. http://www.climatechangeauthority.gov.au/reviews/targets-and-progress-review-3. The CCA then converted its recommended target range to a 2005 baseline. See http://www.climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/CFI/CCA-statement-on-Australias-2030-target.pdf

Table 1: Abatement strategies and associated costs

	Scenario 1 BAU	Scenario 2 Paris Goals	Scenario 3 CN30
Suggested Technologies	**Efficiency improvements**	**Scenario 1 + Biomass boilers**	**Scenario 2 + Behind-the-meter wind and solar OR Biomass cogeneration OR Renewable PPA AND Purchase residual offsets**
Estimated minimum capital required for on-site projects	**$12-27m**	**$425-625m**	**$2.2-3.6bn**
Estimated NPV of all on-site projects	**$5-7m**	**$34-52m**	**$13-128m**
Estimated NPV of all on-site projects with shadow carbon price of $25/tonne	**$15-17m**	**$175-194m**	**$600-720m**

However, inclusion of a shadow carbon price can materially change the NPV by factoring in the potential costs of future policy. The table above includes an illustrative carbon price of $25/t$CO_2$e. Whether this increase in NPV is realised depends on whether policies approximating the impact of the shadow carbon price are implemented in the future. In other words, the shadow carbon price can show the value of avoiding possible future policy costs. For example, installing a biomass boiler in a small facility has a capital cost of around $800,000 and saves 540 tonnes of emissions each year. In the absence of a carbon price the NPV of the investment is about $40,000, but if a carbon price of $25 is introduced, the NPV rises significantly to $171,000.

Recommendations for red meat processors

1. Know your emissions: Develop systems to measure, monitor, and actively manage your emissions so you can track any changes to your emissions profile. This step also enables action on the following recommendations.

   (i) Scope 1 emissions from fuel use can be calculated by multiplying total annual fuel consumption use by the appropriate NGER factors listed in the National Greenhouse Accounts Factors handbook[7].

   (ii) Scope 2 emissions from electricity consumption are often provided on your electricity bills and state-based factors are listed in the National Greenhouse Accounts Factors handbook[8].

2. Prioritise: identify key first actions using tools such as the Implementation Pyramid in the AMPC's Energy benchmarking tool reference to AMPC energy management plan guides to work out which emissions you should address first.

3. Be prepared for changes in policy:

   (i) Use a shadow carbon price. Factoring in the possibility of a carbon price can help weight projects with the best potential both for carbon emissions reduction and climate policy risk reduction. Shadow carbon prices could be based on existing prices in the ERF or offshore markets, and/or on modelled future prices.

   (ii) Monitor changes in your state's grid electricity emission factors (published annually by the National Greenhouse Accounts), and approaches to renewable energy. These will influence the relative benefits of renewable energy projects. Amendments to planned emissions reduction activities can be made in response to developments in the electricity market.

4. Plan ahead: Develop a long-term plan to progressively reduce your emissions and prepare for policy changes. This enables red meat processors to take advantage of policy shifts as they occur, particularly where funding assistance becomes available.

5. Collaborate: the sector can leverage the AMPC as a central coordinator for knowledge sharing, aggregation of buying power or project development and funding. Empowering the AMPC to act in these ways can overcome barriers to investment, particularly for smaller red meat processors, and allow the sector to develop more strategic approaches to opportunities.

[7] https://www.environment.gov.au/system/files/resources/cf13acc9-c660-445e-bd82-3490d74e9d09/files/national-greenhouse-accounts-factors-august-2019.pdf
[8] https://www.environment.gov.au/system/files/resources/cf13acc9-c660-445e-bd82-3490d74e9d09/files/national-greenhouse-accounts-factors-august-2019.pdf

(i) Explore the option of aggregation of electricity load and buying power via a renewable Power Purchase Agreement (PPA). Key areas for investigation include total size of load, number of participating sites, financial positions of participating companies. PPAs are generally based on state-based electricity. (See Box 1: Corporate renewable PPAs and what they can offer the RMP sector on page 28.)

Recommendations for policymakers

1. Understand the differences for large and small facilities and their different capacities to act on emissions reduction. Large users have more capacity to invest in large scale projects whereas smaller operations require both technical expertise and funding support to implement major process changes.

2. Support the red meat industry's CN2030 goal. Consider how existing policy frameworks can be adjusted to address barriers to decarbonisation of red meat processing (funding support to help overcome high capital investment costs) and ensure any policy changes do not raise red meat processing costs.

3. Target assistance toward projects that overcome investment barriers for smaller processors, for example through aggregation of buying power and identifying government funding available. Key areas for policy support include access to demand response and renewable energy both onsite and through multiparty PPAs.

4. Thermal energy use produces a higher proportion of emissions for large processors, so assistance for large processors could focus on transitioning from natural gas, for example through bio-gas capture and reuse.

5. Support and promote the inclusion of biomass in fuel replacement in energy saving schemes such as the ESC and VEET programs, and provide funding to assist in the adoption of new process heat technologies, such as heat pumps.

6. Policy targeting the energy "trilemma" of emissions reduction, reliability and affordability remains essential.

2.0 INTRODUCTION

This research report was commissioned by the Australian Meat Processor Corporation (AMPC). It investigates the risks and opportunities for the red meat processing (RMP) sector associated with climate change policy, and actions that red meat processors can take to reduce their climate policy-related risks and costs and maximise the benefits of reducing emissions.

The report shows what RMPs can do across three scenarios for sector-wide emissions reduction and provides recommendations to RMPs and policymakers.

Red meat processors have already taken steps to reduce their emissions and the sector's emissions have been trending down for over a decade. However, the combination of prolonged domestic policy uncertainty, new opportunities to access low emissions technologies and the emerging international framework of the Paris Agreement all indicate that the sector cannot simply rely on maintaining its past performance to avoid future emissions reduction pressures that could be extremely costly and disruptive.

3.0 PROJECT OBJECTIVES

Considering the recent federal election, AMPC is seeking to provide its members with a policy review of the potential changes to Australia's climate and energy outlook. This paper provides:

1. Overview of key climate and energy issues for the RMP sector
2. Potential emissions reduction requirements for the sector under three scenarios representing the range of plausible national policy and sectoral efforts to reduce emissions
3. Costing and prioritization of cost-effective abatement options for members
4. Additional commentary and recommendations for the sector and for policy makers.

4.0 METHODOLOGY

4.1 Key climate and energy issues for the meat processing industry

It is important to understand that Australia's national greenhouse gas emissions commitments under the UNFCCC are calculated cumulatively. The national target of 26-28% reduction by 2030 is a function of a cumulative reduction in Australia's emissions, as opposed to emissions in the year 2030.

1. Based on a review of the latest scientific literature, we provide an overview of the international agreements to reduce carbon emissions and the relationship between targeted limits on global warming and global carbon budgets.
2. Using the latest national and sectoral emissions data, we estimate a carbon budget for the red meat processing sector based on its share of current emissions.

4.2 Potential policy implications for carbon reduction

Policy implications are considered under three scenarios exploring different levels of government and industry emissions reduction:

1. "Current Policy" – this trajectory is based on Australia's current national emission reduction target for 2030 (a headline reduction in emissions of 26-28 per cent from 2005 levels, which, by counting Kyoto Protocol carryover credits toward the target, results in an effective target of 16 percent[9]).

2. "Paris Goals" - this is based on the 1.5-2°C temperature range referenced in the Paris Agreement[10]; this targets a 63 per cent reduction from 2005 levels[11].

3. "Carbon Neutral 2030" is based on the broader industry goal of carbon neutrality by 2030 (100 per cent reduction from 2005 levels). These scenarios are discussed in more detail in section 5.2.

Under all three scenarios, existing and potential mechanisms for government action are examined and their potential change and implications for the RMP sector are discussed.

4.3 Costs of abatement options for red meat processors

Abatement options are calculated for a large and a small meat processing plant. These are ranked by net project value and capital expenditure. The possible abatement associated with each solution is then shown as an offset to the current emissions of a typical plant. In this way, a possible pathway to each of the levels of emission abatement required by 2030 is demonstrated. The sector's past efforts to reduce emissions and the consequent reduction in availability of some options are accounted for. Two different levels of electricity grid decarbonisation are assumed and the impact of these on abatement costs and options is also presented.

4.4 Recommendations

Recommendations to the industry and to government are developed based on the findings of the above analysis.

5.0 PROJECT OUTCOMES

5.1 How much should the RMP sector emit?

Emissions from red meat processing have been declining for over a decade. Analysis by the AMPC has found that the emissions intensity of red meat processing has fallen from 554 kg CO2e/t HSCW in 2008-9 to 432 kg CO2e/t HSCW in 20112, and research by CSIRO for the Meat and Livestock Association calculated that the sector's total emissions have fallen from 1.45 million

[9] Investor Group on Climate Change, 2019. The Coalition Climate Policy: Too Little Too Late? IGCC, Melbourne.
[10] Paris Agreement, Article 2.1.(a), https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_.pdf
[11] http://www.climatechangeauthority.gov.au/reviews/targets-and-progress-review-3. The CCA then converted its recommended target range to a 2005 baseline. See http://www.climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/CFI/CCA-statement-on-Australias-2030-target.pdf
[12] AMPC, 2015. Environmental Performance Review: Red Meat Processing Sector 2015.

tCO2e in 2005 to 1.39 million in 2015[13]. Based on 2018 production and the 2015 emissions intensity factor the sector's current emissions have now declined to 1.33 million tonnes per year, an 8 per cent decline in total emissions since 2005 and a 22 per cent decline in emissions per t HSCW.

This represents great success in achieving the sector's goal to reduce emissions per t HSCW by 20 percent.14 However, the sector's emissions can be further reduced, and indeed need to be further reduced, to achieve the Australian meat industry's goal of carbon neutrality by 203015, and to contribute fairly to national emissions targets and global emissions goals. A fair contribution is calculated using the concept of a "carbon budget".

A carbon budget is a limit on the total amount of emissions[16] that can be expended to achieve a desired goal. Carbon budgets are based on the physical and chemical reactions that drive climate change and so are focused on total cumulative emissions rather than emission reductions.[17] This is because, particularly with regard to carbon dioxide, it is the total concentration of greenhouse gases in the atmosphere that drives global warming, rather than the rate at which greenhouse gases are emitted by human activity. The following section discusses what a carbon budget is used for and calculates a carbon budget for the red meat processing sector.

5.1.1 The purpose of a carbon budget

A carbon budget can be used to track several aspects of climate-related risk:

1. The impacts on global temperature of current rates of emissions
2. How much current emission reduction policies or activities are aligned with long-term global goals for limiting global warming (such as the objectives of the Paris Agreement)
3. the degree to which policies or activities might have to change to align with long-term goals
4. implications of the timing of changes in policies or activities.

As with regular financial budgets, where spending in one area or at one point of time decreases the available funds to spend elsewhere or at other times, a carbon budget constrains total emissions such that the more emissions are expended in the short term, the fewer are available in the future. Although a carbon budget does not directly define what emissions should be in a given year or by a given date, higher emissions in early years imply that steeper reductions in emissions will be necessary in later years. In Figure 2 below, all three trajectories represent different ways of achieving the same carbon budget (the area under each curve). Although Trajectory 1 requires deeper emission reductions in the first decade, its rate of reduction is gentler over the long term than the other trajectories, does not change dramatically at any point,

[13] CSIRO, Greenhouse Gas mitigation potential of the Australian red meat production and processing. Report for Meat and Livestock Australia, 2018.
sectors
[14] AMPC, 2015. Environmental Performance Review: Red Meat Processing Sector 2015.
[15] https://www.mla.com.au/news-and-events/industry-news/red-meat-industry-can-be-carbon-neutral-by-2030/
[16] The phrase "carbon budget" is commonly applied both to budgets for CO_2 only and for total CO_2e. The IPCC has produced global CO_2 budgets; Australia's Climate Change Authority produced a national CO_2e budget.
[17] See for example http://www.climatechangeauthority.gov.au/files/files/Target-Progress-Review/Targets%20and%20Progress%20Review%20Final%20Report_Chapter%203.pdf

and does not result in the need for negative emissions. This suggests that emitters on Trajectory 1 would be less exposed to changes in climate policy.

By contrast Trajectory 3 demonstrates that with no constraint on emissions in the first decade, keeping within the carbon budget can only be done by steeply reducing emissions to below zero (i.e. through offsets or negative emission technologies). This implies either that the goal associated with the carbon budget will not be achieved or that climate policies will eventually force emitters to achieve negative emissions (through, for example, purchasing carbon offset credits for more emissions than they produce). This scenario represents a risk of delayed but deeply disruptive policy adjustment.

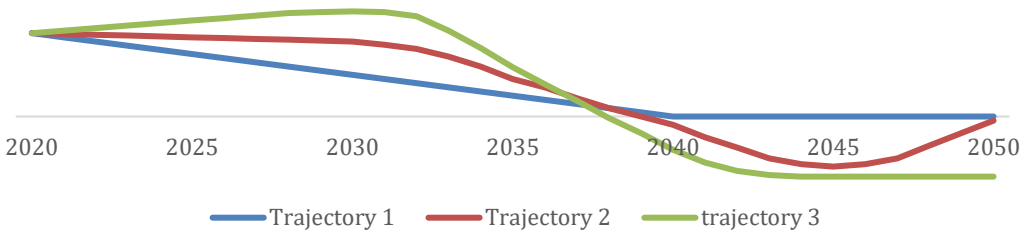


Figure 2: One carbon budget, three possible emission trajectories

5.1.2 Calculating a carbon budget for the RMP sector

Based on the goals of the Paris Agreement, a carbon budget for the red meat processing sector can be estimated by undertaking the following steps:

1. Calculate national carbon budgets for the Paris goals of keeping global temperature rise to "well below" 2°C and pursuing efforts to keep the rise to no more than 1.5°C
2. Calculate emissions from red meat processing as a percentage of national emissions
3. Allocate an equivalent percentage of the national carbon budgets to the RMP sector.

National carbon budgets for <2°C and 1.5°C

The Climate Change Authority (CCA) recommended a national carbon budget for Australia in 2014, based on assessment of a range of methods of allocating the global carbon budget across countries.[18] Analysis by Dr Malte Meinshausen for the Victorian Government in 2019 produced an update of the CCA budget, based on updates to emissions data and Global Warming Potentials (GWP), and developments in carbon budget methodologies.[19] The updated national carbon budget is 8.09 GtCO2e for the period 2017-2050. In other words, Australia can produce net emissions of no more than 8.09 GtCO2e between 2017 and 2050 to contribute fairly to keeping temperature rise below 2°C. Meinshausen also calculated that a national budget consistent with limiting temperature rise to 1.5°C is approximately 5.5 GtCO2e.20

[18] http://www.climatechangeauthority.gov.au/reviews/targets-and-progress-review-3
[19] https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0016/421702/Greenhouse-Gas-Emissions-Budgets-for-Victoria.pdf
[20] https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0018/421704/Deriving-a-1.5C-emissions-budget-for-Victoria.pdf

RMP sector emissions as a share of national emissions

At an emissions intensity of 432 kg CO2e/t HSCW and annual production of 3,071,00021 tonnes in 2018, RMP sector emissions are estimated at approximately 1,300,000 tCO2e per year. This includes both scope 1 (emissions directly produced on-site) and scope 2 emissions (those indirectly generated through the purchase of electricity). The sector's emissions represent 0.24 per cent of total national annual emissions. For context, the total red meat industry producers and processors represents approximately 8 per cent of national emissions.[22]

RMP sector carbon budget

Allocating an equivalent percentage of the national carbon budget gives a sectoral carbon budget of 19.4 MtCO2e for the <2°C goal and 13.2 MtCO2e for the 1.5°C goal. If the RMP sector were to maintain its current rates of emissions, the 2°C budget would be used up within 15 years and the 1.5°C budget within 10 years. Reducing emissions extends the time period during which the sector stays within its carbon budget.

Table 2: Carbon budgets for Australia and the red meat processing sector

Temperature goal	National carbon budget (Mt CO2e)	RMP sector budget (Mt CO2e)	Years left within carbon budget at current emissions rate
<2°C	**8090**	**19.4**	**14.6**
1.5°C	**5500**	**13.3**	**9.9**

Allocating to a sector a share of the national carbon budget according to the share of current emissions is not the most methodologically robust way to allocate "allowable" emissions, as it does not consider historic emissions, future growth, or industries' different capabilities for and costs of emissions reduction. However, it has the virtue of simplicity, and has been used by companies for this reason.23 More rigorous - and complex - methods to develop sector- or company-specific carbon budgets and targets are available through the Science Based Target Initiative.

5.1.3 What the carbon budget can show about 2030 emissions targets

Several illustrative emission trajectories provide insights into plausible pathways for red meat processing emissions. In Figure 3 we outline three trajectories that meet different emissions targets in 2030 but keep within the industry's <2°C carbon budget.

[21] Data provided by AMPC

[22] National Greenhouse Gas Inventory, based on categories used in CSIRO, Greenhouse Gas mitigation potential of the Australian red meat production and processing. Report for Meat and Livestock Australia, 2018.

[23] E.g. AGL, 2018. Powering a Climate Resilient Economy: AGL's approach to climate-related financial risk, August 2018.

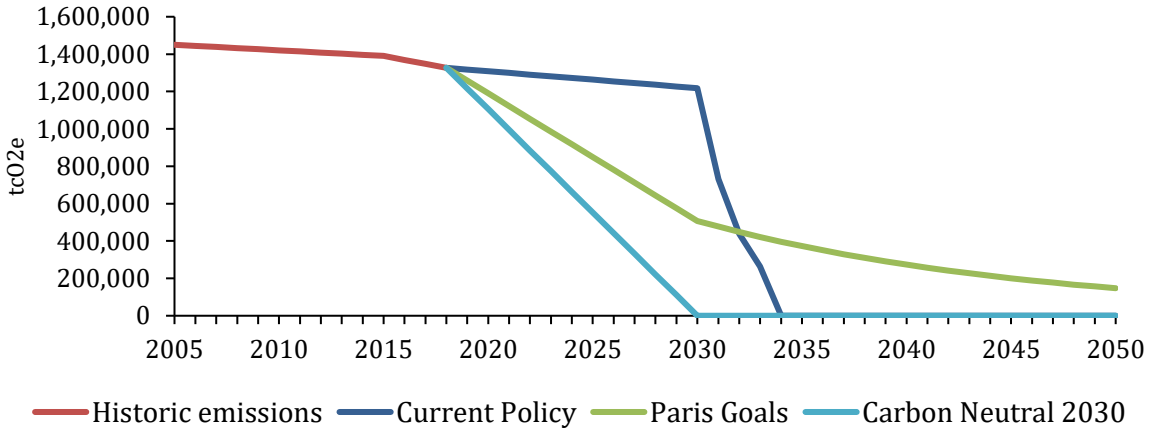
1. “Current Policy” – this trajectory is based on Australia’s current national emission reduction target for 2030 (a headline reduction in emissions of 26-28 per cent from 2005 levels, which, by counting Kyoto Protocol carryover credits toward the target, results in an effective target of 16 percent).

2. “Paris Goals” - this is based on the 1.5-2°C temperature range referenced in the Paris Agreement[24]; this targets a 63 per cent reduction from 2005 levels [25].

3. “Carbon Neutral 2030” – this is based on the broader industry goal of carbon neutrality by 2030 (100% reduction from 2005 levels).

In the Current Policy scenario, the RMP sector will have expended over 90 percent of its <2°C carbon budget by 2030 (and blown its 1.5°C budget by 2026), resulting in the need for drastic emissions cuts over the following decade. In Paris Goals, rapid emission reductions before 2030 defer the need for the sector to reach net zero emissions until after 2050. In Carbon Neutral 2030 (CN2030), a straight pathway to carbon neutrality by 2030 means the industry expends only half of its <2°C carbon budget and three-quarters of its 1.5°C budget.

Figure 3: Implications of a <2°C carbon budget for different 2030 emission targets



5.2 Selected scenarios

This section sets out three scenarios for government climate and energy policy and RMP sector action to reduce emissions – Current Policy, Paris Goals, and Carbon Neutral 2030 (CN2030). Each scenario has different implications for red meat processors’ exposure to climate and energy-related costs and risks.

Scenarios represent a plausible range of the following key risks for red meat processors:

[24] Paris Agreement, Article 2.1.(a), https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_.pdf

[25] The CCA converted to a 2005 baseline its recommended 2030 target range of 40-60 per cent from 2000 levels. http://www.climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/CFI/CCA-statement-on-Australias-2030-target.pdf

1. Potential emissions from the sector: from maintaining current emissions in Current Policy to reaching net zero emissions by 2030 in CN2030.
2. Potential climate and energy policy environments: from minimal emission constraints (Current Policy) to enforced deep decarbonisation of the sector (Paris Goals)
3. Misalignment between sector and government action: both the sector and government policy are unambitious in Current Policy, while policy drives sector action in Paris Goals, and the RMP sector acts in the absence of policy in CN2030.
4. Emissions intensity of grid electricity: in Current Policy and CN2030, the emissions intensity of grid electricity declines slightly, resulting from growth in renewable energy capacity driven by commercial competitiveness. In Paris Goals, government policy changes to drive grid emissions down significantly.

An important consideration is that the scenarios do not differentiate by energy prices or technology costs.

Technology costs are considered not to be materially influenced by policy within the period to 2030. This means costs for solar PV and Wind power equipment will remain much the same for this period.

Gas prices are assumed to remain elevated throughout the period to 2030 under all scenarios. LNG prices will remain elevated for the next ten years based on long-term contracts already in place. The domestic price of natural gas is strongly influenced by the international price of LNG. Government policy to introduce domestic gas supply price and supply reserves has not been put in place. In the next ten years this situation will most likely remain the same.

Electricity prices are assumed to remain elevated through the period to 2030. This may appear to conflict with the very different government policy environments in the Current Policy and Paris Goals scenarios. However, Energetics considers that multiple factors underpinning high electricity prices may not be resolved by 2030 under Current Policy and may mitigate the impact of Paris Goals policy (such as an emissions target for the electricity sector) on electricity prices. These factors include high gas prices (driven by international demand), transmission constraints limiting access to lowest-cost electricity and deterring investment in generation, uncertainty surrounding the exit dates of ageing coal-fired generators, which exposes energy users to price shocks if and when generators close and also deters investment in appropriate replacement generation[26]. Given these factors, electricity prices in Current Policy are highly likely to be volatile and may have sustained periods of elevation. Prices in the Paris Goals scenario are likely to be less volatile but may be elevated for more sustained periods as decarbonisation policy forces substantial investment in the transformation of the electricity system.

The Paris Goals scenario assumes emissions reduction policies are implemented but does not assume specific policies beyond those that are already in operation. This is in recognition of the significant uncertainty surrounding the specifics of potential future climate and energy policies.

[26] CSIRO, Australian National Outlook 2019: Technical Report. https://www.csiro.au/en/Showcase/ANO

Section 5.3 provides an overview of how existing policies may change, what new policies could be implemented, and what the different implications could be for the RMP sector.

5.2.1 Current Policy

In this scenario federal government policy remains to reduce national emissions by 26-28 per cent from 2005 levels, but the use of Kyoto carryover credits renders this an effective target of 16 percent from 2005 levels.[27] This target is pro-rated for the red meat processing sector. This requires the sector's emissions to decline by 8 per cent from current levels by 2030, broadly in line with its historic rate of emissions reduction. This is not assumed to happen automatically.

BAU renewable energy growth results in grid electricity emissions intensity declining from 0.83 tCO_2e/MWh currently to 0.69 tCO_2e/MWh by 2030. Existing climate and energy efficiency policies may be slightly adjusted to facilitate national emissions reduction, but no new policies are implemented.

5.2.2 Paris Goals

In this scenario government policy aims to reduce national emissions by 63 percent from 2005 levels by 2030. The scenario does not consider whether these policies are driven by the federal government or by state and territory governments. The national target is pro-rated for the RMP sector and represents a reduction of 62 percent from current sector emissions. Major changes to existing policies and new policies are assumed to be required to drive economy-wide emissions reduction. These affect the RMP sector directly and indirectly – for example, through faster decarbonisation of the electricity system, which reaches a lower emissions intensity of 0.2 tCO_2e/MWh by 2030[28] [29].

5.2.3 Carbon Neutral 2030

In this scenario the RMP sector pursues carbon neutrality by 2030, but within a context of minimal emissions reduction in the broader economy. Federal government policy and grid decarbonisation are as for Current Policy.

5.3 Implications of scenarios for policy settings

5.3.1 Existing federal climate-related policies

Safeguard Mechanism

The Safeguard Mechanism currently applies only to single facilities with scope 1 emissions over 100,000 tCO_2e per year. Such facilities are set an emissions baseline. There is a transition underway from baselines based on historic emissions to calculated, production-adjusted, and

[27] Investor Group on Climate Change, 2019. The Coalition Climate Policy: Too Little Too Late? IGCC, Melbourne.
[28] CSIRO, 2015. Australian National Outlook 2015 - Supplementary data on electricity supply and emissions. CSIRO, Canberra.
[29] Jacobs, 2016. Modelling illustrative electricity sector emissions reduction policies. Final report for the Climate Change Authority, 21 November.
http://climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/SR%20Modelling%20reports/Jacobs%20modellin g%20report%20-%20electricity.pdf.

benchmark baselines. Emissions over the baseline can be offset through the surrender of Australian carbon credit units (ACCUs). Currently the high emissions threshold for coverage does not capture any RMP facilities.

How this could change

1. The emissions threshold could be lowered, for example to capture all entities reporting under the National Greenhouse Emissions Reporting scheme. (Companies are required to report under NGER if an individual facility emits at least 25,000 tCO_2e (scope 1 and 2 emissions) or consumes at least 100 TJ of energy, or if the corporate group emits at least 50,000 tCO_2e or consumes 200 TJ of energy). This would extend coverage to several RMP sites.
2. Baselines could be set to decline over time, requiring covered facilities to reduce emissions.

Potential role in scenarios

1. In the Current Policy and CN2030 scenarios the Safeguard Mechanism would be very unlikely to change enough to affect RMPs.
2. In the Paris Goals scenario, the emissions threshold could be lowered significantly, capturing the larger RMPs, and the baselines could be set on a rapidly declining trajectory.

Emissions Reduction Fund / Climate Solutions Fund

The Emissions Reduction Fund, rebadged as the Climate Solutions Fund earlier this year, purchases domestically generated emission reductions (ACCUs). Reverse auctions are used to award contracts to project proponents, with the government paying for emissions reductions after they have been delivered and verified.

Eligible activities that could be undertaken by red meat processors include energy efficiency improvements such as replacement or modification of boilers or heating, refrigeration systems, improving control systems and processes, waste heat capture and re-use, replacing low efficiency motors, fans and pumps with high efficiency versions, and fuel switching to renewable sources such as biomass and biogas fired boilers and or cogeneration systems.. Improved wastewater treatments, such as replacing anaerobic lagoons with anaerobic digesters, are also eligible to earn revenue by generating ACCUs.

The government has pledged an additional $2 billion to the Climate Solutions Fund to 2030. To date the average ACCU price contracted by the Fund is $12/$tCO_2e$, with higher prices for the last several auctions.[30] This level of ACCU price usually provides a 5-10% reduction in project capital costs for capital intensive projects, which limits the benefits of this funding program for the RMP sector. Tree plantations and large-scale environmental improvement projects are more suited to this style of funding. An aggregated approach with cattle producers, such as through a tree planting project on cattle farms, could offer opportunities. Projects need to generate a minimum of 2000 ACCUs per year (on average) to be participate in the ERF, but aggregated projects can be much bigger. Most contracted projects are sized to deliver over 20,000 ACCUs annually[31].

[30] http://www.cleanenergyregulator.gov.au/ERF/Auctions-results/july-2019

[31] http://climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/CFI%202017%20December/ERF%20Review%20Report.pdf

ACCUs can also be generated by Fund-compliant methodologies and sold on the secondary market. The RMP sector has access to this market to sell or purchase ACCUs. The spot price for ACCUs on the spot market is generally several dollars higher than the most recent auction price.[32]

How this could change

1. Further development of eligible activities, methods or aggregation models could expand opportunities for RMPs, particularly if these can reduce the administrative costs of participation.
2. If auction prices increase, the Fund could reduce capital costs for projects by more useful amounts
3. The emergence of effective aggregation models for RMPs could expand access to the Fund.

Potential role in scenarios

In the Paris Goals scenario, stronger emissions constraints could see prices paid through the Fund rise, as required abatement moves up the cost curve. However, as the Fund's capacity to scale up is limited by the government's appetite to fund it, higher prices per tonne could result in fewer tonnes of emissions purchased. In all scenarios the Fund could play a similar role, as a provider of industry assistance with marginal impact on emissions.

Renewable Energy Target (RET)

The RET is designed to increase renewable energy capacity by subsidising electricity generated from renewable sources (such as electricity generated from biogas fired turbines or a cogeneration system using biomass fuel in boilers and steam turbines for power generation) through the mandatory purchase by electricity retailers of Renewable Energy Certificates (collectively RECs or Large-scale Generation Certificates (LGCs) for projects over 100 kW or Small-scale Technology Certificates (STCs) for projects under that threshold. Each MWh of eligible renewable electricity produces one LGC or one STC.

RECs must be retired by electricity retailers (and some other liable entities) to meet their mandatory annual renewable energy targets. RECs can also be retired by emitters to meet voluntary zero-emissions or renewable energy goals. LGCs can be sold to retailers or on the voluntary market. However, selling LGCs means that their associated carbon reduction and renewable energy generation cannot be claimed by the seller. In contrast STCs can be sold without affecting the zero-emissions status of the project that generated them.

REC costs are passed through to electricity consumers. Eligible emissions-intensive trade-exposed (EITE) activities are exempt from REC costs. However, rendering of animal by-products is the only RMP activity that is eligible for exemption.[33]

[32] http://www.cleanenergyregulator.gov.au/Infohub/Markets/Pages/Buying%20ACCUs/ACCU%20market%20updates/Australian-Carbon-Credit-Units-Market-Update-%e2%80%93-October-2019.aspx

[33] http://www.cleanenergyregulator.gov.au/RET/Scheme-participants-and-industry/Emissions-intensive-trade-exposed-exemption/Activities-eligible-for-exemption

The large-scale target of 33,000 GWh of renewable energy by 2020 has already been achieved.[34] The ongoing growth of renewable energy capacity has resulted in an oversupply of LGCs that should keep LGC costs to consumers low in the coming decade. This has several different implications for RMPs:

1. The LGC cost component of purchased electricity should decline and remain low
2. The additional revenue that could be generated by selling LGCs from on-site renewable energy is unlikely to be a compelling investment proposition.
3. Keeping LGCs for voluntary retirement becomes a lower-cost option.

The RET's broader effects on the electricity system are controversial. Renewable energy brought into the electricity market by the RET has suppressed prices during periods of oversupply but contributed to more volatile wholesale electricity prices and changed the operating conditions for baseload plants.

How this could change

The RET is unlikely to be adjusted materially as its impact on the electricity system is in decline and no major political party supports the extension or expansion of the mechanism.

Potential role in scenarios.

The RET's role is likely to diminish in all scenarios. However, in Paris Goals, other policies could take over from the RET in significantly increasing the role of renewable energy. These are discussed in section 5.4 below.

Industry assistance through ARENA or CEFC

The Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC) provide support to innovative renewable energy and energy efficiency projects, with ARENA focusing on direct funding for emerging technologies and CEFC investing to introduce clean energy technologies to new sectors, businesses and projects. Access to ARENA and CEFC funding requires projects that fit each organisation's criteria, which presents barriers to assistance to smaller RMP facilities. This means renewable cogeneration, renewable fuel-fired boilers, wind and solar PV projects which are proven technologies and have previously been funded by ARENA and CEFC in the innovation/commercialisation phase will have limited access to further funding. An aggregated approach to introduce renewables and emissions reduction projects across the RMP sector may been seen as innovative and ARENA may be interested in funding aspects of the business structures required to manage this approach (AMPC would be well positioned to manage such a program). A relevant example is the Virtual Power Plant investigated by AGL, which investigated how batteries installed across multiple households and businesses in South Australia could be coordinated to optimise their value.[35]

How ARENA or CEFC could change

[34] http://www.cleanenergyregulator.gov.au/RET/Pages/News%20and%20updates/NewsItem.aspx?ListId=19b4efbb-6f5d-4637-94c4-121c1f96fcfe&ItemId=683

[35] https://arena.gov.au/projects/agl-virtual-power-plant/

1. The technologies, projects and business models supported by each organisation is likely to evolve in order to keep bringing new technologies into the market
2. The government could change the organisations' mandates. For example, CEFC is prohibited from investing in carbon capture and storage (CCS) or nuclear energy but this prohibition could be removed. Changes in mandate could affect the support for technologies relevant to RMPs positively or negatively.

Potential role in scenarios

In Current Policy, both organisations are likely to maintain their current funding programs. In CN2030, ARENA and CEFC could potentially play more active roles in helping red meat processors achieve carbon neutrality. In Paris Goals, both organisations' funding could be increased and their mandates extended.

5.3.2 Existing state and territory climate-related policies

Emissions targets

Queensland, New South Wales, Victoria, Western Australia, Tasmania and the Australian Capital Territory have declared net zero emissions targets by 2050. With the exceptions of Vic[36] and ACT[37], the targets are not enshrined in legislation, and no state currently has policies capable of achieving these targets. The WA target, for example, was announced as an "aspiration"[38]. For these reasons the targets are not included in our Current Policies scenario.

How these targets could change

Targets could be legislated and/or used to guide policy development. Interim targets (i.e. for points before 2050) could be set, influencing short- and medium-term policy and planning. Interim targets are currently under consideration in Victoria, and NSW has recently announced it will develop interim targets.

Potential role in scenarios

1. State-based emissions targets are considered to have no impact in Current Policy or CN2030.
2. In Paris Goals, the net zero targets could be the guiding framework for the required national decarbonisation.

Renewable energy targets

Queensland, Victoria, the ACT and Northern Territory have announced renewable energy targets for electricity. Vic is targeting 40 percent of state-based electricity generation from renewable sources by 2025 and 50 per cent by 2030. To date Vic has conducted one cycle of reverse auctions for renewable generation but has not confirmed when the next reverse auction will be held. Qld is targeting 50 per cent of electricity consumption in the state from renewable sources by 2030. The Queensland government has funded 400 MW of solar PV and has set up CleanCo, a new state-owned utility formed to add competition to the market and invest in renewable

[36] *Climate Change Act 2017*
[37] https://www.legislation.act.gov.au/View/a/2010-41/current/PDF/2010-41.PDF
[38] https://www.perthnow.com.au/news/environment/wa-finally-sets-net-zero-emissions-target-ng-b881306279z

energy. ACT has already run enough reverse auctions for renewable capacity to be on track to achieve 100 per cent renewably sourced electricity (mostly generated from projects outside the territory) by 2020. Tasmania is targeting 100 per cent by 2022, and already has a supply around 85 percent renewable due to its hydropower. SA no longer has a renewable energy target but is on track for more than 70 per cent renewable generation by 2021.[39]

Beyond existing and confirmed renewable energy capacity, these targets are not included in Current Policy as the mechanisms for further renewable energy growth are not implemented. For RMPs, the key implication of the states' approaches to renewable energy is that location will remain the main factor in the emissions intensity of grid-supplied electricity. For RMPs in states with higher renewable shares, the use of grid-supplied electricity will result in fewer emissions, and the incentive to switch to alternative energy sources will be less. This also implies that these RMPs need to do less to reach net zero emissions but that their cost-effective options for getting to net zero are more limited.

How these targets could change

States could establish mechanisms to achieve their full targets, increase, decrease or cancel their targets, and jurisdictions without targets (WA and NSW) could introduce them. RMPs need to consider existing and potential state policy in deciding whether to invest in alternatives to grid-supplied electricity.

Energy saving schemes

NSW and Victoria have energy saving schemes whereby certain commercial and industrial energy saving activities can be subsidised by electricity consumers through the generation of energy efficiency certificates (Victorian Energy Efficiency Target certificates (VEETs) in Victoria; Energy Saving Certificates (ESCs) in NSW). ESCs and VEETs can be claimed by AMPC members for various electrical and gas efficiency and fuel switching projects. The Victorian Energy Upgrades (VEU) program is a Victorian Government initiative that was established under the Victorian Energy Efficiency Target Act 2007 (the Act) and commenced on 1 January 2009. It is legislated to continue in three-year phases until 1 January 2030. The Energy Savings Scheme is legislated to run until 2025 or until there is an equivalent national energy efficiency scheme.

5.4 Potential changes in government policy by scenario

5.4.1 Current Policy and CN2030

In these scenarios, the policy adjustments required to achieve the current national emissions target are expected to be minor. Key policy changes are most likely to be:

1. Future baselines under the Safeguard Mechanism are set to drive a gentle decline in annual emissions (roughly 1-2 per cent per annum[40]). This would not directly affect the RMP sector unless the threshold for coverage were reduced.

[39] Climate Council, 2018. Powering Progress: States Renewable Energy Race. https://www.climatecouncil.org.au/wp-content/uploads/2018/10/States-renewable-energy-report-1.pdf

[40] https://www.energetics.com.au/insights/thought-leadership/the-safeguard-mechanism-is-here-to-stay

2. The Climate Solutions Fund expands its purchase of industrial energy efficiency generated ACCUs. This could increase the benefits of energy efficiency projects for RMPs. However, the price of ACCUs would need to increase to make this viable for energy efficiency projects. Refer to analysis of project costs in Section 3.
3. Energy efficiency policies could more stringently regulate energy consumption and expand into new areas such as heavy vehicle fuel efficiency. This could increase the benefits of energy efficiency projects for RMPs. The inclusion of biomass projects in the ESC program could add another avenue of opportunity.
4. Technologies and business models supported by ARENA and CEFC are likely to evolve gradually in response to commercial rather than policy drivers.

However, the key risk of the Current Policy scenario lies in the post-2030 period, when the carbon budgets for the sector (and the country) run out. At this point there is significant risk of policy changes that would be more extreme and more costly than those described below in the Paris Goals scenario.

5.4.2 Paris Goals

Achieving a 63 per cent decline in emissions from 2005 levels would likely require significant adjustment to existing policies and the implementation of new policies. Given that these policies could include a wide variety of regulations, subsidies and market mechanisms, this section discusses potential future policy directions in broad terms. Key potential policy changes are:

1. Evolution of the Safeguard Mechanism into an emissions trading scheme
2. Implementation of an emissions target for electricity
3. Expanded and ambitious energy efficiency policy framework
4. Sector specific regulation directly targeting high-emitting activities
5. Industry assistance directly targeting emission reduction opportunities
6. Some combination of all of the above

5.4.3 Evolution of the Safeguard Mechanism into an emissions trading scheme

The Grattan Institute has noted that progressive adjustments to the Safeguard Mechanism could make it into an emissions trading scheme driving deep decarbonisation:

1. Tighten baselines and over time reduce them to zero
2. Expand coverage to emitters below the 100,000 tCO_2e/year threshold (e.g. to 25,000 tCO_2e/year). It is estimated that there are less than 10 sites in RMP sector above 25,000 tCO_2e.
3. Replace baselines with carbon permits; run auctions for carbon permits

Linkages with other countries' carbon markets would likely be necessary to minimise domestic carbon prices, but it is likely that carbon prices globally will rise significantly in a 1.5-2°C scenario. Examples of current carbon prices are US$18 (California carbon market) and $5 (Regional Greenhouse Gas Initiative (RGGI)) in the United States, $32 in the European Union, and $2-12

across China's regional schemes[41]. Prices for Kyoto Protocol-era carbon units remain low but their role in the post-2020 Paris Agreement framework is yet to be confirmed. The IEA projects carbon prices consistent with global achievement of the <2C goal to be around US$100/tCO$_2$e by 2030.[42]

5.4.4 An emissions reduction mechanism could be implemented for electricity

There are multiple potential policies or policy combinations for electricity decarbonisation. These include policies that incentivise low emissions generation, such as a clean energy or low emissions target (CET) as recommended by the Finkel Review; policies that disincentivise high emissions generation such as an age limit on coal generators or minimum emissions performance standards (both in operation in Canada); or policies that do both, such as an emissions intensity scheme (EIS).

Irrespective of the mechanism its impact will be similar: progressive displacement of high-carbon electricity with low-carbon electricity. The requirement to build replacement capacity and transmission and modify distribution for more distributed energy resources is likely to keep the costs of electricity high (see grid decarbonisation discussion in Section 5.2).

5.4.5 Energy efficiency policy framework could expand and increase in stringency

Currently Australia's energy efficiency policy framework is fragmented and, in most areas, unambitious. Key areas not covered by energy efficiency policy include light vehicles, which make up the largest share of transport emissions, and existing residential and small commercial buildings. Some states have energy saving schemes, but some do not. However, there are some areas where progress is underway, such as the National Trajectory for Low Energy Buildings adopted by COAG earlier this year.[43]

5.4.6 Sector-specific regulation could directly constrain emitting activities

Instead of a market mechanism, future governments could implement multiple pieces of regulation to constrain emissions across every sector. These could target energy use, emissions intensity, absolute emissions generation, emitting activities, and/or technologies or equipment used in emitting activities. Key disadvantages of this approach to emissions reduction are

1. it is likely to be more inefficient and expensive than technology-neutral market mechanisms as it allows very little flexibility in compliance
2. regulatory settings are unlikely to remain appropriate over time as markets and technologies change

However, a political advantage of this approach is that it could be implemented progressively and without much public attention. This may make it harder for industries to oppose.

5.4.7 Industry assistance could directly target emission reduction opportunities

Industry assistance is already recognised as a useful component of government emission reduction policy frameworks at state and federal levels. Potentially governments could expand

[41] Prices based on World Bank carbon price dashboard, rounded to nearest dollar.
[42] IEA, 2018. World Energy Outlook 2018, Sustainable Development Scenario.
[43] http://www.coagenergycouncil.gov.au/publications/trajectory-low-energy-buildings

assistance to help industry sectors decarbonise more deeply, for example by expanding the remits and budgets available to ARENA and CEFC. However, this approach has several risks:

1. Government appetites to fund industry decarbonisation can change based on other fiscal priorities
2. Spending can be potentially inefficient, with funds going to projects that would have happened anyway
3. Spending can fail to help industry members with low capacity to access assistance due to resource constraints

5.4.8 All of the above

Some combination of elements of all these options is arguably the most likely outcome. Multiple potential combinations are plausible, making it difficult to forecast likely policy settings for national emissions reduction associated with the Paris goals.

5.5 How the RMP sector can manage its climate risk

This section discusses the framework used to assess options for RMPs to reduce emissions. First, the size, operational boundaries and emission sources for large and small facilities are defined. Second, a range of abatement options is identified and discussed. Third, abatement undertaken since 2005 is accounted for. In section 0 results of the analysis are presented as waterfall charts. This is followed by a discussion of the findings.

5.5.1 Defining RMP facilities

The size of a facility determines what the most practical and cost-effective abatement measures will look like. For the purpose of this analysis, RMP facilities are split into two categories: large and small plants. Operational data for a typical facility under each category is presented in Table 3.

Table 3: Operational data for a large and small RMP facility

	Large RMP Plant	Small RMP Plant
Product	**Large (beef, veal)**	**Small (sheep, goat, mixed)**
Throughput	**50,000 tHSCW/year**	**10,000 tHSCW/year**
Electricity consumption	**18,000MWh/year**	**3000MWh/year**
Gas consumption	**100,000GJ/year**	**10,000GJ/year**
Price paid for electricity	**$150/MWh**	**$220/MWh**
Price paid for gas	**$15/GJ**	**$20/GJ**

The key difference in activity between the two categories is whether product is rendered on site. Rendering typically only takes place in large facilities, which leads to a large plant's gas consumption for steam raising being around ten times higher than a small plant's, compared to electricity consumption where the multiplier is only about six.

The high gas consumption of large facilities opens them up to greater savings and abatement opportunities in areas related to alternative fuel combustion and thermal efficiency.

Current emissions for facilities are assumed to arise from three sources:

1. Electricity consumption
2. Gas consumption
3. Flaring of biogas

The solutions discussed in the following sections pertain only to emissions of carbon dioxide, either through fuel combustion or the flaring of biogas. The analysis does not consider biogas that is not flared or otherwise treated before release into the atmosphere. Fugitive methane emissions from uncovered anaerobic lagoons and similar installations are very large emission sources (up to 50% of Scope 1 emissions) for facilities which still use them, due to methane's high global warming potential. This emissions source can be and typically is completely abated using a single solution – covered anaerobic lagoon (CAL) with gas capture and flaring system. Around 30 large RMP facilities have already implemented CALs around Australia.

The emissions level of each plant is calculated using the emission factors in Table 4. Flaring of biogas is a minor contributor to total emissions and estimated by assuming enough biogas is produced to offset 10-15% of a site's natural gas consumption. The resulting current emissions baselines are around 22,000 t CO_2-e/yr for a large plant, and 3,100 t CO_2-e/yr for a small plant.

Table 4: Emission factors for baseline calculations

	Electricity	Gas
Emission Factor	**0.83 kg CO_2-e/kWh**	**51.53 kg CO_2-e/GJ**
Source	**National Greenhouse Account Factors 2019 for individual state grid electricity factors, weighted by state production data from AMPC**	**National Greenhouse Account Factors 2019**

5.5.2 Defining available abatement opportunities

Abatement opportunities examined

A variety of emissions reduction measures have been identified for the RMP plants, which can be grouped into the following categories:

1. Refrigeration heat recovery

Refrigeration (including chilling and freezing) is the largest consumer of electrical energy on most meat processing plants. Large amounts of energy are rejected from condensers in the form of waste heat. This heat can be recovered to supplement the use of natural gas or other fuels for preheating boiler feedwater.

2. Refrigeration efficiency improvements

Apart from heat recovery, there are many other process control and maintenance measures which can be implemented to reduce the electrical consumption of a refrigeration system, including controls on compressors (compressor staging, variable head pressure) and fans (variable speed drive).

3. Boiler efficiency improvements

While refrigeration is the biggest electrical energy consumer, steam generation is the largest consumer of natural gas, LPG, or other fuels in the RMP sector. Many efficiency improvements for boilers are available, such as installing a condensing economiser (for heat recovery), oxygen trim control, and fire tube turbulators. Condensate lines should also be checked for steam leaks.

4. Other electrical efficiency improvements

Minor consumers of electrical energy include compressed air, vacuum systems, and lighting. Efficiency improvements are possible for all systems through process control or replacing equipment (e.g. LED lighting, high efficiency motors and variable speed drives), while power factor control is an option for improving electrical system capacity across a site however has limited impact on site energy use.

5. Other thermal efficiency improvements

Other consumers of thermal energy, such as bio odour filters and blood dryers, can also be replaced and/or maintained.

6. Plant wide efficiency measures

When applied to the whole plant, actions such as extending energy and water monitoring systems or undertaking an energy audit can lead to significant savings through the identification of energy waste and areas for improvement.

7. Renewable energy and alternative fuels

Bioenergy has received increased attention in Australia in recent years, but there is still plenty of potential for growth. Replacing a natural gas boiler with a biomass (e.g. wood chip) boiler can significantly reduce a facility's net carbon emissions, as well as lead to financial savings in the

context of elevated gas prices. Many facilities already treat wastewater in anaerobic lagoons and use the biogas to supplement natural gas used in boilers or power generation systems or at least flare the methane produced; using the biogas to offset natural gas consumption instead can also lead to financial savings.

Small scale behind-the-meter renewable energy, particularly solar PV, offers an opportunity to offset carbon-intensive grid electricity consumption. Although required capital is often high, such a project typically pays back in five to six years and can generate significant positive publicity for a facility which chooses to undertake it. Should a facility wish to partake in renewable energy without the upfront outlay, power purchase agreements (PPAs) are emerging as an attractive option. PPAs are not included within the waterfall charts of options because their customised natures makes them difficult to cost (see Box 1:“PPAs and what they can offer the RMP Sector”).

Box 1: Corporate renewable PPAs and what they can offer the RMP sector

What is a corporate renewable Power Purchase Agreement?
A corporate renewable Power Purchase Agreement (PPA) is a long-term agreement for the purchase of renewable electricity, with prices typically pre-determined over 5-20 years. A PPA is usually struck between the energy buyer (off-taker) and the generator, but retailers, financiers, and regulators may also be involved. The contracted amount can be anywhere between 0.5 and 100GWh per year, but deals are typically on the larger end of the scale. In recent years buyers' groups have established PPAs, expanding access to smaller electricity users. The number of corporate PPAs has grown in recent years, with 80 organisations involved in 30 corporate PPAs with a combined capacity of almost 3900MW.

What are the benefits of a PPA?
There are several important benefits to the energy buyer: zero-emissions electricity, electricity cost predictability, and often lower-cost electricity. Though long-term electricity prices are notoriously hard to predict, electricity prices are expected to remain relatively volatile, and above their historic lows, beyond 2030. A well-negotiated PPA can offer savings of 15-47% on the energy component of a typical 2020 electricity bill, although this saving may be less if a retailer adds a premium for "firming" the power.

What are the opportunities for the RMP sector? A renewable energy PPA can be of significant assistance in a facility's bid for carbon neutrality. The high energy consumption of a large RMP facility is suited to a solo PPA. Smaller facilities with annual energy consumption below 15GWh may benefit from joining an energy buyers' group and contracting together for a lower price. Joining a group can also benefit facilities by reducing transaction costs and increasing collective bargaining power.

What should RMPs look for in a PPA? In general energy buyers should aim to match the time-of-day generation with their time-of-day energy needs to limit market risk, and ideally select a project in the same state as the energy buyer's largest electricity demand to avoid divergence of market prices experienced by each party. For participants in a buyers' group, key considerations include ensuring members have equally strong credit ratings, to secure maximum benefits for each member, and understand the legal and accounting implications of entering into a joint PPA.

What are relevant examples of PPAs struck by buyers' groups? The Melbourne Renewable Energy Project (MREP) was Australia's first successful buyer's group's PPA. In 2017, fourteen organisations including banks, local governments and universities committed to purchase 88GWh of electricity from Pacific Hydro's Crowlands Wind Farm in Victoria. The Southern Sydney Regional Organisation of Councils (SSROC) concluded a deal the following year under which Origin provides the 20 participating councils with around 39,000 MWh of renewable energy a year from Moree Solar Farm until the end of 2030. The balance of their electricity needs will be supplied as regular grid electricity to 2022.

*** https://www.energetics.com.au/media/1844/20181010-nsw-guide-to-corporate-power-purchase.pdf**

Excluded abatement options

One potential route for decarbonisation of red meat processing operations is the electrification of process heat via heat pumps. However, efficiency gains can only be achieved for low-temperature heat (50-60°C), which is reflected in the commercial availability of heat pump technology. In addition, the environmental credentials of this technology are highly dependent on those of the electricity which powers it, and only minor grid decarbonisation is forecast in two of three scenarios.

Heat recovery from waste heat streams such as refrigeration may be undertaken using heat pump technology. Such possibilities have been included.

The use of carbon offsets, such as from land sector projects, has also been excluded. Offsets are not a recommended abatement option for RMPs, for the following reasons:

1. Offsets do not provide sustained emissions reduction. Emissions from activities that are offset in one year will need to be abated or offset again the following year. Offsets thereby represent an ongoing additional cost. In contrast, investments in energy efficiency and renewable energy result in ongoing abatement.
2. The future supply and costs of offsets is highly uncertain. International carbon market rules to be set under the Paris Agreement, as well as domestic policy settings will influence the development of the offset market. This makes it very difficult to forecast or prepare for future offset prices.
3. For lowest-cost economy-wide decarbonisation, the use of offsets is generally best directed to those sectors for which there are no other options. The RMP sector is fortunate to have a wide array of options for emissions reduction.

Box 2: A potential role for RMPs in land sector offset aggregation.

Although RMPs can access a range of cost-effective emissions reduction options, the broader red meat industry faces a more difficult task to achieve the industry goal of carbon neutrality by 2030. Production of offsets by red meat industry landholders is an important element of industry-wide emissions reduction.

However, for these offsets to be counted toward the industry goal, they need to remain within the industry. If offsets are sold to companies in other industries, the associated emissions reductions are allocated to those other industries.

An option that warrants further consideration is for offsets to be purchased by red meat consumers – in effect, for red meat prices to include the costs of offsetting the industry's emissions. This would require offset recognition and aggregation at a point in the value chain between the end consumer and the producer; RMPs are well-situated to play the role of aggregator. This concept is being explored by Meat and Livestock Australia.

Accounting for abatement efforts since 2005

As a 2005 baseline has been used in setting Australia's national target for 2030 and hence is also used in this paper for the RMP sector's potential targets, the RMP sector's past abatement needs

to be accounted for. In effect, required abatement from current levels is percentage-wise lower than the stated targets, because significant work has already been done.

According to AMPC's latest RMPS Environmental Performance Review, emissions intensity fell from 525 kg CO_2-e/t HSCW in 2003/4 to 432 kg CO_2-e/t HSCW in 2013/14, and energy use efficiency has improved from 3389 MJ/t HSCW to 3005 MJ/t HSCW in the same time frame.

On the one hand, past work reduces the amount of abatement still needed to achieve targets, but on the other hand it also reduces the number of tools available to tackle the remaining emissions. The Environmental Performance Review cites the following initiatives as having contributed to abatement efforts since the turn of the century:

1. Biogas capture and use in boilers to replace natural gas
2. Daily gas and electricity use monitoring and increased energy sub-metering
3. LED or efficient lighting installation
4. Variable speed drives on fans and compressors
5. Replacement of aged equipment with energy efficient machines

More than 70% of facilities had a formal energy efficiency target, and given large amounts of industry funding (over $35m) awarded via the Clean Technology Investment Program since 2011, it might be reasonable to assume that a large portion of abatement potential from efficiency activities (items 2 to 6 in Section 0) has already been exhausted.

The study showed that biogas from wastewater treatment accounted for 6.6% of sites' energy use. It is estimated that substitution of around 15% of a large plant's natural gas consumption with biogas from wastewater streams is possible. Using the figures in Table 3 as a basis, the maximum energy use fraction which can be provided by biogas is just over 9%, so approximately two thirds of the biogas boiler potential has also been exhausted already.

Finally, biomass accounted for 6.7% of energy consumption in 2015. The potential for biomass is significantly larger than biogas due to the ability to purchase fuel externally, and a cogeneration system can offset nearly all of a site's grid electricity consumption. The biomass abatement potential is therefore assumed to be unaffected by progress since 2005.

All other renewable energy and heat recovery options are assumed to be unaffected, though it is acknowledged that some plants may have already implemented one or more of these solutions.

The assumptions which have been made to factor in abatement efforts since 2005 are summarised in Table 5. Facilities which feel their individual progress exceeds or falls short of these assumptions can adjust their take on the recommendations accordingly. For example, a facility which has not implemented any efficiency improvements may have many more available options for low- or negative-cost emissions reduction.

Table 5: Factoring in emissions reduction efforts since 2005

	Assumption for Analysis
Efficiency Improvements	**70% of possible improvements already implemented**
Biogas	**67% of potential capacity already implemented**
Refrigeration Heat Recovery	**Minimal implementation**
Biomass and Renewable Energy	**Minimal implementation**

Accounting for grid decarbonisation

Grid decarbonisation is essentially "free abatement" in terms of requiring zero upfront capital. In addition to the proactive approaches described above, grid decarbonisation has been included as a default zero-capital offset, as an increasing share of renewable energy in the grid is expected in the coming decade. In particular, facilities in Victoria, NSW, SA, and WA can expect to benefit from the changes.

Nationwide, the grid emissions factor is forecast to fall to 0.69 tCO_2e/MWh by 2030 following current trends. When weighted by the approximate tonnage of meat processing throughput in each state, this national average falls to 0.67 tCO_2e/MWh, representing a reduction of 20% in grid electricity-associated emissions. This "status quo" decarbonisation level is assumed under Current Policy and CN2030. Under Paris Goals, grid decarbonisation is expected to accelerate along with other emissions reduction efforts. The national grid emission factor is expected to fall to 0.3 tCO_2e/MWh by 2030.

Although grid decarbonisation carries no up-front investment costs, there may be embedded costs in the price of electricity. Electricity prices are expected to remain high and volatile in the coming decade. (Section 0 above discusses the factors driving high and volatile electricity prices.)

5.5.3 Abatement opportunities ranked

The waterfall charts below and in Appendix B rank each of the options (with renewable energy and alternative fuels solutions considered separately) by two metrics, net project value and capital expenditure. In Appendix B the charts present results for each of a large and small meat processing plant under low and high grid decarbonisation scenarios (corresponding to Current Policy/Carbon Neutral 2030 and Paris Goals respectively). Figure 4 and Figure 5 below address the sector under high and low grid decarbonisation scenarios.

The possible abatement associated with each solution is then shown as an offset to the current emissions of a typical plant. In this way, a possible pathway to each of the levels of emission abatement required by 2030 is demonstrated.

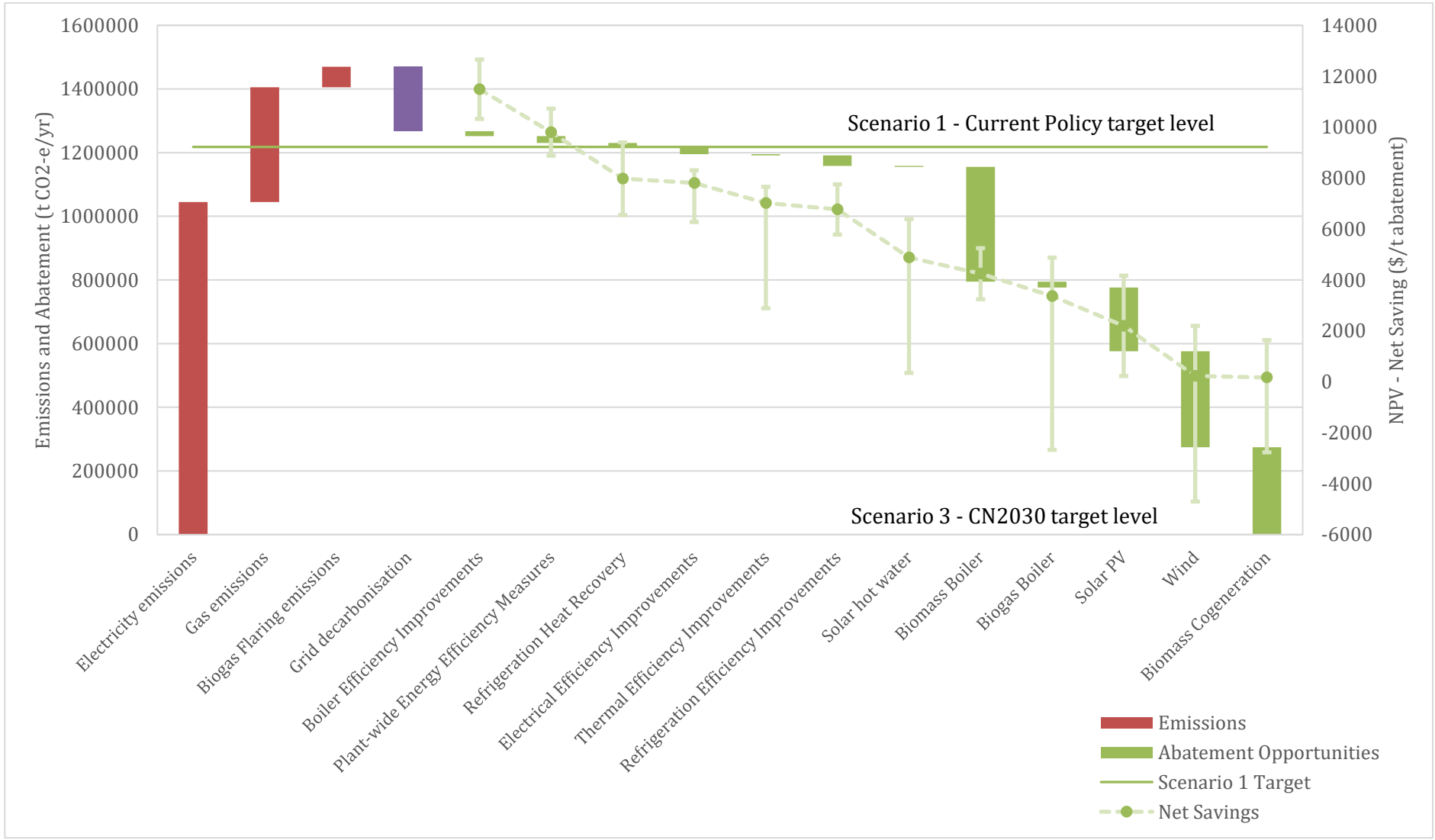


Figure 4: Emissions abatement opportunities for the red meat processing sector under low grid decarbonisation - Current Policy and Carbon Neutral 2030

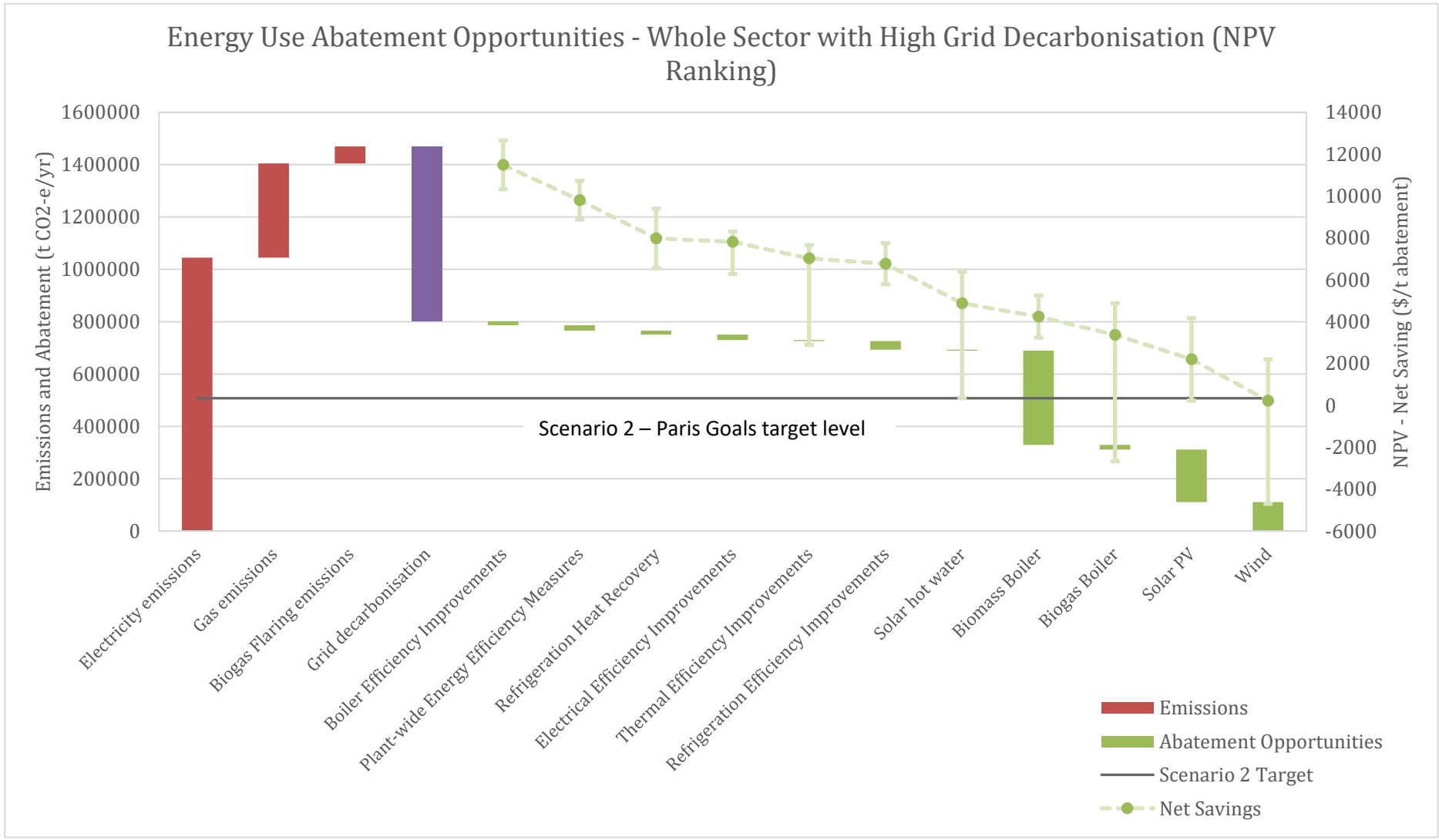


Figure 5: Emissions abatement opportunities for the red meat processing sector under a high grid decarbonisation scenario – Paris Goals

6.0 DISCUSSION

Abatement opportunities fall broadly into three categories described by the Implementation Pyramid in Figure 6. Improving energy performance on a plant should be performed in stages, using this hierarchy as a guide.

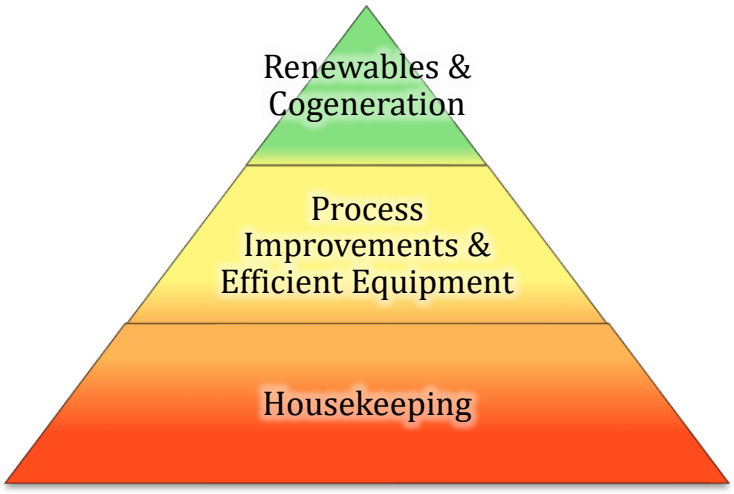


Figure 6: Implementation Pyramid for prioritising emissions reduction options

Housekeeping and efficiency improvements (options 1 – 6) offer minor abatement opportunities, but they are relatively simple and cheap to implement. Minor efficiency improvements and grid decarbonisation alone can enable a plant to reach the Scenario 1 abatement target of 16%. Within the efficiency categories, improvements to refrigeration systems offer the largest potential emissions reduction, while plant-wide measures are the lowest-cost options.

The most significant abatement opportunities correspond to the top tier of the pyramid – renewables & cogeneration. Of these options, the most financially viable is the installation of biomass boilers, followed by biogas boilers. Biomass boilers offer greater emissions reduction potential, as fuel can be purchased from external sources so 100% of a site's natural gas or LPG consumption can essentially be displaced. Examples of biomass include wood waste and waste agricultural products (around $3-4/GJ when available) and wood chips ranging from $5/GJ to $8/GJ.

Biogas boilers or cogeneration can provide more benefits compared to flaring but will likely not be able to completely offset natural gas consumption as the supply of digestible waste is finite. While the use of anaerobic digesters with externally sourced waste is possible, this can be a very capital-intensive option requiring long-term contracts for the supply of wastes of consistent volume and composition. The attractiveness of biogas boilers using site wastewater as feedstock lies in the near-zero cost of the fuel.

The offset of grid electricity consumption is more difficult – behind-the-meter solar PV or wind can be more profitable than biomass cogeneration but are more capital intensive and unable to offset as great a portion of a site's electricity consumption due to the intermittency of renewable generation. A wind

or solar installation could be paired with batteries, but this greatly increases the capital required and payback times are likely to extend well past 10 years at current costs of

7.0 CONCLUSIONS/RECOMMENDATIONS

7.1 Current Policy - some energy efficiency

Expected grid decarbonisation levels of 20% by 2030 will take the RMP sector most of the way to Current Policy's headline 26 per cent (effective 16 per cent) emissions reduction target. In the case of small plants, the whole 16% reduction can be covered by grid decarbonisation. The remainder of abatement for large plants can be achieved by implementing remaining efficiency improvement options. For plants which have exhausted efficiency improvements, investment in a biomass boiler is the next most cost-effective option. Plant-wide measures and improvements to electrical systems are low-capital solutions which pay back quickly, while introducing biomass provides a large reduction in abatement with relatively good financial characteristics.

The Current Policy scenario is a low-action scenario, meaning grid decarbonisation will provide most of the abatement needed to reach the target. Any projects beyond basic efficiency improvements would likely only be pursued for their financial benefits under this scenario.

7.2 Paris Goals – energy efficiency and biomass boilers

Reaching 63 percent abatement requires more effort. Once all efficiency measures have been exhausted, the remaining options involve the use of alternative fuels for heating and/or electricity. The grid is expected to decarbonise in line with the Paris target (i.e. 63% reduction in electricity-associated emissions), which is a key driver of sectoral abatement. For both large and small plants, the remaining abatement can be achieved by investing in renewable heating in the form of biomass boilers. As seen in the waterfall charts, the full biomass potential for each site does not need to be tapped to reach the target – half of the potential offset for large plants and a third for small plants is sufficient, meaning capital expenditure can be limited. Many RMP plants may be well-positioned for this investment as they are situated close to agricultural land or forest, which can significantly reduce the costs of sourcing fuel (see the box "Biomass Potential in the RMP Sector").

7.3 Carbon Neutral 2030

In order to become completely carbon neutral by 2030, the RMP sector will need to invest heavily in renewable energy solutions to eliminate reliance on grid electricity, which is expected to follow the same limited decarbonisation path as the Current Policy scenario. Three pathways to achieving 100% abatement are available:

1. Offset of grid electricity consumption with on-site, behind-the-meter solar and wind farms (if space is available). If only this option is pursued, storage will be required to smooth supply to match the stable demand profile of a meat processing facility. This is a highly capital-intensive option, which is not guaranteed to pay back, especially for a small site, and not applicable to all

sites as there are stringent space and location requirements for successful implementation of renewables, particularly wind. Storage is currently not economic, with options such as batteries carrying payback times in excess of 10 years. While this may change in the coming decade, it is likely that this option will need to be used in conjunction with one of the other offsets (cogeneration or a PPA) to ensure uninterrupted supply.

2. Offset of grid electricity consumption with biomass cogeneration. Although requiring less capital per tonne of abatement, cogeneration is also highly capital-intensive due to its large abatement potential, and significant space is required on site for the cogeneration plant. A cogeneration project is less likely to pay back than a solar project, due to the ongoing cost of fuel (biomass prices may vary over time, and long-term contracts are not guaranteed). The biomass industry is still highly distributed and access to cost effective sources of biomass can be challenging. Wood chips are currently shipped from Australia to Europe where policies such as the Renewable Heating Incentive in the UK help improve the NPV of biomass boilers and cogeneration projects[44]. Domestically, such incentives do not exist, which constrains the development of these projects.

3. Offset of fossil fuel electricity consumption by entering into a power purchase agreement (PPA). This solution is fast becoming popular among organisations wishing to reduce their emissions but not having the land or capital needed to invest in behind-the-meter solutions. However, this option has potentially limited access for smaller plants. While a buyers' group is a possible avenue for small plants, the legal costs and logistics of such a venture present significant barrier. See the box "PPAs and what they can offer the RMP Sector".

Considering the capital intensity and complicated nature of all three options, it is recommended that small facilities focus on implementing energy efficiency measures and boiler fuel switching due to their lower emissions and energy intensity.

Table 6 shows an estimate of the industry-wide expenditure required to achieve each scenario's abatement target, assuming a 90%-10% split between large and small facilities across the industry.

[44] Carbon Trust

Table 6: Suggested abatement strategies and associated costs

	Current Policy	Paris Goals	Carbon Neutral 2030
Suggested Technologies	**Efficiency improvements**	**As for Current Policy + Biomass boilers**	**As for Paris Goals + Behind-the-meter wind and solar OR Biomass cogeneration OR Renewable PPA AND Purchase residual offsets**
Estimated minimum capital required for on-site projects	**$12-27m**	**$425-625m**	**$2.2-3.6bn**
Estimated NPV of all on-site projects	**$5-7m**	**$34-52m**	**$13-128m**
Estimated NPV of all on-site projects with shadow carbon price of $25/tonne	**$15-17m**	**$175-194m**	**$600-720m**

It is important to note that inclusion of a shadow carbon price can materially change the NPV by factoring in the potential costs of future policy. The table above includes an illustrative carbon price of $25/t$CO_2$e. Whether this increase in NPV is realised depends on whether policies approximating the impact of the shadow carbon price are implemented in the future. In other words, the shadow carbon price can show the value of avoiding possible future policy costs.

7.4 Recommendations for red meat processors

1. Know your emissions: Develop systems to measure, monitor and actively manage your emissions so you can track any changes to your emissions profile. This step also enables action on the following recommendations

2. Prioritise: use the Implementation Pyramid in the AMPC's Energy benchmarking tool reference to AMPC energy management plan guides to work out which emissions you should address first

3. Be prepared for changes in policy:

    (i) Use a shadow carbon price. Factoring in the possibility of a carbon price can help weight projects with the best potential both for carbon emissions reduction and climate policy risk reduction. Shadow carbon prices could be based on existing prices in the ERF or offshore markets, and/or on modelled future prices.

    (ii) Monitor changes in your state's grid electricity emission factors (published annually by the National Greenhouse Accounts), and approaches to renewable energy. These will influence the relative benefits of renewable energy projects. Amendments to planned emissions reduction activities can be made in response to developments in the electricity market.

4. Plan ahead: Develop a long-term plan to progressively reduce your emissions and prepare or policy changes. This enables RMPs to take advantage of policy shifts as they occur, particularly where funding assistance becomes available.

5. Collaborate: the sector can leverage the AMPC as a central coordinator for knowledge sharing, aggregation of buying power or project development and funding. Empowering the AMPC to act in these ways can overcome barriers to investment, particularly for smaller RMPs, and allow the sector to develop more strategic approaches to opportunities.

7.5 Recommendations for policymakers

1. Understand the differences for large and small facilities and their different capacities to act on emissions reduction

2. Support industry CN2030 goal. Consider how existing policy frameworks can be adjusted to address barriers to RMP decarbonisation and ensure any policy changes do not raise RMP costs.

3. Target assistance toward projects that overcome barriers for smaller processors, for example through aggregation of buying power or similar solution development. Key areas for policy support include access to demand response and renewable energy both onsite and through multiparty PPAs.

4. Policy targeting the energy "trilemma" of emissions reduction, reliability and affordability remains essential.

5. Support and promote the inclusion of biomass in fuel replacement in energy saving schemes such as the ESC and VEET programs.

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9.0 APPENDICES

9.1 Appendix 1 - Glossary

Abatement – reduction in net greenhouse gas emissions (through reduction or offsetting)

ACCU – Australian Carbon Credits Unit.

Carbon budget – total amount of carbon emissions that can be expended under a specified scenario or goal

CO_2e – carbon dioxide equivalent. All non-CO2 greenhouse gases are converted to CO2e to account for their different atmospheric properties within a consistent framework.

Decarbonisation – reduction in emissions and/or emissions intensity

Emissions target – specific emissions or emissions reductions to be achieved by a certain date or within a certain timeframe

Emissions trajectory – trend changes in emissions over time

Kyoto carryover credits – credits for overachievement of countries' emission reduction targets set under the Kyoto Protocol. Credits may be carried over from the first Kyoto period to the second, and potentially to post-Kyoto target-setting. However the rules for the Paris Agreement on whether Kyoto carryover credits would be recognised under the Paris regime have not yet been agreed.

Kyoto Protocol - The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets.

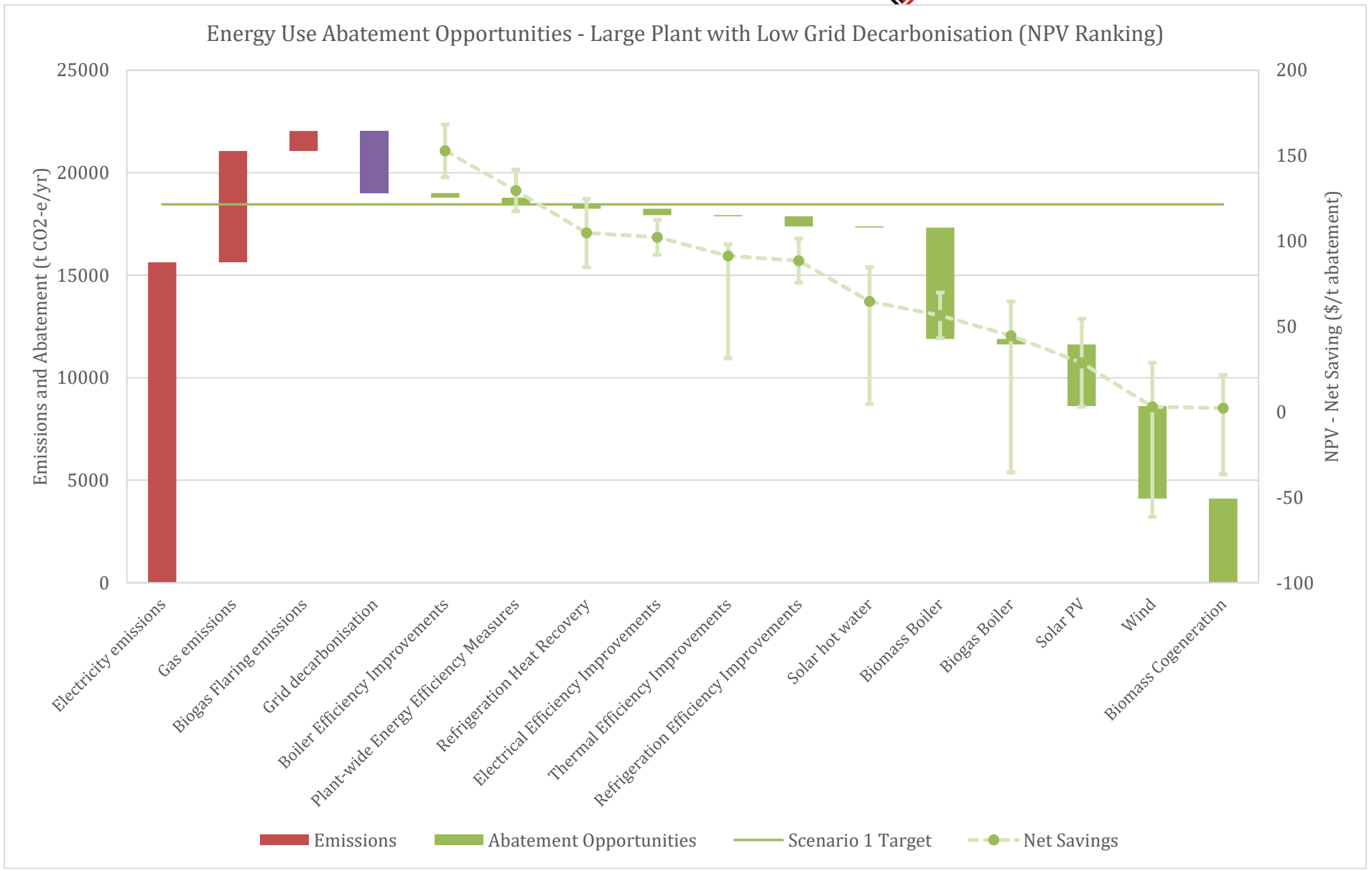
Paris Agreement - The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

RMP - red meat processing sector

9.2 Appendix 2

Charts included in Appendix:

1. Large Plant with Low Grid Decarbonisation (NPV Ranking)
2. Large Plant with Low Grid Decarbonisation (CAPEX Ranking)
3. Large Plant with High Grid Decarbonisation (NPV Ranking)
4. Large Plant with High Grid Decarbonisation (CAPEX Ranking)
5. Small Plant with Low Grid Decarbonisation (NPV Ranking)
6. Small Plant with Low Grid Decarbonisation (CAPEX Ranking)
7. Small Plant with High Grid Decarbonisation (NPV Ranking)
8. Small Plant with High Grid Decarbonisation (CAPEX Ranking)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Biogas Flaring emissions
Grid decarbonisation
Boiler Efficiency Improvements
Plant-wide Energy Efficiency Measures
Refrigeration Heat Recovery
Electrical Efficiency Improvements
Thermal Efficiency Improvements
Refrigeration Efficiency Improvements
Solar hot water
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Abatement Opportunities
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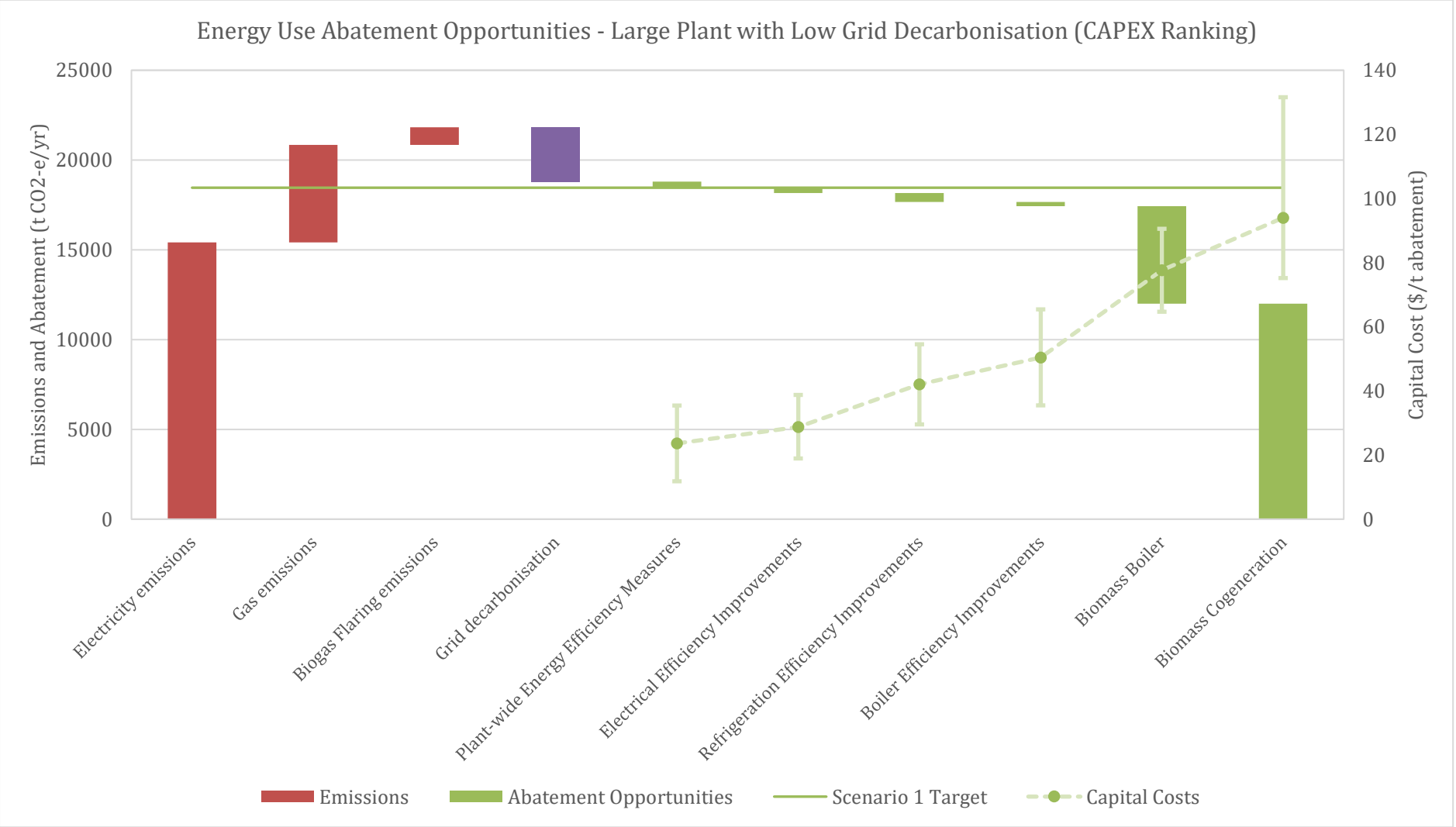
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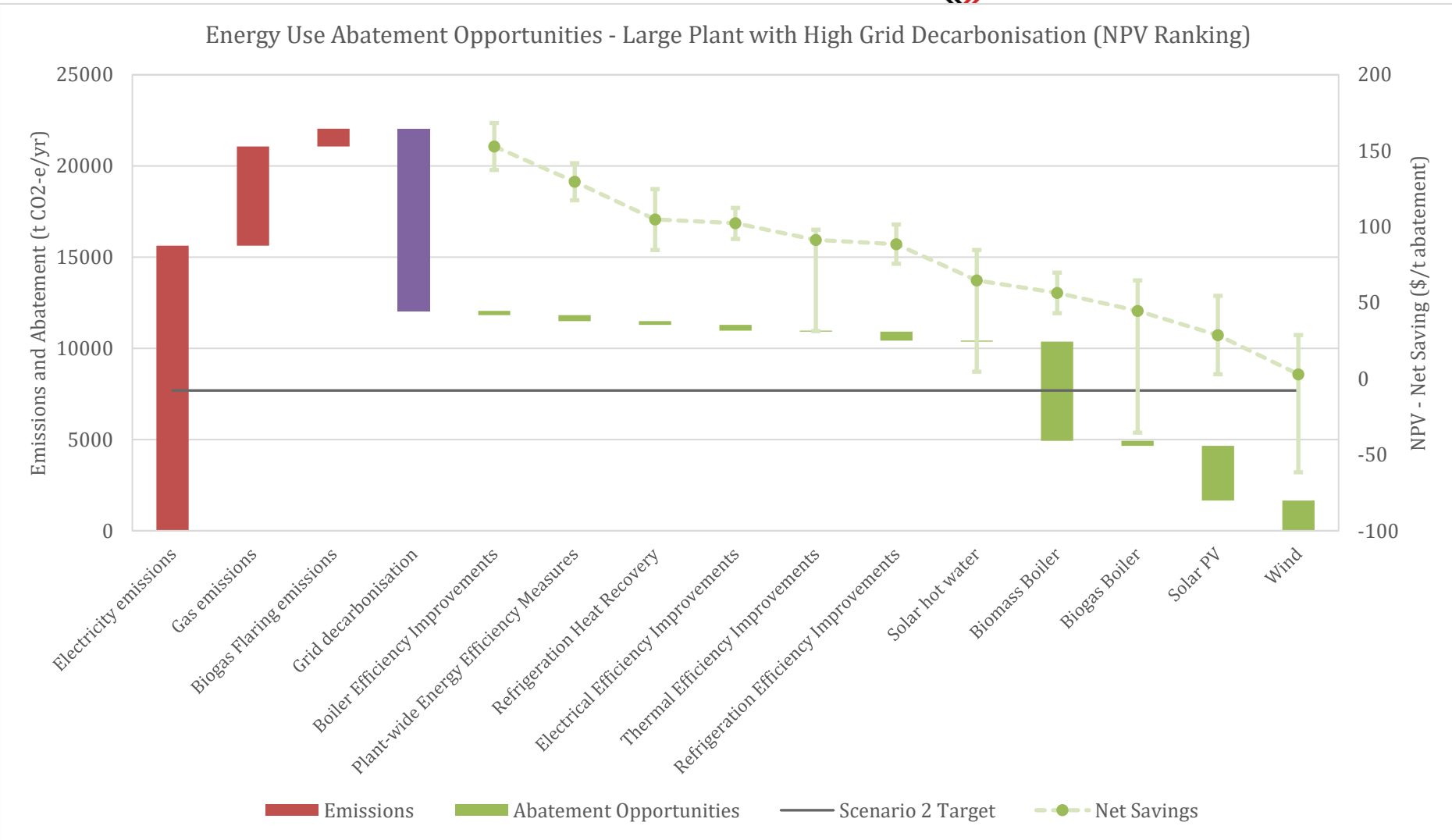
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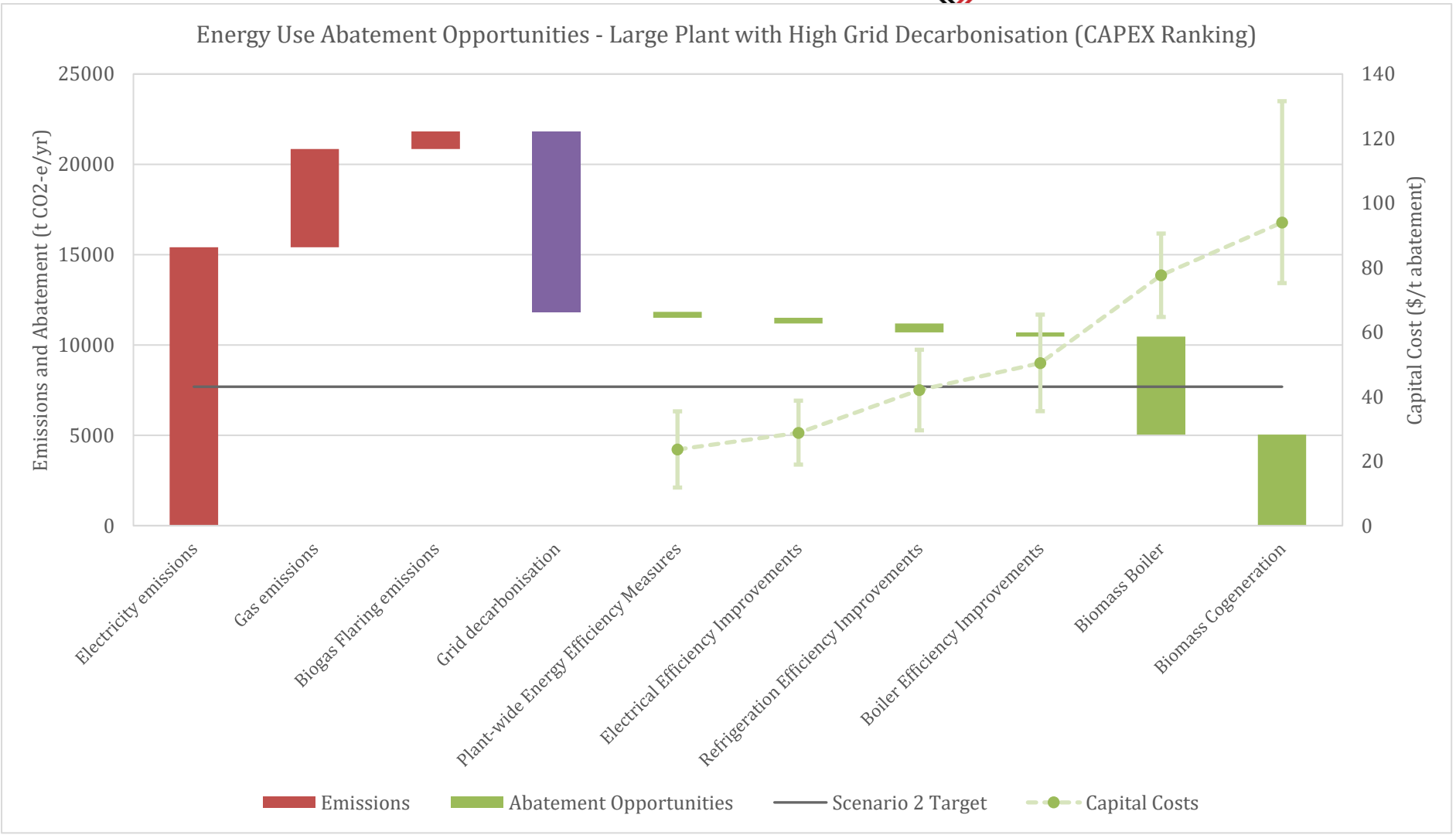
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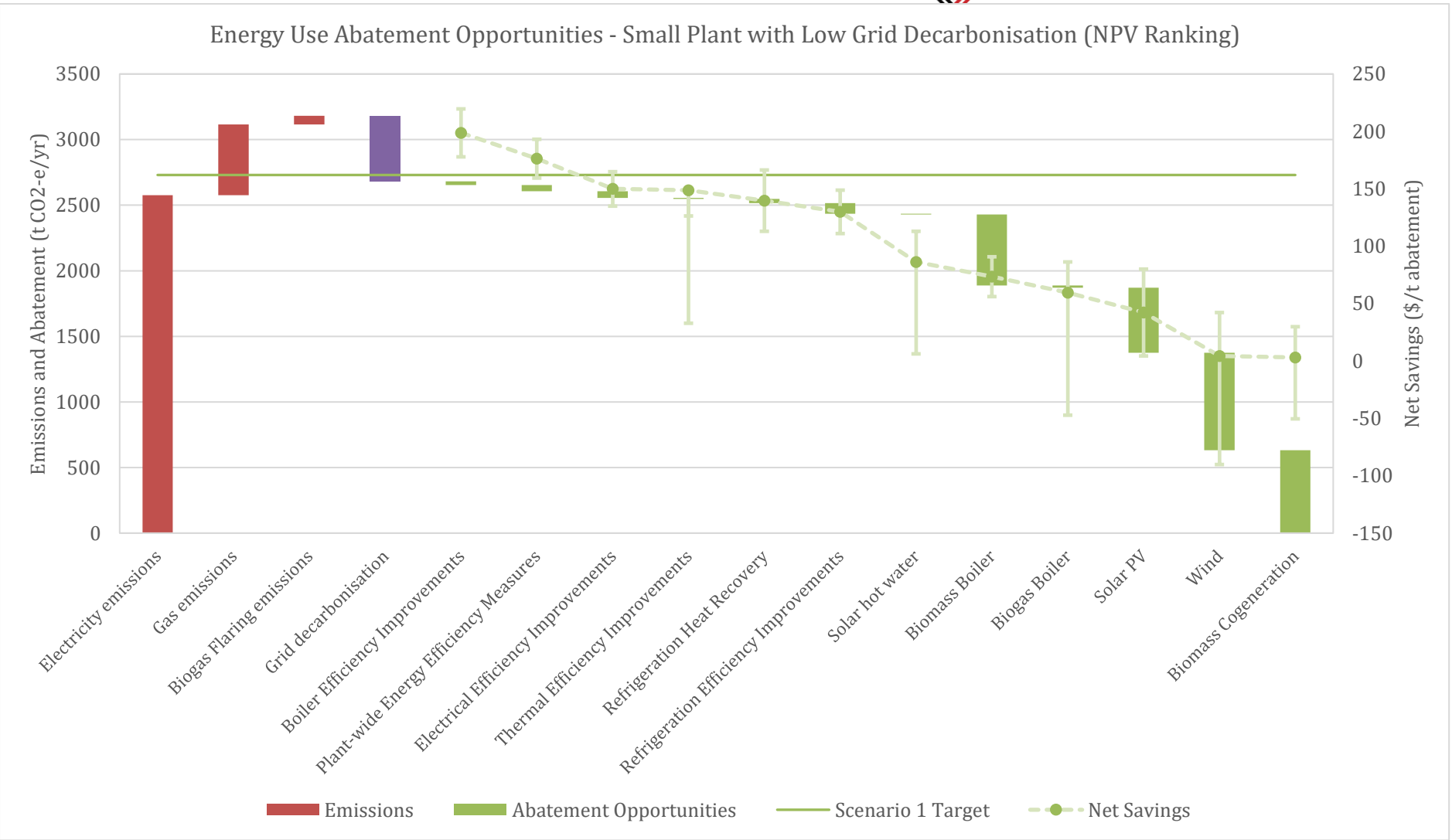
Capital Costs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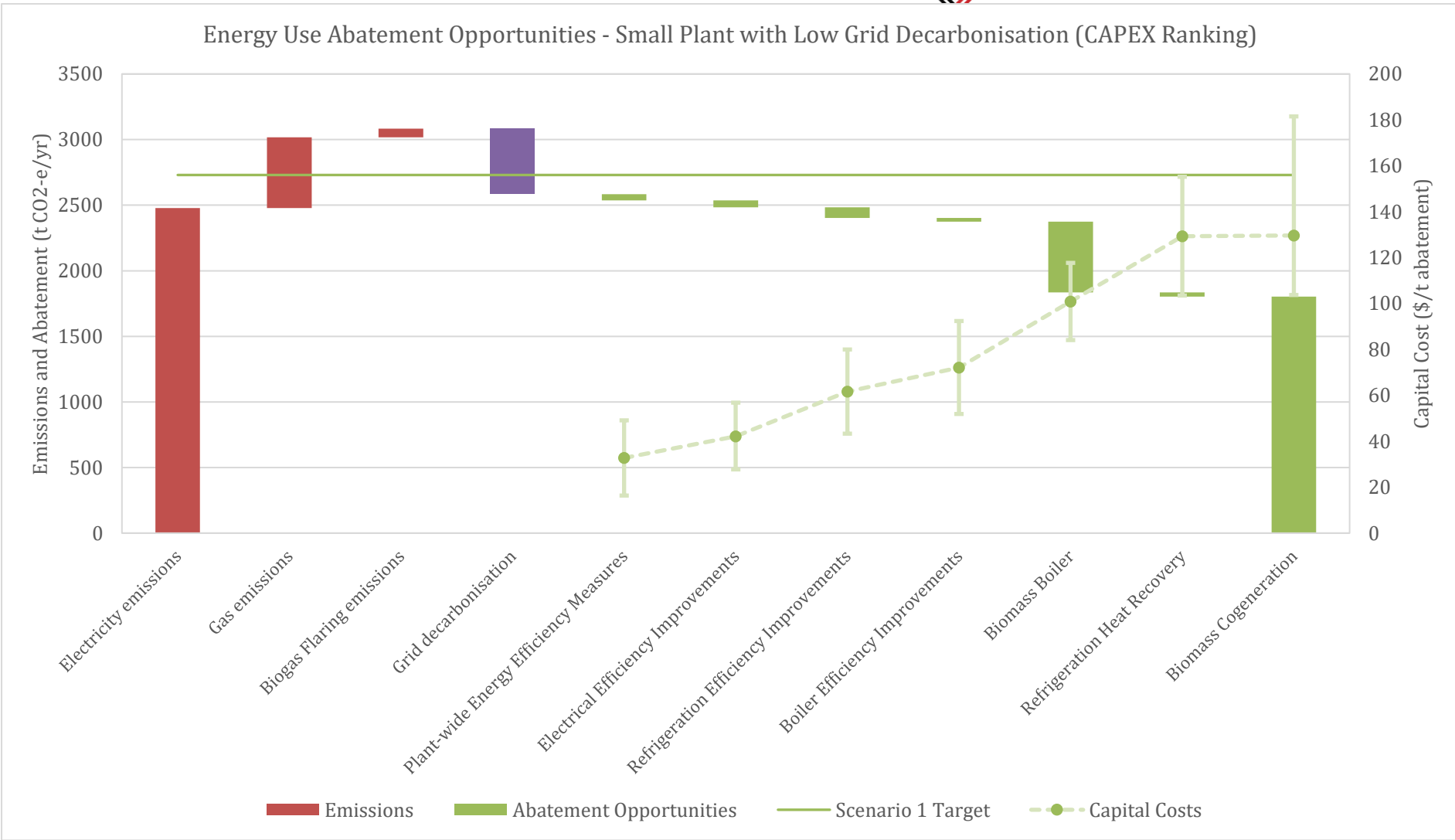
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Capital Cost ($/t abatement)
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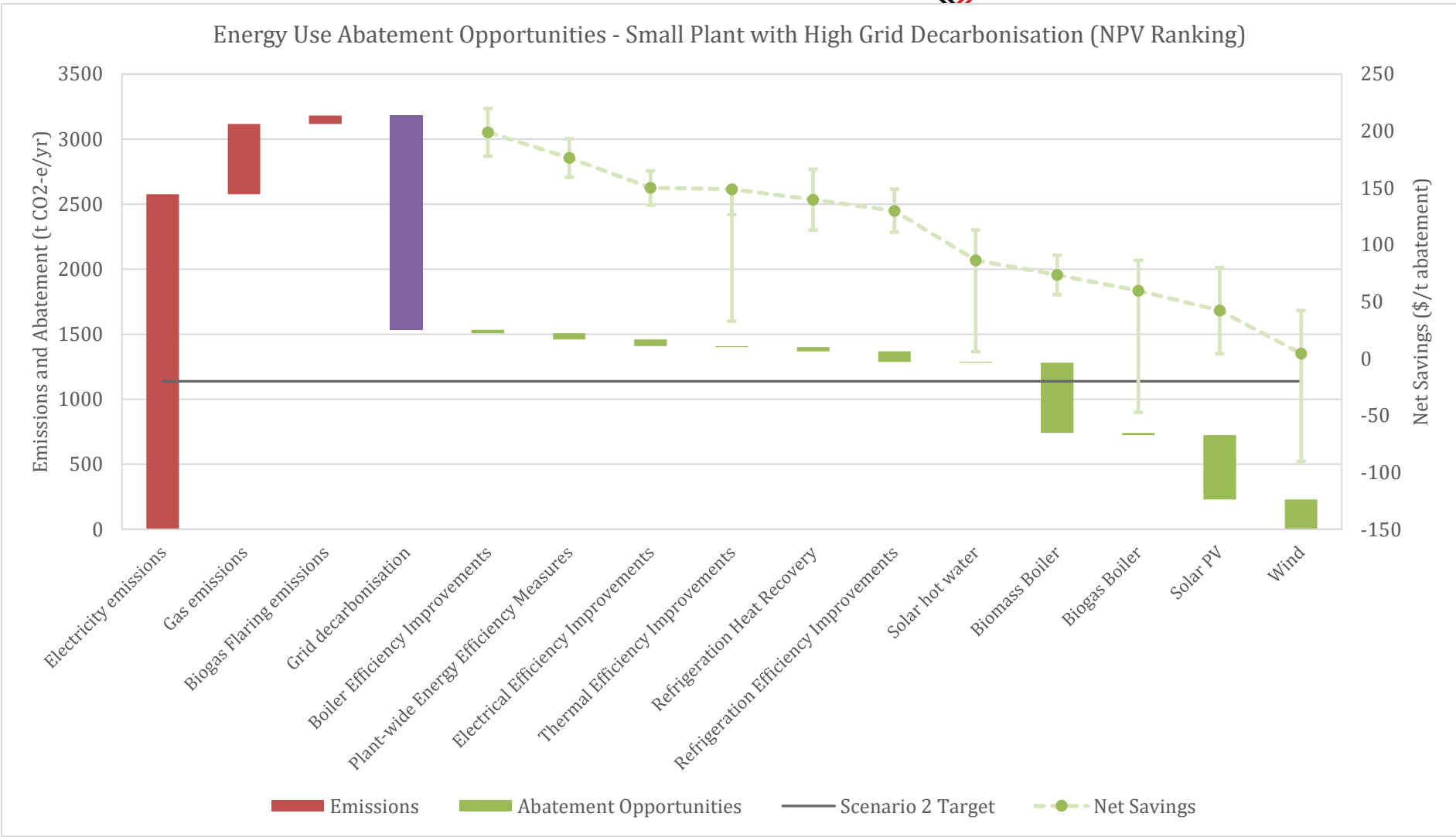
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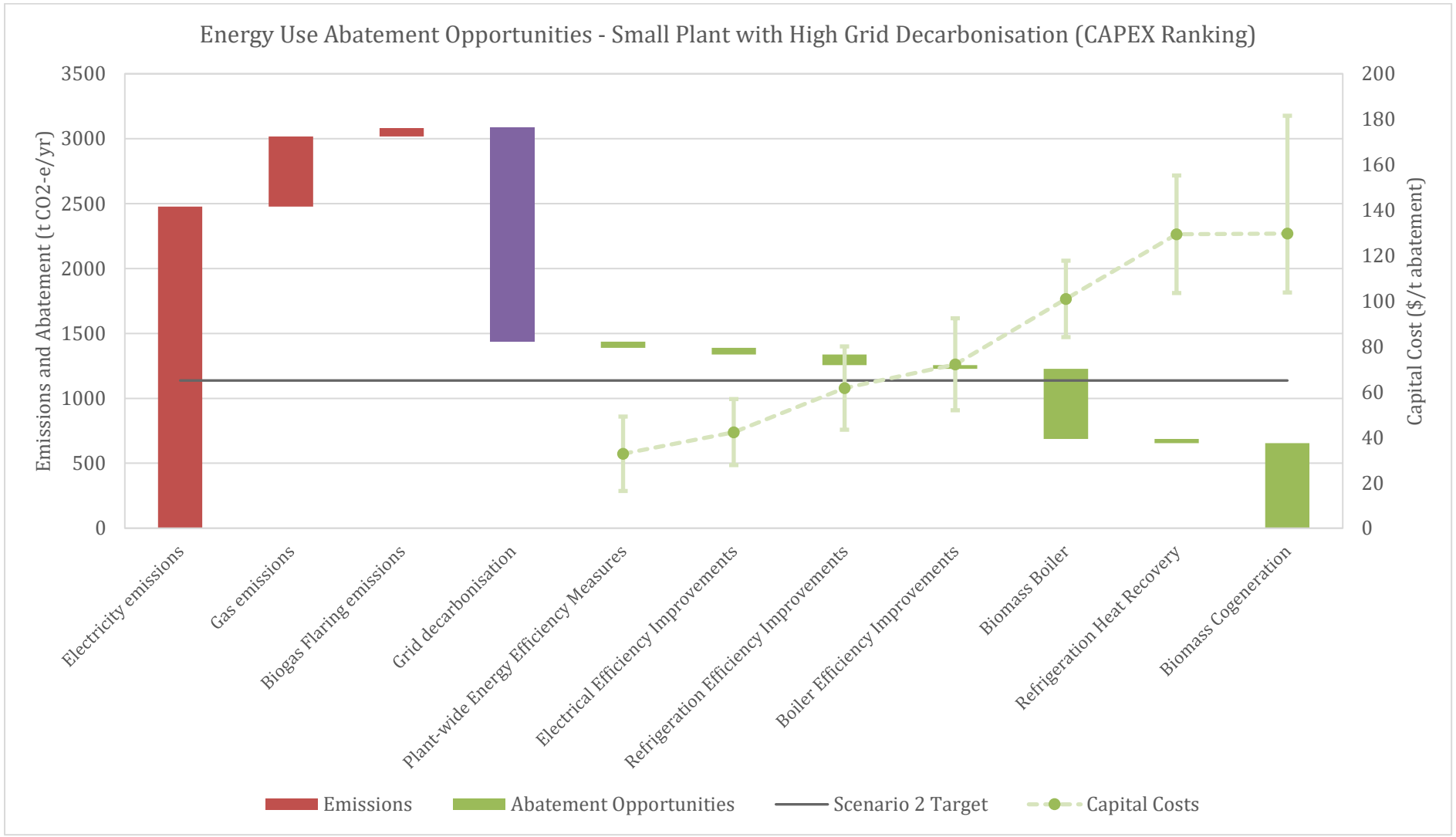
Emissions
Abatement Opportunities
Scenario 2 Target
Net Savings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Electricity emissions
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