Final Report

Closing the Loop on Red Meat Processing Energy & Emissions

Integrated Scenarios & Roadmap
FINAL REPORT

Project code
2024-1011

Prepared by
Megan Williams,
G. & K. O'Connor Pty Ltd

Date submitted
28/02/2025

Published by
AMPC

Date published
28/02/2025

Abstract

G&K O'Connor (GKO) is on a journey to reduce carbon emissions. Like all large energy users, GKO face an uncertain future with regards to energy and carbon emissions costs. This Project has identified that there is no single clear technical or financial solution that will transform GKO's operations to low/no emissions energy types. The Integrated Scenarios presented in this report provide potential integrated strategic options for doing so.

Co-funded by the Australian Renewable Energy Agency (ARENA) and the Australian Meat Processor Corporation (AMPC), the Project involves bringing together technical work carried out by Northmore Gordon, Beam Energy, Johns Environmental Group, and Enhar Pty Ltd to develop integrated scenarios to reduce GKO's process energy consumption, and establish a pathway for significant emissions reduction.

The following technologies are considered in the four integrated scenarios canvassed by the Project. These are grouped in categories for presentation of outcomes.

Table 1 - Technologies considered in scenarios

Tech category	Technology descriptions
Solar	• On site renewable electricity generation using Solar PV systems • Thermal energy storage systems, that input electricity and output steam
Biogas	• On site wastewater treatment using a Covered Anaerobic Lagoon (CAL) to produce biogas for steam generation in place of natural gas.
Energy Efficiency	• Waste heat recovery options using desuperheaters and simple heat exchangers
Heat Pumps	• Heat pumps producing hot water • Hot water tanks to store sterilisation, washdown or handwash water, acting as thermal energy storage.
Electrification	• Electric rather than natural gas boilers producing steam
Other	• A Biomass boiler using logging waste as fuel, replacing the natural gas fired steam boiler

The scenarios modelled are as follows:

Table 2 - Technology focus of scenarios

Scenario	Technology focus
Solar Led	Maximising the amount of solar PV capacity installed and utilising excess solar for thermal energy storage.
Biogas Led	Using conditioned biogas from a new Covered Anaerobic Lagoon (CAL) to substitute a portion of natural gas used for 'difficult to electrify' consumers of natural gas - primarily steam generation.
Efficiency Led	Cost effective and energy efficient technologies, plus a biomass boiler
Full electrification	Replacement of all natural gas consuming equipment with electric alternatives, on site energy storage and the procurement of renewable energy or onsite generation

The recommended scenario for GKO to pursue is the Efficiency Led scenario, as it represents the most appealing payback and highest NPV. This scenario prioritises energy efficiency projects to be completed before electrification of process heat to reduce the amount of energy needed, thereby reducing the size and cost of electrified process heat solutions. This approach is supported by the Energy Efficiency Council's report Putting Energy Efficiency to Work.

The Project has highlighted that effective change requires an incremental pathway particularly where industrial processes are impacted by many variables, and there is a strongly embedded culture of carrying out processes. It is anticipated that regulation and/or customer requirements in relation to decarbonisation will be the key driver of change for privately owned red meat processors given the highly competitive nature of the sector, and the demand on resources.

The Project also included an assessment of the replicability potential for individual technologies in the red meat industry. There are some broad considerations for project applicability across red meat processing including:

• On-site solar electricity generation requires a significant footprint, so is likely to be limited for each application by accessible land or roof area.

• Electrification projects all face limitations of electrical supply from distributors, and from onsite transformers and electrical distribution boards.

• It is critical to consider the inter-relationships of potential energy efficiency projects when evaluating their applicability and merits. For example, a project such as the econolisers that potentially remove heat from wastewater may negatively impact downstream biological processing.

Executive Summary

Problem Statement

G&K O'Connor (GKO) is on a journey to reduce their carbon emissions. Like all large energy users, GKO face an uncertain future with regards to energy and carbon emissions costs.

This Project has identified that there is no single clear technical or financial solution that will transform GKO's operations to low/no emissions energy types. The Integrated Scenarios presented in this report provide potential integrated strategic options for doing so.

Purpose and Objectives

This Integrated Scenarios Study and Roadmap is the final report of GKO's study "Closing the Loop on Red Meat Processing Energy and Emissions". This Study, co-funded by the Australian Renewable Energy Agency (ARENA) and the Australian Meat Processor Corporation (AMPC), involves bringing together technical work carried out by Northmore Gordon, Beam Energy, Johns Environmental Group, and Enhar Pty Ltd and using it as a basis to develop a number of integrated scenarios to establish the optimum road map for GKO to reduce their process energy consumption, and establish a pathway for significant emissions reduction.

Scenarios

The following technologies are considered in the four decarbonisation strategies presented in this report. These are grouped in categories for presentation of outcomes.

Table 1 - Technologies considered in scenarios

Tech category	Technology descriptions
Solar	• On site renewable electricity generation using Solar PV systems • Thermal energy storage systems, that input electricity and output steam
Biogas	• On site wastewater treatment using a Covered Anaerobic Lagoon (CAL) to produce biogas for steam generation in place of natural gas.
Energy Efficiency	• Waste heat recovery options using desuperheaters and simple heat exchangers
Heat Pumps	• Heat pumps producing hot water • Hot water tanks to store sterilisation, washdown or handwash water, acting as thermal energy storage.
Electrification	• Electric rather than natural gas boilers producing steam
Other	• A Biomass boiler using logging waste as fuel, replacing the natural gas fired steam boiler

The scenarios modelled are as follows:

Table 2 - Technology focus of scenarios

Scenario	Technology focus
Solar Led	Maximising the amount of solar PV capacity installed and utilising excess solar for thermal energy storage.
Biogas Led	Using conditioned biogas from a new Covered Anaerobic Lagoon (CAL) to substitute a portion of natural gas used for ’difficult to electrify’ consumers of natural gas - primarily steam generation.
Efficiency Led	Cost effective and energy efficient technologies, plus a biomass boiler
Full electrification	Replacement of all natural gas consuming equipment with electric alternatives, on site energy storage and the procurement of renewable energy or onsite generation

Savings, Costs and Benefits

The charts below show the monetary and carbon emissions savings by technology category for each scenario.

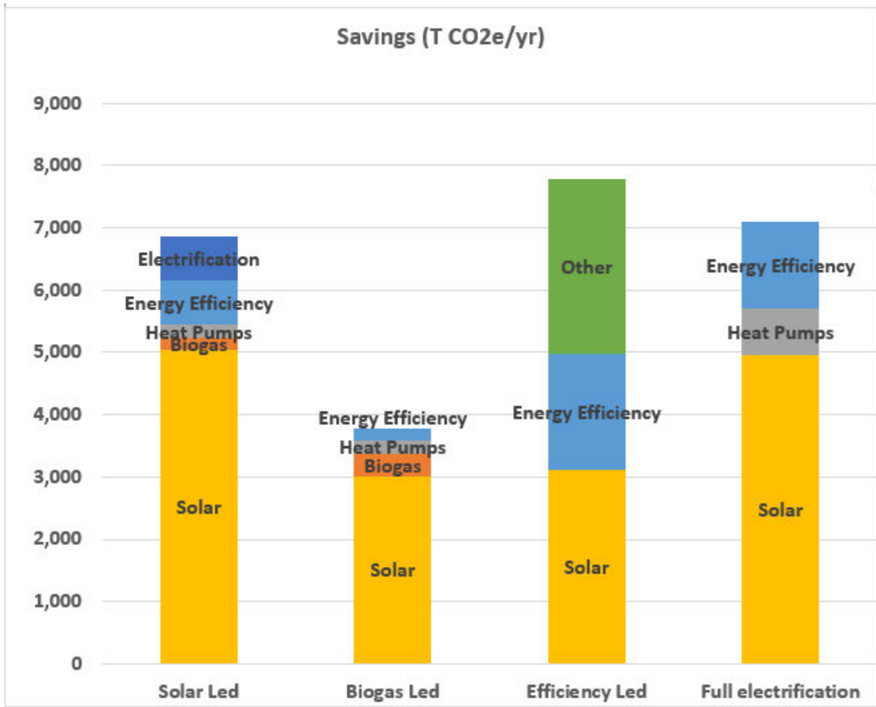


Figure 1 - Monetary & Carbon Savings by Scenario

Projects within the Solar category contribute significantly to savings in each scenario. Biogas cost savings are different between the Solar Led and Biogas Scenarios as their savings include the potential value of product (more is sent to the wastewater plant in the Biogas Led scenario, therefore not saved). The Biogas Led scenario results in significant cost savings but modest emissions reductions. The Energy Efficiency scenario is the opposite.

These charts show that the Solar Led scenario delivers the largest cost savings and second largest emissions savings. The largest emissions savings result from Full Electrification. It should be noted that the above charts do not show the required level of investment, payback or $/T CO_2-e (these are shown in Table 3 below). Therefore these graphs do not show the clear winner – the Energy Efficiency scenario has been recommended as explained below Table 3.

Table 3: Costs and Benefits

Scenario	Electricity Savings (MWh/a)	Gas Savings (GJ/a)	Carbon savings (T-CO2-e p.a.)	Estimated project cost ($) after certificates	Cost savings ($/a)	Simple payback (years) excl. Certificates	Certificate Value ($)	Net Payback, incl certs (years)	Net Present Value ($) incl certs
Solar Led	2,765	74,557	6,866	$36,002,468	$3,660,195	9.8	$3,803,018	8.8	$15,061,424
Biogas Led	2,741	68,733	4,302	$25,275,382	$2,492,446	10.1	$2,236,788	9.2	$9,258,660
Efficiency Led	4,818	88,427	7,777	$12,334,992	$1,944,340	6.3	$3,626,117	4.5	$15,657,465
Full electrification	-7,201	101,297	7,103	$29,567,756	$2,465,165	12.0	$3,498,311	10.6	$5,936,967

Recommended Roadmap

The recommended scenario for GKO to pursue is the Efficiency Led scenario, as it represents the most appealing payback and highest NPV. This scenario prioritises energy efficiency projects to be completed before electrification of process heat in order to reduce the amount of energy needed, thereby reducing the size and cost of electrified process heat solutions. This approach is supported by the Energy Efficiency Council's report Putting Energy Efficiency to Work[1].

The timing of project execution in the Efficiency Led scenario is for GKO to determine based on their emissions reduction goals. An indicative roadmap is shown in Table 4 below, including monetary and carbon savings, capital costs and cashflow. Carbon reduction over time for this indicative roadmap is shown in Figure 2.

GKO's Roadmap short term actions involve implementing an energy management system and cultural change program as a first step to decarbonisation. This first step will provide the basis for GKO to set and own its decarbonisation targets, so that they are fully realised. The study has highlighted that effective change requires an incremental pathway particularly where industrial processes are impacted by many variables, and there is a strongly embedded culture of carrying out processes.

In addition, the short term actions in GKO's roadmap will implement efficiency processes and projects to reduce total energy demand. Significant electrification or fuel switching projects aimed at net zero emissions are challenging for any organisation to implement, fund and justify. It is considered that regulation and/or customer requirements in relation to decarbonisation will be the key driver of change for privately owned red meat processors given the highly competitive nature of the sector, and the demand on resources.

[1] https://www.eec.org.au/policy-advocacy/projects/projects-overview#/forgotten-fuel-series

Table 4 - Indicative Emissions Reduction Roadmap

Costs & Savings	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
	WHE heat recovery + Chiller 6 EE Design	Certificate measurement period	Econolisers & Condensate Return	Certificate measurement period	Biomass Boiler	Certificate measurement period			4.5 MW Solar	Certificate measurement period	
Capital Cost	$644,000		$1,774,492		$3,000,000				$6,916,500		
Cost Savings	$291,107		$197,872		$519,090				$936,271		
Certificate Value			$219,806		$482,984		$1,697,548				$1,225,779
Carbon Savings from Projects (T CO2-e)	1,398		458		2,803				3,119		
Cumulative Energy Cost Savings (p.a)	$291,107	$291,107	$488,979	$488,979	$1,008,069	$1,008,069	$1,008,069	$1,008,069	$1,944,340	$1,944,340	$1,944,340
Total Year on Year Cashflow	**-$352,893**	**$291,107**	**-$1,065,707**	**$488,979**	**-$1,508,947**	**$1,008,069**	**$2,705,617**	**$1,008,069**	**-$4,972,160**	**$1,944,340**	**$3,170,119**
Emissions	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Scope 1 Emissions Baseline	4,557	4,557	4,557	4,557	4,557	4,557	4,557	4,557	4,557	4,557	4,557
Scope 1 Emissions Reduction	582	582	1,671	1,671	4,545	4,545	4,545	4,545	4,545	4,545	4,545
Forecast Scope 1 Emissions (T CO2-e) from Natural Gas	3,975	3,975	2,886	2,886	12	12	12	12	12	12	12
Scope 2 Emissions Baseline	6,645	6,645	6,645	6,645	6,645	6,645	6,645	6,645	6,645	6,645	6,645
Scope 2 Electricity Grid Emissions Factor kg CO2e/kWh	0.70	0.68	0.63	0.59	0.40	0.39	0.38	0.31	0.24	0.12	0.01
Grid Emissions Reduction	757	925	1,346	1,935	3,617	3,533	3,701	4,122	4,794	5,636	6,561
Scope 2 Emissions Reduction	469	455	-82	-73	-47	-48	-45	-39	1,033	564	47
Forecast Scope 2 Electricity Emissions (T CO2-e)	5,419	5,264	5,381	4,783	3,075	3,160	2,989	2,562	817	446	37
Total Emissions (Scope 1 & 2)	**9,394**	**9,239**	**8,266**	**7,669**	**3,087**	**3,172**	**3,001**	**2,574**	**829**	**458**	**49**

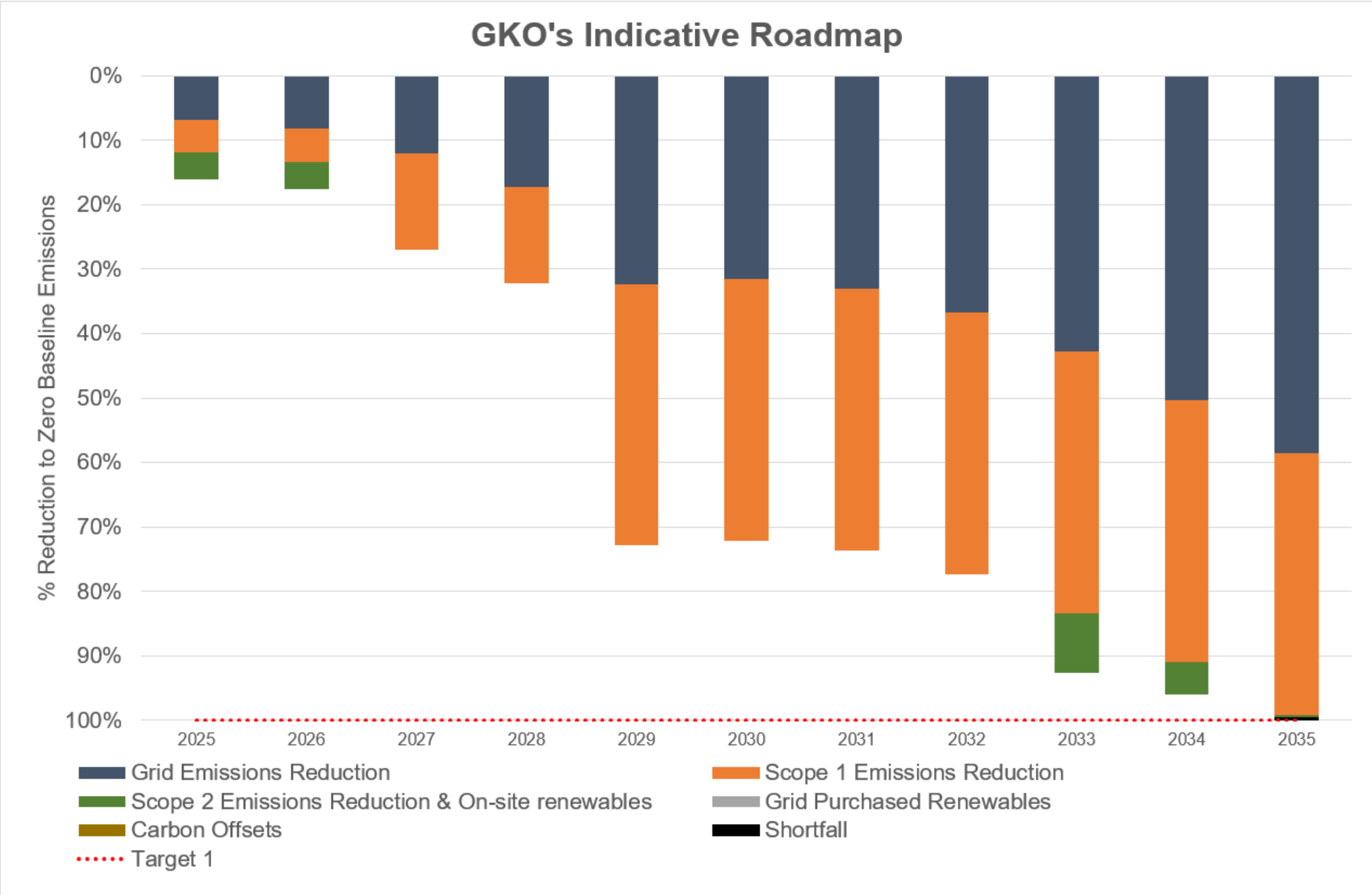


Figure 2 - Indicative Emissions Reduction Roadmap

Main Report

Contents

1. Introduction ... 12
   1.1 Site Description ... 12
   1.2 GKO's Decarbonisation Journey So Far ... 12
   1.3 Objectives ... 12
   1.4 Problem Statement ... 13
   1.5 Assumptions ... 13
      1.5.1 Baseline Period ... 13
      1.5.2 Baseline Operating Conditions ... 13
      1.5.3 Cost of Carbon ... 13
      1.5.4 Energy Prices ... 14
      1.5.5 Electricity Emissions Factor ... 15
      1.5.6 Certificate Prices ... 15
      1.5.7 Expected Asset Life ... 16
      1.5.8 Financial ... 16
      1.5.9 Production ... 17
      1.5.10 Sensitivity Analysis ... 17
      1.5.11 Operating and Maintenance Costs ... 17
2. Current operating situation ... 17
   2.1 Existing equipment & configurations ... 17
   2.2 Site Energy Consumption & Energy Tariff ... 20
   2.3 Energy Balance / Sankey Diagram ... 20
   2.4 Existing Energy and Thermal Flows ... 22
   2.5 Existing Emissions Estimates ... 22
   2.6 Current Planned Projects ... 22
      2.6.1 Current Planned Projects ... 22
      2.6.2 Other capital works underway or planned ... 22
      2.6.3 Recently completed capital works (Rendering plant) ... 22
3. Metering and Monitoring Installed to Inform the Study ... 23
   3.1 Baseline key performance indicators (water, energy, emissions) ... 23
   3.2 Summary of installed metering ... 23
   3.3 Recommendations for future metering ... 23
      3.3.1 Water metering ... 23
      3.3.2 Wastewater metering ... 24
      3.3.3 Submetering for steam ... 24
      3.3.4 Visibility across the abattoir for electricity ... 24
4. Integrated Scenarios using combination of studies ... 24
   4.1 Methodology (Multi-criteria decision matrix and Value-Ease assessment) ... 24
   4.2 Summary of Technology Options ... 25
      4.2.1 Technologies Excluded ... 27
      4.2.2 Interaction Between Projects ... 27
   4.3 Options (Integrated Scenarios) ... 28
      4.3.1 Overview of Scenarios ... 28

4.3.2 Solar led 28
4.3.3 Biogas led 30
4.3.4 Energy efficiency led 32
4.3.5 Full electrification 34
4.4 Cost-Benefit including financial analysis 36
4.5 Sensitivity Analysis (inc. energy prices, production changes) 41
4.5.1 Sensitivity Analysis – Production Changes 41
4.5.2 Sensitivity Analysis – Electricity and Natural Gas Price Changes 43
4.6 Technology Feasibility, reasons for selection and barriers 48
4.6.1 Reasons for Selection 48
4.6.2 Multi-Criteria Decision Matrix 51
4.7 Forecast key performance indicators for the different scenarios 53
4.8 Environmental Impacts and Benefits 53
4.8.1 Emissions Reduction 53
4.8.2 Other Impacts and Benefits 54
4.9 Operational Impacts 54
4.10 Other Barriers and Implementation Risks 55
4.11 Opportunities of funding (further grants, VEU, RET, ERF) 55
4.11.1 Australian Carbon Credit Unit (ACCU) Eligibility 55
4.11.2 Treatment of certificates against emissions targets 55
4.11.3 ARENA 55
4.11.4 RACE for 2030 56
4.12 Estimate of further funding required to implement recommended solutions 56
4.13 Recommendations and Next Steps (detailed) 56
4.13.1 Energy Management System 57
4.13.2 4.5 MW Solar 57
4.13.3 Biomass Boiler 57
4.13.4 WHE Heat Recovery 57
4.13.5 Econolisers 58
4.13.6 Condensate Return HR 58
4.13.7 EE Design 58
4.13.8 Wastewater Study 58
4.13.9 Review of this Roadmap 58
5. Potential Replicability across the AU Red Meat Sector 59
5.1 Addressable Market and industry wide applicability 59
6. Feedback from GKO 61
Glossary 61
Appendix A - Study for Thermal Process Integration, Electrification (Northmore Gordon)
Appendix B - Solar, Energy Storage & Demand Flexibility Options (Beam Energy)
Appendix C - Study for Technical and Economic feasibility of installing a Covered Anerobic Lagoon (Johns Environmental)
Appendix D - Multi-Criteria Decision Matrix and Detailed Project List
Appendix E - Metering and Monitoring Plan (Northmore Gordon)
Appendix F - Electrical Infrastructure Assessment (Enhar)

1. Introduction

1.1 Site Description

GKO use a considerable quantity of electricity and gas (approximately 125,000 GJ/a in total) at its meat processing facility located on the edge of the Melbourne's southern urban area. It is focused on reducing this consumption, and the associated costs and emissions – to close the loop on red meat processing energy and emissions.

Large on-site energy users in the main plant abattoir include two 2MW Presha hot water generators, a 110kW air compressor, two large ammonia refrigeration compressors supplying -40°C for blast freezers, and -10°C for refrigeration, and numerous pumps and motors.

Large energy users in the rendering plant include a 6MW steam boiler with associated pumps and motors. There is significant energy used in water pumping and 120kW of aeration in the wastewater treatment system which has biogas generation potential.

1.2 GKO's Decarbonisation Journey So Far

Northmore Gordon completed a Type 2 Energy Audit in January 2023 and identified several immediate opportunities to action prior to this Study.

Two of these have been implemented so far comprising floating head controls and a heat recovery loop for hot water using reject energy from the render plant.

Separate to this report, Northmore Gordon has also completed two design review studies for upcoming or ongoing changes to the facility. Some of the recommendations of these reviews are directly applicable to this report. This report, and the Roadmap discussed in Section 1.3, include findings from the design review studies.

A 1.26 MW solar system was installed on site and has been operational since 2023. The project reduced electricity consumption by 1,374 MWh and emissions by 1,030 tCO_2-e in the first year of operation (01 Mar 2023- 28 Feb 2024).

The waste body parts and trimmings from slaughtering are recycled in GKO's rendering plant to create meat meal and tallow products for human consumption as well as a valuable feedstock for biofuel and sustainable aviation fuel (SAF).

Overall, processing activities represent 2.1% of carbon emissions generated by the red meat industry. Over 90% of emissions are generated by primary production and 5.8% are from feedlots[2].

1.3 Objectives

The Integrated Scenarios Study and Roadmap is a key part of GKO's "Closing the Loop on Red Meat Processing Energy and Emissions" Project. The integrated scenarios synthesise the technical work carried out by Northmore Gordon, Beam, John's Environmental Group (JEG) and Enhar. This report defines a range of integrated scenarios to recommend an optimum road map for GKO to reduce its process energy consumptions, and establish a pathway for significant emissions reduction.

[2] Ridoutt B (2022). *Greenhouse gas footprint of the Australian red meat production and processing sectors 2020*. Report B.CCH.2301. Pub by Meat and Livestock Australia, North Sydney.

1.4 Problem Statement

GKO is on a journey to reduce their carbon emissions. Like other large energy users, GKO face an uncertain future with regards to energy and carbon emissions costs, and their impact on the cost of production.

There is no single clear technical or financial solution that will transform GKO's operations to low/no emissions energy types. The Integrated Scenarios provide GKO with options for doing so, and a recommended scenario based on the most appealing business case.

1.5 Assumptions

1.5.1 Baseline Period

Calendar Year 2023 is selected as the baseline period for this Project. This provides a full operating cycle of the plant and includes a period of operation after the installation of the existing solar PV system.

1.5.2 Baseline Operating Conditions

The baseline energy consumption considers the CY23 energy consumption.

1.5.3 Cost of Carbon

GKO don't currently have an agreed internal cost of carbon applied to their financial decisions. AMPC recommend alignment with the Paris Agreement – *"net zero by 2050"*[3].

To achieve carbon neutrality, scope 1 and 2 emissions need to be reduced and eliminated using several energy efficiency, electrification and renewable energy generation projects.
The alternative to implementing projects is to purchase and retire recognised carbon offsets.

The purpose of an internal cost of carbon is described by the World Bank[4] as follows:

An increasing number of organizations are using internal carbon pricing to guide its decision-making process:

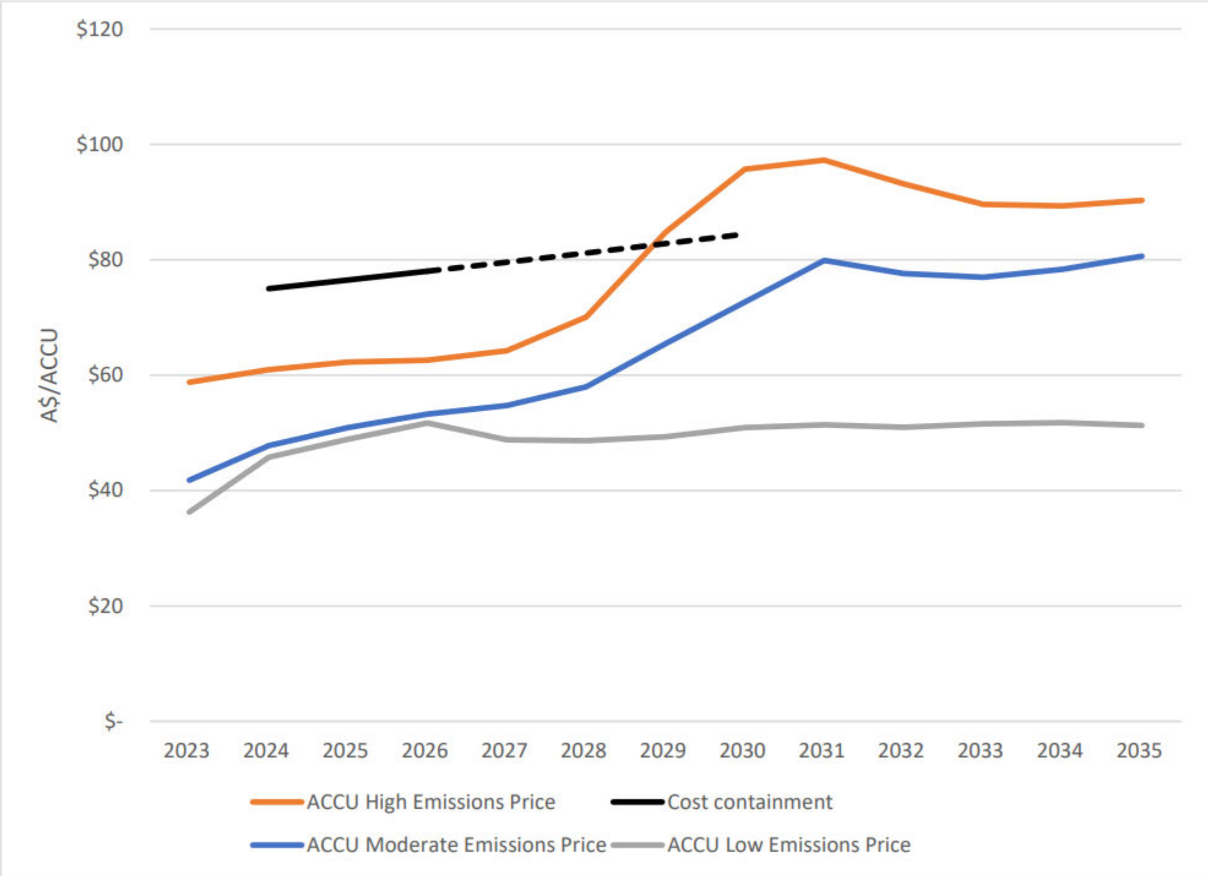
- *Corporate applications of internal carbon pricing include supporting corporate strategic investment decision making and helping companies shift to lower-carbon business models.*

It is recommended that GKO further consider implementing an internal cost of carbon to inform the business case for energy efficiency, electrification and renewable energy generation projects. The purpose of adopting an internal cost of carbon is to apply a cost for carbon that may be applied to GKO's operations in the future through forms of carbon taxes (eg. European Border Adjustment Mechanism) or via increased costs of fossil fuels which contain such a cost.

The forecast ACCU price based on ACCU Market Analysis completed by RepuTex Energy for the Climate Change Authority in August 2023 is shown in Figure 3. This chart provides an indication on the $/tCO$_2$e rate which could be used as the internal cost of carbon – the cost containment line represents a current predictable value of around $80/ACCU. ACCU buyers have the option of forward purchasing to avoid market volatility.

[3] https://www.ampc.com.au/getmedia/93c9e1c8-4d34-40ea-ada8-f2e473616628/AMPC_Snapshot_Report_2023_1004.pdf?ext=.pdf

[4] https://carbonpricingdashboard.worldbank.org/what-carbon-pricing



Note: The cost containment measure allows facilities that have exceeded their baseline to be able to purchase ACCUs form the Government at a fixed price of $75 in 2023-24, increasing with the consumer price index plus 2% each year. A 2026-27 review will consider whether the cost containment measure is sufficient.

Figure 3 - RepuTex ACCU price forecast by scenario[5]

1.5.4 Energy Prices

1.5.4.1 Gas

The price of gas is $15.48GJ for the period of 01/04/2024 – 31/03/2025 – rounded up to $16. This does not consider the Additional Gas Rate of $10/GJ if GKO exceeds the maximum quantities listed in Table 5 below:

Table 5 Maximum gas consumption before Additional Gas Rate applies

Delivery Point	Annual Contract Quantity (GJ/year)	Maximum Daily Quantity (GJ/day)	Maximum Hourly Quantity (GJ/hour)
5320000406 – 940 Koo Wee Rup, Pakenham VIC 3810	101,099	520	38

1.5.4.2 Electricity

The current prices of electricity is shown in Table 6.

Table 6. Current electricity TOU costs

Effective Electricity Cost	Peak Electricity Cost	Off Peak Electricity Cost
$0.163/kWh	$0.175/kWh	$0.132/kWh

Table 6 blends the Peak and Shoulder Ausnet tariffs into a single Peak tariff.

[5] https://www.climatechangeauthority.gov.au/sites/default/files/documents/2023-12/ACCU%20Market%20Analysis%20-%20Final%20Report%20For%20Publication.pdf

1.5.4.3 Demand Charges

The current demand charges as per the FY24 Ausnet Tariff Structure are shown Table 7 below:

Table 7. Current Ausnet demand charges

Critical Peak Demand Cost	Capacity Demand Cost
$64.33/kVA/year	$106.79/kVA/year

The Critical Peak Demand is calculated by taking the average peak electricity demand during the Critical Peak Demand window (3pm-7pm AEDT) on each of the five nominated days.

The Capacity Demand is assigned according to the rating of the cabling and switchgear that makes the customer's connection point.

1.5.4.4 Future Contracts

The price of gas is $15.637/GJ for the period of 1/04/2025 – 31/03/2026. Please note that this does not consider the $10/GJ Additional Gas Rate that applies when G & K O'Connor exceeds the quantities listed in Table 5.

The future prices of electricity is shown in Table 8:

Table 8. Future electricity TOU costs

Effective Electricity Cost	Peak Electricity Cost	Off Peak Electricity Cost
$0.160/kWh	$0.171/kWh	$0.129/kWh

Please note that the Peak and Shoulder Ausnet tariffs were blended into a single Peak tariff.

1.5.4.5 Impact Of Renewable Energy on Future Electricity Prices

It is assumed that an increase of renewable energy supply into the electricity grid will not have a significant impact on electricity prices. The impact of any change to electricity prices is accounted for using sensitivity analysis described in Section 1.5.10.2.

1.5.5 Electricity Emissions Factor

Electricity Emissions Factor (Scope 2) projection for Victoria as determined by the Department of Climate Change, Energy, the Environment and Water is in

Table 9: Electricity Emissions Factor Projection for Victoria

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
kg-CO2-e/kWh	0.79	0.75	0.70	0.68	0.63	0.59	0.40	0.39	0.38	0.31	0.24	0.12	0.01

1.5.6 Certificate Prices

Certificate price projections are subject to numerous factors such as targets set by state/federal governments, voluntary demand, and programme end dates.

Therefore, the certificate prices presented in this section may change drastically subject to changes in policies, markets and programmes.

In addition, the Northmore Gordon certificate fees are subject to the size of each project and complexity. As such, we have assumed a conservative fee for each type of certificate.

1.5.6.1 ACCUS
ACCUS (+/- $20)

Average forecasted ACCU price next 7 years = $66/ACCU

Government Fee = N/A

Assumed NG Fee = $5/ACCU

Net ACCU Value = $61/ACCU

1.5.6.2 VEECS
Average VEEC spot price last 12 months = $84/VEEC

Government Fee = $2.33/VEEC

Assumed NG Fee = $12/VEEC

Net VEEC Value = $70/VEEC

1.5.6.3 LGCS (Large Scale Generation Certificates)
LGCs will be based on the forward price, less an assumed certificate fee ($5/certificate)

1.5.7 Expected Asset Life

1.5.7.1 Abattoir Boilers
The life of the two Presha hot water boilers in the Abattoir is **15 years**[6].

1.5.7.2 6MW Render Steam Boiler
The remaining life of the 6MW steam boiler is 2 years.

1.5.7.3 Refrigeration Equipment
The life of ammonia compressors for refrigeration is 10 years.

1.5.7.4 Render Plant Equipment
The life of render plant equipment is 20 years. Some components face aggressive conditions and are replaced within this timespan.

1.5.7.5 New Assets
The expected Life of new assets including solar and covered anaerobic lagoon is 20 years.

1.5.8 Financial

1.5.8.1 Simple Payback Hurdle
GKO internal payback hurdle is 5 years.

1.5.8.2 Weighted Average Cost of Capital (WACC) Discount Rate
GKO WACC discount rate is 7%.

[6] According to advice from Consolidated Fire and Steam (CFS)

1.5.8.3 Internal Rate of Return (IRR)
GKO does not have a specific Internal Rate of Return (IRR) requirement.

1.5.8.4 Treatment of Study Costs
Costs to perform the Integrated Roadmap Study and associated Feasibility Studies have not been treated as capitalised for the purpose of this report.

1.5.8.5 ARENA Hurdles
ARENA type grants are targeting projects > 5-years simple paybacks.

1.5.9 Production

1.5.9.1 Future
The future output has been estimated at 625-900 heads/day or 150,000 –216,000 heads/year.

1.5.10 Sensitivity Analysis

1.5.10.1 Production
Simple paybacks at +/-25% in production levels is provided.

1.5.10.2 Energy Prices
Simple paybacks at +/-50% in energy prices is provided.

1.5.11 Operating and Maintenance Costs
All new operating and maintenance (O&M) costs for new equipment are assumed to be external, and therefore included in the net change to operating costs (OPEX) for each asset.

2. Current operating situation

2.1 Existing equipment & configurations
GKO's Pakenham facility consists of three key site processes: An abattoir including boning room facility, render plant, and wastewater facility.

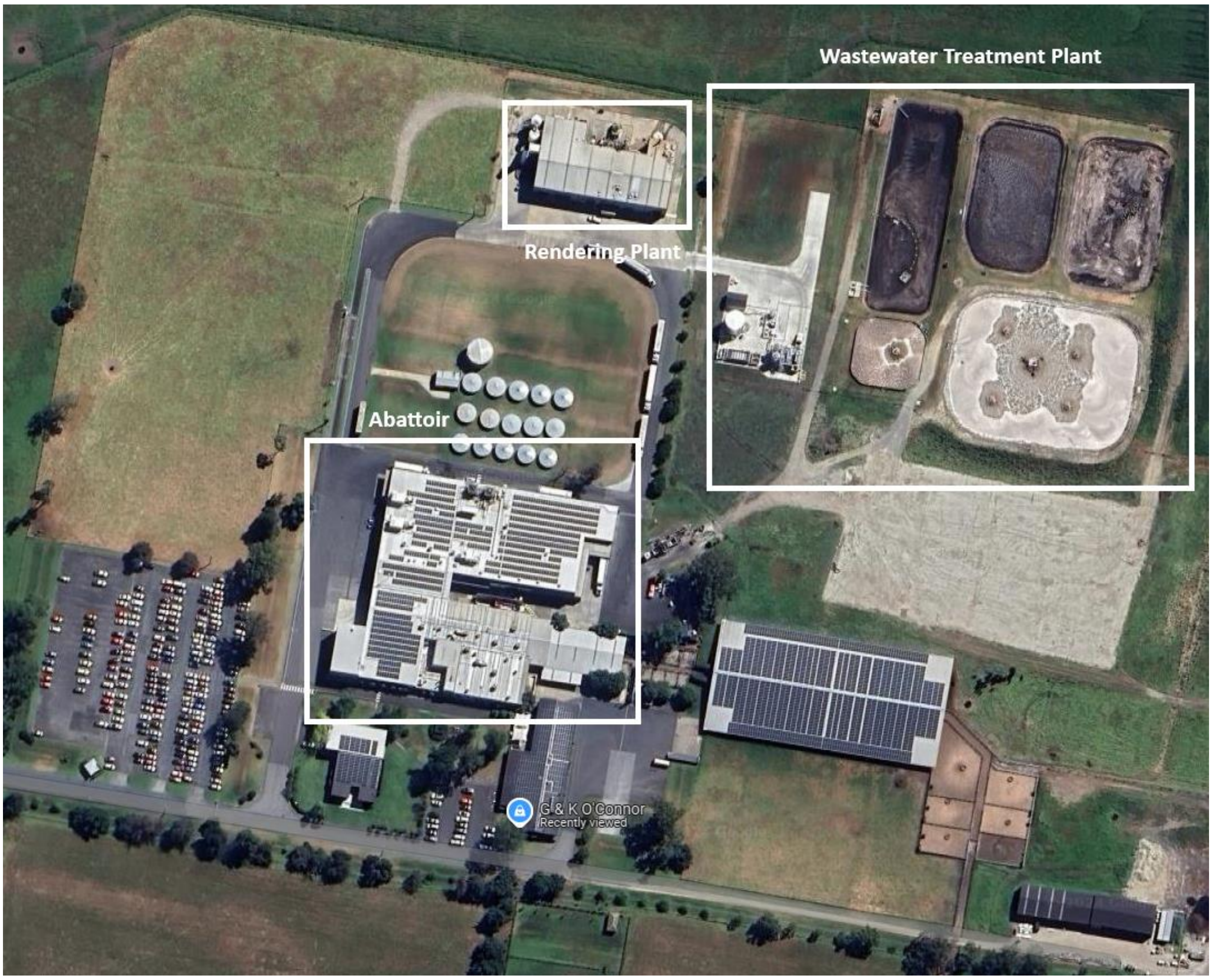


Figure 4 - GKO Site Layout with Main Areas Indicated

Abattoir:

The abattoir main activities include:

- Stockyards
- Slaughtering Chilling and boning Offal processing
- Ancillary operations including hot water, compressed air, and refrigeration/freezer utilities.

The hot water for the abattoir is generated by two 2 MW Presha hot water generators and compressed air by a 110kW screw air compressor without heat recovery. Refrigeration for several of the abattoir areas are provided by a two-stage ammonia refrigeration system (450kW lead and a 250kW booster ammonia compressors) supplying -40°C for blast freezers, and -10°C for refrigeration.

Render Plant:

The low temperature render (LTR) plant converts waste from the abattoir into valuable feed stocks comprising meat and bone meal (MBM), and tallow as represented in Figure 2-5. The plant houses:

- Blood processing line
- Low temperature soft fats plant
- Low temperature prime tallow process line (PDS line) with the contact dryer.

- Waste heat evaporator (WHE) for concentrating stickwater into meal product and for hot water generation.
- 6 MW Steam boiler

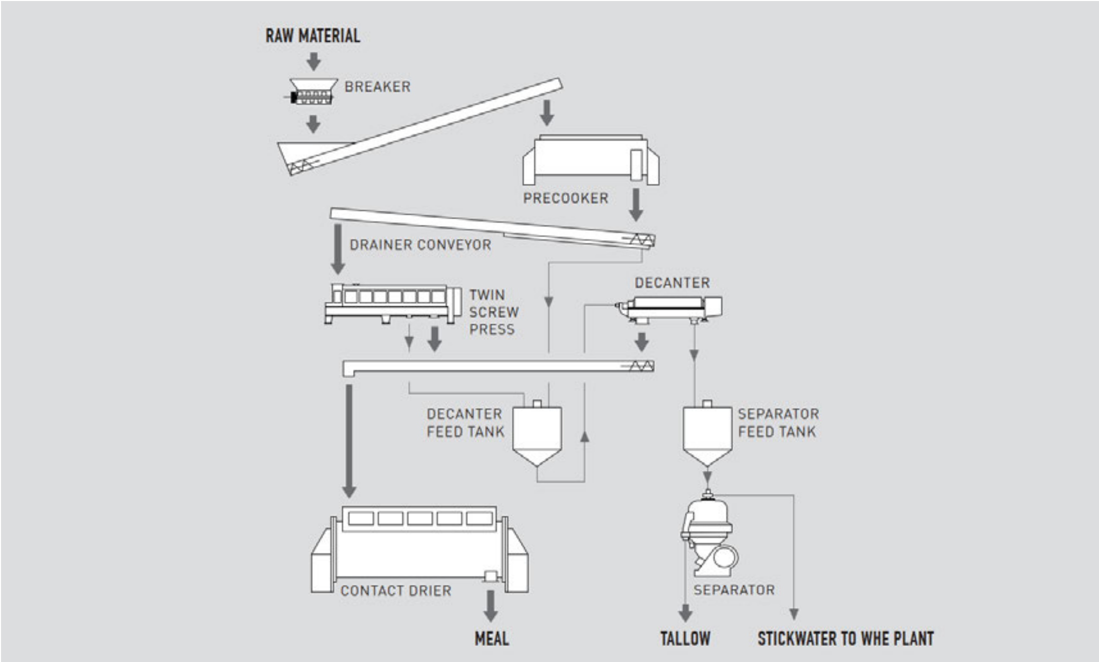


Figure 2-5: Render Plant Process Flow

Waste:
The existing biological wastewater treatment plant consists of a large, aerated pond (AFL) with ~ 100kW of surface aerators and a small sequencing batch reactor, followed by three facultative ponds (Ponds 3-5). Effluent flows through the ponds sequentially and is treated in the dissolved air flotation (DAF) system before discharge to the sewer or irrigated to land during summer in accordance with GKO’s EPA licence.

2.2 Site Energy Consumption & Energy Tariff

Table 10 - Site Energy Consumption for the 2023 Calendar Year

Energy Source	Annual Consumption (MWh)	Annual Consumption (GJ)	Annual Cost ($ excl. GST)	Average Unit Cost ($ excl. GST)	GHG Emissions (tonnes CO2-e)
Electricity	8,630	31,066	$1,406,700	$163.0/MWh	6,645
Gas	24,627	88,657	$1,372,500	$15.48/GJ	4,557
Total[7]	**33,257**	**119,725**	**$2,779,200**	**-**	**11,202**

Annual cost is calculated based on CY24 energy contracts as defined in Section 1.5.4.

2.3 Energy Balance / Sankey Diagram

A thermal energy balance has been completed and results are shown in the Sankey Diagram below. Thermal energy was focused upon as this study aims at reducing emissions from Natural Gas consumption, which is all used for generation of process heat. The thermal energy associated with the refrigeration plant is included in the Sankey Diagram as it can be used as a source of waste heat directly or with heat pumps. A thermal process baseline is detailed in Section 4 of the Study for Thermal Process Integration and Electrification, which is included as Appendix A.

[7] Values are based on billed and metered amounts.

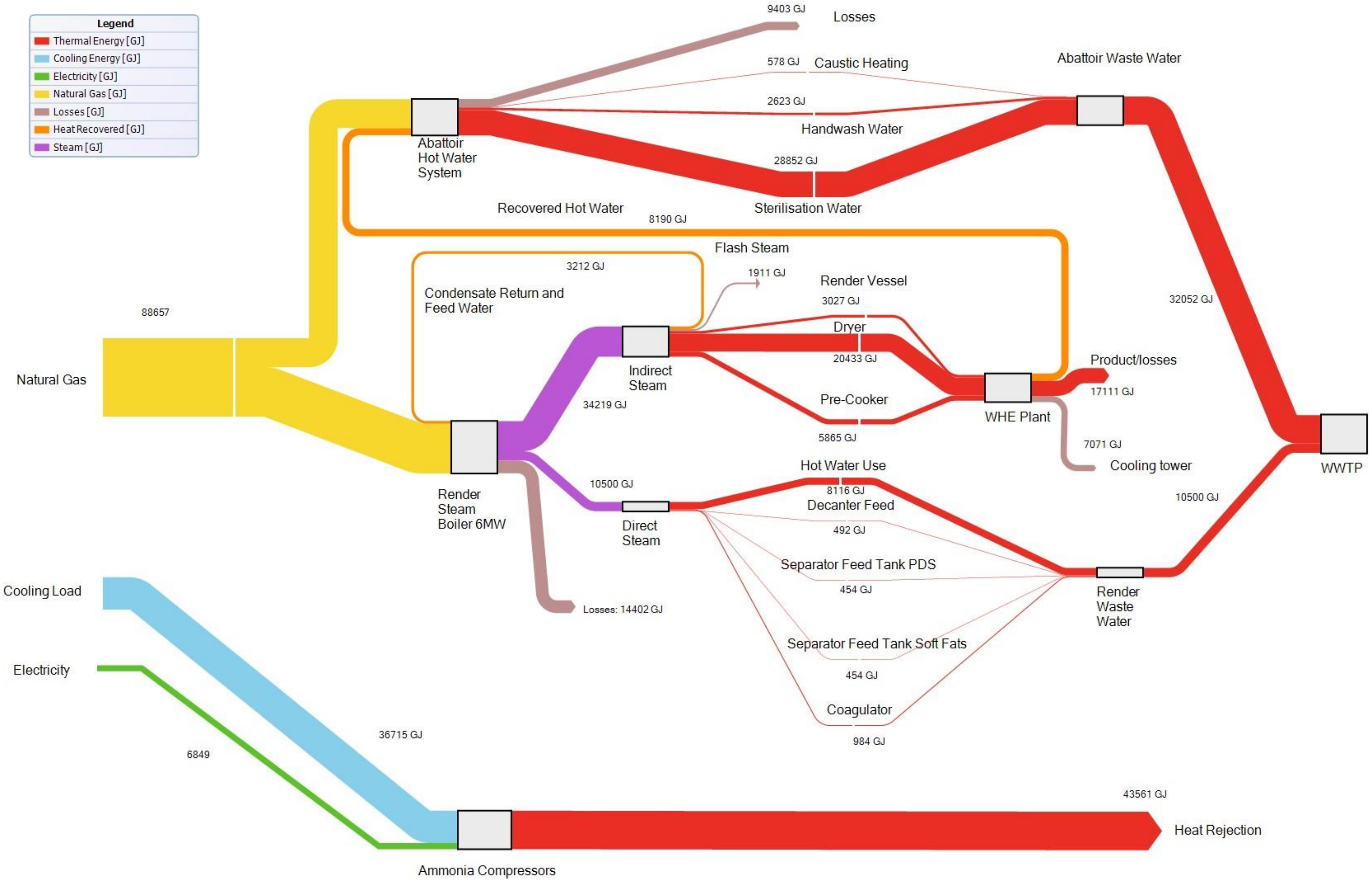


Figure 6 - Thermal Sankey Diagram showing annual energy flow (GJ) through the GKO site

2.4 Existing Energy and Thermal Flows

Quantification of heat sources and sinks, abattoir and render plant hot water demand, heat rejection from the ammonia refrigeration system cooling towers, and hot water recovery from the render plant are documented in detail in Section 3 of the Study for Thermal Process Integration and Electrification, which is included as Appendix A.

2.5 Existing Emissions Estimates

A summary of the site's estimated scope 1 and 2 carbon dioxide emissions based on the CY2023 energy use baseline is in the table below.

Table 11: Baseline emissions

Emissions	Amount	Unit
Scope 1 - Natural Gas (tCO_2-e)	4,557	t-CO_2-e/y
Scope 2 - Electricity (t-CO_2-e)	6,645	t-CO_2-e/y
Scope 1 & 2 Total Emissions	11,202	t-CO_2-e/y

Notes:

- Total Energy derived from 1/1/2023 to 31/12/2023 data.
- Natural gas scope 1 emissions factor = 51.53 kg CO_2-e/GJ (from the Australian National Greenhouse Accounts Factors 2023)

Electricity scope 2 emissions factor = 0.77 kg CO_2-e/kWh (from the Australian National Greenhouse Accounts Factors 2023)

2.6 Current Planned Projects

2.6.1 Current Planned Projects

- New frozen storage facility/plate freezer

2.6.2 Other capital works underway or planned

- Boning room replacement switch board
- Render Plant 6MW Boiler replacement
- Render plant cooling tower replacement
- Carton store
- Upgrades to wastewater infrastructure

2.6.3 Recently completed capital works (Rendering plant)

- Dryer replacement
- Render plant upgrades to both the soft fats plant and main line to increase processing capacity
- Heat recovery from Vacuum Condenser and heat recovery t heat hot water used for processing operations in the main plant
- PLC upgrade
- Additional separator in PDS
- Chiller 6
- Refrigeration floating head controls

3. Metering and Monitoring Installed to Inform the Study

3.1 Baseline key performance indicators (water, energy, emissions)

Table 12 - Baseline KPIs

Description	Value	Unit
Electricity consumption	163	kWh/T HSCW
Natural gas consumption	1,675	MJ/T HSCW
Total energy consumption	2.262	MJ/T HSCW
Gas + electricity emissions	212	kg CO_2-e /T HSCW
Water use	6.1	T/T HSCW

3.2 Summary of installed metering

GKO has recently installed a metering and monitoring program on site. This delivery of this program completed Milestone 1 of this Study and provided the necessary data to inform the findings set out in the technical studies underpinning this final report.

GKO's metering network comprises 69 new and existing instruments on site, which meter and monitor electricity, natural gas, steam, hot water, town water, refrigeration, product and wastewater.

Readings are collected and stored in a central historian, which is accessible by an energy monitoring system.

The resulting combination of sub-metering and integrated software monitoring system provides GKO with a vastly improved picture of energy use on site, enabling the tracking of Energy Performance Indicators (EnPIs) and Key Performance Indicators (KPIs) on a site and system level, as well as a dynamic energy breakdown for various utilities, automatic reporting, and alarming for the notification and addressing of utility use irregularities.

The next steps are to implement an energy management system on site enabling the incorporation of this data into company procedures, tracking of progress towards company objectives, and supporting this progress directly via increased visibility of site and system performance.

3.3 Recommendations for future metering

3.3.1 Water metering

Currently water metering on site measures water flow to the following in the main plant (abattoir and boning room):

- Cold water plant use
- Water to hot water tanks
- Sterilisation water supply and return
- Hand wash water flow
- Hot water to caustic system

In the render plant the following flows are measured:

- Cold water plant use
- Hot water plant use
- Boiler top-up water

Current wastewater metering measures flow from the main plant (abattoir and boning room), wastewater from the render plant as a whole, flows in parts of the DAF and outgoing flow from the site.

Further water metering will enable detailed understanding of other locations and activities that consume water across the site. For example, in future, further metering could be installed to enable visibility of water usage in relation to specific infrastructure such as the existing sterilisers in the main plant in order to provide comparison for projects such as the Econoliser knife sterilising installations in the abattoir and boning room (a significant potential water saving initiative).

3.3.2 Wastewater metering

Currently wastewater flowmeters exist for the abattoir and rendering plant as a whole.
Further meters for wastewater volume and composition will enable GKO to identify individual processes which generate significant waste (volume and yield).

Should GKO proceed with Econoliser installations, additional wastewater meters could also be used to determine the impact of Econolisers on the wastewater plant, especially in respect to volume and wastewater temperature impacts.

3.3.3 Submetering for steam

The render plant designers have advised theoretical steam demands for most parts of the process. Measurement of total steam supplied to the rendering plant has been installed as part of the metering and monitoring system. Individual steam user metering would identify the consumption of specific items of plant, which will assist in uncovering additional energy saving opportunities. Individual user monitoring may also assist with identifying potential for load shifting, which may enable the steam boiler size to be reduced once it is due for replacement.

3.3.4 Visibility across the abattoir for electricity

The main plant (abattoir + boning room) and rendering plant have power metering that summarise total consumption. Sub metering has been implemented in the rendering plant, and the refrigeration plant.

Further sub-metering of process areas within each plant will have provide the opportunity to apply energy performance indicators (EnPIs) to each process area, thereby enabling the measurement of improvements in those areas.

Further sub-metering of large users within a process may allow equipment to be identified that could participate in site demand response initiatives or ensure that high-value users operate efficiently.

4. Integrated Scenarios using combination of studies

4.1 Methodology (Multi-criteria decision matrix and Value-Ease assessment)

A multi-criteria decision matrix (MCDM) is a decision-making tool used to evaluate and prioritise alternatives based on multiple criteria or factors. It's commonly employed in situations where there are several competing options and various factors need to be considered simultaneously to make an informed decision.

MCDM helps to structure complex decision problems and provides a systematic approach for evaluating alternatives.

The basic outline of the MCDM is as follows:

Identify Criteria: Determine the factors or criteria that are relevant to the decision-making process. These criteria should be measurable and relevant to the objectives of the decision.

Weighting Criteria: Assign weights to each criterion based on their relative importance. These weights reflect the significance of each criterion in relation to the overall decision.

Define Alternatives: Identify the different options or alternatives available for consideration.

Score Alternatives: Evaluate each alternative against each criterion and assign scores based on how well they fulfill each criterion. This can be done using qualitative or quantitative methods, depending on the nature of the criteria and available data.

Calculate Total Scores: Multiply the scores of each alternative by the corresponding weights of the criteria and sum them up to obtain a total score for each alternative.

Rank Alternatives: Rank the alternatives based on their total scores. The alternative with the highest total score is considered the most preferable option.

The Value-Ease assessment methodology is used in decision-making to focus on balancing value and ease of implementation. It involves evaluating alternatives based not only on their potential benefits but also on the feasibility and practicality of implementing them. This methodology acknowledges that even the most beneficial options may not be viable if they are too difficult or costly to implement.

Combining MCDM with the Value-Ease assessment methodology involves integrating considerations of both value (benefits, advantages) and ease (feasibility, implementation) into the decision-making process. This ensures that decisions are not only based on the potential outcomes but also take into account the resources, time, and effort required to achieve those outcomes.

In practice, this may involve adjusting the criteria used in the MCDM to include factors related to ease of implementation, such as cost, resource requirements, technical complexity, and time constraints. By considering both value and ease, decision-makers can make more balanced and informed choices that are both effective and feasible.

4.2 Summary of Technology Options

The following technologies are considered in the four decarbonisation strategies presented in the next section of the report.

- Heat pumps to produce hot water
- Waste heat recovery using desuperheaters and simple heat exchangers
- On site wastewater CAL treatment to produce biogas, upgrade the biogas by conditioning to reduce moisture and H_2S content and burn it in the existing steam boiler to produce steam. (known as a Covered Anaerobic Lagoon or CAL)
- On site (behind the meter) rooftop and single axis tracking (ground mount) Solar PV systems to generate electricity
- Thermal energy storage systems, that input electricity and output steam
- Electric boilers to generate steam for the rendering plant
- Hot water tanks to store sterilisation, washdown or handwash water, acting as thermal energy storage.

The complete list of projects is detailed below, which have been drawn from the reports referenced in Appendices A, B and C. Also detailed here are the technology category and shortened name for use in the tables and graphs in the following sections.

Note that there are multiple solar system projects, as each of these is sized differently for each scenario.

Table 13 - Project List

Technology Category	Short Name	Project Name
Solar	9.7 MW Solar	9.7 MW Solar (900 kW rooftop + 8.8 MW ground mount single axis tracking)
Solar	4.4 MW Solar	4.4 MW Solar (900 kW rooftop + 3.5 MW SAT)
Solar	4.5 MW Solar	4.5 MW Solar (900 kW rooftop + 3.6 MW SAT)
Solar	8.8 MW Solar	8.8 MW Solar (900 kW rooftop and 7.9 MW ground-mount)
Solar	Hot Water Storage	368 kL 90°C water storage tank to shift heat pump consumption
Biogas	CAL SW100	19 ML Covered Anaerobic Lagoon (all stickwater to drain option - SW100) capable of producing 18,900 m^3 of conditioned biogas per week.
Biogas	CAL SW30	12.5 ML Covered Anaerobic Lagoon (30% stickwater to drain option - SW30) capable of producing 10,700 m^3 of conditioned biogas per week.
Energy Efficiency	WHE heat recovery	Pre-Heat Abattoir Water Using Second Waste Heat Evaporator Heat Source
Energy Efficiency	Econolisers	Replace sterilisers with econolisers and hand wash heat pump (75°C)
Energy Efficiency	Air Comp HR	Heat recovery from 110 kW Air compressor
Energy Efficiency	Condensate Return HR	Use Condensate Return Flash steam to heat hot water from 55 to 90°C
Energy Efficiency	EE Design	Implementation of energy efficiency projects identified in "Design Review – Frozen Storage-Plate Freezer and Render Plant Upgrades" report and other future energy efficiency opportunities.
Heat Pumps	Ammonia HP Abattoir	Ammonia heat pump to provide 90°C water with storage ($95m^3$) to generate abattoir sterilisation and hand wash water
Heat Pumps	CO2 HP Render	CO_2 heat pump for render hot water
Heat Pumps	Ammonia HP (R+A)	Ammonia heat pump to provide 90°C water with storage ($315m^3$) to generate both abattoir and render hot water
Electrification	Electric Boilers	2 x 2.5 MVA Electric Boilers (1 x Rendering, 1 x Main Plant - feeding Rendering)
Other	Biomass Boiler	Biomass boiler for remaining steam demand
Other	TES w/ Spot Exposure	28 MWh thermal energy storage system exposed to the spot market on a child or separate NMI

Other	Offsite Renewables/Spot Exposure	Purchase of offsite renewable energy to get to 100% renewable electricity/spot exposure

The full project list detailing capital cost, cost savings, simple paybacks with and without certificates, certificate value, carbon emissions savings, implementation timeframe and electricity and gas savings is included in Appendix F.

4.2.1 Technologies Excluded

Below is a list of technologies which were considered but not included as projects, along with reasons for their exclusion:

Table 14 - Technologies Excluded

Technology	Reason for Exclusion
Battery Energy Storage Systems (BESS) to optimise on site renewable energy generation, reduce behind the meter energy costs and generate front of meter revenue.	BESS systems used for optimising on site renewable consumption were uneconomic. Storage of heat is of greater use than storage of electricity, so heat storage was prioritised.
Combined Heat & Power (CHP) plant that input biogas or gas/biogas blend and output electricity and steam/hot water.	Concerns about the economics and maintenance costs associated with co-generation.
High Temperature Heat Pump (HTHP) and/or Mechanical Vapour Recompression of Contact Dryer exhaust to produce steam	Budget pricing found to be higher (exceeding $10M capex), payback longer, and operational cost higher than thermal storage concept.
High Temperature Heat Pump (HTHP) to produce steam using waste heat sources	Technology found not to be commercially available at time of enquiries.

4.2.2 Interaction Between Projects

There were instances where two potential projects make use of the same natural gas saving. For example the energy efficiency project recovering waste heat from flash steam (Condensate Return HR) would reduce the natural gas demand in the render plant, as would implementing a heat pump to generate hot water for the render plant (CO_2 HP Render).

The value-ease approach described in Section 4.1 was applied to the interacting projects to select the projects to be implemented first. In all but one case the projects in the Energy Efficiency category were selected preferentially as they have more appealing ROI. The size of the heat pumps for each scenario was then reduced to match the natural gas quantity remaining to be saved. This can be seen in the complete projects table in Appendix F.

There is one exception to the above approach. The air compressor heat recovery project (Air Comp HR) would not be able to be implemented in the Efficiency Led scenario should the other heat recovery projects be implemented as the other projects will deliver hot water at higher temperatures than this project would. Therefore, this project was excluded from this scenario.

4.3 Options (Integrated Scenarios)

4.3.1 Overview of Scenarios

4.3.1.1 Solar Led

Solar led decarbonisation strategy is focused on the use of solar PV, electric boilers utilising excess solar generation to offset as much electricity and gas consumption as possible, and seeks to use available land and roof space on site to maximise solar generation thereby minimising or eliminating scope 1 and 2 emissions.

4.3.1.2 Biogas Led

It is estimated that CALs are capable of producing about 17,800 m^3 STP of biogas per week (SW100 – all stickwater to drain) which translates to ≈ 18,200 GJ per annum. This is sufficient to offset up to one-fifth of natural gas consumption on site for steam generation while improving treatment of the facility's wastewater. The biogas led decarbonisation strategy will minimise scope 1 emissions from the combustion of natural gas.

4.3.1.3 Efficiency Led

Energy efficiency led decarbonisation strategy will be focused on achieving emissions reduction through the use of cost effective and energy efficient technologies. Included are the energy efficiency projects with the best payback plus a biomass boiler. These are discussed in Northmore Gordon's Study for Thermal Process Integration, Electrification attached as Appendix A.

4.3.1.4 Full Electrification

Full electrification decarbonisation strategy relies on replacement of all natural gas consuming equipment with electric alternatives, on site energy storage and the procurement of renewable energy or onsite generation to match the site electrical load, including the increased consumption due to newly electrified loads. It assumes that no biogas is utilised.

4.3.2 Solar led

The following projects are included in the solar led decarbonisation options:

Table 15 - Projects in the Solar Led Scenario

Technology Category	Short Name	Solar Led
Solar	9.7 MW Solar	Y
Solar	4.4 MW Solar	
Solar	4.5 MW Solar	
Solar	8.8 MW Solar	
Solar	Hot Water Storage	Y
Biogas	CAL SW100	
Biogas	CAL SW30	Y
Energy Efficiency	WHE heat recovery	Y
Energy Efficiency	Econolisers	
Energy Efficiency	Air Comp HR	
Energy Efficiency	Condensate Return HR	Y

Energy Efficiency	EE Design	
Heat Pumps	Ammonia HP Abattoir	Y
Heat Pumps	CO2 HP Render	Y
Heat Pumps	Ammonia HP (R+A)	
Electrification	Electric Boilers	Y
Other	Biomass Boiler	
Other	TES w/ Spot Exposure	
Other	Offsite Renewables/Spot Exposure	

These projects are described below.

4.3.2.1 Solar: 9.7 MW Solar PV (900 kW rooftop and 8.8 MW single axis tracking ground mount solar)

The project involves installing 9.7 MW of solar, connected behind the meter and reducing electricity consumption at the NMI level,across the Main Pant, Rendering Plant & proposed Cold Store as follows:

- Main Plant: 3.0 MW of ground mounted single axis tracking solar installed in the northern portion of the site.

- Rendering Plant: 3.35 MW of solar, consisting of 300 kW of rooftop solar on the rendering plant and carton store, and 3.05 MW of ground mounted single axis tracking solar installed in the northern portion of the site.

- Proposed Cold Store: 3.35 MW of solar, consisting of 600 kW of rooftop solar on the cold store, and 2.75 MW of ground mounted single axis tracking solar installed in the northern portion of the site.

4.3.2.2 Thermal Storage: Large 90°C water with storage tank to shift heat pump consumption

Installation of hot water (90 °C) storage tank sufficient to store at least 368kL. This tank would be used to store hot water produced by the ammonia heat pump, for use in sterilisation and cleaning water. The tank should be insulated to minimise heat loss. The tank volume is optimised for the ammonia hot water heat pump to utilise predominantly excess solar generation.

4.3.2.3 Biogas: 12.5 ML Covered Anaerobic Lagoon (Scenario SW30)

Construct a single 12.5ML working volume CAL on-site with provision to generate 10,100 m^3 STP of biogas per week at 70% methane content.

This is sufficient to displace 10,300 GJ/year of fossil natural gas as fuel to the steam boiler. This option (SW30) assumes utilisation of the existing Waste Heat Evaporator (WHE) in the render plant to divert 70% of the stickwater from the soft fats and prime tallow render processes to dried meat meal reducing stickwater discharge to the WWTP.

Treatment of wastewater by an un-dosed primary Dissolved Air Flotation (DAF) device, the CAL and a downstream Biological Nutrient Removal (BNR) plant delivers the design effluent specification for this option.

The biogas would be conditioned using AWITE desulphurisation technology to reduce moisture and corrosive H_2S.

The existing 6MW Maxitherm steam boiler is near end-of-life and would need replacement with a new boiler capable of co-firing with biogas.

Refer to *Appendix C - Study for Technical and Economic feasibility of installing a Covered Anerobic Lagoon (Johns Environmental)* for more detail.

4.3.2.4 Energy Efficiency: Pre-Heat Abattoir Water Using Second Waste Heat Evaporator Heat Source

A second cooling tower stream at the WHE generates water at >50 °C. This water is used to further heat the 30-35 °C water to 48-53 °C. This option provides the lowest payback and highest energy savings of the Render heat recovery options.

Refer to *Appendix A - Study for Thermal Process Integration, Electrification (Northmore Gordon)* for detail.

4.3.2.5 Energy Efficiency: Use Condensate Return Flash steam to heat hot water from 30 to 95°C

The vapour flashing off the condensate flow could be ducted to the shell side of a shell and tube condenser and energy could be transferred from the vapour to the water on the tube side to heat it to 85 - 90 °C. The pre-heated water from the heat recovery system (at 30°C) could be fed to the condenser.

4.3.2.6 Heat Pump: Ammonia heat pump to provide 90°C water with storage (95m^3) to generate abattoir sterilisation and hand wash water

Replace the existing Presha hot water boilers with a 90°C muti-stage ammonia heat pump, connected as an additional stage to the existing system. Install a 95m^3 buffer tank to enable the waste heat from the refrigeration system to be stored.

Refer to *Appendix A - Study for Thermal Process Integration, Electrification (Northmore Gordon)* for detail.

4.3.2.7 Heat Pump: CO_2 heat pump to generate hot water for the rendering plant

This option considers a standalone CO_2 heat pump for the Render Plant hot water demand. There is the option of using the cooling tower waste source as a heat source for a heat pump, however the 90°C temperature is prohibitive for most commercially available heat pumps. The temperature differential of 15-90°C enables CO_2 to operate at a greater efficiency, due its unique thermodynamic properties as a transcritical gas at higher pressures (100-150 bar). Heat transfer occurs across a temperature glide in the gas cooler component, rather than through condensing to a liquid like most refrigerants.
The following is considered in this electrification option:

- A simple installation using the existing Render Hot Water tank and cutting in prior to the steam connection
- CO_2 heat pumps as one option as they are suitable for a single-shot application such as this (rather than a ring main operating on a temperature differential), achieving greater efficiency

A number of these units are required to make up the ~700kWth required to meet the Render hot water demand. There are size limitations for this technology and multiple small units are used (maximum size is currently around 60-80kWth). This example is based on Automatic Heating (12 x CHE-080Y) which is a commonly used model, albeit relatively expensive.

4.3.2.8 5.0 MVA Electric Steam Boilers

Installation of two 2.5 MVA electric steam boilers, connected to the Main Plant and Rendering Plant. The boilers will utilise excess solar generation that would otherwise be curtailed or exported to supply steam to the rendering plant. Note that the natural gas steam boiler is retained for backup, and for times when it is financially beneficial to operate over the electric boilers.

Refer to *Appendix A - Study for Thermal Process Integration, Electrification (Northmore Gordon)* for detail.

4.3.3 Biogas led

The following additional projects are included in this scenario:

Table 16 - Projects in the Biogas Led Scenario

Technology Category	Short Name	Biogas Led
Solar	9.7 MW Solar	
Solar	4.4 MW Solar	Y
Solar	4.5 MW Solar	
Solar	8.8 MW Solar	
Solar	Hot Water Storage	
Biogas	CAL SW100	Y
Biogas	CAL SW30	
Energy Efficiency	WHE heat recovery	
Energy Efficiency	Econolisers	
Energy Efficiency	Air Comp HR	Y
Energy Efficiency	Condensate Return HR	
Energy Efficiency	EE Design	
Heat Pumps	Ammonia HP Abattoir	Y
Heat Pumps	CO_2 HP Render	Y
Heat Pumps	Ammonia HP (R+A)	
Electrification	Electric Boilers	
Other	Biomass Boiler	
Other	TES w/ Spot Exposure	
Other	Offsite Renewables/Spot Exposure	

These projects are described below.

4.3.3.1 Solar: 4.4 MW Solar (900 kW rooftop and 3.5 MW single axis tracking ground-mount solar)

The project involves installing 4.4 MW of solar across Rendering Plant & Cold Store NMIs, as follows:

- Rendering Plant: 1.8 MW of solar, consisting of 300 kW of rooftop solar on the rendering plant and carton store, and 1.5 MW of ground mounted single axis tracking solar installed in the northern portion of the site.
- Cold Store: 2.6 MW of solar, consisting of 600 kW of rooftop solar on the cold store, and 2.0 MW of ground mounted single axis tracking solar installed in the northern portion of the site.

4.3.3.2 Biogas: 19 ML Covered Anaerobic Lagoon (CAL) with all stickwater to drain (Scenario SW100)

Construct a single 19ML working volume CAL on-site with provision to generate 17,800 m^3 STP of biogas per week at 70% methane content. This is sufficient to displace 18,200 GJ/year of fossil natural gas as fuel to the steam boiler. This option (SW100) includes allowing all stickwater to continue to be discharged to the wastewater treatment plant (WWTP) and receive treatment by an un-dosed primary Dissolved Air Flotation (DAF) device, the CAL and a downstream Biological Nutrient Removal (BNR) plant.

The biogas would be conditioned using AWITE desulphurisation technology and chilling to reduce moisture and corrosive H_2S. The existing 6MW Maxitherm steam boiler is near end-of-life and would need replacement with a new boiler capable of co-firing with biogas.

Refer to *Appendix C - Study for Technical and Economic feasibility of installing a Covered Anerobic Lagoon (Johns Environmental)* for more detail.

4.3.3.3 Energy Efficiency: Pre-Heat Abattoir Water Using Second Waste Heat Evaporator Heat Source

Refer to Section 4.3.2 for description.

4.3.3.4 Energy Efficiency: Use Condensate Return Flash steam to heat hot water from 30 to 95C

Refer to Section 4.3.2 for description.

4.3.3.5 Heat Pump: Ammonia heat pump to provide 90°C water with storage (95m3) to generate abattoir sterilisation and hand wash water

This option considers the installation of an Ammonia Heat pump (up to 2 x 300 kWe, ~3,000kWth) after the high stage compressor of the ammonia refrigeration system to produce ≈ 90°C hot water using 15°C Town water, using a cascade system, without any change to the steriliser process. Install a 95m^3 buffer tank to enable the waste heat from the refrigeration system to be stored.

4.3.3.6 Heat Pump: CO_2 heat pump to generate hot water for the rendering plant

Refer to Section 4.3.2 for description.

4.3.3.7 Heat Pump & Energy Efficiency: Replace sterilisers with econolisers and hand wash heat pump (75ºC)

Replace the existing water sterilisation units with econolisers which generate hot water on demand using a heating element.
Supply the econolisers with water discharged from cascade ammonia heat pump at 70 °C and the econolisers will heat electrically up to 90 °C. The 70°C water line will circulate on a ring main and will only be boosted as needed. 75°C is also possible at a lower efficiency if 70°C is insufficient for hose up.
Refer to *Appendix A - Study for Thermal Process Integration, Electrification (Northmore Gordon)* for detail.

4.3.3.8 Energy Efficiency: Heat recovery from 110 kW Air compressor

Retrofit the 110kW air compressor with a heat recovery unit which can be used to preheat the makeup water going into the sterilisation water tank. A heat recovery retrofit option is available from the air compressor supplier.

Refer to *Appendix A - Study for Thermal Process Integration, Electrification (Northmore Gordon)* for detail.

4.3.4 Energy efficiency led

The following projects are included in this scenario and are described in Sections 4.3.2 and 4.3.3:

- Pre-Heat Abattoir Water Using Second Waste Heat Evaporator Heat Source
- Use Condensate Return Flash steam to heat hot water from 30 to 95ºC

The following additional projects are included in this scenario:

Table 17 - Projects in the Efficiency Led Scenario

Technology Category	Short Name	Efficiency Led
Solar	9.7 MW Solar	
Solar	4.4 MW Solar	
Solar	4.5 MW Solar	Y
Solar	8.8 MW Solar	
Solar	Hot Water Storage	
Biogas	CAL SW100	
Biogas	CAL SW30	

Energy Efficiency	WHE heat recovery	Y
Energy Efficiency	Econolisers	Y
Energy Efficiency	Air Comp HR	
Energy Efficiency	Condensate Return HR	Y
Energy Efficiency	EE Design	Y
Heat Pumps	Ammonia HP Abattoir	
Heat Pumps	CO2 HP Render	
Heat Pumps	Ammonia HP (R+A)	
Electrification	Electric Boilers	
Other	Biomass Boiler	Y
Other	TES w/ Spot Exposure	
Other	Offsite Renewables/Spot Exposure	

These projects are described below.

4.3.4.1 Solar: 4.5 MW Solar (900 kW rooftop and 3.6 MW single axis tracking ground-mount solar)

The project involves installing 4.5 MW of solar across the Main Pant, Rendering Plant & Cold Store NMIs, as follows:

- Main Plant: 1.6 MW of ground mounted single axis tracking solar installed in the northern portion of the site.
- Rendering Plant: 1.3 MW of solar, consisting of 300 kW of rooftop solar on the rendering plant and carton store, and 1.0 MW of ground mounted single axis tracking solar installed in the northern portion of the site.
- Cold Store: 1.6 MW of solar, consisting of 600 kW of rooftop solar on the cold store, and 1.0 MW of ground mounted single axis tracking solar installed in the northern portion of the site.

4.3.4.2 Heat Pump: Ammonia heat pump to provide 90°C water with storage (95m3) to generate abattoir sterilisation and hand wash water

Refer to Section 4.3.2 for description.

4.3.4.3 Heat Pump: CO_2 heat pump to generate hot water for the rendering plant

Refer to Section 4.3.2 for description.

4.3.4.4 Energy Efficiency: Implementation of energy efficiency projects identified in "Design Review – Frozen Storage-Plate Freezer and Render Plant Upgrades" report and other future energy efficiency opportunities.

This report recommended the following energy efficiency projects:

1. Install a desuperheater for abattoir hot water generation - use oil cooling for glycol and recovered heat for glycol backup
2. Specify IE4 class motors for smaller Refrigeration Plant motors
3. Pre-heat 6MW boiler feed makeup water using dryer waste heat
4. Replace smaller Render Plant motors with high efficiency motors at end of life

The report also recommended the implementation of "Use condensate return flash vapour to heat pre-heat water from 55°C to 90°C", however this is already included as a separate project in this scenario.

4.3.4.5 Energy Efficiency: Heat recovery from 110 kW Air compressor

Refer to Section 4.3.3 for description.

4.3.4.6 Energy Efficiency: Pre-Heat Abattoir Water Using Second Waste Heat Evaporator Heat Source

Refer to Section 4.3.2 for description.

4.3.4.7 Energy Efficiency: Use Condensate Return Flash steam to heat hot water from 30 to 95°C

Refer to Section 4.3.2 for description.

4.3.4.8 Biomass Boiler

Thodey Engineering has provided a summary of potential options to install a biomass-fuelled boiler in place of a replacement natural gas fuelled boiler. This can be operated by a contractor and provided as 'energy as a service' without the need for G&K operators to be involved day to day. It should be noted that the capital cost allowed for is the marginal cost to upgrade from a natural gas to a biomass boiler, as the current natural gas fired steam boiler at site is nearing end of life.

4.3.5 Full electrification

The following additional projects are included in this scenario:

Table 18 - Projects in the Full Electrification Scenario

Technology Category	Short Name	Full Electrification
Solar	9.7 MW Solar	
Solar	4.4 MW Solar	
Solar	4.5 MW Solar	
Solar	8.8 MW Solar	Y
Solar	Hot Water Storage	
Biogas	CAL SW100	
Biogas	CAL SW30	
Energy Efficiency	WHE heat recovery	Y
Energy Efficiency	Econolisers	Y
Energy Efficiency	Air Comp HR	
Energy Efficiency	Condensate Return HR	Y
Energy Efficiency	EE Design	
Heat Pumps	Ammonia HP Abattoir	
Heat Pumps	CO2 HP Render	Y
Heat Pumps	Ammonia HP (R+A)	
Electrification	Electric Boilers	Y
Other	Biomass Boiler	
Other	TES w/ Spot Exposure	Y

Other	Offsite Renewables/Spot Exposure	Y

These projects are described below.

4.3.5.1 Solar: 8.8 MW Solar (900 kW rooftop and 7.9 MW single axis tracking ground-mount solar)

The project involves installing 8.8 MW of solar across the Main Pant, Rendering Plant & Cold Store NMIs, as follows:

- Main Plant: 4.0 MW of ground mounted single axis tracking solar installed in the northern portion of the site.
- Rendering Plant: 2.4 MW of solar, consisting of 300 kW of rooftop solar on the rendering plant and carton store, and 3 MW of ground mounted single axis tracking solar installed in the northern portion of the site.
- Cold Store: 2.4 MW of solar, consisting of 600 kW of rooftop solar on the cold store, and 1.8 MW of ground mounted single axis tracking solar installed in the northern portion of the site.

4.3.5.2 5.0 MVA Electric Steam Boilers

Installation of two 2.5 MVA electric steam boilers, connected to the Main Plant and Rendering Plant. The boilers will utilise excess solar generation that would otherwise be curtailed or exported to supply steam to the rendering plant.

4.3.5.3 28 MWh Thermal Energy Storage system

This project involves installing a 28 MWh thermal energy storage (TES) system connected to a new NMI at the site, and fully exposed to the spot price of electricity. The TES will charge at up to 5.5 MVA when the marginal cost of electricity (spot price plus network and environmental charges) are below the marginal cost of natural gas. The TES will discharge at up to 3.5 MVA to produce steam to supply to the rendering plant when required, offsetting the consumption of natural gas in the natural gas boilers.

4.3.5.4 Heat Pump: CO_2 heat pump to generate hot water for the rendering plant

Refer to Section 4.3.2 for description.

4.3.5.5 Heat Pump & Energy Efficiency: Replace sterilisers with econolisers and hand wash heat pump (75ºC)

Refer to Section 4.3.3 for description.

4.3.5.6 Energy Efficiency: Heat recovery from 110 kW Air compressor

Refer to Section 4.3.3 for description.

4.3.5.7 Energy Efficiency: Pre-Heat Abattoir Water Using Second Waste Heat Evaporator Heat Source

Refer to Section 4.3.2 for description.

4.3.5.8 Energy Efficiency: Use Condensate Return Flash steam to heat hot water from 30 to 95ºC

Refer to Section 4.3.2 for description.

4.3.5.9 Energy Purchasing: Purchase of offsite renewable energy to get to 100% renewable electricity/spot exposure

This project involves purchasing 100% renewable electricity from the grid through a power purchase agreement or renewable energy certificates.

4.4 Cost-Benefit including financial analysis

Energy and carbon savings as well as costs/benefits, payback and NPV are shown in the tables below.

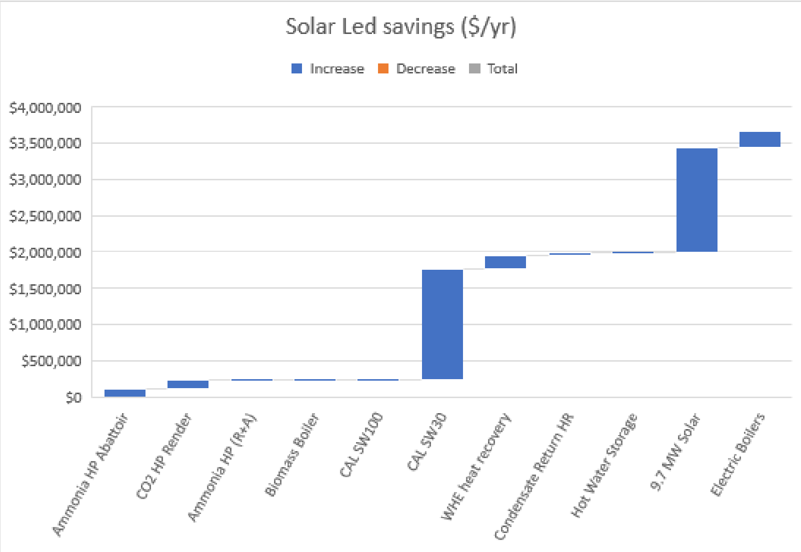
Table 19 - Energy & carbon savings

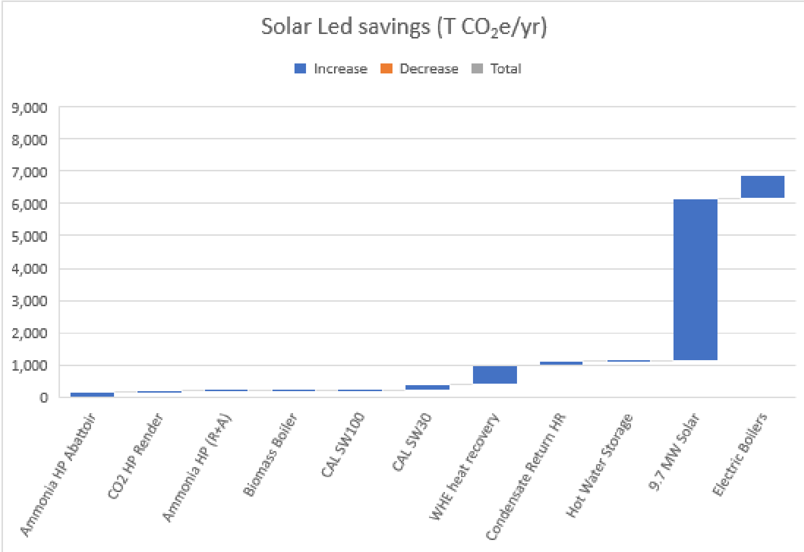
Scenario	Electricity Savings (MWh/a)	Gas Savings (GJ/a)	Carbon savings (T-CO2-e p.a.)
Solar Led	2,765	74,557	6,866
Biogas Led	2,741	68,733	4,302
Efficiency Led	4,818	88,427	7,777
Full electrification	-7,201	101,297	7,103

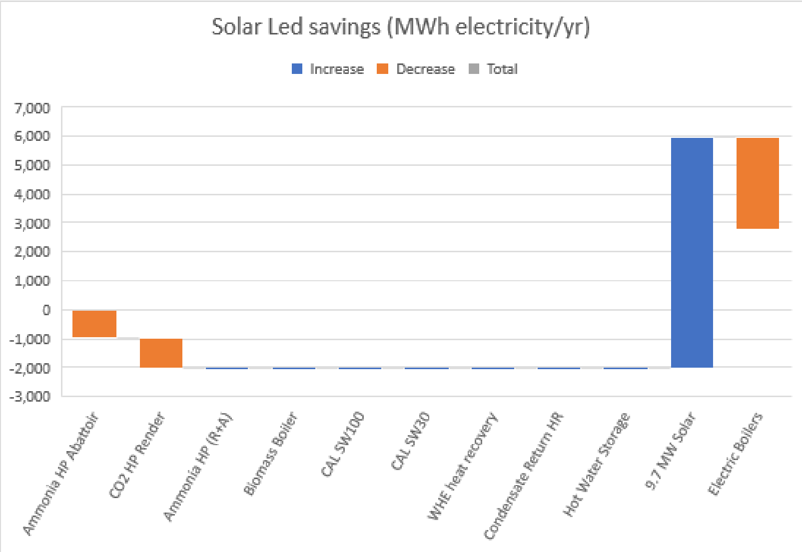
Table 20 - Costs/Benefits, payback & NPV

Scenario	Estimated project cost ($) after certificates	Cost savings ($/a)	Simple payback (years) excl. Certificates	Certificate Value ($)	Net Payback, incl certs (years)	Net Present Value ($) incl certs
Solar Led	$36,002,468	$3,660,195	9.8	$3,803,018	8.8	$15,061,424
Biogas Led	$25,275,382	$2,492,446	10.1	$2,236,788	9.2	$9,258,660
Efficiency Led	$12,334,992	$1,944,340	6.3	$3,626,117	4.5	$15,657,465
Full electrification	$29,567,756	$2,465,165	12.0	$3,498,311	10.6	$5,936,967

The charts below show the benefit contributed by each project per scenario.







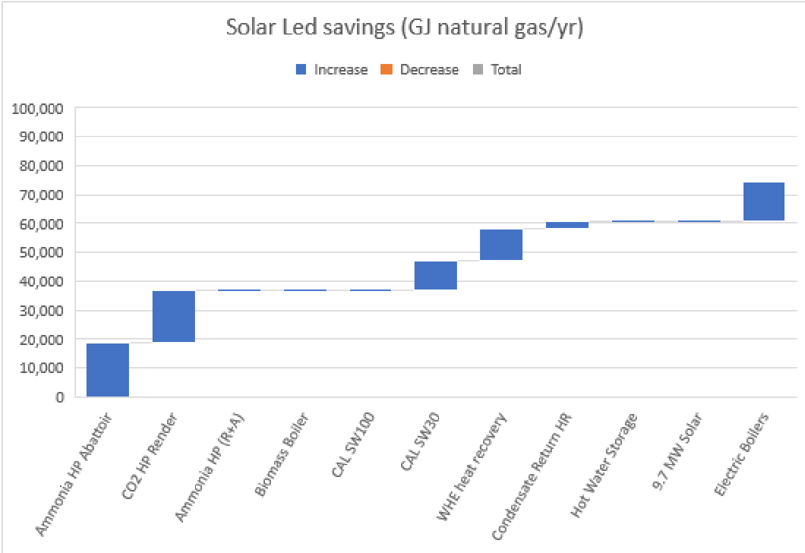
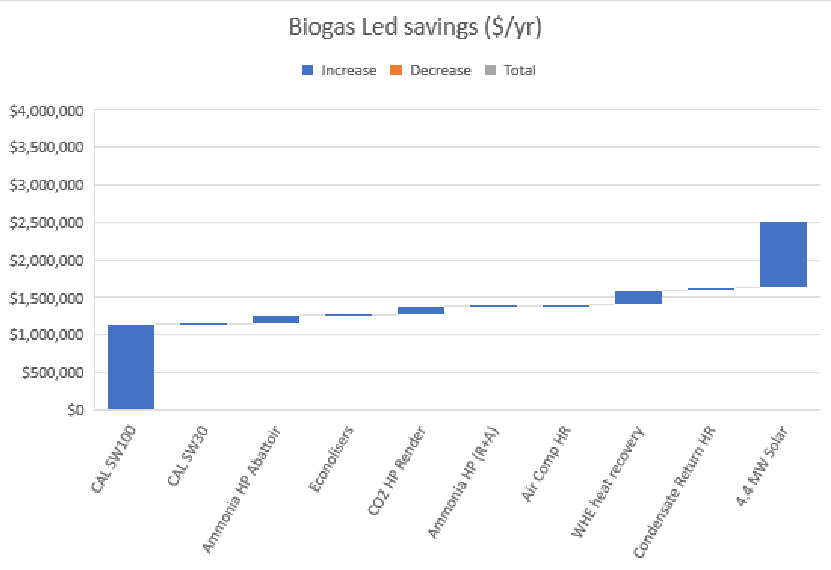
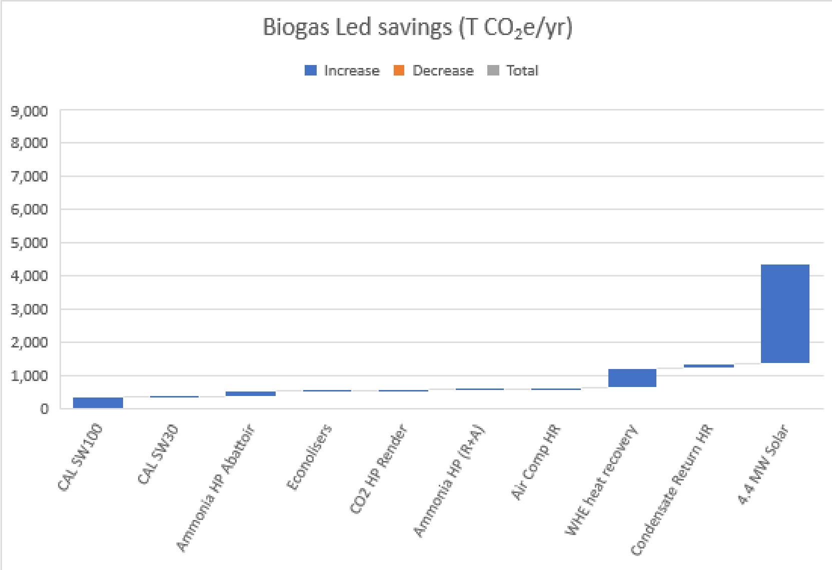
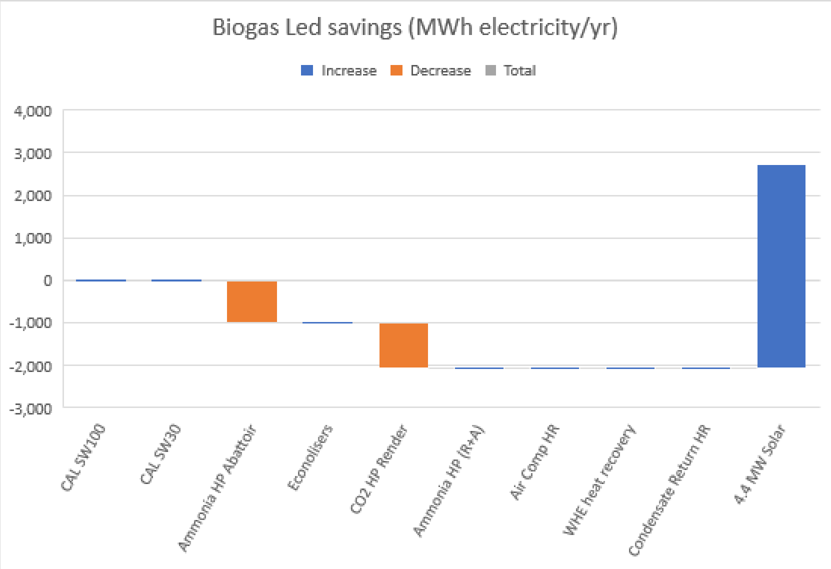


Figure 7 - Solar Led scenario savings







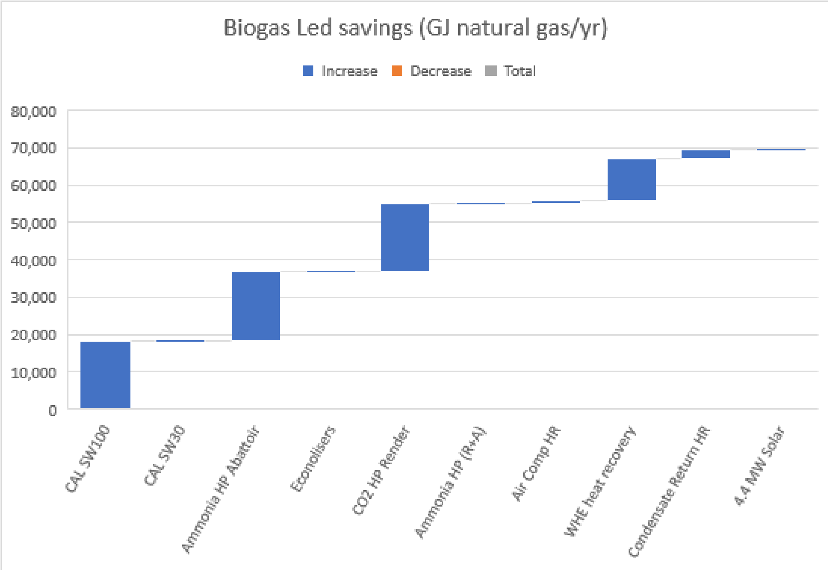


Figure 8 - Biogas Led scenario savings

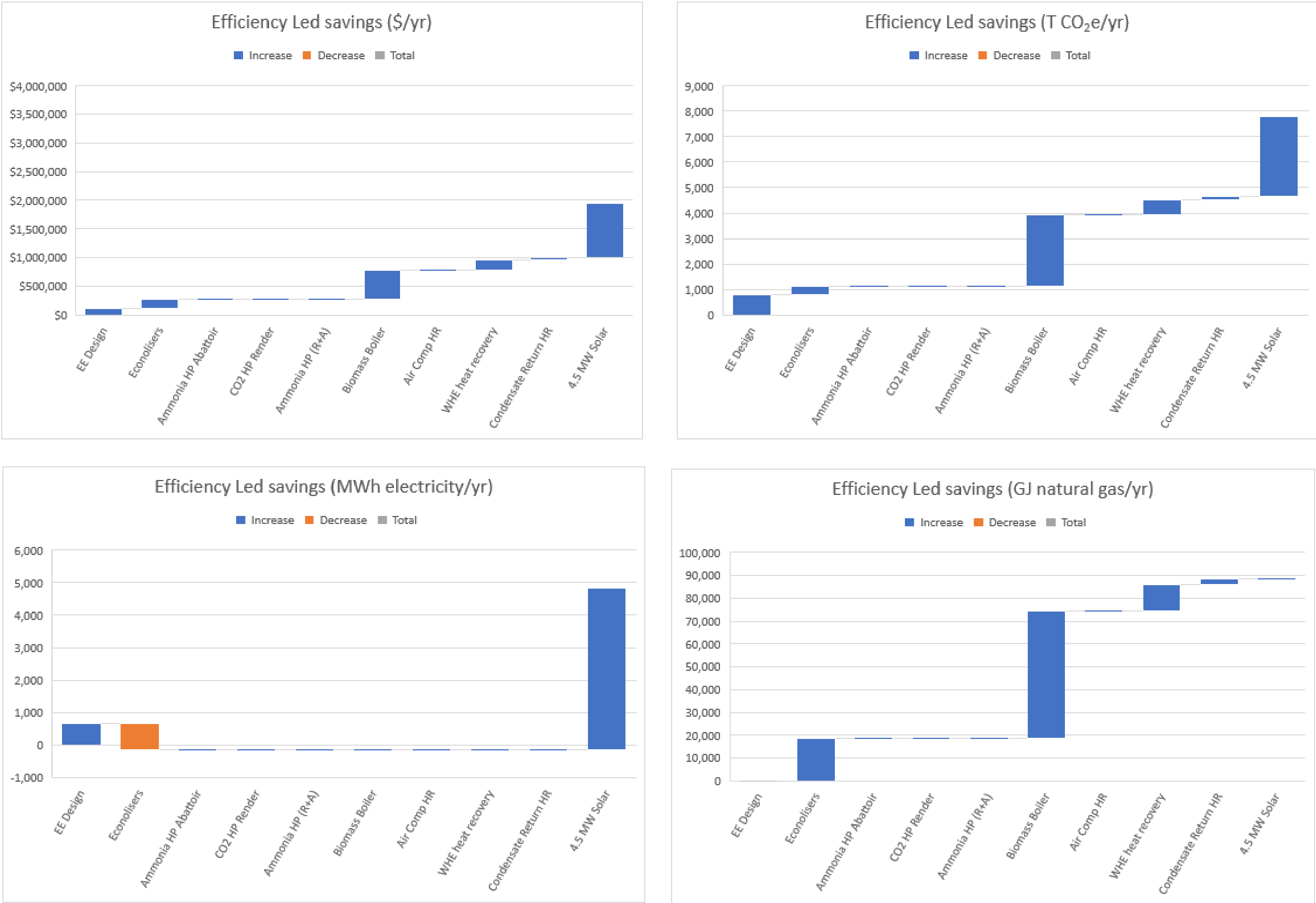


Figure 9 - Efficiency Led scenario savings

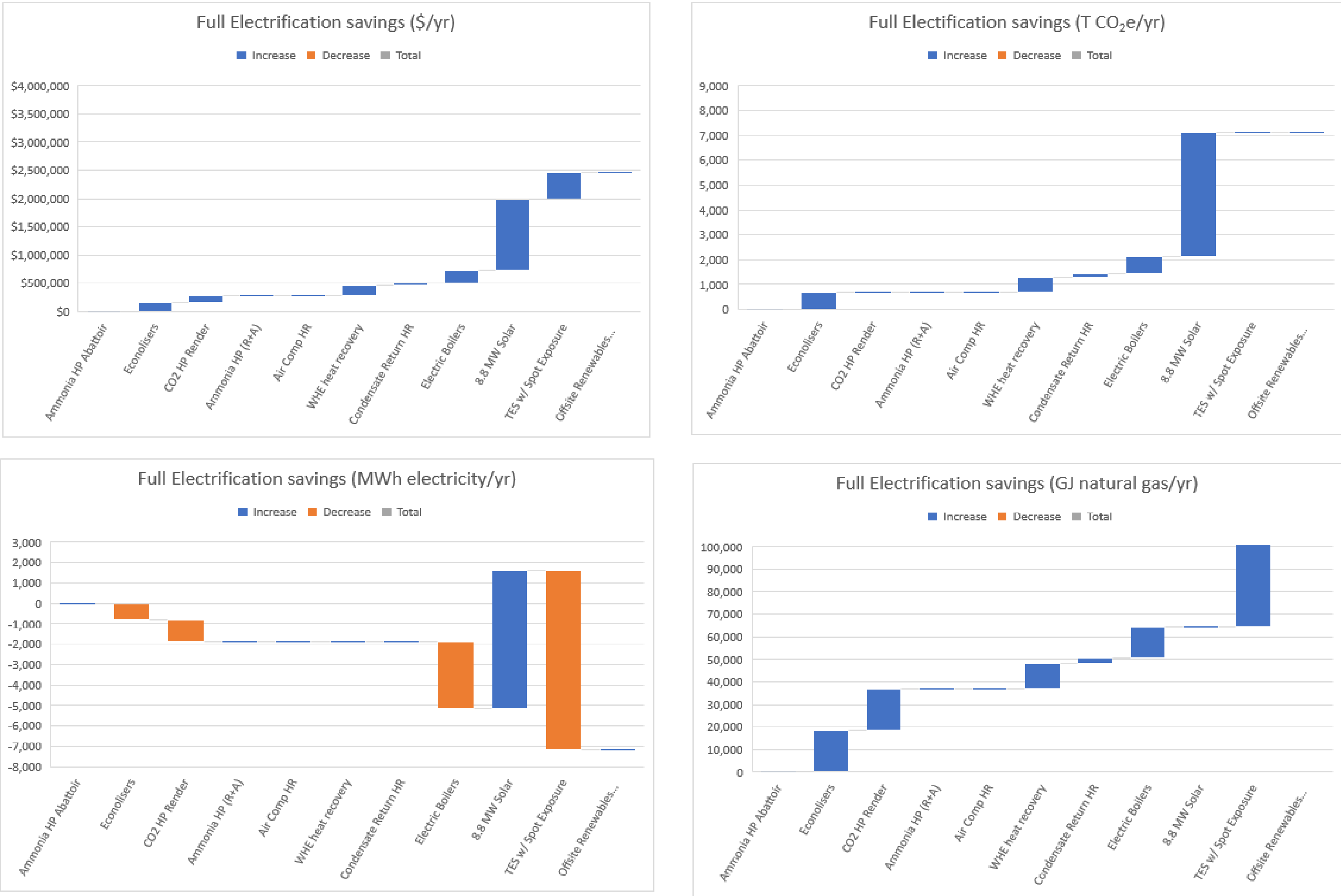


Figure 10 - Full Electrification Led scenario savings

4.5 Sensitivity Analysis (inc. energy prices, production changes)

4.5.1 Sensitivity Analysis – Production Changes

The following section includes the sensitivity analysis of production volume (annual kg HSCW) change, ranging from a decrease of 25% to an increase of 25% in production. This analysis will help us understand the impact of different production levels on key financials such as NPV[8] and Total savings from all projects in each scenario.

[8] NPV is calculated for a 20-year cash flow by considering 3% and 7% as the CPI and Discount Rate respectively.

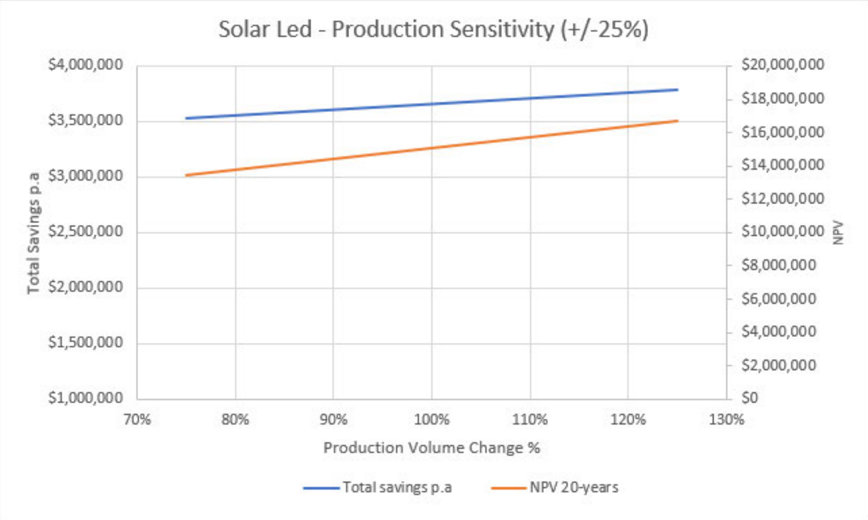


Figure 11 - Solar Led scenario - Production Sensitivity

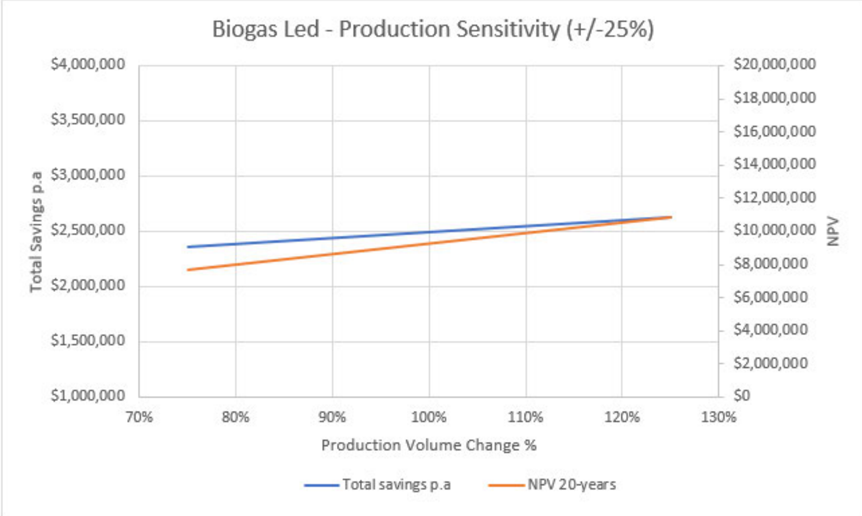


Figure 12 - Biogas Led scenario - Production Sensitivity

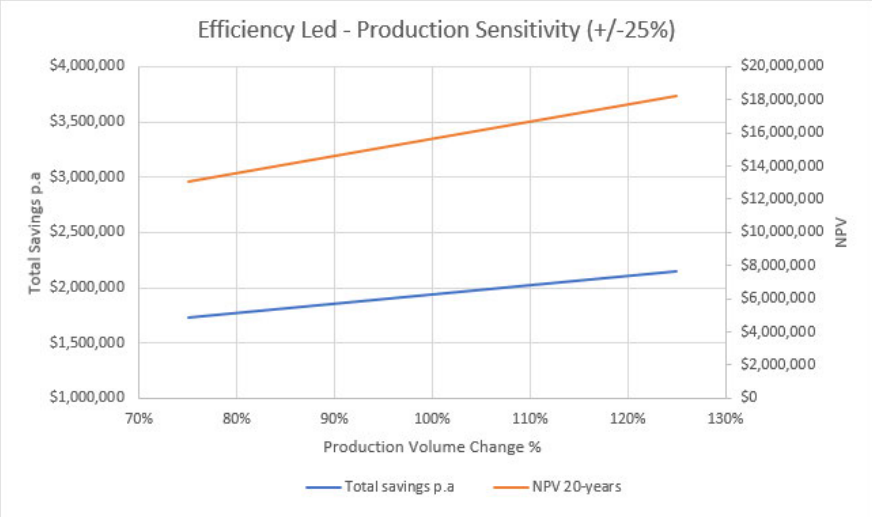


Figure 13 - Efficiency Led scenario - Production Sensitivity

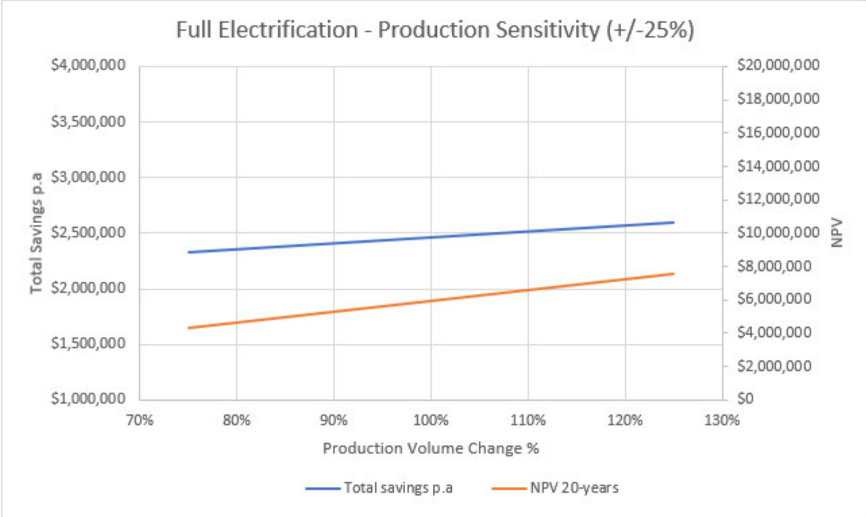


Figure 14 - Full Electrification scenario - Production Sensitivity

As shown in the graphs above, as production increases the savings value (blue lines in graphs above) from each scenario increases (as energy consumption increases as production volume increases). NPV, shown as the orange line increases linearly with production volume also. As production increases, the NPV of all scenarios improve.

The rate of increase for each curve (slope of the lines) is a significant outcome from this analysis. The rate of change for the Solar Led and Biogas Led scenarios are identical. The Full Electrification Led scenario has a slightly higher rate of change for each parameter, and the Efficiency Led scenario has nearly double the rate of change. Therefore, it can be concluded that variation in production volume has the most impact on the savings in the Efficiency Led scenario. This occurs as a greater proportion of the savings delivered by the Efficiency Led scenario projects are reductions in energy consumed as a result of production activity. Therefore, as the production volume changes, the savings vary to a greater extent than with other scenarios.

4.5.2 Sensitivity Analysis – Electricity and Natural Gas Price Changes

Below are the results of sensitivity analysis of the NPV of each scenario in relation to fluctuations in electricity and natural gas prices. Natural gas price is shown on the horizontal axis. Different electricity prices in $/MWh are shown as each coloured line. This graph can be used either to identify the impact of changing electricity and natural gas prices on NPV of a selected project or scenario, or to identify what the energy prices need to be to achieve a desired NPV. A worked example for how to use these graphs is shown in Figure X

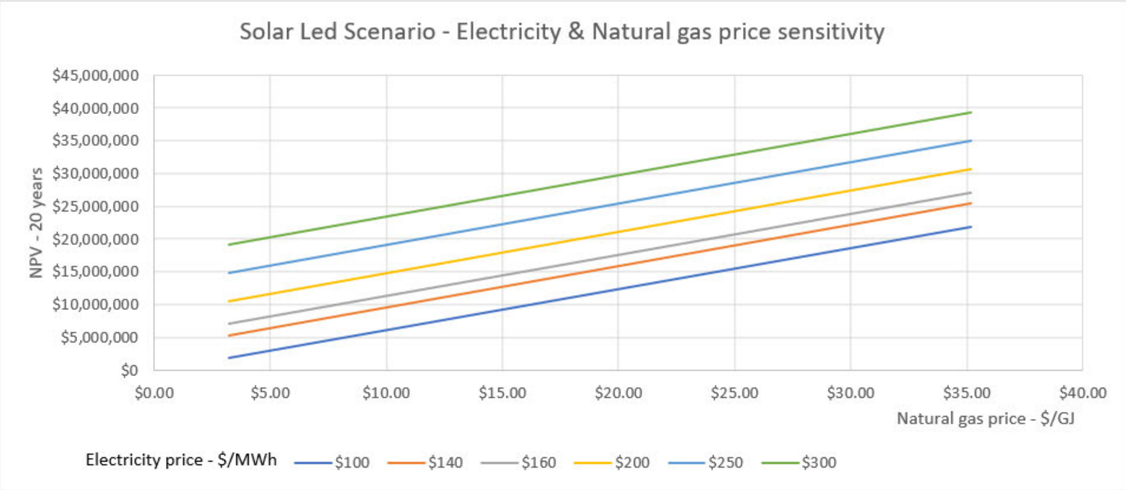


Figure 15 - Solar Led scenario - electricity & natural gas price sensitivity

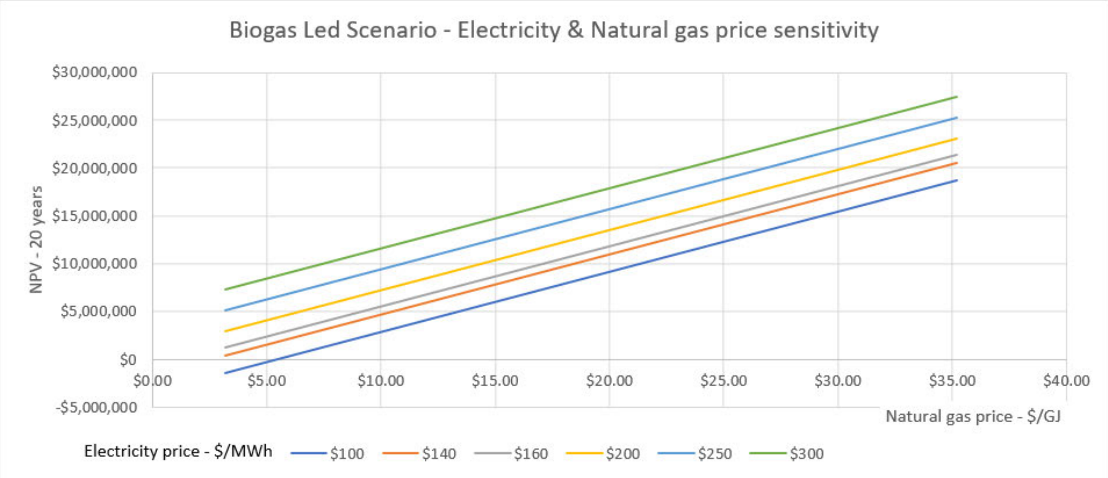


Figure 16 - Biogas Led scenario - electricity & natural gas price sensitivity

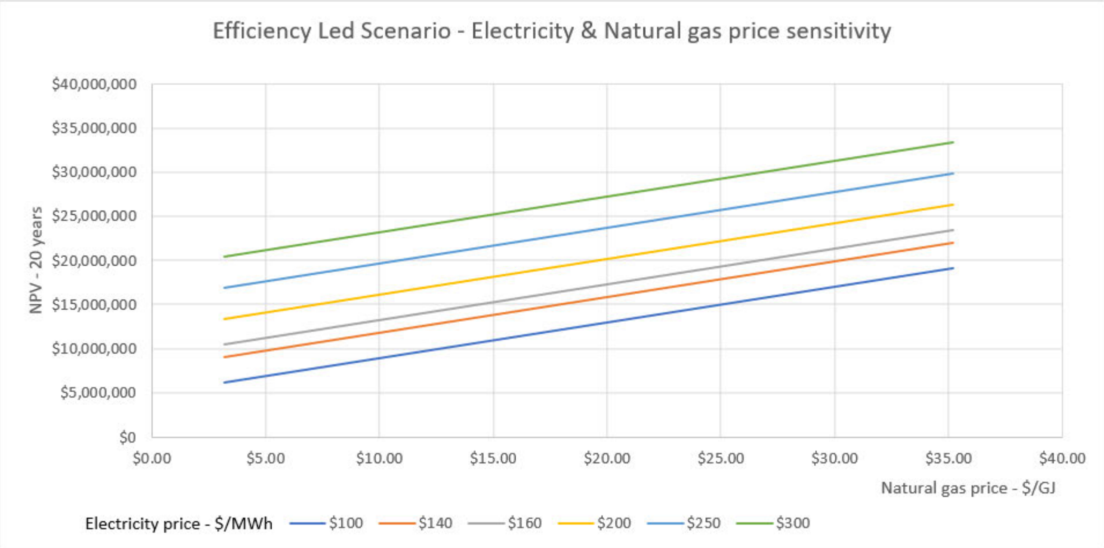


Figure 17 - Efficiency Led scenario - electricity & natural gas price sensitivity

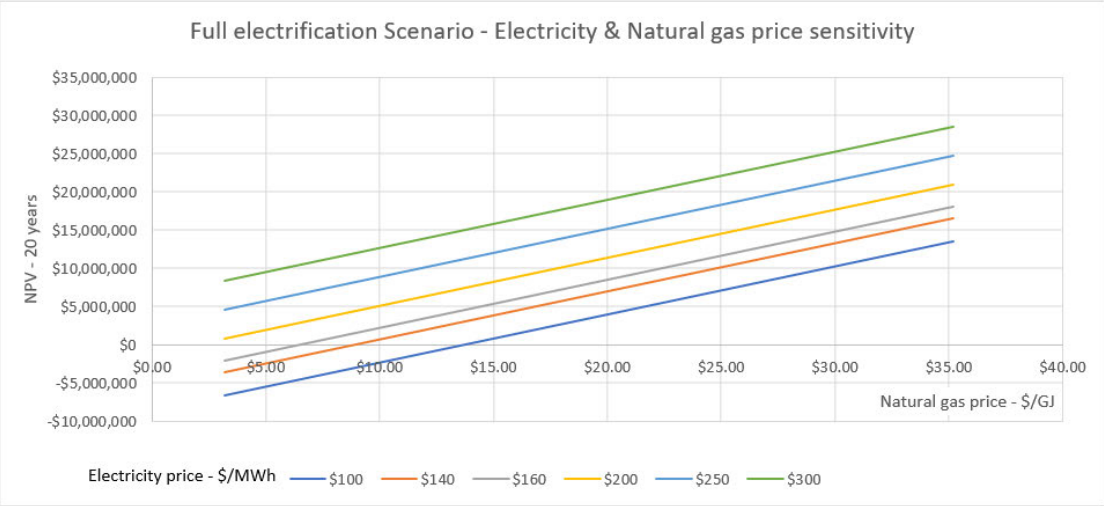


Figure 18 - Full Electrification Led scenario - electricity & natural gas price sensitivity

4.5.2.1 Sensitivity Analysis Examples

Below are two examples showing how changing of an energy price can impact the NPV for a scenario.

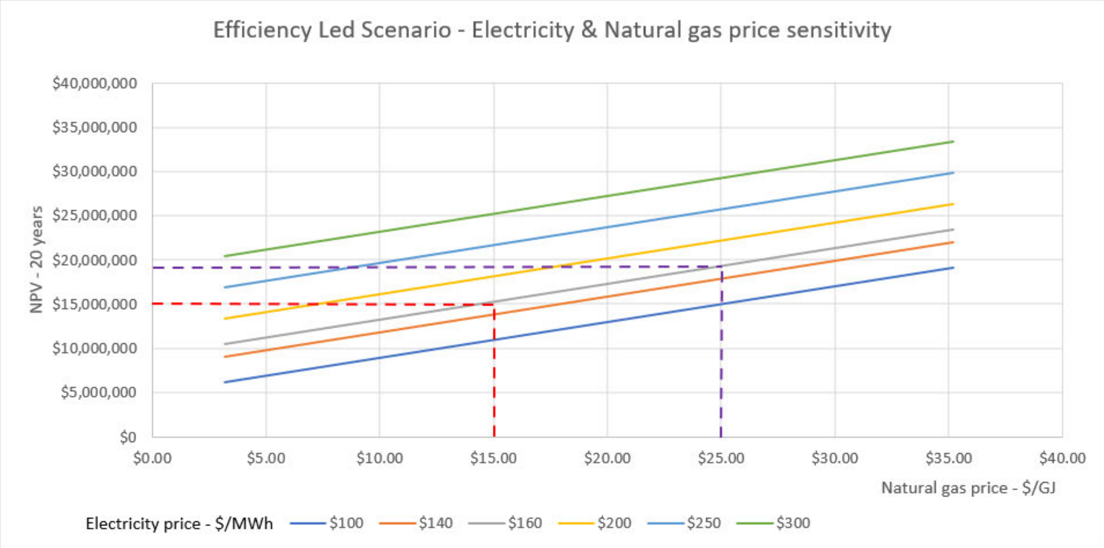


Figure 19 - Gas price change example

In this example the natural gas price increases from $15/GJ to $25/GJ (electricity price remains the same). The impact of this price change causes the NPV for this scenario to increase from $15M to $19.5M.

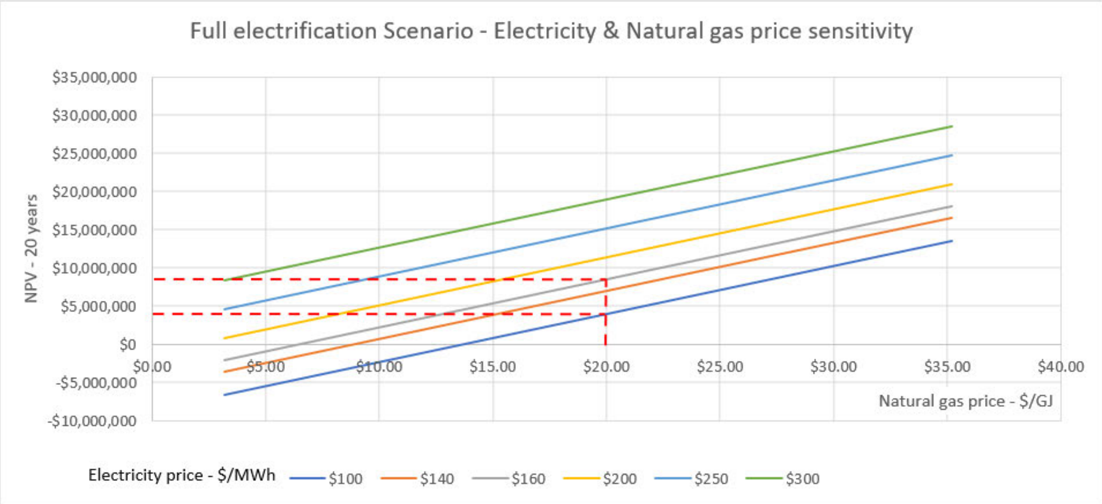


Figure 20 - Electricity price decrease example

In this example the electricity price decreases from $160/MWh to $100/MWh (natural gas price remains the same). The impact of this price change causes the NPV for this scenario to decrease from $9M to $4.5M.

4.6 Technology Feasibility, reasons for selection and barriers

4.6.1 Reasons for Selection

The reasons specific projects were or were not included in specific scenarios are stated below.

The solar system projects are excluded from this list as they are included in each scenario with a size applicable to that scenario.

Table 21 - Solar Led scenario project Inclusions and Exclusions

Solar Led Scenario			
Technology category	**Project**	**Included**	**Reason for Inclusion/Exclusion**
Solar	Hot Water Storage	Y	Enables load shifting.
Biogas	CAL SW100	N	Worse payback than SW30 CAL option
Biogas	CAL SW30	Y	Better payback than SW100 option. Offsetting natural gas consumption still useful in this scenario.
Energy Efficiency	WHE heat recovery	Y	Reduces amount of heat that has to be provided by heat pump.
Energy Efficiency	Econolisers	N	Ammonia HP Abattoir selected due to increased shiftable load it provides.
Energy Efficiency	Air Comp HR	N	Not effective if WHE heat recovery implemented also.
Energy Efficiency	Condensate Return HR	Y	Reduces amount of heat that has to be provided by heat pump.
Energy Efficiency	EE Design	N	Not the focus of this scenario.
Heat Pumps	Ammonia HP Abattoir	Y	Provides shiftable load for solar electricity when combined with storage. Individual abattoir and render heat pumps provide project implementation flexibility.
Heat Pumps	CO2 HP Render	Y	Provides shiftable load for solar electricity when combined with storage. Individual abattoir and render heat pumps provide project implementation flexibility
Heat Pumps	Ammonia HP (R+A)	N	Individual abattoir and render heat pumps provide project implementation flexibility
Electrification	Electric Boilers	Y	The electric boilers were selected as they materially reduce natural gas consumption at the site.
Other	Biomass Boiler	N	Focus of scenario is on providing heat via solar electricity.
Other	TES w/ Spot Exposure	N	Only required for the full electrification scenario.
Other	Offsite Renewables/Spot Exposure	N	Only required for the full electrification scenario.

Table 22 - Biogas Led scenario project inclusion

Biogas Led Scenario			
Technology category	**Project**	**Included**	**Reason for Inclusion/Exclusion**

Solar	Hot Water Storage	N	Load shifting not required for this scenario.
Biogas	CAL SW100	Y	Maximum biogas generation is the focus of this scenario
Biogas	CAL SW30	N	Produces less biogas than CAL SW100.
Energy Efficiency	WHE heat recovery	N	Energy efficiency is not the focus of this scenario, so higher capex/longer ROI projects not included.
Energy Efficiency	Econolisers	N	Energy efficiency is not the focus of this scenario, so higher capex/longer ROI projects not included.
Energy Efficiency	Air Comp HR	Y	Best payback energy efficiency project, and WHE heat recovery not implemented so this project is effective.
Energy Efficiency	Condensate Return HR	Y	Reduces the natural gas consumption of the rendering plant steam boiler.
Energy Efficiency	EE Design	N	Energy efficiency is not the focus of this scenario, so higher capex/longer ROI projects not included.
Heat Pumps	Ammonia HP Abattoir	Y	Reduces the natural gas consumption in the abattoir.
Heat Pumps	CO2 HP Render	Y	Reduces the natural gas consumption of the rendering plant steam boiler.
Heat Pumps	Ammonia HP (R+A)	N	Individual abattoir and render heat pumps provide project implementation flexibility
Electrification	Electric Boilers	N	Electrification of the steam boiler is not the aim of this scenario.
Other	Biomass Boiler	N	Biogas used as a fuel substitute in the steam boiler in this scenario.
Other	TES w/ Spot Exposure	N	Only required for the full electrification scenario.
Other	Offsite Renewables/Spot Exposure	N	Only required for the full electrification scenario.

Table 23 - Efficiency Led scenario project inclusion

Efficiency Led Scenario			
Technology category	**Project**	**Included**	**Reason for Inclusion/Exclusion**
Solar	4.5 MW Solar	Y	Reduces grid exposure
Solar	Hot Water Storage	N	Load shifting not required for this scenario.
Biogas	CAL SW100	N	Biogas generation not required for this scenario.
Biogas	CAL SW30	N	Biogas generation not required for this scenario.
Energy Efficiency	WHE heat recovery	Y	All effective energy efficiency projects are included in this scenario.
Energy Efficiency	Econolisers	Y	The econolisers have been implemented in this project as they both reduce the amount of heat require, and the project includes a heat pump for the remaining hot water.
Energy Efficiency	Air Comp HR	N	This project would not be effective as the WHE heat recovery project delivers hot water at a higher temperature.
Energy Efficiency	Condensate Return HR	Y	All effective energy efficiency projects are included in this scenario.
Energy Efficiency	EE Design	Y	All effective energy efficiency projects are included in this scenario.
Heat Pumps	Ammonia HP Abattoir	N	The econolisers have been implemented in this project as they both reduce the amount of heat require, and the project includes a heat pump for the remaining hot water.
Heat Pumps	CO2 HP Render	N	The biomass boiler will generate steam and hot water for the render plant.
Heat Pumps	Ammonia HP (R+A)	N	Individual abattoir and render heat pumps provide project implementation flexibility
Electrification	Electric Boilers	N	Electrification of the steam boiler is not the aim of this scenario.
Other	Biomass Boiler	Y	The natural gas steam boiler for the render plant is replaced with a biomass boiler in this scenario.
Other	TES w/ Spot Exposure	N	Only required for the full electrification scenario.
Other	Offsite Renewables/Spot Exposure	N	Only required for the full electrification scenario.

Table 24 – Full Electrification scenario project inclusion

Full Electrification Scenario			
Technology category	**Project**	**Included**	**Reason for Inclusion/Exclusion**
Solar	Hot Water Storage	N	Load shifting not required for this scenario.
Biogas	CAL SW100	N	Biogas generation not required for this scenario.
Biogas	CAL SW30	N	Biogas generation not required for this scenario.
Energy Efficiency	WHE heat recovery	Y	Effective energy efficiency projects are included in this scenario to reduce the required energy demand.
Energy Efficiency	Econolisers	Y	The econolisers have been implemented in this project as they both reduce the amount of heat require, and the project includes a heat pump for the remaining hot water.

Energy Efficiency	Air Comp HR	N	This project would not be effective as the WHE heat recovery project delivers hot water at a higher temperature.
Energy Efficiency	Condensate Return HR	Y	Effective energy efficiency projects are included in this scenario to reduce the required energy demand.
Energy Efficiency	EE Design	Y	Effective energy efficiency projects are included in this scenario to reduce the required energy demand.
Heat Pumps	Ammonia HP Abattoir	N	The econolisers have been implemented in this project as they both reduce the amount of heat require, and the project includes a heat pump for the remaining hot water.
Heat Pumps	CO2 HP Render	Y	The biomass boiler will generate steam and hot water for the render plant.
Heat Pumps	Ammonia HP (R+A)	N	Individual abattoir and render heat pumps provide project implementation flexibility
Electrification	Electric Boilers	Y	All available electrification projects are included in this scenario.
Other	Biomass Boiler	N	Electrification is the focus of this scenario.
Other	TES w/ Spot Exposure	Y	Enables full generation of steam load via electricity.
Other	Offsite Renewables/Spot Exposure	Y	Enables full electrification and net zero emissions.

4.6.2 Multi-Criteria Decision Matrix

12 criteria were developed for the assessment of the scenarios using the MCDM described in Section 4.1.

Weightings were not applied to the criteria as it was decided GKO should decide on these based on their own objectives and preferences.

Each project was scored by the team consisting of GKO, Northmore Gordon, Beam and Johns Environmental.

Cumulative scores were created by adding individual scores for each project selected for each scenario. A summary table is provided below with the full MCDM supplied in Appendix F.

Table 25 - MCDM Summary

Rating	Score Range	Scenario Cumulative Scores			
		Solar Led	Biogas Led	Efficiency Led	Full Electrific-ation
Rating 1: Capex[9]	5 = < 100k, 4 = < $500k, 3 = < $1m, 2 = < $5m, 1 = > $10m	3	3	3	3
Rating 2: Payback w/o Certificates	5 = < 1 years, 4 = 2 years, 3 = 3-5 years, 2 = 5-7 years, 1 = > 7 years	2	2	2	2
Rating 3: Payback with Certificates	5 = < 1 years, 4 = 2 years, 3 = 3-5 years, 2 = 5-7 years, 1 = > 7 years	2	2	3	2

[9] This represents the average rating for Capex of projects within the scenario – specifically the average Capex for the projects is between $500k and $1M. The total Capex for all of the projects within the scenario is greater – refer to Table 20.

Rating 4: Cost savings ($/a) w/o certificates	5 = >$1m, 4 = < $1m, 3= < $500k, 2 = < $200k, 1 = > $50k	3	3	2	3
Rating 5: Certificate value ($)	5 = >$1m, 4 = < $1m, 3= < $500k, 2 = < $200k, 1 = > $50k	3	3	3	4
Rating 6: Speed of implementation	5 = 1 year, 4 = 2 years, 3 = 3 years, 2 = 4 years, 1 = > 5 years	4	4	4	4
Rating 7: Cultural change	5 is < no change to BAU 4 is change within 1 year 3 is change with0in 2 years 2 is change within 3-4 years 1 is > 5 years	4	4	4	4
Rating 8: Operational risk	5 = Automated/invisible 4 = Minimal operator interaction with plant (start/stop) 3 = Moderate operator activity (some manual activities) 2 = Some automated activities 1 = Reliant on operator activity	4	4	4	4
Rating 9: Certainty of savings	5 = High, 3 = Mod, 1 = Low	3	3	4	3
Rating 10: Commercial Readiness[10]	5 - CRI stages 5-6 4 – CRI stage 4 3 - CRI stage 3 2 – CRI stage 2 1 - CRI stages 0-1	4	4	5	4
Rating 11: Carbon Savings	5 is > 5,000 tCO2 p.a, 4 is 1000 - 5000 tCO2 p.a, 3 is 500 - 1,000 tCO2 p.a 2 is 100 - 500 tCO2 p.a 1 is <100 tCO2 p.a	3	2	3	3
Rating 12: Electricity Supply Capacity Increase	5 is less than zero (adding supply) 4 is nil - 1000 kVA 3 is 1000- 2,000 kVA 4 is 2000 - 5000 kVA 1 is increase of >5,000 kVA	4	4	4	4
Total Score %		**64%**	**59%**	**62%**	**57%**

To summarise the outcomes of the MCDM, the scenarios score closely. All represent a feasible path forward. As there is no clear winner from the rating above, a recommendation is drawn from other factors below.

It is worthwhile referring to the costs and benefits presented in Table 20, and repeated below.

Table 26 - Costs/Benefits, payback & NPV

Scenario	Estimated project cost ($) after certificates	Cost savings ($/a)	Simple payback (years) excl. Certificates	Certificate Value ($)	Net Payback, incl certs (years)	Net Present Value ($) incl certs
Solar Led	$36,002,468	$3,660,195	9.8	$3,803,018	8.8	$15,061,424
Biogas Led	$25,275,382	$2,492,446	10.1	$2,236,788	9.2	$9,258,660
Efficiency Led	$12,334,992	$1,944,340	6.3	$3,626,117	4.5	$15,657,465
Full electrification	$29,567,756	$2,465,165	12.0	$3,498,311	10.6	$5,936,967

The recommended scenario for GKO to pursue is the Efficiency Led scenario, as it represents the most appealing payback and highest NPV. This scenario prioritises energy efficiency projects to be completed before electrification of process heat in order to reduce the amount of energy needed,

[10] CRI stands for Commercial Readiness Index. The ratings are categorised by ARENA's Commercial Readiness Index: https://arena.gov.au/assets/2014/02/Commercial-Readiness-Index.pdf

thereby reducing the size and cost of electrified process heat solutions. This approach is supported by the Energy Efficiency Council's report Putting Energy Efficiency to Work[11]. Furthermore, the Efficiency Led scenario can be kicked off with efficiency activities without the need for significant capital up front.

4.7 Forecast key performance indicators for the different scenarios

The impact on the three areas of interest in energy projects (energy, CO_2e and cost) are summarised below. While gas is typically cheaper per GJ than electricity, the efficiency of heat pumps when replacing gas heating means that fewer GJ of energy will be supplied. The values below are based on GKOs current energy costs, as per Section 1.5.4.

Energy certificates earned from project implementation have been excluded as these earnings are not continuous as compared to production and energy purchases upon which the site energy cost KPI is calculated.

Table 27 - Forecast Key Performance Indicators

Scenario	Site energy (GJ/T HSCW)	Site emissions (T CO2e / T HSCW)	Site energy cost ($/T HSCW)
Baseline (2023)	2.47	0.23	$55.53
Solar Led	0.87	0.10	$12.28[12]
Biogas Led	0.98	0.15	$24.54[12]
Efficiency Led	0.47	0.09	$18.79
Full electrification	1.05	0.10	$8.95

It should be noted that whilst this table is useful to show reductions in energy and emissions intensity, it does not consider the capital cost of the implementing the scenarios.

4.8 Environmental Impacts and Benefits

4.8.1 Emissions Reduction

The total emissions reductions achieved by each scenario are shown in Table 19 and reproduced below.

Table 28 - Energy & carbon savings

Scenario	Electricity Savings (MWh/a)	Gas Savings (GJ/a)	Carbon savings (T-CO2-e p.a.)
Solar Led	2,765	74,557	6,866
Biogas Led	2,741	68,733	4,302
Efficiency Led	4,818	88,427	7,777
Full electrification	-7,201	101,297	7,103

It should be noted that the emissions factor for the electricity grid changes over time as increasing amounts of renewable electricity generation are added to the electricity grid. This is shown in Section 1.5.5, and replicated below also.

---

[11] https://www.eec.org.au/policy-advocacy/projects/projects-overview#/forgotten-fuel-series
[12] Excludes operational cost savings from the biogas projects.

Table 29: Electricity Emissions Factor Projection for Victoria

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
kg-CO2-e/kWh	0.79	0.75	0.70	0.68	0.63	0.59	0.40	0.39	0.38	0.31	0.24	0.12	0.01

4.8.2 Other Impacts and Benefits

In addition to the reduction in grid electricity consumption, fossil natural gas usage and associated carbon emissions, there are other environmental and operational benefits from the technologies proposed in this feasibility study.

The biogas CAL30 and CAL100 options improve the treatment of wastewater from the facility enabling a more robust and reliable delivery of final treated effluent to South East Water authorities. The addition of H_2S desulphurisation of biogas in-situ in the CAL and covering of the anaerobic lagoon largely eliminate offensive odour emissions from the process.

Disposal of solid wastes from treatment are a major cost to the red meat processing industry. CALs reduce solid waste quantity from the biological WWTP and permit the upstream DAF to operate without chemical dosing. This reduces K100 DAF sludge volume and costs by about 50% and eliminates chemical consumption in the DAF. However, as noted in the JEG technical report, there are other options including tricanter technology which provides opportunities for creating a second grade tallow without the capital expenditure associated with a CAL.

The addition of solar electricity generation capacity to the site will reduce the electricity demand, from the grid. This will reduce the requirement for additional electricity supply infrastructure such as transformers, and/or reduce the risk of the site reaching its maximum demand limit. These benefits have been partially realised with the existing 1,265 kW solar system at the site.

4.9 Operational Impacts

With a number of different technologies considered in this report, there are operational considerations that need to be taken into account in assessing whether they are suitable for use.

For example, it is known that econoliser technology uses instantaneous sprays rather than constant water flow in the sterilisation process. It is also known that econolisers will have a significant impact on the operation of the wastewater plant on the basis that their operation results in a reduction in wastewater temperature. Further, it is known that in general this reduction negatively impacts the effectiveness of biological treatment of wastewater. It is recommended that the impact of reducing the volume of hot water sent to the wastewater plant be carefully considered before installing a significant number of econolisers.

Another example is that the CAL30 and CAL100 options represent a different mode of wastewater treatment to the current process. While robust, this process will require a different skillset to operate. A balance will need to be struck between treating the wastewater to the required degree versus optimising the generation of biogas to replace natural gas use on site.

A further example is the CO_2 and ammonia heat pumps for generating hot water. Whilst they are not new technology and easily automated, they would be new technology to site which would require upskilling of GKO's maintenance team. The CO_2 system runs at high pressures that by nature is harder wearing on components. Both will have water storage systems to buffer high instantaneous demands to reduce the required heat pump size.

Biomass boilers represent a fundamentally different fuel source. Management of this is likely best to be outsourced. There would also be more truck movements on site. The management of the fuel source would be a new process that would require a specialist team to run as GKO does not have existing expertise on site to manage it.

Projects to recover heat from air compressors, flashing steam condensate or rendering waste heat will operate in the background and not negatively impact operations.

The impact of solar panel operation are known to site.

4.10 Other Barriers and Implementation Risks

There is no commercial or regulatory requirement to make a change away from Natural Gas, therefore GKO has no external driver to change.

As renewables become a larger contributor to the grid network, electricity will have less carbon associated with it. Delaying project implementation will reduce the carbon-reduction savings possible from avoided grid electricity and therefore the credits that can be earned.

CAL30 and CAL100 options generate biogas. As a flammable gas, an asphyxiant and a potential source of odour, its safe management will need to be addressed in the engineering design.

With regards to econolisers, the impact of their implementation is still to be understood for all applications. AMPC is leading industry studies for econoliser implementation including regulatory and cultural barriers which may need to be overcome. The impact on wastewater processing is noted in section 4.9.

Waste heat recovery from the rendering evaporator will need re-evaluation after recent maintenance changed the performance characteristics of the plant. Less waste heat may be available as a result.

Electrically-driven thermal storage (heat bricks) has yet to be widely commercialised, with only one known installation in Australia.

Electrification will increase site demand above its present capacity, which will require significant change to the electrical infrastructure onsite and in the supply system (grid/transformer).

4.11 Opportunities of funding (further grants, VEU, RET, ERF)

On the basis that GKO's roadmap to decarbonisation requires projects that lack financial viability, it is relevant as part of this Report to consider public funding opportunities to support decarbonisation.

4.11.1 Australian Carbon Credit Unit (ACCU) Eligibility

Under the Carbon Credits (Carbon Farming Initiative—Domestic, Commercial and Industrial Wastewater) Methodology Determination 2015, sites are eligible for creating ACCUs by treating wastewater in a treatment facility that destroys methane emissions that would otherwise arise if the eligible wastewater was treated in a deep open anaerobic lagoon. Given that the existing lagoons at GKO are aerobic, the site will not be eligible for ACCUs under this methodology.

4.11.2 Treatment of certificates against emissions targets

Carbon certificates represent 1 ton of CO2 emissions to the atmosphere. The party who claims the reduction is the party who retires the certificate (removing it from the certificate market). Therefore, should certificates be generated by a project at GKO and SOLD, that emissions reduction can only be claimed by the party who purchased the certificate. Should the certificate be retired (not be sold and removed from the carbon market) then the emissions reduction can be claimed by GKO.

4.11.3 ARENA

The National Industrial transformation (NIT) by ARENA supports the reduction of greenhouse gas emissions related to industrial activity including industrial electrification initiatives.

The program offers co-funding and grant recipients are typically expected to provide match funding through both cash and in-kind contributions. The program has a total maximum grant amount of $15 million for each project, however, ARENA will contribute a maximum of 50% of eligible costs for projects. Projects that require lesser contributions from ARENA may be considered with higher merit.

This program represents the most suitable for GKO's needs, and it is recommended that GKO apply for funding for their selected group of projects.

4.11.4 RACE for 2030

RACE for 2030 consists of five research programs including RACE for Business which covers energy productivity and cost cutting by digitisation, electrification and value chain optimisation.

The program involves co-investing with one or more industrial partners to create leverage on investment. While there is no cap, each project budget cash contributions are typically in a 20%:40%:40% ratio to research, industry and RACE respectively. The project aims for the in-kind contributions to be double of the cash expenses. Project funding is provided as both cash contributions and in-kind funding.

This program appears focused on identifying industry partners for co-funding. There may be opportunity to partner with AMPC for electrification projects under this program.

4.12 Estimate of further funding required to implement recommended solutions

Projects that exceed the GKO payback threshold of 5 years will require further funding to be implemented. By applying a maximum 5 year payback for individual projects within each scenario, the following additional funds would be required:

Table 30 - Funding required for 5 year payback

Scenario	Solar Led	Biogas Led	Efficiency Led	Full electrification
Current capital required ($)	$36,002,468	$25,275,382	$12,334,992	$29,567,756
Current simple payback excl certs (yr)	9.8	10.1	6.3	12.0
Funding required for 5yr payback excl certs ($)	$12,485,943	$13,649,088	$3,449,227	$18,077,867
Current simple payback incl certs (yr)	8.8	9.2	4.5	10.6
Funding required for 5yr payback incl certs ($)	$8,928,330	$11,619,105	$1,322,914	$14,786,361

4.13 Recommendations and Next Steps (detailed)

It is recommended that GKO proceed with progressing the Efficiency Led scenario as recommended in Section 4.6.2 through adoption of the following road map in the first instance. The next steps are described below. A summary of these follows.

- Implement an Energy Management System
- Assess the 4.5 MW Solar system once the other activities in the scenario have been completed
- Conduct a detailed feasibility study on a Biomass Boiler
- Complete design and quoting for the WHE Heat Recovery project

4.13.1 Energy Management System

As a first step, further building on its metering and monitoring system, it is recommended that GKO progress the development of an Energy Management System which has as its objective improving the energy efficiency of GKOs operations by harnessing the knowledge of its staff and supporting suppliers. This is considered a fundamental first step in ensuring that GKO's culture leads its decarbonisation program.

It is intended that GKO's energy management system would signpost the integrity of GKO's commitment to working toward decarbonising its operations through a program of continuous improvements to energy management on site. Initially, it is envisaged that GKO's Energy Management System would be aligned with international standard ISO50001 for Energy Management.

It is proposed that implementation of the Energy Management System would be led by an energy team made up of stakeholders from across the organisation.

The energy team would have the strong support of GKO's leadership to set energy reduction goals, identify and implement actions, measure results and report on energy performance across the organisation. Actions implemented may be in the form of operational process change, purchasing standards, training or projects.

The following sub-sections include a discussion of each of the key elements of the Energy Efficiency Scenario and the key first steps to progressing further detailed analysis of the merits of each project.

4.13.2 4.5 MW Solar

It is recommended that a decision to proceed with this project be made after the assessments of the projects below have been completed, as the solar system should be sized according to the predicted electrical load. This accounts for the fact that on further investigation some of the other projects might not progress or proceed in a different format or scope. Once these assessments are complete, the solar component of the efficiency led scenario should be further progressed using the existing solar installation on site as relevant precedent.

4.13.3 Biomass Boiler

A detailed feasibility study is recommended for a biomass boiler. This should address the following aspects of this potential project:

- Fuel security, guarantee of supply and duration of supply contract
- Logistics of fuel supply
- Required on-site footprint
- Planning and compliance requirements
- Operation model – build-own-operate, self owned & operated, etc.
- Capital and operational costs to G&K O'Connor
- Project implementation timing
- Requirements for emissions certificate program eligibility (VEECS)

4.13.4 WHE Heat Recovery

In order to carry out a detailed investigation of this project, the next steps comprise the following:

- Acquire a quote and concept design for rerouting of the identified waste heat source
- Have the concept design independently validated to ensure the calculated savings can be achieved
- Approve and implement the project. For expected outcomes refer to Appendix A.
- Measure the result using the metering & monitoring system

4.13.5 Econolisers

Noting the potential barriers to implementation discussed in Sections 4.9 and 4.10 of this Report, it is recommended that econolisers are considered for implementation once the waste water study has been completed (refer to Section 4.13.8 below), and once econolisers have regulatory approval. An industry adoption project is in development by AMPC – it is recommended that GKO apply to take part.

4.13.6 Condensate Return HR

This project requires engineering design and quotation. It is recommended that GKO seek this from their steam boiler service supplier. The recommended actions are as per Section 4.13.4 above.

4.13.7 EE Design

GKO have a shovel ready project to construct a cold storage facility on site. As part of the design process, the proposals incorporate a number of opportunities which close the loop on process energy and emissions. Specifically, these opportunities comprise:

1. Install a desuperheater for abattoir hot water generation - use oil cooling for glycol and recovered heat for glycol backup
2. Specify IE4 class motors for smaller Refrigeration Plant motors
3. Pre-heat 6MW boiler feed makeup water using dryer waste heat
4. Replace smaller Render Plant motors with high efficiency motors at end of life

In the even that GKO proceeds with this project, then its delivery including these initiatives will represent best practice in terms of optimising opportunities for energy efficiency

4.13.8 Wastewater Study

The work completed over the course of this project have identified opportunities for improvements in GKO's wastewater system.

A pre-requisite to implementation, however, is competition of the render plant upgrades including re-commissioning GKO's Waste Heat Evaporator. Once these upgrade works are completed, then a detailed wastewater sampling campaign should occur on site with the objective of confirming the composition and volume of wastewater that continues to be sent to drain.

Once this position is quantified and taking into account GKO's plans for future growth, a forward plan for the on-site wastewater treatment can be finalised having regard to the options set out in the JEG analysis at Appendix C to this report with the objective of satisfying best practice requirements, meeting South East Water's Trade Waste Agreement requirements, and maximising revenue from product whilst minimising the cost and energy required to dispose of wastewater.

4.13.9 Review of this Roadmap

It is recommended that the projects that make up the selected roadmap be reviewed at least annually to ensure they align with GKO's goals (which may change over time), and that they are still current with regards to costs and savings. As operational activities evolve, this may alter project applicability, cost, savings and scale.

5. Potential Replicability across the AU Red Meat Sector

5.1 Addressable Market and industry wide applicability

An assessment of applicability for individual projects is detailed in the table below. There are some broad considerations for project applicability across red meat processing and other Australian industries:

- On-site solar electricity generation requires a significant footprint, so is likely to be limited for each application by accessible land or roof area.
- Electrification projects all face limitations of electrical supply from distributors, and from onsite transformers and electrical distribution boards.
- It is critical to consider the inter-relationships of potential energy efficiency projects when evaluating their applicability and merits. For example, a project such as the econolisers that potentially remove heat from wastewater may negatively impact downstream biological processing.

Table 31 - Industry and Market Applicability

Project	Applicability – Industry/Market
Onsite Solar	• Red Meat Industry: All • Broader market: All electricity users • Limitations: Land/roof area
Hot Water Storage	• Red Meat Industry: Processors of medium to large scale • Broader market: Industries using hot water of medium to large scale • Limitations: Application specific – may be space, planning regulations or economies of scale considerations that must be considered
Covered Anaerobic Lagoon (CAL)	• Red Meat Industry: Processors with onsite wastewater treatment, medium to large scale • Broader market: Industries generate and process wastewater that generates methane. • Limitations: Land area and economies of scale
WHE heat recovery	• Red Meat Industry: Processors with onsite low temperature rendering process. • Broader market: Industries using waste heat evaporators and have a requirement for hot water. • Limitations: Heat recovery potential is specific to the evaporator design.
Econolisers	• Red Meat Industry: Processors with hot water knife sterilisers. • Broader market: Applications with hot water knife sterilisers.

	• Limitations: Impact on wastewater temperature; potential regulatory hurdles relating to food hygiene and export requirements
Air Comp HR	• Red Meat Industry: All • Broader market: Industries with air compressors and hot water demand. • Limitations: Heat recovery is less effective on air cooled compressors than oil cooled compressors – this may affect usefulness of recovered heat.
Condensate Return HR	• Red Meat Industry: All • Broader market: Industries with air compressors and hot water demand. • Limitations: Heat recovery is less effective on air cooled compressors than oil cooled compressors – this may affect usefulness of recovered heat.
EE Design	• Red Meat Industry: All new cool rooms/refrigerated storage spaces • Broader market: Industries with new cool rooms/refrigerated storage spaces • Limitations: None
Ammonia HP	• Red Meat Industry: All sites with ammonia refrigeration systems • Broader market: All sites with ammonia refrigeration systems and hot water demand. • Limitations: Electricity supply capacity
CO2 HP	• Red Meat Industry: All sites with 90°C hot water demand • Broader market: All sites with 90°C hot water demand. • Limitations: Electricity supply capacity
Electric Boilers	• Red Meat Industry: All sites with steam demand • Broader market: All sites with steam demand • Limitations: Electricity supply capacity, onsite solar or spot market electricity contract to avoid increased energy cost from electricity (greater than natural gas at current prices)
Biomass Boiler	• Red Meat Industry: All sites with steam demand • Broader market: All sites with steam demand • Limitations: Onsite space, fuel availability and security, site emissions limitations; complexity of operating fuel supply
TES w/ Spot Exposure	• Red Meat Industry: All sites with steam demand • Broader market: All sites with steam demand • Limitations: Capital costs are significant, making this less relevant to sites with smaller steam demands.

Offsite Renewables/Spot Exposure	• Red Meat Industry: All sites with a net zero emissions requirement • Broader market: All sites with a net zero emissions requirement • Limitations: Spot exposure value likely to be realised only by sites with significant electricity demand.

6. Feedback from GKO

On 16 October 2024, GKO CEOs were briefed on the outcomes of the Study and recommended Roadmap. GKO's leadership supports progressing the recommended roadmap and commencing its implementation with immediate actions including:

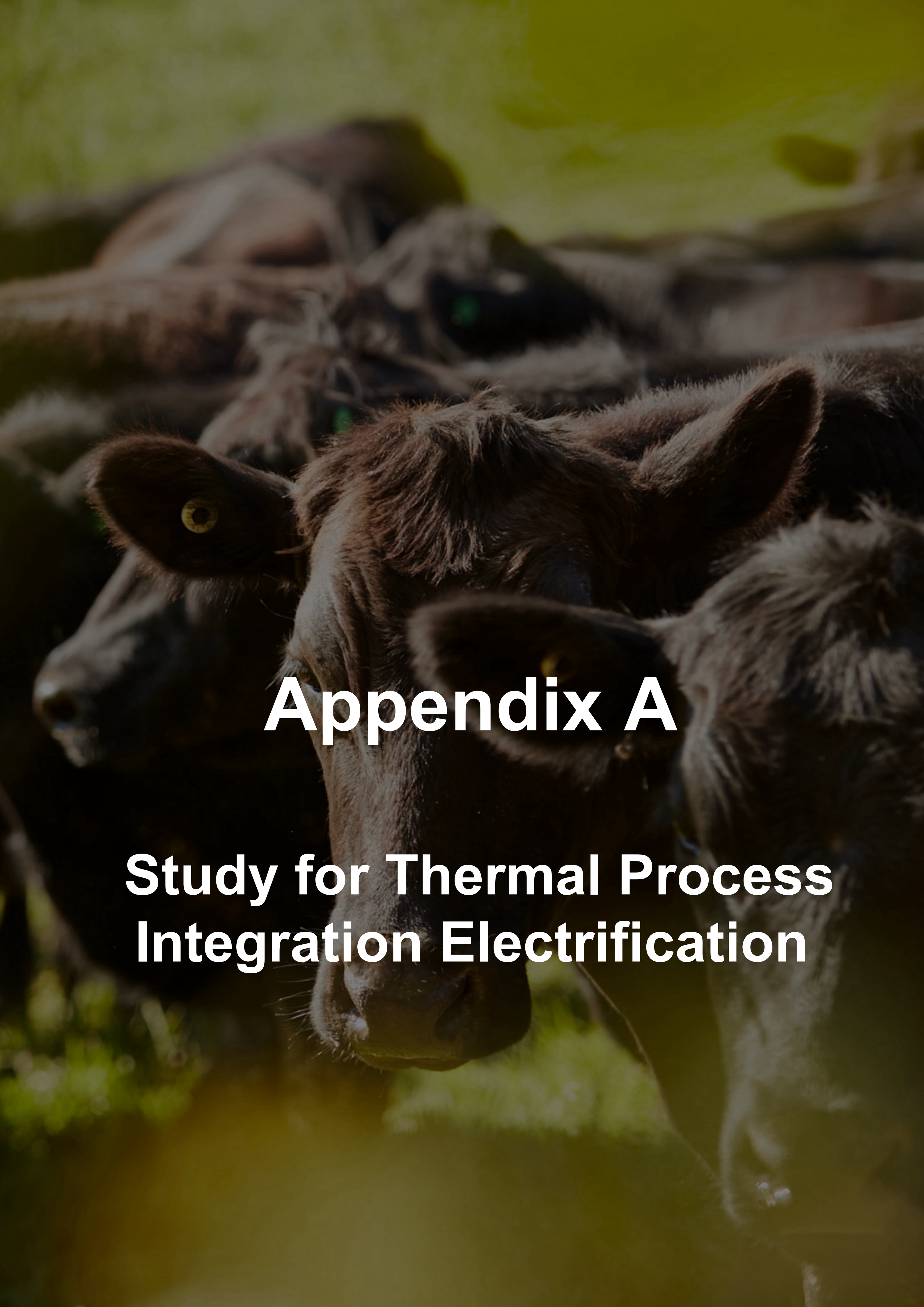
- Focus on identifying a commercially viable solution for replacing the render plant boiler (which is reaching the end of its life and is the largest consumer of natural gas on site), with a decarbonisation solution that closes the loop on process energy and emissions, and avoids replacing the boiler with a like for like unit.

Glossary

ACCU	**Australian Carbon Credit Unit.** ACCUs are an additional income source for individuals and businesses running ACCU Scheme projects. One ACCU represents one tonne of carbon dioxide equivalent (tCO_2-e) that would have otherwise been released into the atmosphere
AFL	Aerated Floatation Lagoon. An aerated wastewater pond with floating aerators.
AMPC	Australian Meat Processor Corporation
ARENA	Australian Renewable Energy Agency
Ausnet	An electricity distribution network service provider
Baseline data	Baseline data is a set of data collected at the beginning of a study before intervention has occurred.
CAL	Covered Anaerobic Lagoon
CAPEX	Capital Expenditure – the capital cost of a project.
CO_2-e	Carbon dioxide equivalent

Desuperheater	A desuperheater is a component used in HVAC systems to reduce the temperature of superheated refrigerant vapor. It achieves this by transferring heat from the refrigerant to a secondary fluid, such as water, causing the refrigerant to partially condense. This process helps optimise system efficiency and can be particularly useful in heat pump systems for heating water or in industrial applications requiring precise temperature control.
EnPIs	Energy Performance Indicators (EnPIs) is a measure of energy intensity for a given site, usually in the terms of energy consumed per unit output. A lower EnPI indicates less energy is needed to produce the same output.
ERF	The Emissions Reduction Fund is a method developed to credit abatement from new carbon capture and storage projects.
GJ	Giga-Joules – a unit energy representing 1 billion joules.
GKO	G&K O'Connor Pty Ltd.
Heat Exchanger	A heat exchanger is a device used to transfer heat between two or more fluids, without mixing them, typically to either heat or cool the fluids.
HSCW	The Hot Standard Carcass weight measured in kg.
IRR	Internal Rate of Return - a metric used in financial analysis to estimate the profitability of potential investments
JEG	John's Environmental Group
KPI	Key Performance Indicators
kVA	Kilo-volt-amperes – a term used for the rating of an electrical circuit. kVA is the product of the circuits maximum current and voltage rating.
kW	Kilowatt. A unit of power equal to one thousand watts
kWh	Kilowatt Hours. A kilowatt hour (MWh) equals 1 kilowatt of electricity generated/consumed per hour and is used to measure electric output or consumption.
LTR	Low temperature render
MBM	Meat and bone meal
MCC	Motor Control Centre. An air-conditioned room which houses VSDs and power electronics which run electrical equipment around a site.
MJ	Mega-Joules – a unit energy representing 1 million joules.
MW	Mega-Watt. A unit of power equal to one million watts
MWh	Mega-Watt Hours. A megawatt hour (MWh) equals 1,000 kilowatts of electricity generated/consumed per hour and is used to measure electric output or consumption.
NMI	The National Meter Identifier is a unique meter number for a property.
NPV	The net present value is the difference between the present value of cash inflows and the present value of cash outflows over a period of time.

OPEX	Operational Expenditure – operational costs.
PDS	Press Dewatering System
PLC	Programmable Logic Controller. This is an industrial computer which receives inputs and sends outputs to plant devices (valves, instruments, pumps, motors etc) to control plant equipment automatically.
PV	Photo-voltaic. The technology used in solar panels.
RET	The Renewable Energy Target is an Australian Government scheme that aims to reduce greenhouse gas emissions in the electricity sector and increase renewable electricity generation.
ROI	The return on investment is a performance measure used to evaluate the efficiency and profitability of an investment.
SAF	Sustainable aviation fuel.
SAT	Single axis solar tracking system (SATs) have only one axis about which the rotation is possible to align the solar panels to the sun's horizontal position.
Scope 1	Emissions caused by activities within a boundary or site such as combustion of natural gas.
Scope 2	Emissions caused by consumption of grid electricity
Scope 3	Emissions incurred by other companies, people or parties as a result of the activities of the organisation, such as third party transport companies combusting fuel while transporting GKO's goods.
STP	The Standard Temperature and Pressure is defined to be $0^{o}C$ and 1 bar.
T CO_2-e	Tonnes of carbon dioxide equivalent emissions.
TES	A Thermal Energy Storage system is a technology that stocks thermal energy by heating or cooling a storage medium so the stored energy can be used at a later time.
TOU	A Time of use cost is a billing rate in which the price of energy varies during the day and is usually determined by the level of demand.
VEEC	Victorian Energy Efficiency Certificates (VEECs) are part of the Victorian Energy Efficiency Target program and represents a saving of one tonne of greenhouse gas emissions. VEECs are created by accredited entities when an approved energy saving activity. They have a trading value and can be used to offset the cost of implementing an opportunity.
VEU	The Victorian Energy Upgrades program reduces greenhouse gases by providing access to discounted energy efficient products and services.
VSD	A Variable Speed Drive (VSD) is a type of an adjustable speed drive that controls the motor speed and torque by varying the motor input frequency and voltage.
WAAC	The Weighted Average Cost of Capital calculates a company's cost of capital, proportionately weighing its use of debt and equity financing.
WHE	Waste heat evaporator



Appendix A

Study for Thermal Process Integration Electrification

Feasibility Study – Thermal Process Integration and Electrification

Client: *G&K O'Connor Pty Ltd*

Final Report

12 September 2024

Contact Details:

Phil Woodward

Energy Optimisation Manager

Northmore Gordon Pty Ltd
P: 1300 854 561
M: +61 428 332 500
E: phil.woodward@northmoregordon.com

Executive Summary

Northmore Gordon has been engaged by G&K O'Connor Pty Ltd to a feasibility assessment to assess Thermal Process integration and Electrification options.

The scope includes:

- Quantification and categorisation of waste heat sources and sinks.
- Cost benefit analysis of heat integration options.
- Cost benefit analysis of electrification options.
- Basis of design documents for issuing to suppliers of major cost items for heat pump equipment and EPC contractors (including preliminary data and performance requirements)

Main Findings

A heat pump solution can provide all Abattoir hot water needs for a simple payback of less than 10 years. The Render Plant hot water can also potentially be electrified using the same system, once the new plate freezer is constructed and provides additional heat rejection. Natural gas consumption can be reduced by 37% by installing a heat pump for the Abattoir and natural gas can be eliminated completely using alternative fuels.

The key outcomes from this report are:

- At the current gas:electricity price ratio, electrification projects have a relatively high simple payback period. Future changes to this can significantly change the business case for a heat pump solution.
- A heat pump can effectively eliminate scope 1 emissions and gas costs from the abattoir, whilst keeping gas as a back up
- Econolisers present a significant opportunity to reduce gas consumption in the abattoir and minimise the potential capital cost and efficiency of a heat pump. There are several barriers to their uptake which would need to be overcome, including understanding the level of microbe reduction they would need to achieve.
- Biomass, whilst not a key focus of this study, is a clearly attractive and low payback option which warrants further investigation as a replacement for the steam boiler – and along with the heat pump in the abattoir, could effectively enable elimination of natural gas use on site. This can be operated by a contractor company as 'energy as a service'.
- The significant electrical loads (minimum 600kVA) that are recommended to achieve electrification are not currently possible on any of the existing or proposed transformer capacities. An upgrade to the supply infrastructure would be required to achieve this.

The biomass opportunity would need to be studied in further detail; including an assessment of the available fuel stocks, including supply and emissions. It is effectively out of scope for a thermal integration and electrification study, but noted here due to its importance for inclusion in the overall roadmap, particularly at a time when the natural gas boiler is due for replacement.

All capital costs in this document are estimated based on Northmore Gordon's cost estimate process, which includes consideration of comparable recently quoted projects.

Once a concept is finalised for the heat pump, we will provide input from vendors for sizing and prices for the various options presented in this report, for use in the Roadmap. GEA and Coldforce have been approached for budget pricing on the heat pump solution.

A summary of the opportunities recommended for implementation are shown in the table below.

Table 1. Electrification Options Summary

#	Area of Plant	Description of Opportunity	Estimated Cost ($)[2]	Energy Cost Savings ($ p.a.)	Simple Payback[1]	VEEC revenue ($)	Simple Payback (years, inc VEECs)	Electricity Savings (MWh p.a.)	Gas Savings (GJ p.a.)	GHG Savings (tCO2-e p.a.)	Section Ref
	Refrigeration Plant										
1	Kill floor and boning room	Replace sterilisers with econolisers and hand wash heat pump	$2,749,146	$326,291	8.4	$769,101	6.1	-1,150	32,518	687	4.4.1
2	Refrigeration Plant	Install an ammonia heat pump to provide 90°C water to Abattoir	$5,216,105	$223,105	23.4	$642,888	20.5	-1,732	32,518	186	4.4.2
3	Workshop	Heat recovery from 110 kW Air compressor	$28,500	$16,560	1.7	$14,005	0.9	0	1,035	53	4.7.1
	Render Plant										
4	Waste heat evaporator plant	Pre-Heat Abattoir Water Using Second Waste Heat Evaporator Heat Source	$70,000	$181,187	0.4	$206,806	N/A	0	11,324	584	4.8.1
5	Steam Plant	Use Condensate Return Flash steam to heat hot water from 55 to 90C	$342,400	$40,901	8.4	$77,087	6.5	0	2,556	132	4.8.2
6a	Hot water plant	Install a CO2 heat pump to provide Render hot water	$1,868,464	$120,059	15.6	$331,710	12.8	-1,051	18,015	24	4.4.4
6b	Hot water plant	Incorporate Render hot water into the Abattoir heat pump and new frozen storage design	$7,530,910	$324,651	23.2	$886,895	20.5	-2,202	43,557	351	4.4.3
7	Steam Plant	Replace steam boiler at end of life with biomass boiler	$3,000,000	$628,719	4.8	$1,908,960	1.7	0	62,961	3,152	4.10

[1] Including VEEC revenue at $70 net value to customer

[2] Cost estimates based on budget estimates/industry values for major items of plant. Factors applied for balance of plant. Cost estimates do not include upgrades to electrical supply infrastructure, or additional refrigeration plant room civil works for heat pumps. G&K O'Connor may wish to apply additional contingency to these cost estimates

Appendix B

Solar Energy Storage & Demand Flexibility Options

Feasibility Study: Solar, Energy Storage & Demand Flexibility

Customer	G&K O'Connor
Project	Industrial Transformation
Author	Andrew Lister
Reviewer	Zac Inglis
Date	28/10/2024
Version	V4.2 FINAL

beam

1 Executive Summary

G&K O'Connor are aiming to close the loop on red meat and food processing energy and emissions by integrating the deployment of renewable energy, energy efficiency and biogas production at their Pakenham, Vic facility. The first step in this journey is an Integrated Assessment of the Feasibility of Net Zero Pathway.

Following the completion of draft feasibility studies for the project, four integrated scenarios were considered for evaluation: 1. Solar Led, 2. Biogas Led, 3. Efficiency Led and 4. Full Electrification. Recommended projects for each scenario are provided below.

Solar Led Recommendations

The combined project involves installing 9.7 MW of solar at a cost of $14.9 million, a 368 kL hot water storage tank at an estimated cost of $834k and 5.0 MVA of electric boilers at a cost of $2.3 million, for a total estimated investment of $18.0 million. Annual cost savings are projected to be $1.7 million and are expected to generate $2.8 million of certificates (VEECs). The projects have a payback of 10.8 years excluding certificates and 9.2 years including certificates. A financial summary of the recommended projects for the Solar Led scenario is provided in Table 1 and an energy and emissions summary is provided in Table 2.

Table 1: Financial summary of recommended projects

NMI/Area	Recommended System	Estimated Project cost ($)	Cost savings ($ p.a.)	Payback Period Exc. Certificates	Certificate Value ($)	Payback Period Inc. Certificates
Total	9.7 MW Solar	$14,872,000	$1,442,632	10.3 years	$2,780,352	8.4 years
Total	5.0 MVA eBoiler	$2,310,000	$219,583	10.5 years		10.5 years
Total	Combined	$18,015,986	$1,662,215	10.8 years	$2,780,352	9.2 years

The projects are expected to provide carbon savings of 5,759 tCO_2-e and reduce electricity consumption by 49% of total consumption (including the reduction associated with the existing 1,265 kW solar system). Approximately 10% of solar electricity generated is projected to be in excess of site usage requirements.

Table 2: Energy & emissions summary of recommended projects

NMI/Area	Recommended System	Carbon savings (tCO_2-e p.a.)	Electricity Savings (MWh)	Electricity Savings (% of NMI)	Excess Electricity (MWh)	Excess Electricity (%)
Total	9.7 MW Solar	5,052	8,019	*36%	5,613	41%
Total	5.0 MVA eBoiler	707	-3,210	-13%	-3,210	-29%
Total	Combined	5,759	11,230	*49%	2,403	10%

* Includes the reduction from the existing 1,265 kW solar system

Biogas Led Recommendations

The combined project involves installing 4.4 MW of solar at a cost of $6.7 million, annual cost savings of $887k and generating $1,184k of certificates (VEECs). The projects have a payback of 7.5 years excluding certificates and 6.2 years including certificates. The projects are expected to provide carbon savings of 3,015 tCO_2-e and reduce electricity consumption by 29% of total consumption (including the reduction associated with the existing 1,265 kW solar system). A projected 20% of electricity generated will be in excess of site usage requirements. A financial summary of the recommended projects for the Biogas Led scenario is provided in Table 3 and an energy and emissions summary is provided in Table 4.

Table 3: Financial summary of recommended projects

NMI/Area	Recommended System	Estimated Project cost ($)	Cost savings ($ p.a.)	Payback Period Exc. Certificates	Certificate Value ($)	Payback Period Inc. Certificates
Total	4.4 MW Solar	$6,688,900	$887,366	7.5 years	$1,184,722	6.2 years

Table 4: Energy & emissions summary of recommended projects

NMI/Area	Recommended System	Carbon savings (tCO_2-e p.a.)	Electricity Savings (MWh)	Electricity Savings (% of NMI)	Excess Electricity (MWh)	Excess Electricity (%)
Total	4.4 MW Solar	3,015	4,785	*29%	1,224	20%

* Includes the reduction from the existing 1,265 kW solar system

Efficiency Led Recommendations

The combined project involves installing 4.5 MW of solar at a cost of $7.0 million, annual cost savings of $936k and generating $1,226k of certificates (VEECs). The projects have a payback of 7.4 years excluding certificates and 6.1 years including certificates. The projects are expected to provide carbon savings of 3,119 tCO_2-e and reduce electricity consumption by 33% of total consumption (including the reduction associated with the existing 1,265 kW solar system). A projected 25% of electricity generated will be in excess of site usage requirements. A financial summary of the recommended projects for the Efficiency Led scenario is provided in Table 5 and an energy and emissions summary is provided in Table 6.

Table 5: Financial summary of recommended projects

NMI/Area	Recommended System	Estimated Project cost ($)	Cost savings ($ p.a.)	Payback Period Exc. Certificates	Certificate Value ($)	Payback Period Inc. Certificates
Total	4.5 MW Solar	$6,969,100	$936,097	7.4 years	$1,225,779	6.1 years

Table 6: Energy & emissions summary of recommended projects

NMI/Area	Recommended System	Carbon savings (tCO_2-e p.a.)	Electricity Savings (MWh)	Electricity Savings (% of NMI)	Excess Electricity (MWh)	Excess Electricity (%)
Total	4.5 MW Solar	3,119	4,951	*33%	1,610	25%

* Includes the reduction from the existing 1,265 kW solar system

Full Electrification Recommendations

The combined project involves installing 8.8 MW of solar at a cost of $13.4 million, 5.0 MVA of electric boilers at a cost of $2.3 million, and a 28 MWh thermal energy storage system at a cost of $10.1 million for a total estimated investment of $25.9 million. Annual cost savings are projected to be $1.97 million and are expected to generate $2.5 million of certificates (VEECs). The projects have a payback of 13.2 years excluding certificates and 11.9 years including certificates. A financial summary of the recommended projects for the Solar Led scenario is provided in Table 7 and an energy and emissions summary is provided in Table 8.

Table 7: Financial summary of recommended projects

NMI/Area	Recommended System	Estimated Project cost ($)	Cost savings ($ p.a.)	Payback Period Exc. Certificates	Certificate Value ($)	Payback Period Inc. Certificates
Total	8.8 MW Solar	$13,414,800	$1,265,800	10.6 years	$2,476,811	8.6 years
Total	5.0 MVA eBoiler	$2,310,000	$223,304	10.3 years		10.3 years
Total	28 MWh TES	$10,130,000	$476,943	21.2 years	$0	21.2 years
Total	Combined	$25,854,800	$1,966,047	13.2 years	$2,476,811	11.9 years

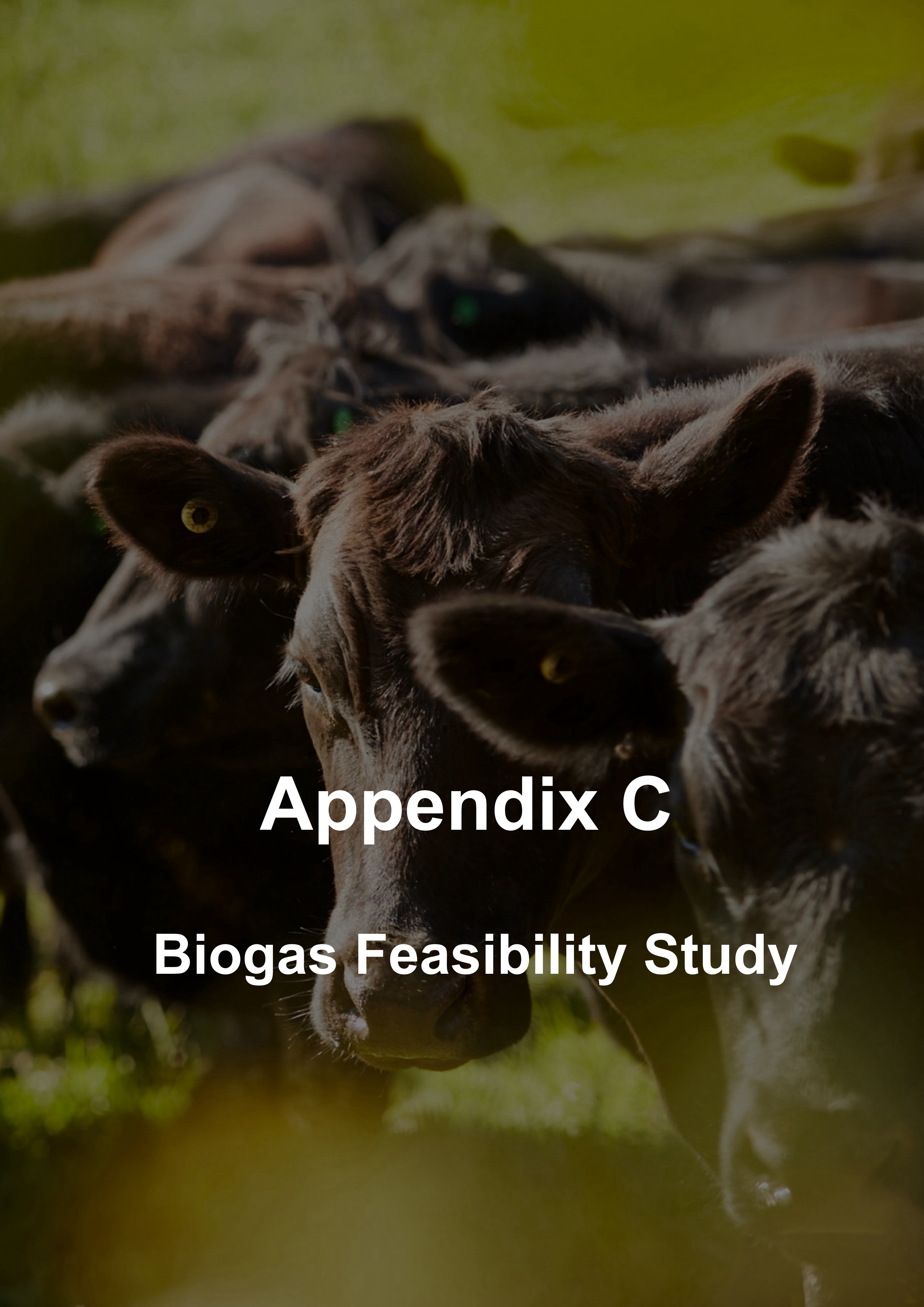
The projects are expected to reduce greenhouse gas emissions by 1,315 tCO_2-e under the current carbon accounting methodology. The solar projects are projected to reduce emissions by 4,246 tCO_2-e and the electric boiler projects by 719 tCO_2-e. This is offset by an increase in emissions from the thermal energy storage project of 3,650 tCO_2-e.

An additional 5,330 MWh of electricity will be consumed by the site, an increase of 35% of total consumption (including the reduction associated with the existing 1,265 kW solar system). This is due to 3,265 MWh of additional consumption from the electric boilers and 8,804 MWh of additional consumption from the thermal energy storage system, offset by 6,739 MWh of electricity consumption generated from solar. Approximately 7% of solar electricity generated is projected to be in excess of site usage requirements.

Table 8: Energy & emissions summary of recommended projects

NMI/Area	Recommended System	Carbon savings (tCO_2-e p.a.)	Electricity Savings (MWh)	Electricity Savings (% of NMI)	Excess Electricity (MWh)	Excess Electricity (%)
Total	8.8 MW Solar	4,246	6,739	*25%	5,598	45%
Total	5.0 MVA eBoiler	719	-3,265	-10%	-3,265	-33%
Total	28 MWh TES	-3,650	-8,804			
Total	Combined	1,315	-5,330	*-35%	2,333	7%

* Includes the reduction from the existing 1,265 kW solar system



Appendix C

Biogas Feasibility Study

JOHNS ENVIRONMENTAL

Biogas to Boiler Feasibility Study Report

Closing the Loop on Red Meat Processing Energy and Emissions
ARENA grant 2023/IET003

Prepared for: G & K O'Connor Pty Ltd.
Attention: Megan Williams

Prepared by: Johns Environmental Group, Brisbane
Authors: Dr. Mike Johns & Dr Stewart McGlashan

September 2024

Johns Environmental Group Pty Ltd ABN 42 613 187 849, ACN 613 187 849
PO Box 534 Aspley QLD 4034 Australia
Mob 0418 711 843

Executive Summary

This feasibility report assessed the financial and technical benefits and costs associated with adopting Covered Anaerobic Lagoon (CAL) technology to treat wastewater at the Pakenham meat processing facility of G&K O'Connor Pty Ltd (GKO). The study forms part of the ARENA project "Closing the Loop on red meat processing energy and emissions" which is co-funded through the Australian Meat Processor Corporation.

The study predicted the design wastewater volumes and raw composition associated with 10-year future throughput forecasts from GKO. To allow like for like comparison between wastewater treatment plant (WWTP) scenarios, the target treated effluent composition was set to correspond to trade waste quality characteristic settings.

Four scenarios were assessed:

- **Business as usual (BAU)**, in which a chemically-dosed DAF and new Biological Nutrient Removal (BNR) plant are adopted to treat wastewater including all stickwater from the render processes.
- **SW30** – where 70% of the stickwater is recovered as meat meal product using the render waste heat evaporator and drier, with the remainder to drain. The WWTP incorporates an undosed DAF, a CAL and a new BNR system. Biogas generated from the CAL is used as boiler fuel to displace fossil natural gas.
- **SW100** – as for SW30, except that all stickwater goes to drain.
- **Combined** – capturing the higher CAPEX of the SW100 with lower OPEX of SW30. This assumes construction of a SW100-sized WWTP but with the intention to recover stickwater and operate as SW30 as reliable stickwater recovery is developed.

Future WWTP scenarios which do not include biogas production, but which could be suitable alternate options (for example using a tricanter, or AFL+BNR+tertiary DAF) were outside the scope of this study.

Capital and operating costs were generated for the scenarios and used to perform a cost benefit analysis (CBA) of the scenarios using assumptions common to the other components of the closing the Loop study. The table below compares outcomes.

	Units	BAU	SW30	SW100
CAPEX	$million	8.0	12.9	13.5
Total OPEX (incl. K100 costs)	$million/yr	2.3	1.35	1.5
K100 sludge costs	$million/yr	1.09	0.45	0.54
Annual benefits (biogas + meal)	$million/yr	0	0.61	0.47
Biogas GJ/total NG GJ consumption	%	0	10.3	18.2
NPV	$million	-	10.1	5.6
Simple payback	years	-	3.7	5.6
Installed WWTP power	kW	670	895	1,030
Energy (NG & electricity) savings	$/yr	-	$130,790	$239,125
VEECs from NG substitution	$/yr	-	$43,800	$77,200
Electricity savings on BAU	MWh/yr	-	-555	-937
Carbon emissions savings on BAU	tCO_2-e/yr	-	174	354

Major findings include:

1. The BAU case has the cheapest CAPEX but has crippling K100 DAF sludge disposal costs representing almost 50% of annual operating costs. There are no benefits (stickwater recovery to product or biogas) other than treated effluent. Carbon emissions are highest mainly because there is no

displacement of fossil natural gas (NG) by biogas. Note that the installed power of the BAU WWTP is substantially higher than the existing AFL/SBR facility (670kW vs existing 406kW) due mainly to the allowance for additional nitrogen removal at future throughput levels.

2. The SW30 scenario with 100% biogas burnt in boiler yields the most attractive financial outcomes for the project. This comes with significant technical risk. If it is not possible to have reliable incorporation of 70% stickwater into meat meal, the wastewater treatment system will not function according to specification and the financial returns from meal falls. The high installed aeration power is due to high nitrogen concentrations in the wastewater relative to the BAU case.

3. The SW100 scenario generates the most biogas (substituting ~18% of current NG demand) and the lowest carbon emissions but comes at higher costs and fewer benefits. The substitution of boiler NG usage by biogas provides overall energy savings of $239,000 p.a. despite the higher electrical consumption. The high nitrogen levels in the raw wastewater make nitrogen reduction challenging for this scenario.

4. The Combined scenario is the equivalent of ‘planning for the worst and hoping for the best’. The $600,000 (or 4.4%) estimated additional capital for SW100 is a small cost to provide risk mitigation if less than 70% of stickwater can be added to meat meal. The SW100 CAPEX deployment would mean the system could cope with any range of stickwater inclusion. Accordingly, the Combined scenario is considered the least-risk scenario provided issues with excess nitrogen load on the BNR system can be resolved.

5. High nitrogen concentrations in the raw wastewater from the facility have a major impact. Approximately 80% appears to come from the render plant, although this figure is rubbery. The high levels reduce biogas yield and increase electrical power demand in the WWTPs for all scenarios. Reducing nitrogen especially through converting stickwater to meal product and other means would reduce treatment costs.

6. All scenarios generate K100 DAF sludge and exceed available spare power at the facility.

Several recommendations to reduce these impacts are provided.

Appendix D

Multi-Criteria Decision Matrix & Detailed Project List

Appendix D – Multi-Criteria Decision Matrix and Detailed Project List

Table 1 - Solar Led Scenario Multi-Criteria Decision Matrix

Rating	Steps to take	Priority Score range	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.80	1.90	1.10	1.11
Short Name		**Project name**		Ammonia HP Abattoir	CO2 HP Render	Ammonia HP (R+A)	Biomass Boiler	CAL SW100	CAL SW30	WHE heat recovery	Condensate Return HR	Hot Water Storage	9.7 MW Solar	Electric Boilers
		Project included in scenario?		Y	Y				Y	Y	Y	Y	Y	Y
Rating 1: Capex	- Sort projects by Capex in descending order - Draw a line above the project which sits just over each Capex threshold	5 = < 100k, 4 = < $500k, 3 = < $1m, 2 = < $5m, 1 = > $10m	3	2	3	2	2	1	1	5	4		1	2
Rating 2: Payback w/o Certificates		5 = < 1 years, 4 = 2 years, 3 = 3-5 years, 2 = 5-7 years, 1 = > 7 years	2	1	1	1	3	2	3	5	1		1	1
Rating 3: Payback with Certificates	- Government funding (ESCs, LGCs, ACCUs etc) - Government grants	5 = < 1 years, 4 = 2 years, 3 = 3-5 years, 2 = 5-7 years, 1 = > 7 years	2	1	1	1	4	2	3	5	2		1	2
Rating 4: Cost savings ($/a) w/o certificates		5 = >$1m, 4 = < $1m, 3= < $500k, 2 = < $200k, 1 = > $50k	3	3	2	3	2	5	5	2	1		4	3
Rating 5: Certificate value ($)		5 = >$1m, 4 = < $1m, 3= < $500k, 2 = < $200k, 1 = > $50k	3	4	2	4	5	5	1	3	2		5	4
Rating 6: Speed of implementation	- Rate projects by speed of implementation (This assumes asset availability and technical viability)	5 = 1 year, 4 = 2 years, 3 = 3 years, 2 = 4 years, 1 = > 5 years	4	4	4	4	3	4	3	5	5		4	2
Rating 7: Cultural change	- Extent of cultural change for the organisation	5 is < no change to BAU 3 is change within 2 years 1 is > 5 years	4	5	5	5	5	2	2	5	5		1	3
Rating 8: Operational risk	- Impact to effort or difficulty to operate plant - Reliability of equipment or supply	5 = Automated/invisible 1 = Reliant on operator activity	4	4	3	3	2	4	2	5	5		5	4
Rating 9: Certainty of savings	- Technical certainty of achieving savings	5 = High, 3 = Mod, 1 = Low	3	3	3	3	5	3	3	4	3		5	3
Rating 10: Commercial Readiness	- How well established is the technology in the market? Rate on Commercial Readiness Index (CRI)	5 - CRI stages 5-6 3 - CRI stages 3-4 1 - CRI stages 0-3	4	4	3	4	5	4	4	5	5		5	1
Rating 11: Carbon Savings	- Extent of carbon savings	5 is > 5,000 tCO2 p.a, 4 is 1000 - 5000 tCO2 p.a, 3 is 500 - 1,000 tCO2 p.a 2 is 100 - 500 tCO2 p.a 1 is <100 tCO2 p.a	3	2	1	2	4	3	2	3	2		5	4
Rating 12: Electricity Supply Capacity Increase	- How much additional capacity is required?	5 is less than zero (adding supply) 4 is nil - 1000 kVA 3 is 1000- 2,000 kVA 4 is 2000 - 5000 kVA 1 is increase of >5,000 kVA	4	4	4	4	4	4	4	4	4		5	4
Total Scores	**- Sum of scores for each opportunity**		**64%**	**62%**	**53%**	**60%**	**73%**	**65%**	**55%**	**85%**	**65%**	**0%**	**70%**	**55%**

Table 2 - Biogas Led Scenario Multi-Criteria Decision Matrix

Rating	Steps to take	Priority Score range	2	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	2.10
Short Name		Project name		CAL SW100	CAL SW30	Ammonia HP Abattoir	Econolisers	CO2 HP Render	Ammonia HP (R+A)	Air Comp HR	WHE heat recovery	Condensate Return HR	4.4 MW Solar
		Project included in scenario?		Y		Y		Y		Y	Y	Y	Y
Rating 1: Capex	- Sort projects by Capex in descending order - Draw a line above the project which sits just over each Capex threshold	5 = < 100k, 4 = < $500k, 3 = < $1m, 2 = < $5m, 1 = > $10m	3	1	1	2	2	3	2	5	5	4	1
Rating 2: Payback w/o Certificates		5 = < 1 years, 4 = 2 years, 3 = 3-5 years, 2 = 5-7 years, 1 = > 7 years	2	2	3	1	1	1	1	4	5	1	1
Rating 3: Payback with Certificates	- Government funding (ESCs, LGCs, ACCUs etc) - Government grants	5 = < 1 years, 4 = 2 years, 3 = 3-5 years, 2 = 5-7 years, 1 = > 7 years	2	2	3	1	2	1	1	5	5	2	1
Rating 4: Cost savings ($/a) w/o certificates		5 = >$1m, 4 = < $1m, 3= < $500k, 2 = < $200k, 1 = > $50k	3	5	5	3	3	2	3	1	2	1	5
Rating 5: Certificate value ($)		5 = >$1m, 4 = < $1m, 3= < $500k, 2 = < $200k, 1 = > $50k	3	5	1	4	4	2	4	1	3	2	5
Rating 6: Speed of implementation	- Rate projects by speed of implementation (This assumes asset availability and technical viability)	5 = 1 year, 4 = 2 years, 3 = 3 years, 2 = 4 years, 1 = > 5 years	4	4	3	4	3	4	4	5	5	5	4
Rating 7: Cultural change	- Extent of cultural change for the organisation	5 is < no change to BAU 3 is change within 2 years 1 is > 5 years	4	2	2	5	3	5	5	5	5	5	1
Rating 8: Operational risk	- Impact to effort or difficulty to operate plant - Reliability of equipment or supply	5 = Automated/invisible 1 = Reliant on operator activity	4	4	2	4	4	3	3	5	5	5	5
Rating 9: Certainty of savings	- Technical certainty of achieving savings	5 = High, 3 = Mod, 1 = Low	3	3	3	3	3	3	3	4	4	3	5
Rating 10: Commercial Readiness	- How well established is the technology in the market? Rate on Commercial Readiness Index (CRI)	5 - CRI stages 5-6 3 - CRI stages 3-4 1 - CRI stages 0-3	4	4	4	4	5	3	4	5	5	5	5
Rating 11: Carbon Savings	- Extent of carbon savings	5 is > 5,000 tCO2 p.a, 4 is 1000 - 5000 tCO2 p.a, 3 is 500 - 1,000 tCO2 p.a 2 is 100 - 500 tCO2 p.a 1 is <100 tCO2 p.a	2	3	2	2	3	1	2	1	3	2	4
Rating 12: Electricity Supply Capacity Increase	- How much additional capacity is required?	5 is less than zero (adding supply) 4 is nil - 1000 kVA 3 is 1000- 2,000 kVA 4 is 2000 - 5000 kVA 1 is increase of >5,000 kVA	4	4	4	4	4	4	4	4	4	4	5
Total Scores	**- Sum of scores for each opportunity**		59%	65%	55%	62%	62%	53%	60%	75%	85%	65%	70%

Table 3 - Efficiency Led Scenario Multi-Criteria Decision Matrix

Rating	Steps to take	Priority Score range	3	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10
Short Name		**Project name**		EE Design	Econolisers	Ammonia HP Abattoir	CO2 HP Render	Ammonia HP (R+A)	Biomass Boiler	Air Comp HR	WHE heat recovery	Condensate Return HR	4.5 MW Solar
		Project included in scenario?		Y	Y	0	0	0	Y	0	Y	Y	Y
Rating 1: Capex	- Sort projects by Capex in descending order - Draw a line above the project which sits just over each Capex threshold	5 = < 100k, 4 = < $500k, 3 = < $1m, 2 = < $5m, 1 = > $10m	**3**	3	2	2	3	2	2	5	5	4	2
Rating 2: Payback w/o Certificates		5 = < 1 years, 4 = 2 years, 3 = 3-5 years, 2 = 5-7 years, 1 = > 7 years	**2**	2	1	1	1	1	3	4	5	1	1
Rating 3: Payback with Certificates	- Government funding (ESCs, LGCs, ACCUs etc) - Government grants	5 = < 1 years, 4 = 2 years, 3 = 3-5 years, 2 = 5-7 years, 1 = > 7 years	**3**	2	2	1	1	1	4	5	5	2	2
Rating 4: Cost savings ($/a) w/o certificates		5 = >$1m, 4 = < $1m, 3= < $500k, 2 = < $200k, 1 = > $50k	**2**	2	3	3	2	3	2	1	2	1	2
Rating 5: Certificate value ($)		5 = >$1m, 4 = < $1m, 3= < $500k, 2 = < $200k, 1 = > $50k	**3**	1	4	4	2	4	5	1	3	2	5
Rating 6: Speed of implementation	- Rate projects by speed of implementation (This assumes asset availability and technical viability)	5 = 1 year, 4 = 2 years, 3 = 3 years, 2 = 4 years, 1 = > 5 years	**4**	2	3	4	4	4	3	5	5	5	4
Rating 7: Cultural change	- Extent of cultural change for the organisation	5 is < no change to BAU 3 is change within 2 years 1 is > 5 years	**4**	5	3	5	5	5	5	5	5	5	1
Rating 8: Operational risk	- Impact to effort or difficulty to operate plant - Reliability of equipment or supply	5 = Automated/invisible 1 = Reliant on operator activity	**4**	5	4	4	3	3	2	5	5	5	5
Rating 9: Certainty of savings	- Technical certainty of achieving savings	5 = High, 3 = Mod, 1 = Low	**4**	3	3	3	3	3	5	4	4	3	5
Rating 10: Commercial Readiness	- How well established is the technology in the market? Rate on Commercial Readiness Index (CRI)	5 - CRI stages 5-6 3 - CRI stages 3-4 1 - CRI stages 0-3	**5**	5	5	4	3	4	5	5	5	5	5
Rating 11: Carbon Savings	- Extent of carbon savings	5 is > 5,000 tCO2 p.a, 4 is 1000 - 5000 tCO2 p.a, 3 is 500 - 1,000 tCO2 p.a 2 is 100 - 500 tCO2 p.a 1 is <100 tCO2 p.a	**3**	3	3	2	1	2	4	1	3	2	4
Rating 12: Electricity Supply Capacity Increase	- How much additional capacity is required?	5 is less than zero (adding supply) 4 is nil - 1000 kVA 3 is 1000- 2,000 kVA 4 is 2000 - 5000 kVA 1 is increase of >5,000 kVA	**4**	4	4	4	4	4	4	4	4	4	5
Total Scores	**- Sum of scores for each opportunity**		**62%**	**62%**	**62%**	**62%**	**53%**	**60%**	**73%**	**75%**	**85%**	**65%**	**68%**

Table 4 - Full Electrification Scenario Multi-Criteria Decision Matrix

Rating	Steps to take	Priority Score range	4	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10	4.11	4.12
Short Name		**Project name**		Ammonia HP Abattoir	Econolisers	CO2 HP Render	Ammonia HP (R+A)	Air Comp HR	WHE heat recovery	Condensate Return HR	Electric Boilers	8.8 MW Solar	TES w/ Spot Exposure
		Project included in scenario?		0	Y	Y	0	0	Y	Y	Y	Y	Y
Rating 1: Capex	- Sort projects by Capex in descending order - Draw a line above the project which sits just over each Capex threshold	5 = < 100k, 4 = < $500k, 3 = < $1m, 2 = < $5m, 1 = > $10m	**3**	2	2	3	2	5	5	4	2	1	1
Rating 2: Payback w/o Certificates		5 = < 1 years, 4 = 2 years, 3 = 3-5 years, 2 = 5-7 years, 1 = > 7 years	**2**	1	1	1	1	4	5	1	1	1	1
Rating 3: Payback with Certificates	- Government funding (ESCs, LGCs, ACCUs etc) - Government grants	5 = < 1 years, 4 = 2 years, 3 = 3-5 years, 2 = 5-7 years, 1 = > 7 years	**2**	1	2	1	1	5	5	2	2	1	2
Rating 4: Cost savings ($/a) w/o certificates		5 = >$1m, 4 = < $1m, 3= < $500k, 2 = < $200k, 1 = > $50k	**3**	3	3	2	3	1	2	1	3	4	4
Rating 5: Certificate value ($)		5 = >$1m, 4 = < $1m, 3= < $500k, 2 = < $200k, 1 = > $50k	**4**	4	4	2	4	1	3	2	4	5	5
Rating 6: Speed of implementation	- Rate projects by speed of implementation (This assumes asset availability and technical viability)	5 = 1 year, 4 = 2 years, 3 = 3 years, 2 = 4 years, 1 = > 5 years	**4**	4	3	4	4	5	5	5	2	4	2
Rating 7: Cultural change	- Extent of cultural change for the organisation	5 is < no change to BAU 3 is change within 2 years 1 is > 5 years	**4**	5	3	5	5	5	5	5	3	1	3
Rating 8: Operational risk	- Impact to effort or difficulty to operate plant - Reliability of equipment or supply	5 = Automated/invisible 1 = Reliant on operator activity	**4**	4	4	3	3	5	5	5	4	5	4
Rating 9: Certainty of savings	- Technical certainty of achieving savings	5 = High, 3 = Mod, 1 = Low	**3**	3	3	3	3	4	4	3	3	5	3
Rating 10: Commercial Readiness	- How well established is the technology in the market? Rate on Commercial Readiness Index (CRI)	5 - CRI stages 5-6 3 - CRI stages 3-4 1 - CRI stages 0-3	**4**	4	5	3	4	5	5	5	1	5	1
Rating 11: Carbon Savings	- Extent of carbon savings	5 is > 5,000 tCO2 p.a, 4 is 1000 - 5000 tCO2 p.a, 3 is 500 - 1,000 tCO2 p.a 2 is 100 - 500 tCO2 p.a 1 is <100 tCO2 p.a	**3**	2	3	1	2	1	3	2	4	5	4
Rating 12: Electricity Supply Capacity Increase	- How much additional capacity is required?	5 is less than zero (adding supply) 4 is nil - 1000 kVA 3 is 1000- 2,000 kVA 4 is 2000 - 5000 kVA 1 is increase of >5,000 kVA	**4**	4	4	4	4	4	4	4	4	5	1
Total Scores	**- Sum of scores for each opportunity**		**57%**	**62%**	**62%**	**53%**	**60%**	**75%**	**85%**	**65%**	**55%**	**70%**	**52%**

Table 5 - Solar Led Scenario Project List

Technology Category	Short Name	Project Name	Project selection	Estimated project cost ($) before certificates	Cost savings ($/a)	Simple payback (years) excl. Certificates	Certificate Value ($)	Net Payback, incl certs (years)	Carbon savings (T-CO2-e p.a.)	Time-frame	Electricity Savings (MWh)	Gas Savings (GJ)
		Solar Led Scenario		**$36,002,468**	**$3,660,195**	**9.8**	**$3,803,018**	**8.8**	**6,866**	**Oct-27**	**2,765**	**74,557**
Solar	9.7 MW Solar	9.7 MW Solar (900 kW rooftop + 8.8 MW ground mount single axis tracking)	Y	$14,872,000	$1,442,632	10.3	$2,780,352	8.4	5,052	Jun-26	8,019	0
Solar	Hot Water Storage	368 kL 90°C water storage tank to shift heat pump consumption	Y	$833,986	$0	0.0	$0	0.0	0	Jun-26	0	0
Biogas	CAL SW100	21 ML Covered Anaerobic Lagoon (All Stickwater to Drain option - SW100) capable of producing 18,900 m3 of biogas per week and Biogas treatment to upgrade Biogas to Biomethane.		$13,500,000	$1,143,600	5.6	$68,000	5.6	354	Dec-27	0	18,200
Biogas	CAL SW30	12.5 ML Covered Anaerobic Lagoon (30% Stickwater to Drain option - SW30) capable of producing 10,700 m3 of biogas per week and Biogas treatment to upgrade Biogas to Biomethane.	Y	$12,900,000	$1,536,500	3.7	$38,600	3.7	174	Dec-27	0	10,300
Energy Efficiency	WHE heat recovery	Pre-Heat Abattoir Water Using Second Waste Heat Evaporator Heat Source	Y	$70,000	$181,187	0.4	$206,806	N/A	584	Jun-25	0	11,324
Energy Efficiency	Econolisers	Replace sterilisers with econolisers and hand wash heat pump (75oC)		$2,749,146	$326,291	8.4	$769,101	6.1	687	Dec-27	-1,150	32,518
Energy Efficiency	Air Comp HR	Heat recovery from 110 kW Air compressor		$28,500	$16,560	1.7	$14,005	0.9	53	Jun-25	0	1,035
Energy Efficiency	Condensate Return HR	Use Condensate Return Flash steam to heat hot water from 55 to 90C	Y	$342,400	$40,901	8.4	$77,087	6.5	132	Dec-25	0	2,556
Energy Efficiency	EE Design	Implementation of energy efficiency projects identified in “Design Review – Frozen Storage-Plate Freezer and Render Plant Upgrades” report and other future energy efficiency opportunities.		$574,000	$109,920	5.2	$13,000	5.1	814	Dec-25	687	0
Heat Pumps	Ammonia HP Abattoir	1 - Ammonia heat pump to provide 90°C water with storage (95m3) to generate abattoir sterilisation and hand wash water	Y	$2,805,619	$119,333	23.5	$368,463	20.4	193	Jun-26	-993	18,637
Heat Pumps	CO2 HP Render	6a - CO2 heat pump for render hot water	Y	$1,868,464	$120,059	15.6	$331,710	12.8	24	Dec-26	-1,051	18,015
Heat Pumps	Ammonia HP (R+A)	6b - Ammonia heat pump to provide 90°C water with storage (315m3) to generate both abattoir and render hot water		$7,530,910	$324,651	23.2	$886,895	20.5	351	Jan-00	-2,202	43,557
Electrification	Electric Boilers	2 x 2.5 MVA Electric Boilers (1 x Rendering, 1 x Main Plant - feeding Rendering)	Y	$2,310,000	$219,583	10.5	$0	10.5	707	Jun-26	-3,210	13,724
Other	Biomass Boiler	7 - Biomass boiler for remaining steam demand		$3,000,000	$519,090	5.8	$1,697,548	2.5	2,803	Dec-27	0	55,909
Other	TES w/ Spot Exposure	28 MWh thermal energy storage system exposed to the spot market on a child or separate NMI		$10,130,000	$476,943	21.2	$0	21.2	0	Dec-26	-8,804	36,807

Table 6 - Biogas Led Scenario Project List

Technology Category	Short Name	Project Name	Project selection	Estimated project cost ($) before certificates	Cost savings ($/a)	Simple payback (years) excl. Certificates	Certificate Value ($)	Net Payback, incl certs (years)	Carbon savings (T-CO2-e p.a.)	Time-frame	Electricity Savings (MWh)	Gas Savings (GJ)
		Biogas Led Scenario		**$25,275,382**	**$2,492,446**	**10.1**	**$2,236,788**	**9.2**	**4,302**	**Dec-27**	**2,741**	**68,733**
Solar	4.4 MW Solar	4.4 MW Solar (900 kW rooftop + 3.5 MW SAT)	Y	$6,688,900	$887,366	7.5	$1,184,722	6.0	3,015	Dec-27	4,785	0
Solar	Hot Water Storage	368 kL 90°C water storage tank to shift heat pump consumption		$833,986	$0	0.0	$0	0.0	0	Jun-26	0	0
Biogas	CAL SW100	21 ML Covered Anaerobic Lagoon (All Stickwater to Drain option - SW100) capable of producing 18,900 m3 of biogas per week and Biogas treatment to upgrade Biogas to Biomethane.	Y	$13,500,000	$1,143,600	5.6	$68,000	5.6	354	Dec-27	0	18,200
Biogas	CAL SW30	12.5 ML Covered Anaerobic Lagoon (30% Stickwater to Drain option - SW30) capable of producing 10,700 m3 of biogas per week and Biogas treatment to upgrade Biogas to Biomethane.		$12,900,000	$1,536,500	3.7	$38,600	3.7	174	Dec-27	0	10,300
Energy Efficiency	WHE heat recovery	Pre-Heat Abattoir Water Using Second Waste Heat Evaporator Heat Source	Y	$70,000	$181,187	0.4	$206,806	N/A	584	Jun-25	0	11,324
Energy Efficiency	Econolisers	Replace sterilisers with econolisers and hand wash heat pump (75oC)		$2,749,146	$326,291	8.4	$769,101	6.1	687	Dec-27	-1,150	32,518
Energy Efficiency	Air Comp HR	Heat recovery from 110 kW Air compressor		$28,500	$16,560	1.7	$14,005	0.9	53	Jun-25	0	1,035
Energy Efficiency	Condensate Return HR	Use Condensate Return Flash steam to heat hot water from 55 to 90C	Y	$342,400	$40,901	8.4	$77,087	6.5	132	Dec-25	0	2,556
Energy Efficiency	EE Design	Implementation of energy efficiency projects identified in "Design Review – Frozen Storage-Plate Freezer and Render Plant Upgrades" report and other future energy efficiency opportunities.		$574,000	$109,920	5.2	$13,000	5.1	814	Dec-25	687	0
Heat Pumps	Ammonia HP Abattoir	1 - Ammonia heat pump to provide 90°C water with storage (95m3) to generate abattoir sterilisation and hand wash water	Y	$2,805,619	$119,333	23.5	$368,463	20.4	193	Jun-26	-993	18,637
Heat Pumps	CO2 HP Render	6a - CO2 heat pump for render hot water	Y	$1,868,464	$120,059	15.6	$331,710	12.8	24	Dec-26	-1,051	18,015
Heat Pumps	Ammonia HP (R+A)	6b - Ammonia heat pump to provide 90°C water with storage (315m3) to generate both abattoir and render hot water		$7,530,910	$324,651	23.2	$886,895	20.5	351	Jun-26	-2,202	43,557
Electrification	Electric Boilers	2 x 2.5 MVA Electric Boilers (1 x Rendering, 1 x Main Plant - feeding Rendering)		$2,310,000	$219,583	10.5	$0	10.5	707	Jun-26	-3,210	13,724
Other	Biomass Boiler	7 - Biomass boiler for remaining steam demand		$3,000,000	$519,090	5.8	$1,697,548	2.5	2,803	Dec-27	0	55,909
Other	TES w/ Spot Exposure	28 MWh thermal energy storage system exposed to the spot market on a child or separate NMI		$10,130,000	$476,943	21.2	$0	21.2	0	Dec-26	-8,804	36,807

Table 7 - Efficiency Led Scenario Project List

Technology Category	Short Name	Project Name	Project selection	Estimated project cost ($) before certificates	Cost savings ($/a)	Simple payback (years) excl. Certificates	Certificate Value ($)	Net Payback, incl certs (years)	Carbon savings (T-CO2-e p.a.)	Time-frame	Electricity Savings (MWh)	Gas Savings (GJ)
		Efficiency Led Scenario		**$12,334,992**	**$1,944,340**	**6.3**	**$3,626,117**	**4.5**	**7,777**	**Dec-27**	**4,818**	**88,427**
Solar	4.5 MW Solar	4.5 MW Solar (900 kW rooftop + 3.6 MW SAT)	Y	$6,916,500	$936,271	7.4	$1,225,779	6.1	3,119	Dec-27	4,951	0
Solar	Hot Water Storage	368 kL 90°C water storage tank to shift heat pump consumption		$833,986	$0	0.0	$0	0.0	0	Jun-26	0	0
Biogas	CAL SW100	21 ML Covered Anaerobic Lagoon (All Stickwater to Drain option - SW100) capable of producing 18,900 m3 of biogas per week and Biogas treatment to upgrade Biogas to Biomethane.		$13,500,000	$1,143,600	5.6	$68,000	5.6	354	Dec-27	0	18,200
Biogas	CAL SW30	12.5 ML Covered Anaerobic Lagoon (30% Stickwater to Drain option - SW30) capable of producing 10,700 m3 of biogas per week and Biogas treatment to upgrade Biogas to Biomethane.		$12,900,000	$1,536,500	3.7	$38,600	3.7	174	Dec-27	0	10,300
Energy Efficiency	WHE heat recovery	Pre-Heat Abattoir Water Using Second Waste Heat Evaporator Heat Source	Y	$70,000	$181,187	0.4	$206,806	N/A	584	Jun-25	0	11,324
Energy Efficiency	Econolisers	Replace sterilisers with econolisers and hand wash heat pump (75oC)	Y	$1,432,092	$156,971	9.1	$405,897	6.5	326	Dec-27	-820	18,637
Energy Efficiency	Air Comp HR	Heat recovery from 110 kW Air compressor		$28,500	$16,560	1.7	$14,005	0.9	53	Jun-25	0	1,035
Energy Efficiency	Condensate Return HR	Use Condensate Return Flash steam to heat hot water from 55 to 90C	Y	$342,400	$40,901	8.4	$77,087	6.5	132	Dec-25	0	2,556
Energy Efficiency	EE Design	Implementation of energy efficiency projects identified in “Design Review – Frozen Storage-Plate Freezer and Render Plant Upgrades” report and other future energy efficiency opportunities.	Y	$574,000	$109,920	5.2	$13,000	5.1	814	Dec-25	687	0
Heat Pumps	Ammonia HP Abattoir	1 - Ammonia heat pump to provide 90°C water with storage (95m3) to generate abattoir sterilisation and hand wash water		$2,805,619	$119,333	23.5	$368,463	20.4	193	Jan-00	-993	18,637
Heat Pumps	CO2 HP Render	6a - CO2 heat pump for render hot water		$1,868,464	$120,059	15.6	$331,710	12.8	24	Dec-26	-1,051	18,015
Heat Pumps	Ammonia HP (R+A)	6b - Ammonia heat pump to provide 90°C water with storage (315m3) to generate both abattoir and render hot water		$7,530,910	$324,651	23.2	$886,895	20.5	351	Jun-26	-2,202	43,557
Electrification	Electric Boilers	2 x 2.5 MVA Electric Boilers (1 x Rendering, 1 x Main Plant - feeding Rendering)		$2,310,000	$219,583	10.5	$0	10.5	707	Jun-26	-3,210	13,724
Other	Biomass Boiler	7 - Biomass boiler for remaining steam demand	Y	$3,000,000	$519,090	5.8	$1,697,548	2.5	2,803	Dec-27	0	55,909
Other	TES w/ Spot Exposure	28 MWh thermal energy storage system exposed to the spot market on a child or separate NMI		$10,130,000	$476,943	21.2	$0	21.2	0	Dec-26	-8,804	36,807

Table 8 - Full Electrification Scenario Project List

Technology Category	Short Name	Project Name	Project selection	Estimated project cost ($) before certificates	Cost savings ($/a)	Simple payback (years) excl. Certificates	Certificate Value ($)	Net Payback, incl certs (years)	Carbon savings (T-CO2-e p.a.)	Time-frame	Electricity Savings (MWh)	Gas Savings (GJ)
		Full Electrification Scenario		**$29,567,756**	**$2,465,165**	**12.0**	**$3,498,311**	**10.6**	**7,103**	**Dec-27**	**-7,201**	**101,297**
Solar	8.8 MW Solar	8.8 MW Solar (900 kW rooftop and 7.9 MW ground-mount)	Y	$13,414,800	$1,265,800	10.6	$2,476,811	8.6	4,958	Dec-26	6,739	0
Solar	Hot Water Storage	368 kL 90°C water storage tank to shift heat pump consumption		$833,986	$0	0.0	$0	0.0	0	Jun-26	0	0
Biogas	CAL SW100	21 ML Covered Anaerobic Lagoon (All Stickwater to Drain option - SW100) capable of producing 18,900 m3 of biogas per week and Biogas treatment to upgrade Biogas to Biomethane.		$13,500,000	$1,143,600	5.6	$68,000	5.6	354	Dec-27	0	18,200
Biogas	CAL SW30	12.5 ML Covered Anaerobic Lagoon (30% Stickwater to Drain option - SW30) capable of producing 10,700 m3 of biogas per week and Biogas treatment to upgrade Biogas to Biomethane.		$12,900,000	$1,536,500	3.7	$38,600	3.7	174	Dec-27	0	10,300
Energy Efficiency	WHE heat recovery	Pre-Heat Abattoir Water Using Second Waste Heat Evaporator Heat Source	Y	$70,000	$181,187	0.4	$206,806	N/A	584	Jun-25	0	11,324
Energy Efficiency	Econolisers	Replace sterilisers with econolisers and hand wash heat pump (75oC)	Y	$1,432,092	$156,971	8.4	$405,897	6.1	687	Dec-27	-820	18,637
Energy Efficiency	Air Comp HR	Heat recovery from 110 kW Air compressor		$28,500	$16,560	1.7	$14,005	0.9	53	Jun-25	0	1,035
Energy Efficiency	Condensate Return HR	Use Condensate Return Flash steam to heat hot water from 55 to 90C	Y	$342,400	$40,901	8.4	$77,087	6.5	132	Dec-25	0	2,556
Energy Efficiency	EE Design	Implementation of energy efficiency projects identified in "Design Review – Frozen Storage-Plate Freezer and Render Plant Upgrades" report and other future energy efficiency opportunities.	Y	$574,000	$109,920	5.2	$13,000	5.1	814	Dec-25	687	0
Heat Pumps	Ammonia HP Abattoir	1 - Ammonia heat pump to provide 90°C water with storage (95m3) to generate abattoir sterilisation and hand wash water		$2,805,619	$119,333	23.5	$368,463	20.4	193	Jun-26	-993	18,637
Heat Pumps	CO2 HP Render	6a - CO2 heat pump for render hot water	Y	$1,868,464	$120,059	15.6	$331,710	12.8	24	Dec-26	-1,051	18,015
Heat Pumps	Ammonia HP (R+A)	6b - Ammonia heat pump to provide 90°C water with storage (315m3) to generate both abattoir and render hot water		$7,530,910	$324,651	23.2	$886,895	20.5	351	Jun-26	-2,202	43,557
Electrification	Electric Boilers	2 x 2.5 MVA Electric Boilers (1 x Rendering, 1 x Main Plant - feeding Rendering)	Y	$2,310,000	$223,304	10.3	$0	10.3	719	Dec-26	-3,265	13,957
Other	Biomass Boiler	7 - Biomass boiler for remaining steam demand		$3,000,000	$519,090	5.8	$1,697,548	2.5	2,803	Dec-27	0	55,909
Other	TES w/ Spot Exposure	28 MWh thermal energy storage system exposed to the spot market on a child or separate NMI	Y	$10,130,000	$476,943	21.2	$0	21.2	0	Dec-26	-8,804	36,807

Appendix E
Metering & Monitoring Plan

Metering and Monitoring Plan

Prepared for G & K O'Connor

31 May 2024

Contact:

Huon Seymour

Senior Consultant

Northmore Gordon

E: h.seymour@northmoregordon.com

M: +61 474 216 534

1.2 Objectives

This Metering and Monitoring Plan includes recommendations for additional metering at the Pakenham facility and a high-level monitoring strategy.

The primary objectives of the Metering & Monitoring Project are to:

- Install additional metering to address the gaps in the existing metering systems for electricity, gas, steam and water.
- Consolidate existing metering and new metering into a single monitoring system.
- Implement a monitoring system, to collect and present information from relevant site meters.
- Configure the monitoring system with the following key features:
    - Automatic meter data collection and collation.
    - Automatic reporting of key consumption information and trends.
    - Energy use visualisation via monitoring dashboards.
    - Energy performance indicator (EnPI) and KPI tracking for key plant areas/equipment
    - Automated notifications for abnormal energy use.

Completion of this project will allow G&K O'Connor to:

- Reduce workload and inefficiencies associated with manually recording and tracking energy and water data.
- Increase visibility of and access to energy and water data across the Pakenham site.
- Enable an energy and water balance analysis to be conducted, breaking down total consumption by different areas of the site.
- Baseline energy and water performance so that savings from energy and water efficiency projects can be estimated.
- Identify unexpected increases to energy use and water consumption.
- Validate billing information against onsite meters.
- Track energy and water use for each area of the plant, assigning resource costs to these areas.
- Streamline routine environmental reporting procedures.
- Ensure that energy and water consumption does not drift over time.
- Build on the monitoring system implementation to develop a formal Energy Management System (EnMS)
- Enable the creation and sale of energy savings certificates from future energy efficiency initiatives.
- Detect poorly performing areas or equipment early.

1.3 Metering Methodology

The proposed methodology for rolling out metering across the G&K O'Connor site involves four stages that focus on first getting visibility of the energy service and then focussing on end users:

1. Site-level energy and water use, where the meters are placed at the site boundary and are recording the energy/resource input (e.g. gas, electricity, water).
2. Behind-the-meter (i.e. on site) energy generation, where meters are placed at the output of energy generation equipment or services (e.g. gas-fired steam boilers).
3. Plant area or production-line level energy use, where meters are placed at the boundary of energy using systems (e.g. render plant or refrigeration).

4. End-use equipment (e.g. production equipment, individual chillers, fans).

This approach enables increased understanding of energy use by use area. The stages are rolled out as G&K O'Connor find value in using the energy data to improve operational decision-making and identify plant improvements. This metering and monitoring plan will focus on implementing metering which will provide the most useful insight across the four stages. There will be comprehensive stage 1 (site level) and stage 2 (generation) metering, high level area metering for stage 3 (abattoir, refrigeration plant, render plant and waste water plant), and metering of specific large energy using equipment. This approach has been chosen as:

- The type 2 energy audit provided guidance as to the Significant Energy Users (SEUs), and the approach chosen reflects these (refer below).
- Electricity distribution information was not well documented at the commencement of the metering project, so was not able to be used to identify deeper area level electricity metering.
- In discussion with subject matter experts regarding electricity distribution, it was identified that the electrical distribution boards are not necessarily aligned with production areas/lines in the abattoir. As a result, metering of the numerous distribution boards would not provide a clear pictureFigure 1 of energy use by production area/line.

The electricity use breakdown from the Type 2 Energy Audit is shown below. This shows that there are notable large individual users (the refrigeration plant, aerators etc), and there are usage categories which consist of many items spread across the site (pumps, motors & fans).

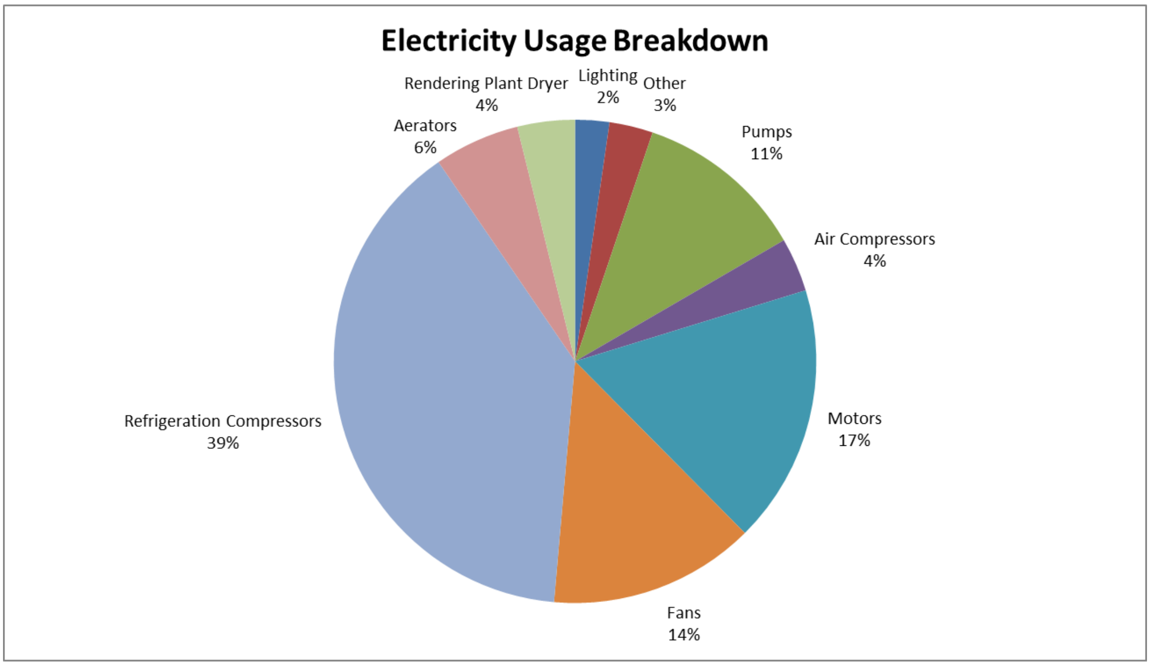


Figure 1-1 - Electricity end use breakdown - Figure 10 in the Type 2 Energy Audit by Northmore Gordon

Existing Meters

To minimise metering costs, existing meters are used where available and suitable. Where there are existing meters, the metering installation (particularly important for flow meters) and meter suitability have been checked to ensure that they are providing accurate data before they are relied upon for ongoing monitoring and performance tracking. Where meters require some alteration (for example if they don't have a suitable communications protocol), they are listed as “modified” in the meter list. Existing and modified meters are included in Appendix B - Meter List.

Virtual Meters

For smaller plant equipment or equipment with low operating hours, it may be suitable to set up a virtual/proxy meter, which will leverage existing equipment to *estimate* energy use. If a relevant and appropriate point is already available in the SCADA, such as motor current draw (amps), a proxy meter may be set up as a calculation within the PLC. This is the lowest cost way to begin monitoring the energy use of the equipment or system, however, also provides the lowest accuracy data and must be used with caution.

The best example of this is a variable speed drive (VSD) that has an analogue output of the estimated power draw the motor it is controlling. This analogue output is based on an internal calculation within the VSD based on real current (amps) reading and assumed voltage and so is not a true power measurement. In this case, if the power draw of the VSD is not currently monitored by the SCADA, there may be some programming or wiring costs to connect and configure them in the SCADA system. This power draw may then be monitored and if deemed necessary, can be used to justify the installation of additional real power metering. Energy consumption from VSDs are identified in Appendix B - Meter List.

1.4 Monitoring Methodology

Currently a limited amount of sub-metering data is available via the refrigeration and Render 6MW steam boiler HMIs, and the Render plant SCADA system. No historian system is installed, and data is only being stored for up to 20 days.

Without effective monitoring, any type of metering is of little value. As such, it is recommended that all electrical, gas, compressed air, water and steam metering be connected to a dedicated energy/environmental monitoring software system. Additionally, any metering with process implications should be connected to the existing site SCADA system, if not already connected.

The selection of a suitable monitoring software platform and the configuration of this platform to meet G&K O'Connor's needs is discussed in depth in Section 2.

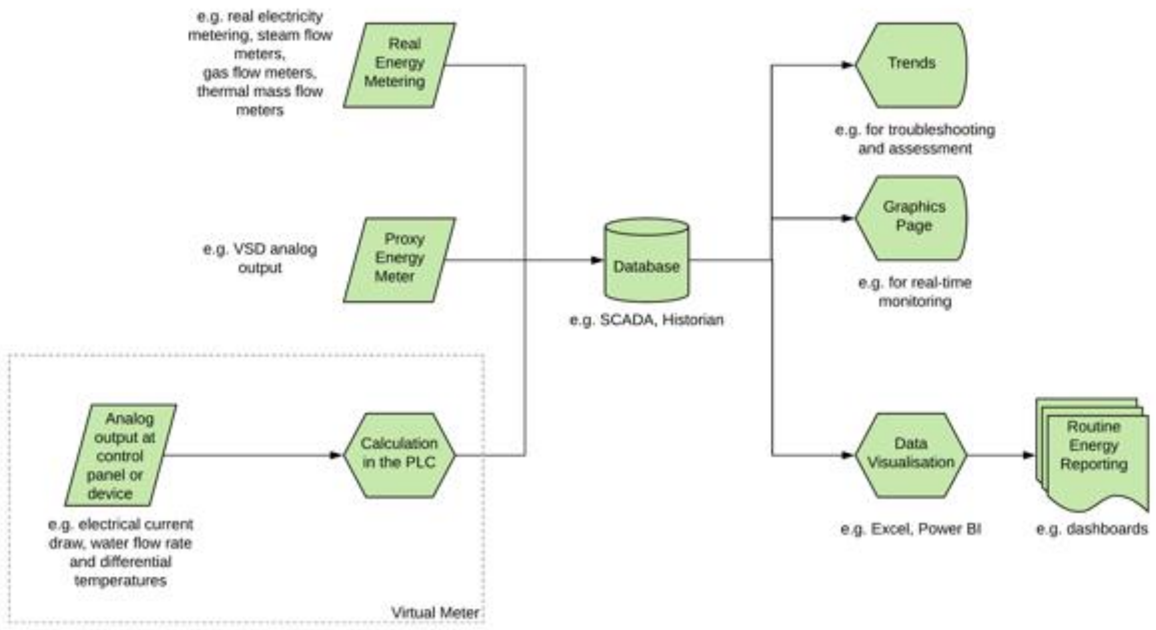


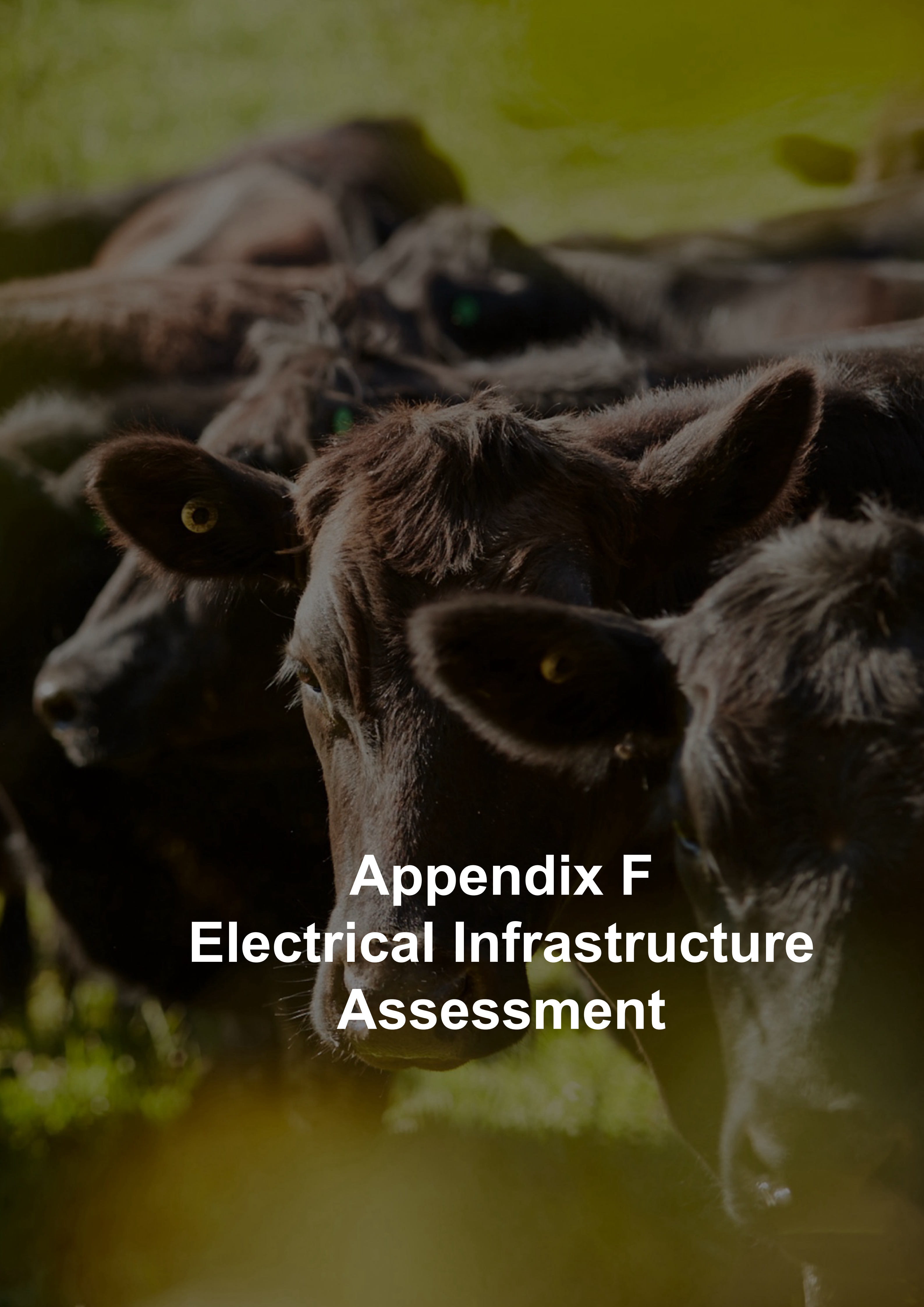
Figure 12. Example monitoring plan methodology & data flow

1.5 Assumptions and Limitations

During the development of this metering and monitoring plan, a number of assumptions and limitations were identified:

- An up to date inventory of key equipment was not available for the Pakenham site and so primary equipment was determined via discussions with G&K O'Connor personnel and available P&IDs.
- There are no P&IDs available for much of the Abattoir (production processes, hot and cold water, compressed air). P&IDs do exist for refrigeration, the rendering plant and waste water.
- Single Line Diagrams (SLDs) for electricity have low levels of availability. The rendering plant SLD has the supply from the incomer to the three separate feeds (render MCC, waste water & the vent fan). The refrigeration plant has available SLDs, but the abattoir does not.
- The first round of metering will focus on capturing sufficient energy and water consumption data at the site and key process/equipment level, with specific opportunity metering to be handled in later rounds of metering.
- Metering and monitoring system assessments and recommendations are made based on the information provided by G&K O'Connor personnel at the time of the project. This information may not always be complete or accurately reflect the situation on site, and so discrepancies may occur.
- Upgrades of the Render plant including PLC and SCADA, wastewater plant and a new cold storage facility are being undertaken as separate projects by G&K O'Connor. These affect the implementation timing of the metering recommended in this plan.

Consideration will have to be made of potential disruptions to production during the installation of metering. The single greatest disruption to the metering rollout may be the need to organise metering installation around production (in particular, for meters requiring areas of the plant to be temporarily shut down).



Appendix F
Electrical Infrastructure
Assessment

5 Grid connection: Initial review

5.1 General

Enhar has conducted an initial review of grid connection constraints and requirements; based on initial system sizes by another consultant. The final connection details are unknown; however based on initial discussions the follow configurations could be adopted:

- **Main plant**:
  - **Existing:** 2 X 1000kVA Transformers; with existing 1040kVA existing solar capacity.
  - **Proposed**: up to 3MVA new solar all export limited to 2MVA; new 1MVA biogas unit, and potential large BESS. Generation/BESS capacity significantly larger than transformer capacity
- **Render plant**:
  - **Existing:** 1.5MVA existing transformer with no existing solar PV
  - **Proposed:** 2.5MVA new solar export limited to 1.5MVA; and potential large BESS. Generation/BESS capacity significantly larger than transformer capacity
- **New Cold Storage Facility**:
  - **Existing**: 1.5MVA transformer; Ausnet approved new transformer of this capacity.
  - **Proposed**: 2.5MVA new solar export limited to 1.5MVA; potential for large BESS. Generation/BESS capacity significantly larger than transformer capacity

5.2 Initial Ausnet review and meeting

Enhar conducted an initial meeting with Ausnet to discuss potential connection requirements and constraints for the system sizes.

There is significant concern and risk to the viability of system sizes recommended by the solar consultant, with the addition of significant capacity of PV, cogen and batteries; which is significantly higher kVA than current transformer and switchboard capacity. Without full upgrade of existing transformers and considering significant capacity proposed the following questions were asked at the meeting with Ausnet:

1. **Will Ausnet allow in principle the following arrangement or similar?**

- Main plant: 2MVA existing transformer with new 1MVA biogas unit, 1MVA existing solar and 3MVA new solar all export limited to 2MVA
- Render plant: 1.5MVA existing transformer with 2.5MVA new solar export limited to 1.5MVA
- New Cold Storage Facility: 1.5MVA transformer with 2.5MVA new solar export limited to 1.5MVA

Note this is not the final recommended configuration, however Enhar wanted to have specific system sizes for them to consider and confirm that we can size the generation larger than the kVA supply with export limiting; rather than full site upgrades.

Ausnet answered that we can have oversized generators > kVA transformer rating, provided that the export limit and import limit controls can meet the required time frames and avoid tripping the site main breaker. This is likely to require hardwired comms to all inverter/battery systems to ensure required timeframes. This is also likely to require a separate protection trip of the solar/battery when the site main switch gets close to tripping in either direction.

Existing PV systems would be required to be incorporate into the central hardwired protection system; located at the MSB.

2. **Will Ausnet allow in principle the addition of 1MVA batteries to each supply listed above with export and import limiting?**

Note this is not final recommended configuration from the consultants – however Enhar wanted to have specific system sizes for Ausnet to consider and confirm that we can size the generation larger than the supply with export limiting; rather than undertake full site upgrades.

Ausnet's responses were positive and batteries can be added with the same caveats as answer 1.

3. **Ausnet SOP 11-16 requires protection for generator systems >1.5MVA to be located on the customers HV main switch. Can we locate it on the LV side as we are an LV customer?**

This is acceptable; and Ausnet will allow low voltage protection. Noting that systems above 1.5MVa normally required a HV protection.

4. Is there any detail available on the required protection and system studies?

The protection requirements are in Ausnet SOP 11-16. At the time of report preparation Ausnet had not yet provided the final details of the system studies required for the grid connection application.

5. Are there any constraints on the system?

For the purposes of the preliminary Ausnet meeting and without the final system capacities;

The main plant will be in the bracket 1.5MVA to 5MVA. The other two sites will only be in the bracket 1.5MVA to 5MVA if batteries are added.

A protection study is required from 1.5MVA to 5MVA for the main plant as detailed in Ausnet SOP 11-16

A protection study is required from 1.5MVA to 5MVA for the other two sites only if batteries are added, as detailed in Ausnet SOP 11-16

There are no other large generators on the existing HV feeder.

There is a major line on Koo-Wee-Rup road which can handle significant load and generation capacity.

A significant risk to the project is that upgrade of the HV feeder from Koo Wee Rup Road may be required, but this will only be confirmed following HV grid studies undertaken during a full grid application.

Another risk to the project is that each application for the separate NMI's will be treated separately; and additional requirements and restrictions required for later systems.

6. What is the Ausnet fee structure?

The Ausnet fee structure for an LV application up to 1.5MVA will be approx. $3k per NMI.

The Ausnet fee structure for an LV application in the bracket of 1.5MVA to 5MVA will be approx. $60k per NMI

It is understood that all systems being recommended will fall into the 1.5MVA to 5MVA bracket

7. What about converting to become a HV customer?

If the system was converted to a single HV connection then G. & K. O'Conner would buy the transformers from Ausnet and run a single connection application for the whole site. All operations and maintenance of the G. & K. O'Conner owned HV assets would then be by G. & K. O'Conner so specialised HV operators would be required. This is often contracted out. Enhar understands that the transformer condition is below average.

In terms of system capacity, this would result in a system capacity above 5MVA connected to a single electrical connection/NMI and would therefore be subject to AEMO compliance and requirements. Refer to discussion in section 5.5.

5.3 Grid connection of various sizes proposed in the feasibility study

The current option for 9MVA of solar inverter capacity (total new and existing) is being considered. This could consist of the following breakdown:

- Main plant: 2MVA existing transformer with new 1MVA biogas unit, 1MVA existing solar and 3MVA new solar all export limited to 2MVA
- Render plant: 1.5MVA existing transformer with 2.5MVA new solar export limited to 1.5MVA
- New Cold Storage Facility: 1.5MVA transformer with 2.5MVA new solar export limited to 1.5MVA
- Options for 1MVA batteries on each supply.

This arrangement is feasible, based on Ausnet advice as detailed above; however will require generation export control to be implemented.

The typical DC panel capacity would be 10.8MWp and will depend on the final configuration recommended by the solar consultants.

5.4 AusNet grid connection requirements for various system sizes, 200kVA to 1.5MVA and 1.5MVA to 5MVA

- **Grid protection:** Ausnet require the grid protection relay voltage sensing to be located at the main switchboard. This is also a requirement of AS4777.1 however other supply authorities allow the voltage sensing to be located at the PVDB. Enhar notes that there are a number of existing systems on site which don't comply with the Ausnet requirement. Enhar believes these systems will be required to be upgraded during any future solar installation.
- **Volt Rise:** Ausnet requires AC volt rise of all solar together to be less than 2%. This is also a requirement of AS5033.
- **SLD formatting:** Ausnet requires SLDs to be in a particular format with tables for the protection and the ratings as well as statements about the failsafe nature of the protection arrangements.
- **Injection testing**: Ausnet requires injection testing of the grid protection relay and power quality testing of the inverter system at final commissioning.
- **Back Stop Facility/remote distributor control**: The Victorian Government has recently gazetted a requirement that all systems above 200kVA have a backstop facility. With this facility the supply authority can turn off the solar remotely. So far Ausnet have not communicated any detailed requirements for this; however considering a Victorian Government requirements, it is likely to be required when systems are installed. This will be problematic at the Main plant with the existing systems
- **Protection and HV studies From 1.5MVA to 5MVA**: Ausnet require protection studies and other system studies. Ausnet are providing information on the system studies requirements.

5.5 AEMO requirements, risks, barriers for systems above 5MVA

For generation capacity above 5MVA the compliance requirements are significantly higher, the timelines significantly longer and the resultant costs significantly higher.

Total system capacity at the site is above >5MVA at the site, however the generation will be connected to 3 NMI's/electrical supplies with a system capacity of <5VA on each NMI/electrical connection. Each transformer is connected via a single HV feeder.

There is a risk to the project that the system may be considered above 5MVA; considering a single HV feeder and 3 separate NMI's on a single site, and therefore there is a risk that AEMO compliance may be required.

Normally only one NMI is allowed per property; however a new transformer has recently been approved by Ausnet.

AEMO PROCESS: AEMO have a process to follow for system sizes between 5MVA to 30MVA. AEMO modelling requirements are available at:

https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/modelling-requirements

These requirements state that applications to meet AEMO's requirements go through the supply authority, in this case Ausnet.

The Ausnet process for >5MVA is detailed at:

https://www.ausnetservices.com.au/-/media/project/ausnet/corporate-website/files/solar/5000kw-or-greater/embedded-generation-guidelines-sop-33-05_issue-5---jul-2023.pdf?rev=93456385a30e4d65a79c91e6ff4775aa

This Ausnet guideline includes the following flowchart:

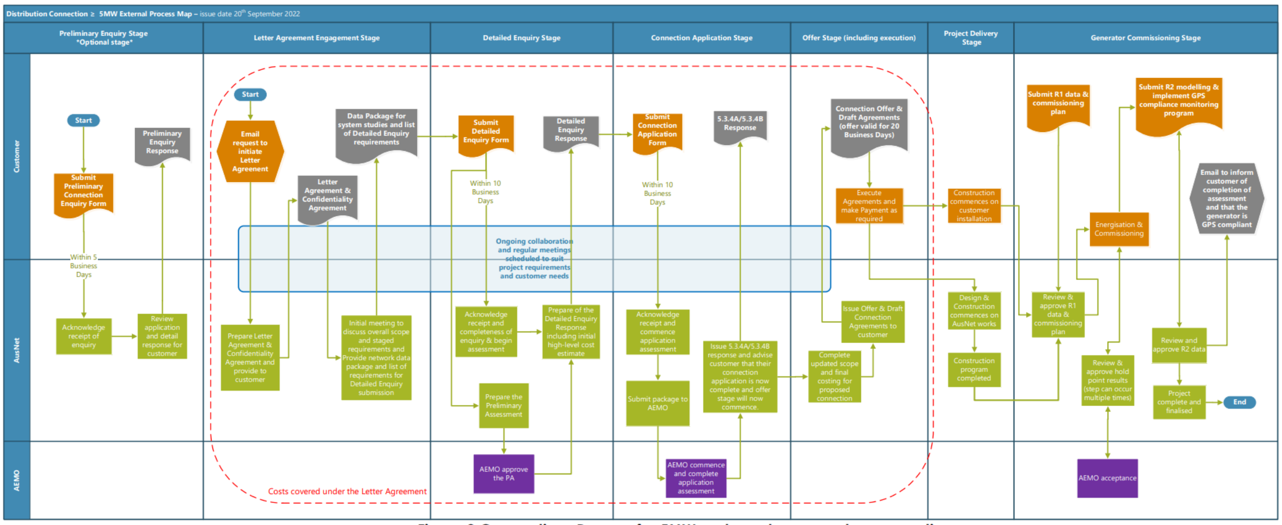


Figure 2 Connections Process for 5MW and greater generator connections

Figure 5-1: Ausnet process >5MVa

The AEMO process for grid connection approval will take approximately 2 years.

Modelling Requirements: The modelling requirements of >5MVA are more strict than those of <5MVA Pages 20 and 21 section 4.1.1. Access standards shows the generator access standards which must be met and which of these include AEMO checks.

Additional protection and control requirements: Additional protection and controls are required for >5MVA as per these generator access standards. A new HV switchboard would be required to incorporate the additional protection and controls. This would mean that LV connection is not viable; the site would need to become a HV customer and existing PV systems incorporation.

Costs: Estimated charges for the Ausnet component of the work are provided in table 3 on page 40. The estimated total application cost is on average $600K; dependant on the final studies required. This cost does not include additional HV protection requirements.

5.6 Recommendations on optimum sizing and solutions

Based on grid connection requirements, the optimum system sizing would be below 1.5MVA installed to each NMI/electrical connection, as well maintaining total capacity to below <5MVA to limit risk of AEMO compliance.

5.7 Required grid protection requirements for proposed system options and viability

A grid protection relay is required by the distributor to back up the protection in the inverters. This relay is programmed for under and over voltage, average overvoltage, under and over frequency, rocof and vector shift. The purpose is to avoid islanding of the group of inverters as a whole.

The inverters themselves are programmed for stage 1 and stage 2 under and over voltage, average overvoltage, under and over frequency and active anti-islanding (usually the frequency shift method). The purpose is to avoid islanding.

Some supply authorities require neutral voltage displacement protection on systems above 1.5MVA however Ausnet have not required this. It would be hard to implement in this case as it requires voltage transformers on the HV side; however this provides a risk to the project if Ausnet requires it.

Above 1.5MVA Ausnet require a protection report showing the discrimination studies for the generation and battery. This will show selectivity and cascading of the protection elements (circuit breakers and fuses) from the site main switch to the inverters. Ausnet also require a model which they can fit into their existing model of the HV system.

5.8 Required metering requirements for proposed system options

For Large Scale Generation Certificate (LGC) systems a powermeter is required on the solar generation. This power meter must comply with the requirements of the Clean Energy Regulator. Some inverter manufacturers sell power meters that comply with the requirements and this can be a good option as a single portal can be used for the meter and the solar inverters and there may be no ongoing management fees.

For Frequency control Ancillary Services (FCAS) a powermeter must be installed on the battery connection and site output. This meter must be suitable for high speed recording and reporting, depending on the markets the system is participating in.

For export limiting a powermeter is connected on the consumers mains and is used to ramp the inverters to keep the site output from exceeding a set value. The set value is provided by the Supply Authority Ausnet. This powermeter is usually the same brand as the solar inverters.

For import limiting a powermeter is connected to the consumers mains and is used to ramp the battery charging to keep the site import from exceeding a set value. This set value is normally the site main switch setting minus a small offset.

5.9 Required power systems modelling required for the system options presented

At the time of report preparation Ausnet had not provided final details.

5.10 Publicly available information on the Ausnet network

There is publicly available information on the Ausnet network but it does not include constraints. As the sites will be export limited to below transformer capacity there will be no change to transformer capacity. From dapr.ausnetservices.com.au we get:

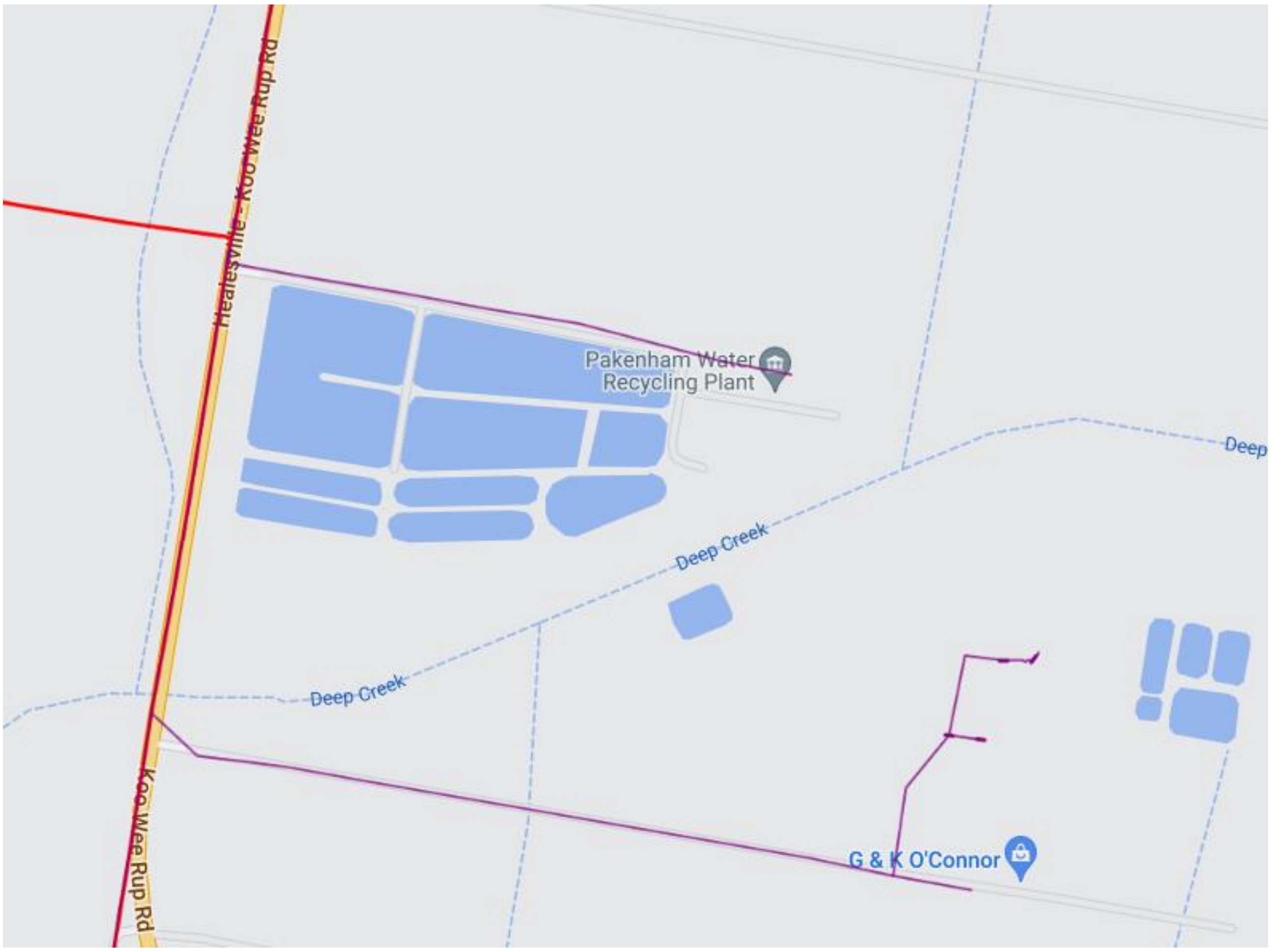


Figure 5-2: Public information on HV feeders

- **Red is 66kV**: The main red line (CLN-PHM-LLG) has capacity of 406MVA and maximum demand of 286MVA (2023)
- **Purple is 22kV**: The main purple line (PHM22) capacity is not available. The "min demand PV capacity is 2MW"

5.11 Major risks and barriers to grid connection for the system options

- **Medium Risk**: **HV connection:** There is a risk that Ausnet will reconsider and insist that a HV connection be implemented. This will result in AEMO applications which are onerous.
- **Low Risk: Generation>Supply capacity** There is a risk that Ausnet will reconsider and insist that inverter capacity is less than or equal to transformer capacity. This is a low risk, as Ausnet has initially recommended that this will not be required with suitable export control.
- **High Risk: Grid connection timeframes:** There is a risk that the connection application takes so long to approve that the installation is delayed. This is usually due to system studies taking time to develop and a lot of back and forth with Ausnet. A company with a good reputation for undertaking system studies and grid connection management should be engaged.
- **Medium Risk: Supply Upgrades:** Full upgrade of existing 22kV HV feeder to 66kV HV feeder on Koo Wee Rup road; this will only be determined following a grid application with required HV system studies completed; and comes at a very large financial cost.
- **Medium Risk: Additional constraints for separate grid applications:** Each system will be treated separately by Ausnet and grid applications may be conducted in stages; in particular the Cold Storage Facility which is yet to be constructed. There is a risk that additional requirements and restrictions will be required for the later connection applications.
- **Medium Risk: AEMO compliance:** AEMO may consider the proposed 3 separate systems as a single point of connection; due to the same HV feeder in use. Therefore the generation will be above 5MVA and be subject to AEMO requirements. This would involve significantly higher compliance, significantly longer timelines and the significantly higher costs for grid connection and controls. This would also require the site to become a HV customer; due to the requirements of a HV connection and protection.
- **Medium Risk: HV grid protection required :** Ausnet have indicated during the initial meeting that LV protection is a viable design at this site. If this is not approved by Ausnet during the final application process, then the site will be required to become a HV customer to allow a HV protection.