Meat Industry Technology Scan

April 2024

Executive Summary

EECA is committed to assisting meat processing businesses in aligning with New Zealand's climate objectives. This includes supporting the meat industry goal of reducing greenhouse gas emissions 50% by 2030, based on 2005 levels. Through the Sector Decarbonisation Programme, EECA aims to catalyse transformative changes within the industry. This Global Technology Scan offers recommendations for decarbonisation, highlighting high-impact opportunities such as heat pumps, biogas utilisation, and alternative steam generation. Additionally, demand-side strategies play a crucial role, ensuring affordability in operational and capital expenditures.

Figure 1 represents a breakdown of typical thermal energy demand onsite. The opportunities discussed within this report have been categorised to show which portion of the demand they reduce or replace.

Typical Thermal Energy Breakdown and Associated Reduction Opportunities

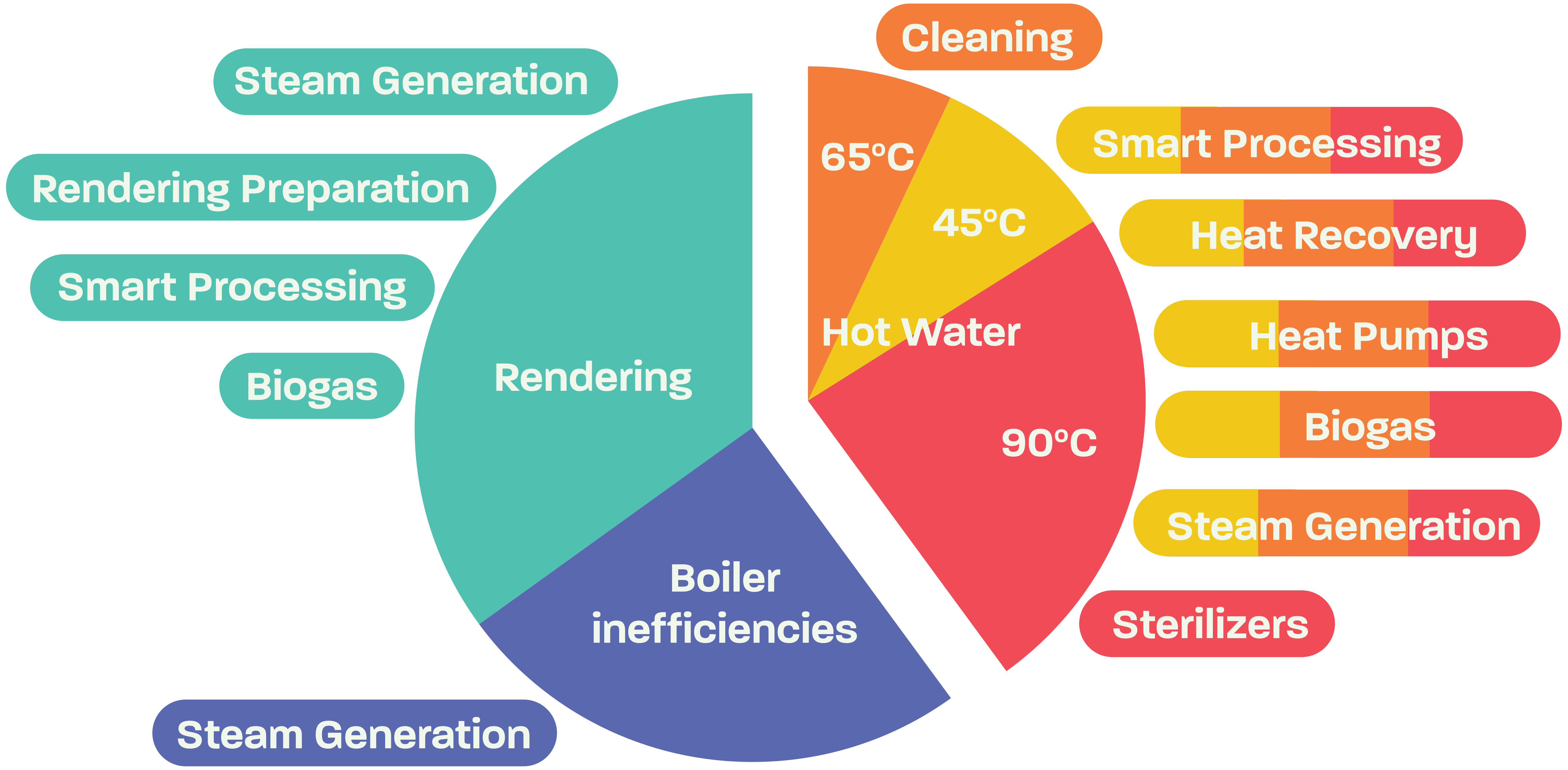


Figure.1. Typical Thermal Energy Breakdown and Associated Reduction Opportunities

Processing Overview

While the specific process flow may vary slightly across meat plants, a simplified representation typically includes the following steps. The meat processing itself generally maintains a relatively low carbon footprint, primarily relying on mechanical and electric systems powered by New Zealand's renewable electricity. However, ancillary tasks like cleaning, washing, and sterilisation significantly contribute to carbon emissions. Hot water, often heated by fossil fuels, is crucial throughout the process and constitutes the primary energy use. Decarbonisation efforts should prioritise reducing hot water consumption and then adopting high-efficiency technologies such as heat pumps and heat recovery to lessen the impact of generation. Some facilities further process byproducts through rendering, a process heavily reliant on steam which has a significant emissions impact, presenting challenges for carbon reduction due to more limited replacement options.

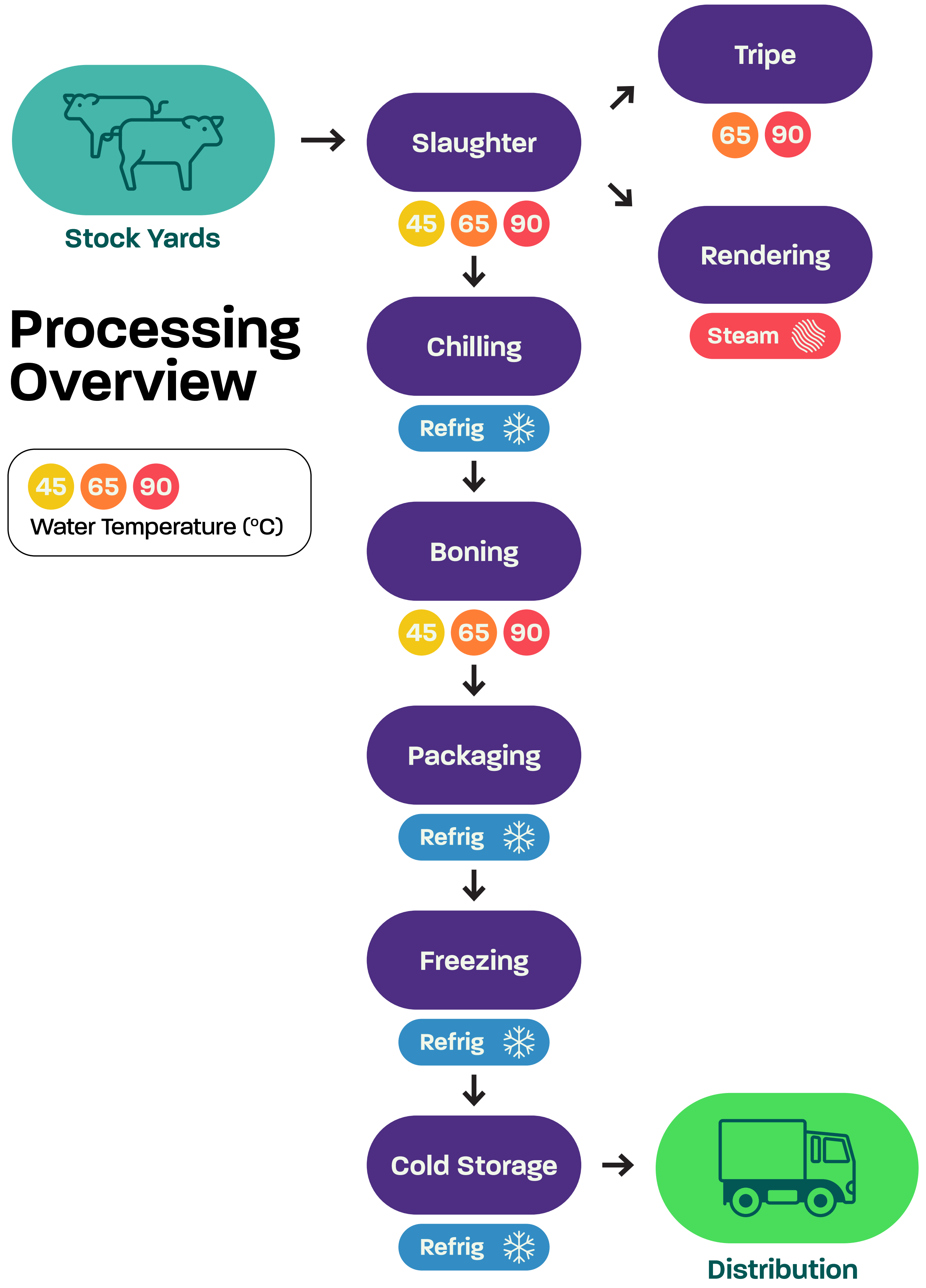


Figure.2. Processing Overview

Typical Breakdown of Electrical Energy Use

Refrigeration compressors	50%
Refrigeration fans	18%
Pumping	5%
Other	5%
Lighting	6%
Processing equipment	8%
Compressed air	8%

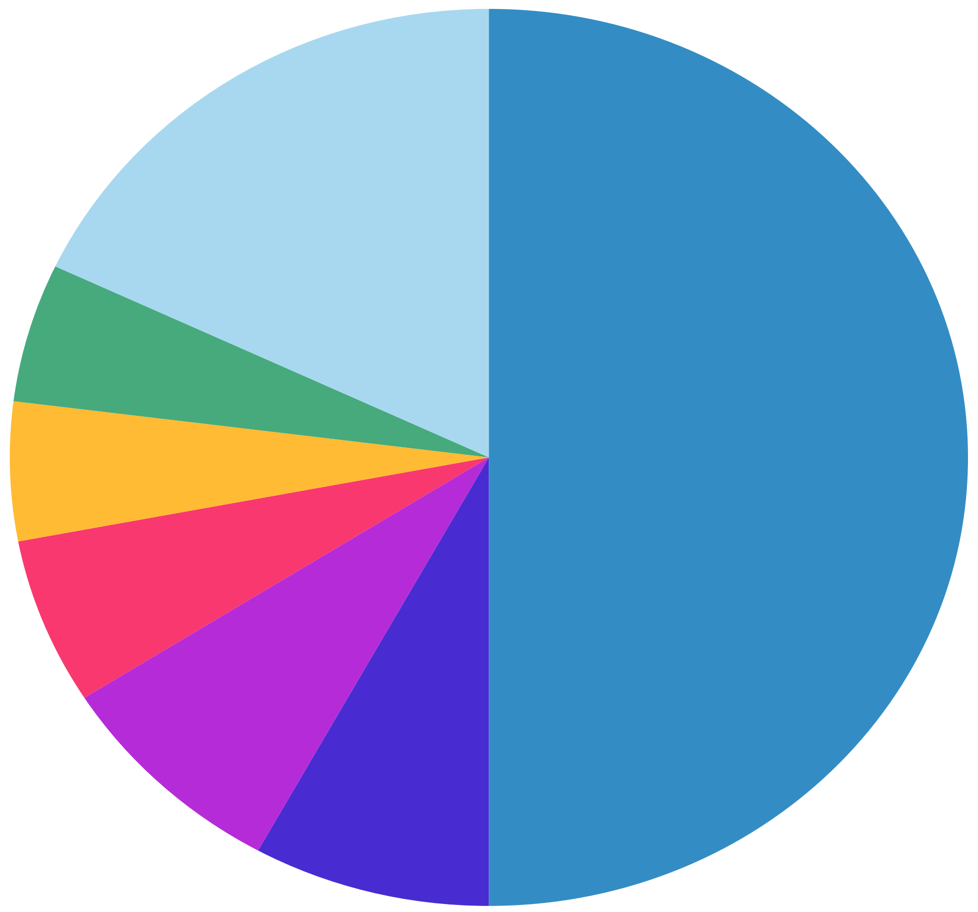


Figure.3. Typical Breakdown of Energy Use

Typical Breakdown of Thermal Energy Use

Rendering	35%
Boiler inefficiencies & Distribution losses	25%
90°C water - sterilisation	24%
45°C water - hand/apron wash	9%
65°C water - washdown hoses	7%

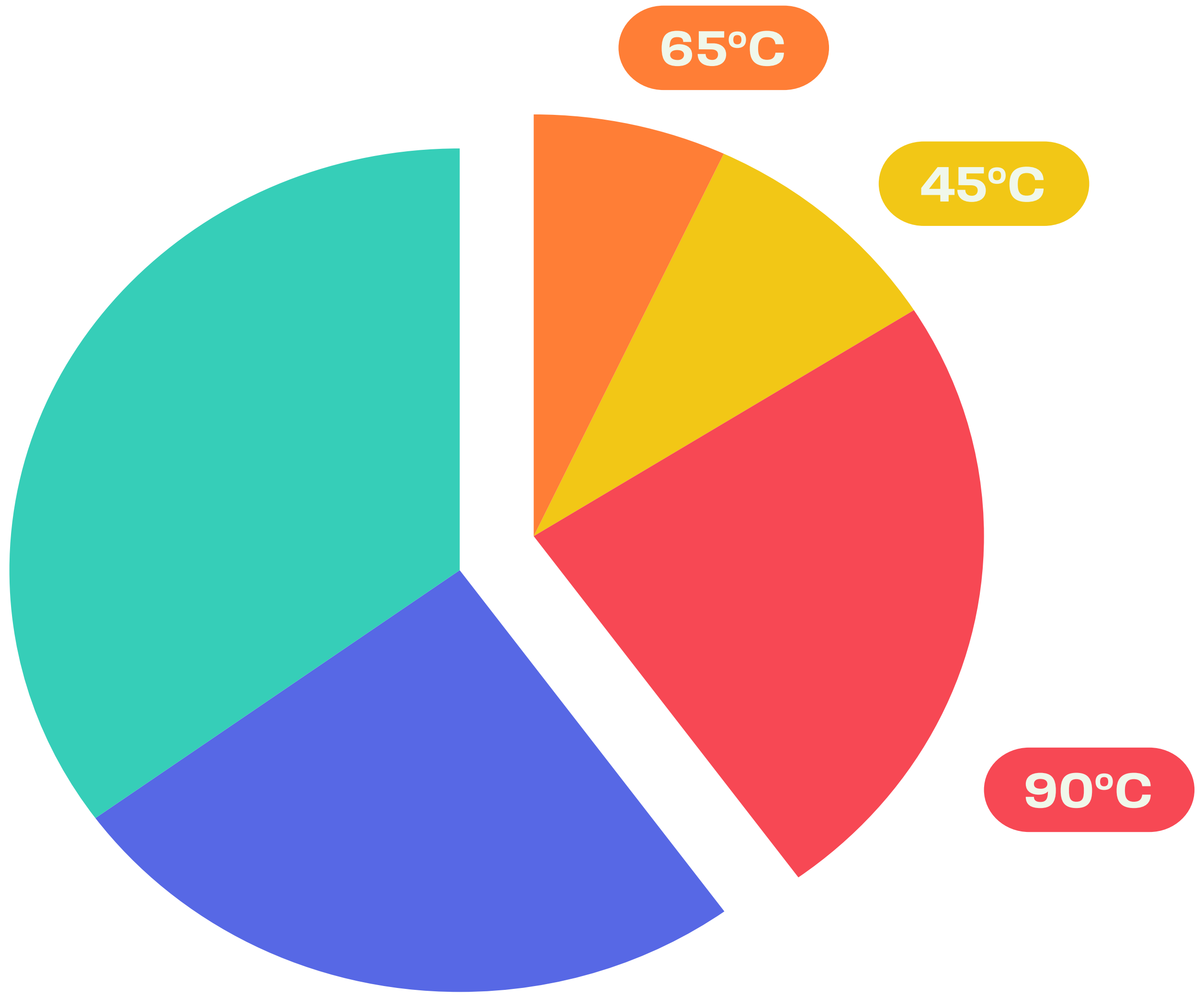


Figure.4. Typical Breakdown of Thermal Energy Use

Representative breakdown of energy usage in abattoirs derived from data collected by DETA during 7 energy audits across NZ Abbatoirs.

Global Best Practice

Energy Efficiency and Decarbonisation Strategies: Opportunities which are current best practice in the wider meat processing industry globally.

Energy Systems (Fuel Switching Opportunities)

FUEL SWITCH

- Ammonia or CO_2 Hot Water Heat Pump
- Steam boilers run using biomass, electricity or renewable diesel

Operational Processes (Technology Change)

TECHNOLOGY CHANGE

- Low water sterilisation, UV knife sterilisation
- Rendering preparation – fine crusher, moisture removal
- Smart Processing / AI / Automation
- Chemical cleaning

Waste Utilisation

WASTE UTILISATION

- Heat recovery
- Biogas

→ Top 10 Meat Exporting Countries

Key Global Markets

Differences between countries

In both Australia and Europe, biogas plants are now standard technology and are a common way to treat waste from processing plants to create a source of energy. The USA, China, and Brazil focus more on automation technology to reduce waste. Conserving and recycling water is a major concern for all countries. Brazilian company JBS are also diversifying into the lab grown meat market.

Brazil

- Largest environmental impact of industry is deforestation.
- High level of automation in both slaughter and processing of meat.
- Brazilian manufacturer JBS has started construction of commercial lab-grown meat plant with targeted 1,000 metric tonnes annual production.

USA

- Incorporating AI tech to optimise processing meat in plants through automation and reducing waste.
- Implementation of water efficiency and recycling technology, including high efficiency nozzles for cleaning and water reuse in condensers.

Australia

- Biogas capture from the meat industry wastewater, using covered anaerobic lagoon technology or high-rate reactors, is common practice in Australia. The technology significantly reduces wastewater organic loading, and the captured biogas can be used to fuel a boiler or for co-generation.
- Reduction of hot water demand by using electrical sensors on hand and apron wash stations, insulation of sterilisers to reduce heat loss, fix continuous flow sterilisers to minimum flow rate, reuse of steriliser wash water to wash yards.

Europe

- Biogas plants implemented to process by-products of the meat processing industry to reduce emissions and use biogas for fuel.

China

- Prioritising water efficiency through recycling water and increasing capacity in automation monitoring over water discharge.

Carbon Reduction Approach Applied

The focus of the analysis was on reduction of energy related emissions from 'stationary' equipment and therefore centered on the main thermal energy users at sites.

Good energy management practice suggests that demand side optimisation and energy efficiency opportunities should be focused on first, followed by fuel switching.

After compiling a comprehensive list of options, which incorporates novel and innovative technologies, the most suitable technology options were shortlisted and analysed in more detail.

Links

→ [Meat Processing Decarbonisation Pathway | EECA]

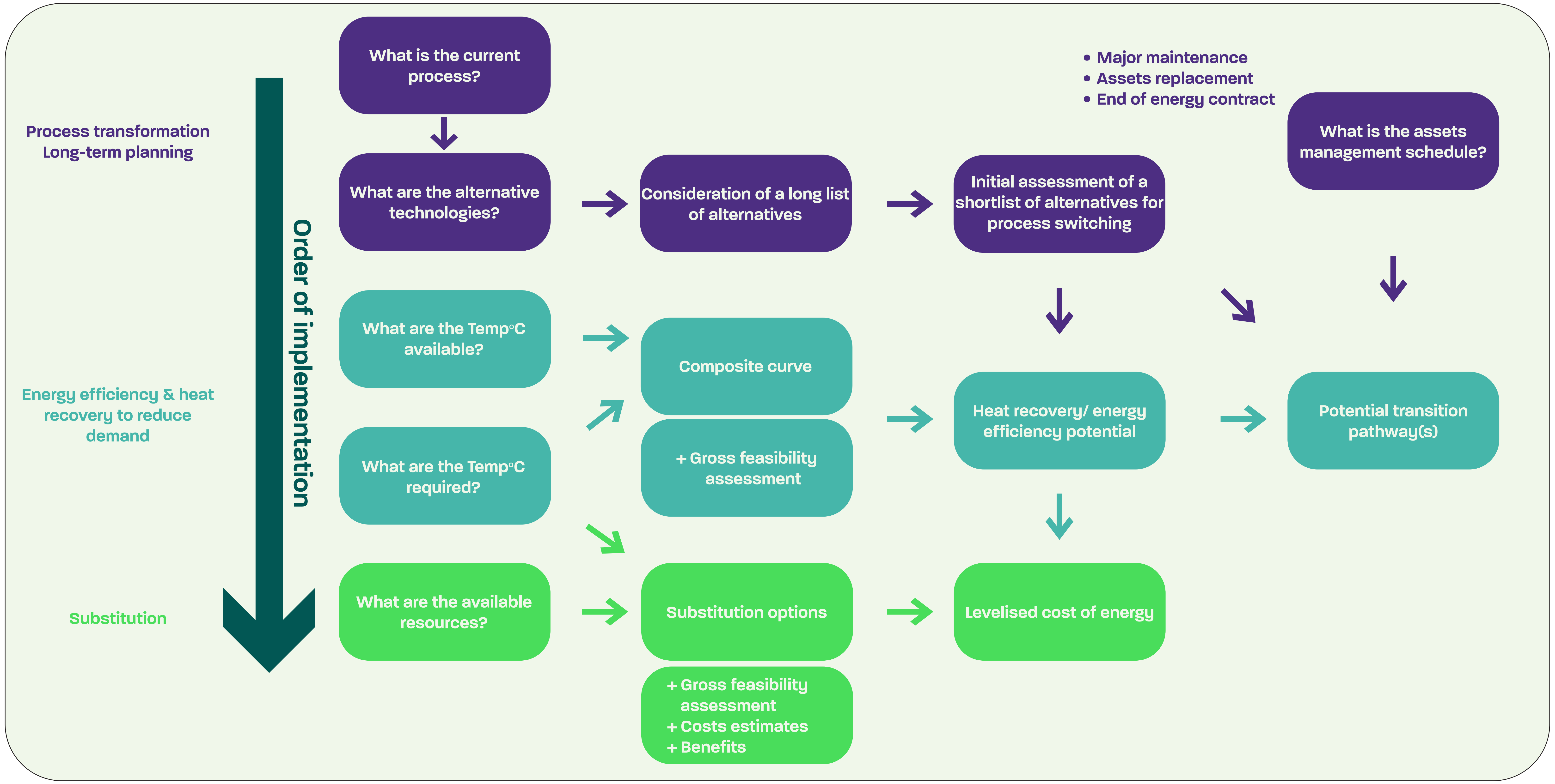


Figure.5. Recommended site carbon reduction approach

Methodology

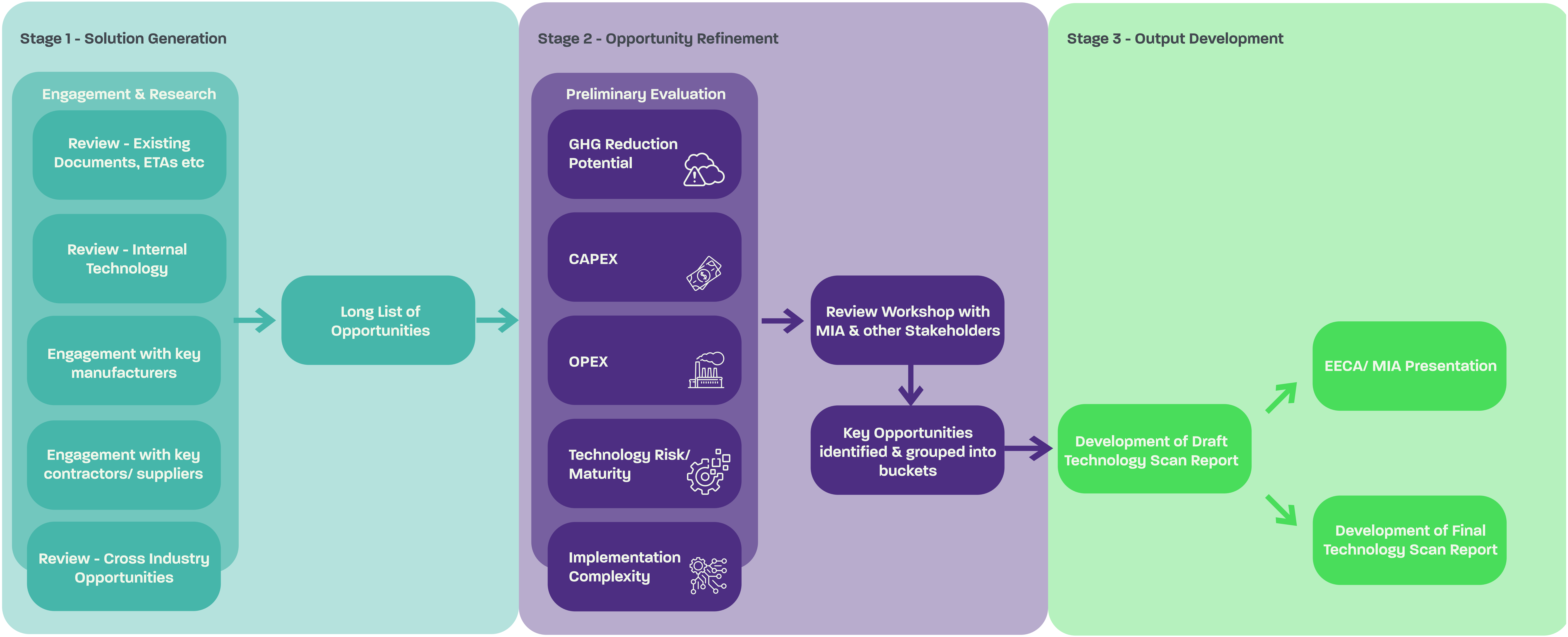
This study focuses on reducing stationary emissions across New Zealand's meat processors. It aims to summarise global best practices, including both currently available technologies and those in development, that facilitate cost-effective decarbonisation in the short to medium term.

1. DETA used its experience in the industry, researched, and generated ideas to produce a long list of 65 opportunities.

2. Each opportunity was evaluated based on the criteria shown given a score. The opportunities and scoring were reviewed by EECA and MIA to deliver the final shortlist of opportunities which would deliver the biggest impact based on the agreed criteria.

3. Chosen technologies were classified into 8 groups where processors could focus their efforts in achieving decarbonisation. Ideas were elaborated on, key ideas summarised, and suppliers and case studies researched.

Figure.6. Methodology



DISCLAIMER: The capital and operational costs, along with GHG emissions rankings, are crucial metrics for comparing options within abattoirs. The focus is on relative differences between options rather than absolute costs, with all options developed to a comparable level of precision. Investment in CAPEX/OPEX will vary depending on the size of the abattoir and the existing equipment/technologies. Moreover, only operational GHG emissions have been taken into account, with embedded carbon in equipment and construction omitted. Throughout, supporting information from leading global experts, case studies, and potential suppliers within the abattoir industry is cited.

Assessment/ Evaluation Criteria

GHG Reduction Potential

For assessing the GHG reduction potential of a technology, the relative reduction was compared with the industry standard or older technology it is likely to replace.

Score	Site Reduction
1	<1% of site emissions
2	1-5% of site emissions
3	5-15% of site emissions
4	15-30% of site emissions
5	>30% of site emissions

CAPEX

For assessing relative capex cost of each opportunity, CAPEX was compared with the old technology it is likely to replace. For technology which is not replacing anything existing, the estimated payback was used as a qualitative indicator.

Score	Relative CAPEX	If non existing
1	100%+ higher cost than alternative	>10 year payback
2	50-100% higher cost to alternative	<7 year payback
3	20-50% higher cost	<5 year payback
4	0-20% higher cost	<3 year payback
5	Equal or lower cost to alternative	<1 year payback

OPEX

For OPEX, cost for each opportunity was compared with the running costs of the industry standard or fossil fuel equivalent. Energy, maintenance and labour costs were also considered.

Score	Relative OPEX
1	30+% increase in cost
2	10-30% increase in cost
3	Cost Parity (-10%-+10%)
4	10-30% reduction in cost
5	30+% reduction in cost

Technology Risk / Maturity

For asssesing the technology maturity of each opportunity - the following criteria was used to assess how accessible it is to New Zealand meat processors.

Score	Relative Technology Maturity
1	Novel technology - research stage only
2	Some commercial examples of implementation overseas
3	Proven tech - common practice overseas, or within other industries
4	Proven tech - some installations in NZ
5	Proven tech - standard practice in NZ - multiple local suppliers

Install Complexity

For assessing how easily the chosen technology could be implemented into an existing process/ site the following scores were given.

Score	Relative Technology Maturity
1	Complex integration or complete process change
2	Moderate process change required – likely downtime
3	Simple process change required – possibly some downtime
4	Simple integration – little to no downtime required
5	Simple integration – no downtime required

Calculation of Overall Score

For calculating the overall score for each opportunity, the criteria scores were added together, however a weighted factor was applied to each in order to prioritise & add further weighting to those deemed most important by the MIA and EECA.

Factor	Site Reduction
3	GHG Factor
2	CAPEX Factor
2	OPEX Factor
2	Technology Maturity Factor
1	Install Complexity

Example Calculation - see page 9

Opportunity Technology *Weighting Factor*	GHG *3*	CAPEX *2*	OPEX *2*	Maturity *2*	Install *1*	Overall
Covered Anaerobic Lagoons	5	4	5	4	3	44

Overall Score

(3x5) + (2x4) + (2x5) + (2x4) + (1x3)

= 44

Biogas

WASTE UTILISATION

Biogas is a gaseous energy source, formed from the biological degradation of organic matter. The source of this organic matter can vary greatly, for meat processors this could include things such as yard waste, paunch, wastewater treatment sludge, animal by-products and blood. However, due to the high nitrogen content of abattoir input streams, it is recommended to co-digest them with alternative materials (e.g., food scraps or other carbohydrate heavy inputs).

The composition of biogas varies based on feedstocks and processing conditions, but typically contains methane (45-75%), carbon dioxide (25-55%), hydrogen sulfide (<5000 ppm) and other minor contaminants.

In its raw state, biogas can be used in a boiler with relatively minor pre-treatment. Typically, this pre-treatment will involve some moisture removal, H_2S management and minor scrubbing in an activated carbon filter. Note that for elevated levels of H_2S, a purpose-built biogas boiler is recommended for improved corrosion protection.

As emissions associated with biogas combustion are considered biogenic, biogas offers a zero carbon alternative to natural gas. Unlike other forms of renewable energy, this is not limited by enabling infrastructure (e.g., electricity).

The anaerobic digestion process, which produces biogas also produces a solid-liquid slurry by-product, called digestate. It is important to consider the future end use cases for this slurry as part of the design process. Due to the potential of prions, some limitations may exist around the application of digestate to grazed pasture. Regardless of use case, pasteurisation of digestate product is likely required. Guidelines and industry standards regarding the post-processing and application of digestate to land, including for abattoirs, are currently in development by the Bioenergy Association of New Zealand (BANZ).

Biogas can be integrated into existing facilities with minimal changes. For existing natural gas users, a low capital option is to replace the existing boiler burners for suitable biogas-compatible replacements. Additional changes may be required to the combustion air control and economisers/ heat-recovery to maintain sufficiently high flue temperatures to avoid acidic condensates. Note retrofitting biogas into existing assets may reduce the asset life if not properly controlled and maintained.

Three Key Advantages:

- **Waste utilisation**
- **Reuse of existing assets**
- **Cost and carbon reduction**

Opportunities

1. Covered Anaerobic Lagoons
2. Complete Mix Digestors

1. Covered Anaerobic Lagoons

- Low CAPEX, OPEX and maintenance compared to complete mix digestors. Generally, this technology is utilised as a method of wastewater treatment
- Unheated and minimal process control resulting in variable methane output, generally lower than complete mix reactors
- Retention times of 30-60 days, requiring larger hold-up volumes and therefore large on-site space requirements
- This is a suitable technology if the purpose is to minimise waste on site, or if capital limitations exist
- Some additional considerations for environmentally sensitive areas to minimise chance of leaks and contamination
- Although the anaerobic digestion process produces heat, performance may be reduced in cooler months

GHG	5
CAPEX	4
OPEX	5
Maturity	4
Complexity	3
Overall	44

Covered Anaerobic Lagoon at a meat processing plant in AUS. Credit: Hydroflux

Case Study

→ MLA: Waste to Energy Technology

Suppliers - Design/ Optimisation

ALPSecoscience

C02 Capture

PENTAIR

Pumps & Gas Mixing

Landia

Turnkey Suppliers

BPO

NIWA Taihoro Nukurangi

Biogas to Biomethane

Where possible Biogas produced should be used on site, however, if excess exists it can be upgraded and exported. Biogas is a near drop-in replacement for natural gas. With a methane content of 45-75%, the energy density of biogas (16-28 MJ/m^3) is significantly lower than that of natural gas (36 MJ/m^3). However, biogas can be purified into biomethane (also known as renewable natural gas) for improved energy density and combustion efficiency. As the purer biomethane, this gas can be injected into the existing natural gas pipeline and is compatible with existing infrastructure and assets.

Biomethane purification can be undertaken through a variety of methods, including membrane separation and chemical absorption. These processes typically generate moderate-to-high purity CO_2 as a by-product which can also be sold. However, these processes are both capital and energy intensive. Biomethane generation is not recommended in most circumstances unless other strategic advantages exist (e.g., sale of biomethane or CO_2 to third-parties). Generally, it is more beneficial for abattoirs to utilise biogas to displace other high cost and high carbon fuels used for steam generation. Other challenges also exist, including the storage of large volumes of flammable gas and regulatory requirements.

2. Complete Mix Digestor

- Mesophilic digestors typically operate at ~35-40°C
- CAPEX, OPEX and initial development costs of each digestor should be optimised for the specific inputs
- Targeted total solids of up to 4-8%
- Shorter retention times of 20-30 days, resulting in smaller hold up volumes than for lagoons
- Vertical tanks reduce on-site footprint
- This technology is suited for the maximisation of gas production
- Co-benefits including waste diversion (e.g. paunch, washdown water and processing by-products) which can deliver wider cost savings
- Inflatable digestor roof "domes" can offer some short-term gas storage, to enable some flexibility in time of use across a day
- Additional ground-mounted gas storage systems are available for longer-term storage but are costly and highly space-inefficient (due to the gas low pressure and presence of CO_2)

- Alternative technologies also exist, such as:
  - * Upflow Anaerobic Sludge Blanket (UASB) digestors utilise a sludge blanket in the bottom of the digestor to break down incoming waste streams entering from below. While these systems can process wastes with high Chemical Oxygen Demand (COD), they are incompatible with wastes containing high levels of fats or suspended solids.
  - * High-rate digestors support high COD loading rates however there are tighter constraints for suitable input materials and may require pretreatment.
  - * Internal Circulation (IC) reactors are similar to UASB reactors but can offer improved biogas yields and calorific value. Commonly used in multistage digestion, these systems are more complex than the UASB systems.

Digestor Mixing System. Credit: Landia

As a wide range of Anaerobic Digestor (AD) technologies exist, it is recommended to contact an AD expert to find the best solution for a given waste stream profile. It is also important to consider future serviceability and operational support.

Case Studies

→ IEA Bioenergy: Biogas from Slaughterhouse Waste
→ Irish Farmers Journal: Meat Processors Double Down on Renewables
→ CEFC finance for Bindaree Beef biogas and rendering upgrade - fact sheet

Suppliers - Design/ Optimisation

ALPS ecoscience
BIOGAS HOCHREITER Innovation aus einer Hand

Reactors Systems

HoST BIOENERGY SYSTEMS
Gaia EnviroTech

Turnkey Suppliers

WELTEC BIOPOWER
DELOREAN CORPORATION
BIOGEST®
HYDROFLUX NZ industrial
FINNBIOGAS

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
5	3	5	4	3	42

FUEL SWITCH

Heat Pumps

Heat pumps are ideally suited for water heating applications in abattoirs as they can supply both heating and cooling demands simultaneously with extremely high efficiencies.

Heat pumps utilise the same technology and vapour compression cycle as traditional refrigeration systems, only at higher pressures with the evaporator pressure being at the temperature of the heat source and the condenser pressure at the corresponding target temperature for the heat sink. This means that heat pumps can achieve a Coefficient of Performance (COP), or energy output per input, much higher than traditional thermal fuels as they transfer existing heat rather than generating it.

In instances where there are substantial low grade heat sources, heat pumps can further boost available reject heat to higher temperatures. If no traditional heat recovery sources are available, air or water sourced heat pumps can also pull energy from traditional 'cold' streams.

They work best when coupled with thermal storage (buffer tanks) as these can help smooth timing mismatch between heating and cooling demands. This also aids in demand management. Existing electrical infrastructure and capacity should be considered when assessing the feasibility of a heat pump.

Three Key Advantages:

- **Benefit of heating and cooling**
- **High efficiency**
- **Large offset of thermal energy requirement**

Opportunities

1. Ammonia Heat Pumps
2. CO_2 Heat Pumps
3. Hybrid Heat Pumps

1. Ammonia (NH_3) Heat Pumps

Industrial ammonia heat pumps are advanced systems used for heating and cooling in industrial settings, and are currently the most common hot water heat pump (HTHP) implemented in industrial applications. These heat pumps utilise ammonia (NH_3) as a refrigerant, which offers high efficiency and environmentally friendly properties. They extract heat from low-temperature sources such as air, water, or waste heat streams, and upgrade it to higher temperatures suitable for industrial processes or space heating. These systems are versatile and can be customised to meet specific temperature requirements, making them suitable for a wide range of industrial applications. Industrial ammonia heat pumps offer benefits such as energy efficiency, environmental sustainability, and cost-effectiveness, making them an attractive choice for industries aiming to reduce their carbon footprint and operating costs.

Ammonia heat pumps perform well at small or large scale and offer the additional benefit of being able to tie in directly to existing site ammonia refrigeration systems. In these instances an intermediate "high pressure" pot is utilised instead of a heat exchanger meaning efficiency losses can be reduced and superior performance achieved due to not needing to have a temperature driving force.

Foulkes, Robbie, (2023) Integrated ammonia heat pump at ANZCO Kokiri, West Coast. [Photograph]

Ammonia is a hazardous gas which is both toxic and flammable. For this reason, any installations must conform to regulations and have the appropriate safety measures. The additional costs of these safety measures is typically justified by the efficiency benefits for systems over 100 kW in size, and where ammonia is already present on site.

For further information on requirements, refer to:

- Technical bulleting: Ammonia Refrigeration | WorkSafe
- Industrial Heat Pumps for Process Heat | EECA

Case Study

- Hellers Hot Water Heat Pump | DETA
- DETA and ANZCO Foods - first EECA GIDI Decarbonisation Initiative

NZ Installers

Excel
Active refrigeration
ECOCHILL

Suppliers

Bitzer
GEA
MYCOM
MAN Energy Solutions
SABROE

GHG 4 | CAPEX 4 | OPEX 4 | Maturity 4 | Complexity 4 | Overall 40

2. Carbon Dioxide (CO_2) Heat Pumps

Although CO_2 industrial heat pumps are less common in industrial settings compared to their ammonia-based counterparts, they are frequently used in commercial applications. These systems often require multiple compressor banks for large-scale operations. Thanks to their transcritical operational mode, CO_2 heat pumps can achieve higher temperature increases in a single pass, making them suitable for applications that require substantial temperature lift. While the plant footprint for CO_2 heat pumps is generally more compact, the systems can be more expensive, primarily due to the high pressures at which they operate.

Transcritical CO_2 heat pumps operate under high refrigerant pressures, often exceeding 100 bar, which means they do not have a fixed condensation temperature. Instead, an average temperature is determined by analysing the temperatures at the gas cooler's inlet and outlet. For efficient operation of CO_2 heat pumps, the incoming water temperature should be low. If the CO_2 is not sufficiently cooled by the incoming fluid, the system's efficiency significantly decreases, making ammonia heat pumps a more viable option for recirculation systems, or where heat recovery is already being used.

CO2 heat pump skid. Credit: Vitalis

Case Studies

- 2020 Projects - Glaciem Cooling
- NH_3/ CO_2 Warehouse Refrigeration: Industrial Refrigeration - Case Study | Carnot Refrigeration

Suppliers

MITSUBISHI HEAVY INDUSTRIES

VITALIS

MAYEKAWA MYCOM

ECOCHILL

GLACIEM COOLING TECHNOLOGIES

CLADE

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
4	4	4	3	4	38

3. Hybrid Heat Pumps

Current pressure vessel manufacturing limitations in New Zealand mean that ammonia heat pumps are typically restricted to an outlet pressure of 60 bar or approximately 95°C.

There has been some developments on a hybrid heat pump which works on the principle of using an ammonia / water blend rather than pure ammonia. Water is separated out at the compression step, and then reintroduced afterwards. This allows higher temperatures (of around 120°C) to be achieved than with traditional heat pumps while simultaneously requiring lower pressure.

A hybrid heat pump consists of the following main components:

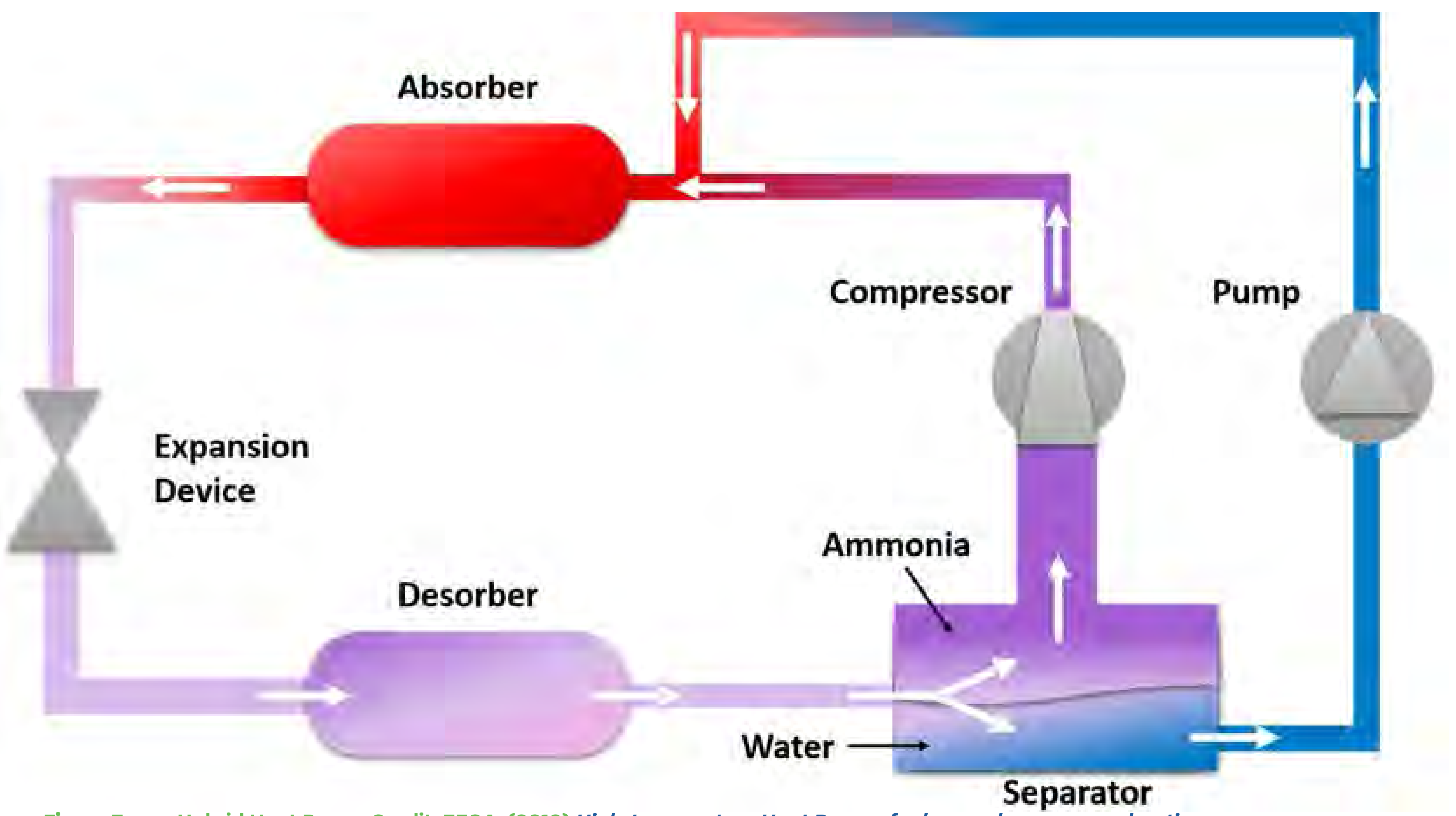


Figure.7. Hybrid Heat Pump. Credit: EECA. (2019) *High-temperature Heat Pumps for low carbon process heating.*

Desorber:

Waste heat is extracted from the outside environment into the refrigerant mixture.

Separator:

The separator separates water and ammonia.

Pump:

The pump increases the water pressure.

Compressor:

Ammonia is compressed to a high pressure inside the compressor.

Absorber:

Useful heat is released towards the environment.

Expansion element:

The pressure of the mixture is lowered.

Suppliers HybridEnergy

GHG 5

CAPEX 3

OPEX 4

Maturity 2

Complexity 4

Overall 37

Steam Generation - Boiler Replacement

FUEL SWITCH

Replacing the on-site steam boilers with renewably powered alternatives remains the single biggest opportunity to reduce carbon emissions on the supply side of meat processing.

Traditionally thermal heating and steam production has always been achieved using fossil fuel boilers – either coal, diesel, or natural gas. The emissions from these boilers represents the majority of on-site emissions at most sites.

There are three leading options for the green replacement of these boilers:

- Biomass Boilers
- Electric/ Electrode Boilers
- Steam Heat Pumps

NB: for sites with diesel boilers, renewable bio-diesel also presents an effective and easy decarbonisation alternative. This is a drop-in fuel which can be used in existing boilers, however, currently is prohibitively expensive and unlikely to present a long-term solution unless there is a significant change in the market.

In the past when energy costs have been low, boilers have often been oversized and run inefficiently, while any new heating loads have just been supplied with steam because it was cheap and easy. As with any decarbonisation journey, the efficiency of existing operations should be maximised first with any lower temperature heating demands which do not require steam being transferred to other heat sources.

Carrying out these thermal demand reductions first is of paramount importance to ensure that the replacement boiler is appropriately sized and to minimise CAPEX and OPEX investment needed.

Three Key Advantages:

- **OPEX improves as carbon prices increase**
- **High fossil fuel elimination**
- **Prioritise demand side to minimise costs**

Opportunities

1. Biomass Boilers
2. Electric/ Electrode Boilers
3. Steam Heat Pumps

1. Biomass Boilers

Biomass boilers are a mature technology that significantly reduces the carbon emissions and fossil fuel consumption of a site. A significant advantage of transitioning to biomass boiler technology is that in many cases existing coal boilers can be converted to biomass boilers with the primary modifications required in the fuel handling and storage. This can help reduce the capital burden of transition with the fuel able to be blended progressively to help the adjustment both operationally and financially.

The suitability of biomass boilers is linked to the availability and quality of biomass feedstock with a wide variety of biomass feedstocks available. The cost and energy density characteristics of each type vary significantly as well as their ability to be utilised in existing boilers. These factors should be assessed and investigated in detail before embarking on any sort of boiler conversion or replacement.

Biomass fuel currently costs more than coal, however the gap is closing as carbon prices increase. Obtaining a firm contract for biomass fuel supply is recommended when committing to converting to a biomass boiler. Typically the stable and sufficient biofuel supply should be within 100 km of the site for a biomass boiler to be a sustainable alternative to steam generation. (Note: this distance can be further for pellets as they are more energy dense). Consider collaborating with nearby companies or agricultural operations that may have biowaste to contribute to the boiler fuel.

Biomass boilers are less efficient than electric boilers and require more maintenance, however if a biomass source is in proximity and the electricity connection is constrained or would be expensive or too slow to upgrade, they are an attractive option to decarbonise steam generation.

While biomass boilers still produce an amount of ash, it is much less toxic than coal ash and is cheaper to dispose of.

For further information on biomass and its potential suitability see:

→ Biomass boilers for industrial process heat | EECA

For types of biomass and their advantages/ disadvantages refer:

→ Appendix: Biomass Fuel Types

Case Studies

→ AMP: Biomass boiler delivered to first red meat processing site

→ Fonterra: Coal boiler conversion

Suppliers of New Boilers

POLYTECHNIK Biomass Energy

Advance Boiler Services NZ Ltd

Lyttelton Engineering MARINE AND INDUSTRIAL ENGINEERS

Windsor Energy

ComMec Combustion Mechanical BOILERS - HVAC - PIPELINES

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
5	4	2	5	4	41

2. Electric/ Electrode Boilers

As opposed to thermal combustion boilers, electric boilers have near perfect turndown meaning that even at part load an efficiency of 99% can be achieved. In contrast, most fossil fuel combustion boilers operate at a less optimal 70-80% efficiency when at full load, which decreases even further when the load is reduced.

Physically, electric boilers have a much smaller footprint than fossil fuel boilers, they have no fuel handling required and much fewer moving parts, meaning they are typically simpler and cheaper to install and will also require less ongoing maintenance.

A caveat to the reduced installation cost is the electrical power supply to the boiler. As the steam generation load being replaced is often significant, this can mean a large increase to the site power supply required. It is important to consider the capacity of the electricity network that supplies the site and if there is suitable capacity in the lines to cater for the addition of an electric boiler.

Where the lines capacity needs to be upgraded this can significantly increase the project cost, sometimes rendering it uneconomic. Engaging with local lines companies and electricity providers early on in these projects is important, as funding options may be available, including CAPEX, operationalising costs, and special electricity pricing for new loads to reduce running costs.

As an alternative to a centralised hot water generation plant, heating water at point of use also presents a viable alternative when using electricity. In these instances, water can be reticulated at lower temperatures around the site and then be boosted by small hot water boilers or generators near where the demand is located. This approach generally results in less heat losses, less wasted energy, and a distributed demand which depending on electrical infrastructure can be advantageous.

New Zealand's relatively low emission electricity means that any conversion from a fossil fuel to electricity will greatly reduce the carbon impact of producing that heat.

Electric boilers offer great demand flex opportunities, which should, where processing allows, be negotiated with electricity providers to help offset the relatively high OPEX costs. Hybrid options, such as combining with a heat pump also help improve the economic viability of this option.

Electric Boiler. Credit: BOSCH

Case Studies

- → Reducing plant carbon footprint with an electric steam boiler | Tubman
- → PARAT with the first Power to Heat system in Spain

Suppliers

- → Energy Plant Solutions

BOSCH
VAPEC
TUBMAN HEATING BOILER & BURNER SPECIALISTS
Windsor Energy
PARAT

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
5	4	1	5	4	39

3. Steam Heat Pumps

Steam heat pumps are a relatively new technology that has the potential to significantly reduce carbon emissions. The lack of maturity increases the CAPEX of this technology, however the OPEX is relatively low. Steam heat pumps utilise the same technology as a heat pump that produces hot water, however for steam generation this hot water is further heated to be turned into steam through additional heating stages, with condensing at higher pressures.

Powered by low emissions electricity, steam heat pumps are very energy efficient due to the much higher Coefficient of Performance (COP) compared to conventional steam generation methods which leads to significant energy savings. Heat pumps currently available on the market are three to five times more energy efficient than natural gas boilers.

While this technology is currently not widely commercially used in New Zealand, it is important to be aware of this as an option in the near future.

Thermbooster. Credit: SPH

Case Studies

- → IEA report on The Future of Heat Pumps
- → Fonterra and MAN Energy Solutions project

Suppliers

- AtmosZero
- SPH
- enertime
- PILLER Blowers & Compressors
- MAN Energy Solutions
- BRONSWERK Heat Transfer
- skyven technologies

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
5	2	4	2	4	35

WASTE UTILISATION

Heat Recovery

Abattoirs are in the fortunate position where they have both significant heating and cooling demands. There are many opportunities on typical meat processing sites where heat can be recovered from existing processes to heat water and offset the heating demand from thermal fuels. Often there is the co-benefit of cooling the heat source which can further reduce electrical costs of alternative cooling equipment.

The concept of heat recovery is not new, however, heat exchange technology is constantly improving which increases the amount and type of heat recovery that is feasible. Improvements have allowed for more varied waste streams of different phases to be utilised while increasing the transfer area, reducing approach temperatures and improving the overall efficiency.

Heat Recovery Source	Maximum outlet temperature achievable (°C)
Air Compressors	65 - 70
Rendering	80 - 90
Refrigeration - DSH, Oil Cooling	65 - 70
Refrigeration - Condensors	25 - 30
Waste Liquid Streams	70 - 75

It is important to still retain redundancy for processes that require consistent cooling. Pinch Analysis should be performed to best match and optimise the heat transfer between heating and cooling sources.

For an overview of Pinch Analysis see link below. If further assistance is required, engage an expert.

→ Process Integration and Pinch Analysis for emissions reductions in New Zealand | EECA

Three Key Advantages:

- **Often little to no operating cost**
- **Fossil fuel reduction**
- **Dual heating and cooling benefit**

Opportunities

1. Refrigeration Heat Recovery
2. Rendering Heat Recovery
3. Waste Heat Recovery

1. Refrigeration Heat Recovery

There are four types of heat that can typically be recovered from site refrigeration systems. Refrigeration heat recovery is easiest when there is a centralised refrigeration system, however, can also be done from smaller isolated units.

Case Studies

→ ANZCO Foods Heat Recovery | DETA
→ Waste Recovery from Refrigeration in a Meat Processing Facility | tamu.edu

Suppliers

→ Heat NZ

PRESSURE WORX ENERGY TRANSFER SOLUTIONS

Liquid Dynamics

ALFA LAVAL

Sub coolers

Lowest grade. After refrigerant gas has been condensed there is further sensible heat which can be removed. Typically 0-5% of total refrigeration up to 20°C.

Condensers

Low grade, large quantity of heat recovery from the latent heat phase change from discharge refrigerant gas to a liquid. Replaces the need for typical evaporative, air cooled, or water cooled condensers. Typically up to 90% of total refrigeration heat rejection available up to about 30°C.

Desuperheaters

High grade sensible heat recovered from the discharge stream of refrigeration systems reducing the temperature of the refrigerant gas from its discharge temperature to its condenser temperature. Typically, around 10% of total refrigeration heat rejection up to about 70°C.

Oil cooling heat recovery (screw compressors) / Piston head cooling (reciprocating compressors)

High grade sensible heat recovered either from oil cooling heat exchangers (screw) or directly from piston heads (reciprocating). Effectively capturing the heat generated (inefficiency) of the compression process. Typically between 5-20% of total heat rejection up to about 70°C.

NB: Superheat can also be removed with condensing in a single heat exchanger, however, splitting them out means that a portion of the heat can be recovered at higher temperature. Typically not all heat recovery would be utilised separately as represented in the diagram, this will depend on temperatures, load size, and flow rates, and so the diagram is for illustrative purposes only.

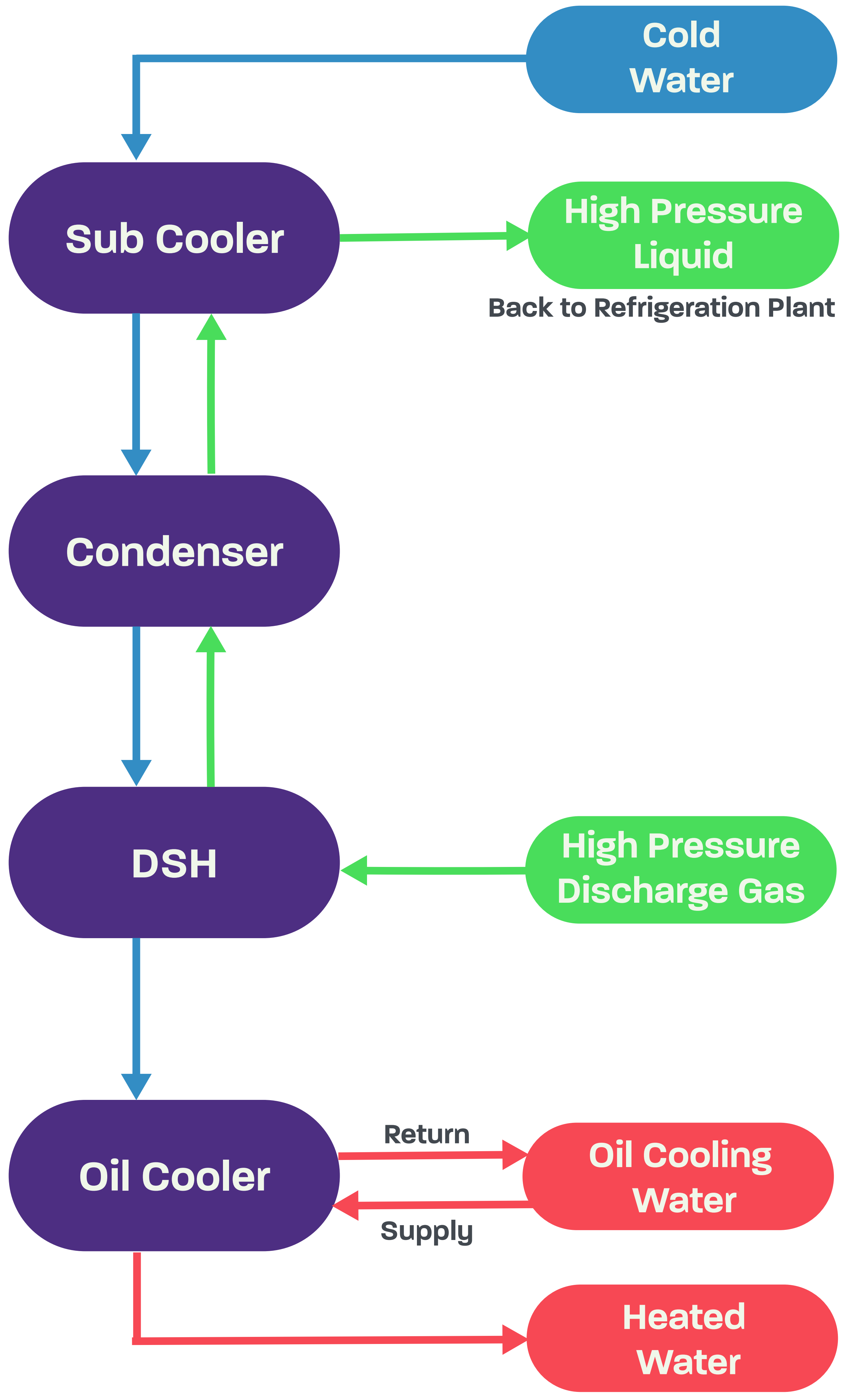


Figure.8. illustration of refrigeration heat recovery integration (refer to note)

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
3	3	4	5	5	38

2. Rendering Heat Recovery

For processors which have onsite rendering, this presents a significant opportunity for heat recovery. The scale of the opportunity varies depending on the method and efficiency of the rendering operation, however, recovering 30-50% of steam input to the rendering process is not unrealistic.

Specific locations where heat can be recovered include the following:

- Steam from cookers
- Hot water from condensers
- Exhaust gases from dryers
- Boiler flue gases
- Heat from presses
- Flash steam recovery

Heat recovered can either be reused in the rendering process or used to heat process water for use elsewhere in the facility.

Heat Exchanger. Credit: MAVITEC

For further information:

- Goulston, Charles L. *The Potential for Heat Recovery from Beef Rendering Operations* (USDA)
- Waste Heat Recovery | Meat Research Corporation
- Case Study: Rendering Plant Energy Optimisation| MLA

Suppliers

TG-MACHINES Process Engineering

RENDERTECH

HAARSLEV

MAVITEC

GHG 2

CAPEX 4

OPEX 4

Maturity 4

Complexity 4

Overall 34

3. Waste Heat Recovery

A significant and often underutilised heat resource on many processing sites is the wastewater pipes. Abattoirs have a high quantity of hot water which runs off the processing floors whether it be from sterilisers, wash stations, cleaning or processing units. Despite being used for their primary purpose already, these waste streams still contain large amounts of energy which can be captured and reutilised as a heat source.

The key complexity in utilising this resource is the non-uniform nature, with the liquid often containing high amounts of material contamination, carcass debris, and other solids which can make the use of traditional heat exchangers challenging.

There are two main approaches to reduce the chances of clogging and buildup on heat exchange surfaces. The first is to use simpler heat exchangers with less surface area for particles to get trapped on or to use scraped surface heat exchangers that mechanically prevent buildup. The other option is to pre-treat the waste stream through maceration or solids removal to enhance its compatibility with traditional heat exchangers.

While the waste sources are different, these approaches and technologies are widely applied overseas, particularly by councils with residential waste water.

R Series Rotating Scraped Surface Heat Exchanger. Credit: HRS

Case Studies

- → [Case studies of four installed wastewater heat recovery systems in Sweden | ScienceDirect]
- → [Case studies of waste water heat recovery | Recoup WWHRS]
- → [Case studies of waste water heat recovery | Maximizer]

Suppliers

HRS heat exchangers

SHARC ENERGY

VAPORTEC LTD SPIREX

VOGELSANG

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
3	4	5	4	4	39

TECHNOLOGY CHANGE

Cleaning

Abattoirs use significant amounts of hot water throughout the processing operation in order to maintain the required hygiene and food safety requirements.

There are opportunities for hot water usage to be reduced or in some instances completely replaced, via the use of chemicals.

Three Key Advantages:

- **Demand reduction**
- **Hygiene compliance**
- **Water reduction**

Opportunities

1. **Washdown/ Hose up Chemicals**
2. **Carcass Wash/ Intervention**

1. Washdown/ Hose up Chemicals

Large amounts of hot (usually 65°C) water is typically used for washing down the processing facility at the end of each production day. With the application of chemicals to help remove fats and hard to remove residues, there is the opportunity to use smaller amounts of hot water or even cold water only for hose-ups.

There are a variety of products on the market with potential:

- Enzyme based
- Chemical Based
- Electrolysed Oxidised Water

It is important to make sure whichever solution is used has the approval of MPI, and buy-in from the cleaners, ensuring they understand the "why". Depending on the site, 10-20% of total water heating demand could be saved which has significant impact on carbon emissions and the bottom line.

Hot water high-pressure cleaner. Credit: Karcher

Electrolysed oxidizing water (EOW), produced by electrolysing a saline solution, dissociates into alkaline and acidic forms; the acidic form contains hypochlorous acid, a powerful antimicrobial agent. In the meat industry, EOW can be applied via pressure sprayers or foggers for cleaning and sanitising surfaces, tools, and equipment, offering a potent and eco-friendly alternative to traditional chemical sanitisers.

Refer to the following link for a list of MPI approved chemicals. Other chemicals which are found effective, can be submitted for approval.

→ Maintenance compounds register and list | NZ Government (mpi.govt.nz)

For more information see:
→ Cleaning for Butchers | Karcher

Suppliers

RX MARINE INTERNATIONAL

Hygiene Technologies Smarter Cleaning Systems

Bio-Zyme

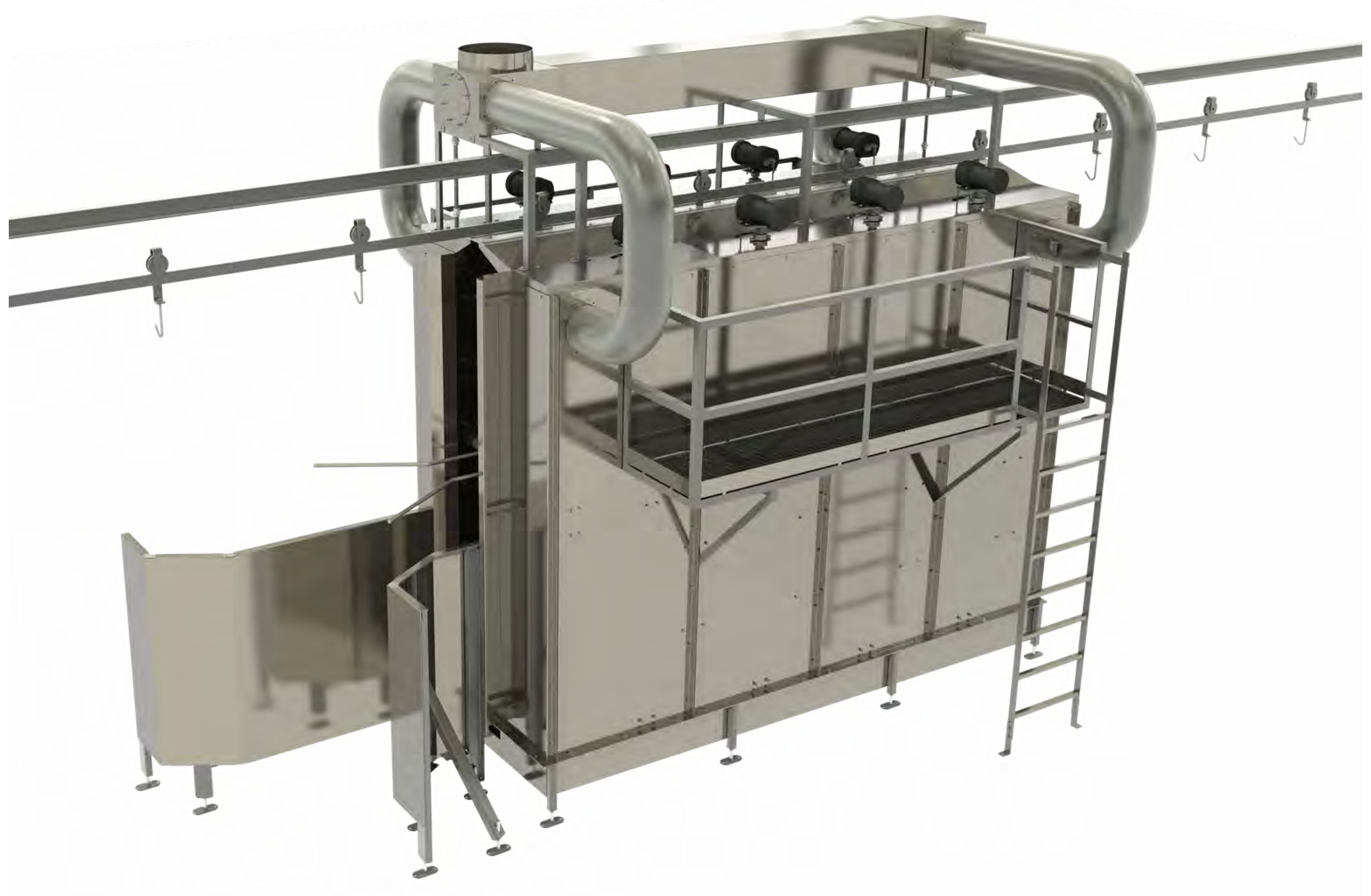
GHG	CAPEX	OPEX	Maturity	Complexity	Overall
3	5	3	4	5	38

2. Carcass Wash/ Intervention

The cleaning process for bobby calf/ lamb carcass wash and beef interventions traditionally involves the use of steam or hot water to avoid bacterial contamination of product. The same (or better) compliance in this regard can be achieved by spraying the carcasses with lactic acid.

Specifically, for the bobby carcass wash, a temperature of 88°C at the point of use is required, which is 6°C higher than that of a standard steriliser. As a result, it is common for the temperature of the hot water supply to the entire site to be elevated, rather than solely targeting the carcass wash area. This adjustment increases the potential savings associated with removing this load.

While beef intervention is primarily to ensure low levels of STEC and bacterial contamination to maintain market eligibility requirements, the energy savings from using sprayed chemical rather than purely high temperature water or steam, also have an energy impact.



Oscillating Carcass Spray System. Credit: MidWest Machine LLC

Case Studies

- → Beef Cattle Research Council of Canada: In-plant Mitigation of Pathogens

Equipment Suppliers

MIDWEST MACHINE LLC.

Chemical Suppliers

Diversey™

FLUIDCHRISTEYNS

spirax sarco

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
2	3	3	4	4	30

TECHNOLOGY CHANGE

Rendering Preparation

A large portion of the energy utilised in rendering plants is due to the removal of moisture.

By reducing the particle size and moisture content of the raw materials fed into the process, energy consumption can be significantly reduced.

Three Key Advantages:

- **Thermal fuel reduction**
- **Large efficiency benefit**
- **Increased capacity**

Opportunities

1. Particle Size
2. Mechanical Dewatering

1. Particle Size

Reducing the particle size of incoming raw material into the rendering process has several benefits. Reduced particle size increases the throughput which can be achieved through product pumps and the overall plant capacity. Smaller particles are easier to handle and dry quicker which reduces production time required and steam usage in downstream processes such as in the dryer and evaporator.

A fine crusher with outlet particle size of around 18mm is found to be ideal in balancing energy savings and not running into fine issues.

Other benefits including reduced maintenance and staffing time (due to less run hours), as well as improved product quality can be expected.

Fine Crusher. Credit: HAARSLEV


Fine Crusher. Credit: RENDERTECH

Fine crushers can be retrofitted easily into existing processes, and should typically be installed directly following the pre-crusher in the raw material processing area.

Suppliers

HAARSLEV™
RENDERTECH
Franklin Miller

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
2	5	4	5	4	38

2. Mechanical Dewatering

Reducing the amount of water in your rendering material is critical for keeping energy costs down. Where possible, no additional water should be added to raw materials for transport via blow pots or other means.

Typically, mechanical separation of solids and liquids, either at the raw material stage or within the process, is much more efficient than having to drive this water off thermally, which requires achieving the heat of vaporisation for that mass of water. This is the crux of low-temperature rendering processes, however, even without doing a complete process change, some of these principles can be applied, and mechanical dewatering utilised. Mechanical dewatering offers efficient removal of moisture from rendering materials, reducing energy costs and improving process sustainability. This method allows for better control over moisture content and yields higher-quality products without the need for excessive thermal treatments.

Twin Screw Press. Credit: RENDERTECH

Several technologies exist for mechanical dewatering including:

- Press dewaterer
- Screw press
- Belt press
- Decanter centrifuge

The energy savings from mechanical dewatering depend on the efficiency of the equipment, the change in moisture content of the material, and the energy costs of heating and drying. Typically, a 1% decrease in moisture content can reduce the energy needed for drying and heating by about 0.5-1.0%. Low temperature rendering which maximises the use of mechanical dewatering uses approximately 50% less steam than traditional high temperature rendering processes.

Suppliers

TG-MACHINES Process Engineering

RENDERTECH

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
2	4	3	4	4	32

TECHNOLOGY CHANGE

Sterilisers

By far and away, sterilisers are the largest hot water user at typical meat plants and the biggest end user of carbon for non-renderers. 82°C water at point of use, often means 90°C water at point of supply. Reducing the volume used for sterilisation is the largest potential for demand side reduction. Another key benefit, other than water / energy consumption, is reduced condensation on slaughter floors.

Three Key Advantages:

- **Demand reduction**
- **Water reduction**
- **Possible technology change**

Opportunities

1. Proprietary – Low Water Sterilisers
2. Plant Engineering Solutions
3. Alternative Possible Future Tech

1. Proprietary – Low Water Sterilisers

These are specially designed units which aim to use minimal water possible per sterilisation ~125ml per iteration (4.5 seconds) – water reductions up to 90% can be achieved, depending on current operation. Typical water flows for continuous flow sterilisers are 10-15 litres per minute. Without the use of sensors, the water usage is often independent of production throughput meaning water consumption remains the same regardless of the number of animals processed.

Sterilisers can either be fed with hot water from existing ringmains or can have their own electric heating system and be fed with cold water.

Low Water Steriliser System. Credit: ECONOLISER

Suppliers

AES Food Equipment

ECONOLISER™ Hygiene by Design

Southern Engineering Solutions

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
4	3	5	4	3	39

2. Plant Engineering Solutions

As an alternative to buying proprietary sterilisers which administer a specific dose, significant savings can also be made by in-house modifications. Flow restrictors on dunk sterilisers or preferably magic eyes (sensors) on spray sterilisers can also achieve significant hot water savings.

Magic eye sterilisers follow the same principle as proprietary low water sterilisers and require continuously flowing water from the ring main as well as the return line. The reason for this is to ensure the water delivered is at the required temperature and does not sit in the line and cool.

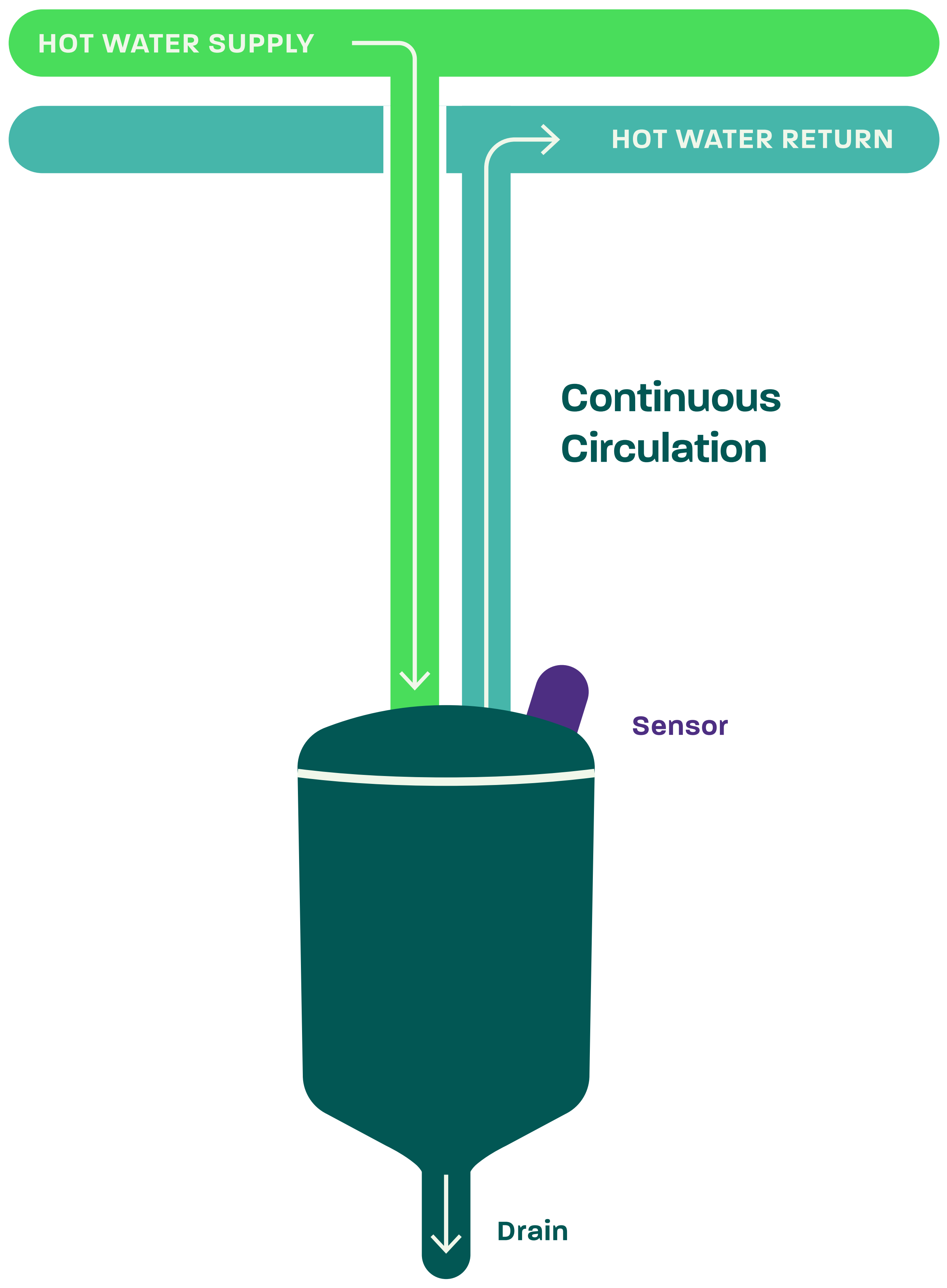


Figure.9. Magic Eye Steriliser Principle

Vigilance is required by shift supervisors to ensure operators do not jam sensors "on" (or alternatively this can be overcome with automation) as this would obviously negate savings. In most cases, water reduction well in excess of 50% is achievable for typical plants.

Case Study

→ [Alliance Pukeuri Hot Water System Upgrade| DETA]

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
3	3	5	3	3	34

3. Alternative Possible Future Tech

UV Sterilisers

UV sterilisers completely remove the need for hot water in the sterilisation process and the energy use compared to current practice is practically nil. They work by using ultraviolet light to penetrate the cells of any microorganisms present on the knives surface, damaging their DNA and thereby sterilising the knife. One uncertainty is the time taken to provide acceptable sterilisation, and so several knives may be required per operator.

This technology is ready for use in industrial applications, however, the main barrier is regulation. This would need to be overcome as an industry, with UV sterilisation approved as an acceptable method by overseas markets before it would be worth trying to overcome any other installation or operational challenges. Cold water is still required to remove any meat residue prior to sterilisation.

UV Knife Steriliser. Credit: Anderson Biosafety

Glow Discharge Plasma

Another approach in the early stages of research is the plasma-activation of aqueous solutions of chloride and sodium sulphate by glow discharge (PAW) in relation to the inactivation of microorganisms.

→ [Research paper on Glow Discharge Plasma| MDPI]

Suppliers

BURDIS

roser

Anderson

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
4	3	5	2	1	33

Smart Processing / AI / Automation

TECHNOLOGY CHANGE

The potential impact of automation in the meat industry is significant, with the ability to enhance efficiency, safety and sustainability throughout the entire process.

Currently, plants can optimise setpoints for individual units, however technology such as AI and Smart Processing is now available to holistically analyse multiple unit setpoints and change process variables that will result in the least disruption to the process and provide the greatest overall energy reduction.

Some of the key areas where smart processing technologies can be effectively applied are:

- Rendering
- Refrigeration
- Hot water

The benefits of this technology includes continuous commissioning, process timing and smart adjustment, increased automation of set points for different operating conditions, understanding unintended impacts of process changes, good instrumentation, and multi-site adaptive setpoint management.

The ability for multiple devices to all share real-time data for AI to then decide the optimal alteration of parameters is possible due to Internet of Things (IoT) and machine learning. IoT is a network of interrelated devices that connect and exchange data with other IoT devices and the cloud, allowing adjustment of the process as a whole.

In order for smart controllers to be effective, comprehensive metering and instrumentation is required, with the value delivered decreasing if less information is available.

Three Key Advantages:

- **Reduces operator input, freeing up skilled workers**
- **Fossil fuel reduction**
- **Increased knowledge on where energy is used**

Opportunities

1. Rendering Automation
2. Refrigeration Automation
3. Hot Water Distribution Automation

1. Rendering Automation

Smart Processing in rendering allows the optimal decisions to be made to reduce energy load on the plant when variation occurs.

As feed composition changes, process variables must be adjusted to maintain product quality.

Manually altering a process variable upstream affects downstream processes and it can be complex to decide which process variable to adjust, and by how much, to achieve optimal energy load across the process.

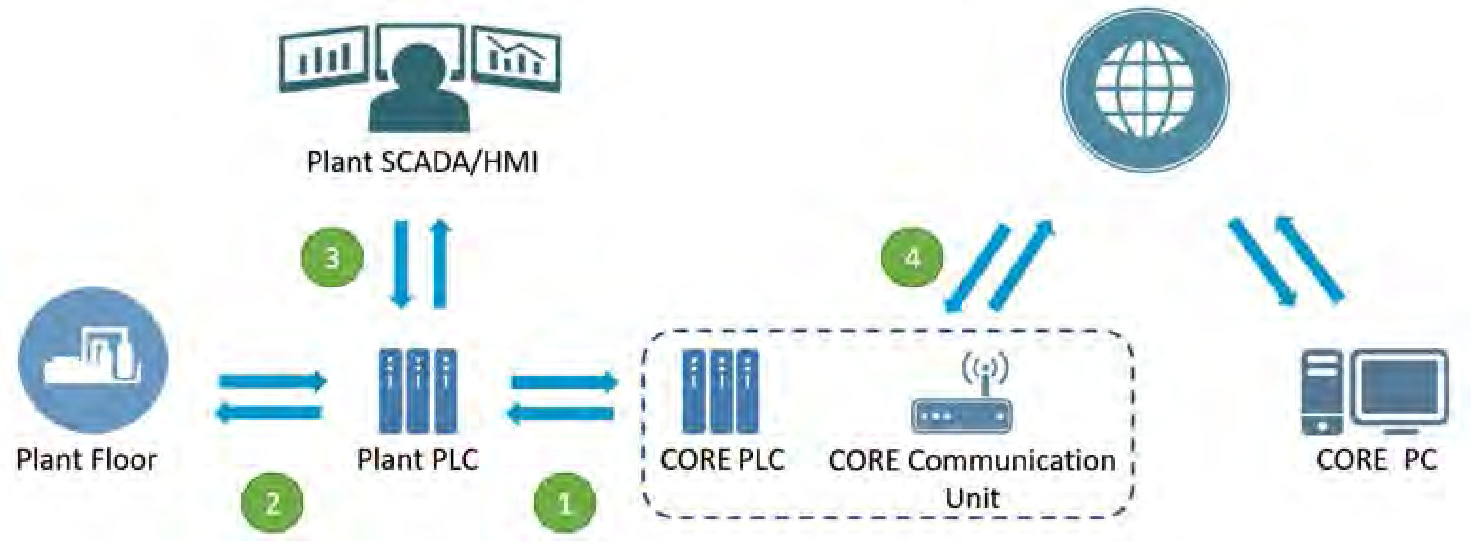
Adjusting the evaporator to account for increased moisture in the rendered product may increase the energy load more due to transferring load to the dryer. AI and Smart Processing removes the hassle of decision making and reduces the opportunity for error as well as time taken to make the change.

Controllers can be fitted to selected equipment and complete production lines. Smart processing builds a data-driven model for how each unit operates based on process responses to adjustments, and uses this model to predict how the process will respond to changes. The differences between the actual response and the response predicted are used to finetune the model. Controllers, such as those designed by CORE are able to significantly reduce such variations – usually by as much as 30–60%.

Figure.10. Units for application and the process variables adjusted for. CREDIT: Haarslev

MACHINE	MAIN TARGET
Cooker/Disc Dryer	Temperature/Moisture
Press	Amperage/Torque
Preheater	Temperature
Evaporator	Dry matter
Decanter	Torque

Figure.11. Typical process integration for controller.. CREDIT: Haarslev



1. Communication between the CORE PLC to the plant PLC(s) is typically via Ethernet.
2. Signals to/ from the machines on the plant floor, including additional measurements if needed and control signals.
3. Additional signals to/ from the SCADA/ HMI system, including setpoints and on/ off buttons for the CORE controllers.
4. Connection from the CORE communication unit to the internet, enabling Haarslev to communicate with the CORE PLC.

Case Study & Suppliers

→ [Tyson Foods: Meat Grinder Automation with AVEVA]

GHG 3

CAPEX 5

OPEX 4

Maturity 3

Complexity 5

Overall 38

2. Refrigeration Automation

Smart Processors leverage real-time data from refrigeration systems, utilising AI algorithms to dynamically adjust system parameters. This optimisation of setpoints maximises overall efficiency. For instance, AI can modulate the condensing pressure of a plant to optimally balance power consumption between compressors and condenser fans, minimising energy use. In scenarios with multiple compressors and varying refrigeration loads, AI strategically operates each compressor to ensure efficient performance while meeting the plant's cooling requirements.

Beyond enhancing energy consumption, AI systems offer several additional advantages, including:

- Multi-site adaptive setpoint management, using optimised algorithms adaptable to changing conditions.
- Continuous energy commissioning for improved energy efficiency.
- AI-driven digital twins that facilitate early problem detection through condition-based alarms.
- Predictive detection of refrigerant leaks, identified by AI through changes in performance trends.

DMTouch & miniDM. Credit: Resource Data Management

Suppliers

GEA

Resource Data Management

Industrial Automation

AXIOM CLOUD

Articae SMART TECHNOLOGIES

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
2	4	3	5	5	35

3. Hot Water Distribution Automation

Controlling the hot water distribution network using automation reduces water wastage where taps/ hoses/ nozzles would be left open, or flow rate is too high and water is lost before it is used. Reducing the use of heated water reduces the load on boilers and wastewater systems, and ensures that energy is not being lost down the drain.

Sensors and controls on tanks, boilers, pumps and valves are interconnected to achieve optimal use of water and the energy required to heat it.

Smart processing can adjust pump speeds and valves for demand changes and find the most efficient pump arrangement in multi-pump systems.

With the diversification and spread of hot water generation across sites, tank management and optimising flowrates through various processing units can deliver considerable benefits to maximise heating from free sources such as heat recovery, while still catering for the varying production requirements.

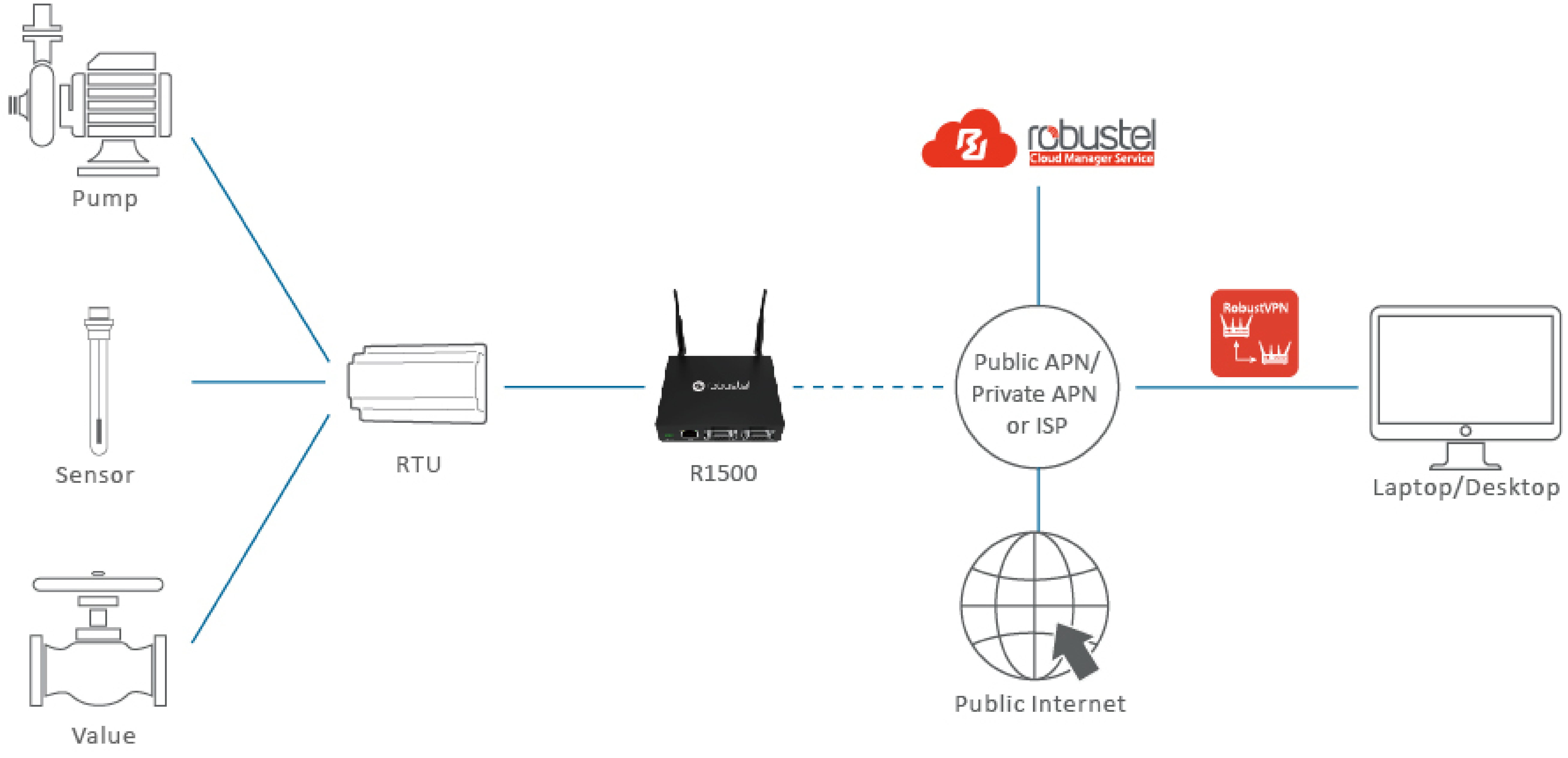


Figure.12. Example showing smart processing integration network. CREDIT: Robustel

Suppliers

HIGH TIDE TECHNOLOGIES

robustel

CR AUTOMATION

GRUNDFOS

GHG	CAPEX	OPEX	Maturity	Complexity	Overall
2	4	4	5	5	37

Summary & Recommendations

There are many opportunities available for small to medium processors to reduce the carbon emissions produced by their operations.

For non-renderers, the key focus should be on the minimisation of hot water usage. The application of chemicals can help reduce cleaning demands, and restricting flow and demand sensors, while not glamorous can have a huge impact. Other technologies are in development for high temperature sterilisation; however, none are yet commercial, and regulatory changes would be required before these can be adopted. The rapid advancement of AI and smart processing technology is a relatively low-cost opportunity to get the best out of existing equipment which should be considered as an easy win and can offer benefits across all SCADA controlled operations and utilities.

On the supply side, the utilisation of heat recovery sources should be maximised first where possible, as these provide the lowest cost option. Heat pumps are the most efficient for further boosting water temperatures and where shortfalls in temperature or energy remain, these can be met using boilers powered by renewable energy. For non-renderers, any small steam users should be replaced with electric, to completely eliminate the need for steam on site.

For sites with rendering, steam remains a requirement. A site specific feasibility study is required to determine which of the options is most suitable. For sites with existing gas boilers and unused waste streams, biogas may provide a good path for continuing to use existing infrastructure. There are many examples overseas where this has been made a reality.

Demand Reduction

- Sterilisers
- Chemical Cleaning
- Smart Automation
- Rendering Preparation

Supply Optimisation

- Heat Recovery
- Heat Pumps

Fuel Switch

- Biogas
- Boiler Replacement

Integration Risks & Opportunities

This report outlines the main technologies that can significantly improve efficiency and reduce carbon emissions in New Zealand's abattoirs. Integrating these technologies into existing operations does come with challenges, but it also offers substantial benefits that can transform the environmental impact of the industry. Each technology should be carefully assessed for compatibility with existing operations to ensure optimal results and to pre-empt any potential adverse effects.

It is important to assess the individual feasibility and suitability of each technology for any given site, involving experts in technology integration and environmental management to ensure that the desired benefits are realised.

With carbon pricing forecast to rise considerably and the future availability of fossil fuels becoming increasingly uncertain, the economic case for transitioning to greener technologies becomes even more compelling. The financial benefits, such as cost savings from reduced energy consumption and enhanced compliance with forthcoming regulatory changes, are expected to grow over time.

By addressing these challenges head-on and harnessing the opportunities outlined in this report, New Zealand's abattoirs can lead the way in sustainability and efficiency, setting a global benchmark for the industry.

The impact of a change in carbon price can be seen on various fuel types in Figure 13.

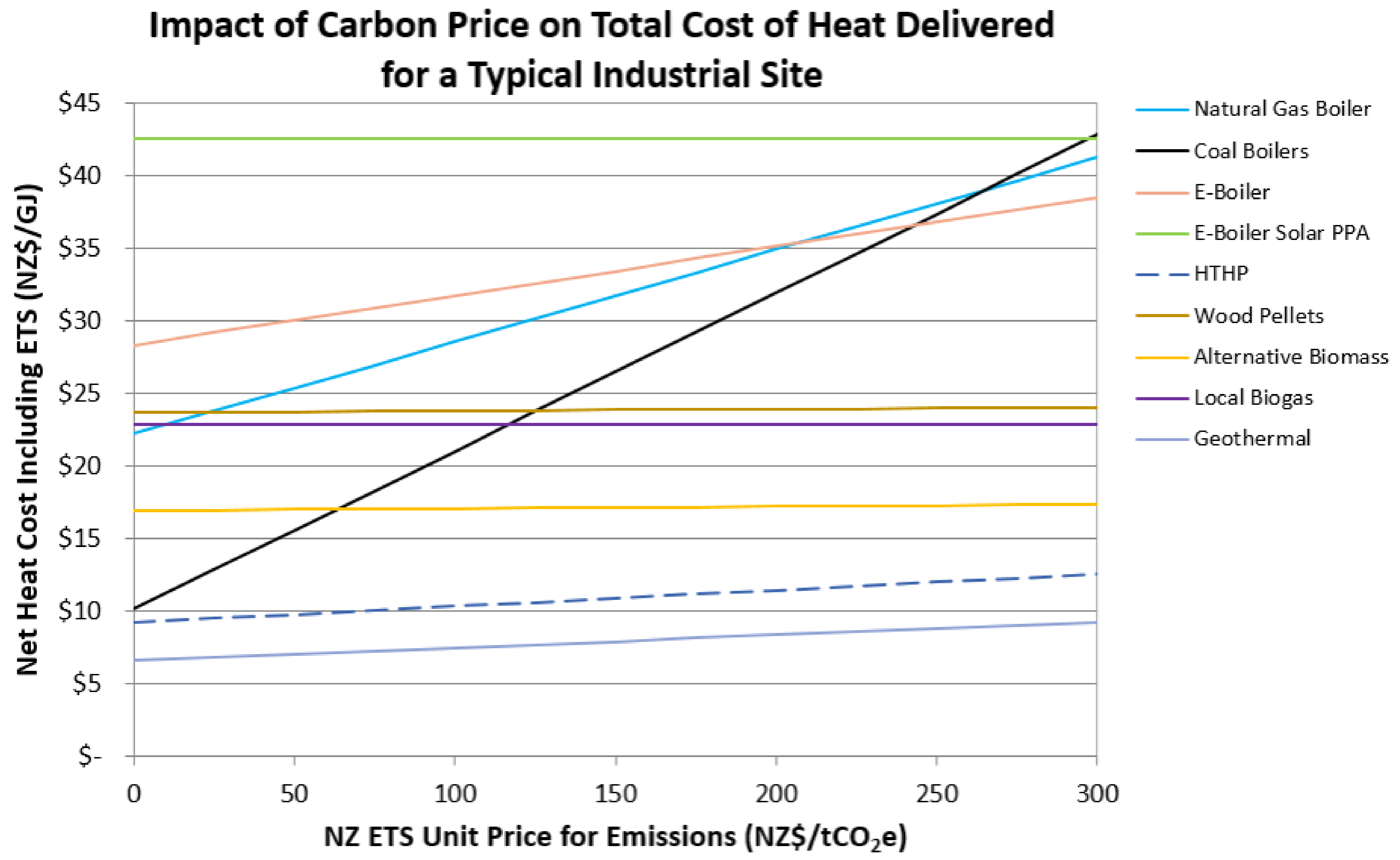


Figure.13. Impact of Carbon Price on Total Cost of Heat Delivered for a Typical Industrial Site

Opportunities List

Scoring Category	GHG Score	CAPEX Score	OPEX Score	Maturity Score	Install Complexity	Overall
Weighting Factor	3	2	2	2	1	50

	Bucket	Process Area	Opportunity Technology	GHG	CAPEX	OPEX	Maturity	Complexity	Overall
1	Biogas	Waste	Covered anaerobic lagoons	5	4	5	4	3	44
2	Biogas	Waste	Hydraulic reactor	5	3	5	4	3	42
3	Steam Generation	Hot Water Supply	Biomass boilers	5	4	2	5	4	41
4	Hot Water Heat Pump	Hot Water Supply	Ammonia heat pump for HW	4	4	4	4	4	40
5	Rendering tech change	Rendering	Low temperature rendering	3	5	5	5	1	40
6	Sterilisers	Hot Water Demand	Low water sterilisation	4	3	5	4	3	39
7	Steam Generation	Hot Water Supply	Electric boilers	5	4	1	5	4	39
8	Heat Recovery	Hot Water Supply	Heat recovery from waste liquid streams	3	4	5	4	4	39
9	Steam Generation	Hot Water Supply	Renewable diesel	5	5	1	3	5	38
10	Hot Water Generation	Hot Water Supply	Solar water heater	2	4	5	5	4	38
11	Hot Water Heat Pump	Hot Water Supply	CO2 heat pump for HW	4	4	4	3	4	38
12	Chemical Cleaning	Processing	Chemical washdown - with cold water	3	5	3	4	5	38
13	Rendering Preparation	Rendering	Fine crusher	2	5	4	5	4	38
14	Smart Processing Automation	Rendering	Core advanced process control	3	5	4	3	5	38
15	Heat Recovery	Refrigeration	Heat recovery refrigeration	3	3	4	5	5	38
16	Heat Pumps	Hot Water Supply	Hybrid heat pumps	5	3	4	2	4	37
17	Insulation	Hot Water Demand	Lagging refrigerant and steam/ condensate piping	2	4	4	5	5	37
18	Smart Processing Automation	Hot Water Demand	Hot water distribution timing/ automation	2	4	4	5	5	37
19	Boiler Optimisation	Hot Water Supply	Boiler tuning	2	5	3	5	5	37
20	Temperature Change	Hot Water Demand	Temperature hose up	2	4	4	5	5	37

	Bucket	Process Area	Opportunity Technology	GHG	CAPEX	OPEX	Maturity	Complexity	Overall
21	Demand Reduction	Hot Water Demand	Gut buggies	2	5	4	5	3	37
22	Boiler Optimisation	Hot Water Supply	Boiler economisers	2	4	4	5	4	36
23	Heat Recovery	Hot Water Supply	Heat recovery from rendering evaporators	2	4	4	5	4	36
24	Refrigeration Optimisation	Refrigeration	EC fans etc.	1	4	5	5	5	36
25	Insulation	Rendering	Dryer insulation	1	5	4	5	5	36
26	Heat Recovery	Hot Water Supply	Compressed air heat recovery	2	4	4	5	4	36
27	Boiler Optimisation	Hot Water Supply	Maximise steam condensate return	2	4	4	5	4	36
28	Boiler Optimisation	Hot Water Supply	Boiler blowdown heat recovery	2	4	4	5	4	36
29	Demand Reduction	Hot Water Demand	Hose up flow restrictors	2	4	4	5	4	36
30	Steam Generation	Hot Water Supply	Steam heat pumps	5	2	4	2	4	35
31	Renewables	Utilities	Renewable energy certificates	2	5	2	5	5	35
32	Smart Processing Automation	Utilities	Refrigeration smart automation	2	4	3	5	5	35
33	Temperature change	Hot Water Demand	Steriliser temperatures reduction	3	5	4	1	5	34
34	Sterilisers	Hot Water Demand	Various equipment low water sterilisation	3	3	5	3	3	34
35	Heat Recovery	Rendering	Cooker vapour heat recovery (multiple effect evaporators)	2	4	4	4	4	34
36	Heat Recovery	Rendering	Heat recovery dryer exhaust	2	4	4	4	4	34
37	Hot Water Generation	Hot Water Supply	Combined heat and power plant	3	3	4	4	3	34
38	Refrigeration Optimisation	Refrigeration	VSD's on pumps and fans	1	4	4	5	5	34
39	Refrigeration Optimisation	Refrigeration	Floating discharge	1	5	3	5	5	34
40	Renewables	Utilities	Onsite solar PV/ batteries	2	2	5	5	4	34
41	Renewables	Utilities	Wind turbine	2	2	5	5	4	34
42	Sterilisers	Hot Water Demand	UV knife sterilisation	4	3	5	2	1	33
43	Rendering Optimisation	Rendering	Continuous rendering	2	4	4	4	3	33
44	Rendering Optimisation	Rendering	Condensate return system	2	4	4	3	4	32

	Bucket	Process Area	Opportunity Technology	GHG	CAPEX	OPEX	Maturity	Complexity	Overall
45	Rendering Optimisation	Rendering	Lamella pump (vs traditional piston)	1	4	4	4	5	32
46	Rendering Optimisation	Rendering	Air cooled condenser (vs shell and tube)	1	5	4	4	3	32
47	Demand Reduction	Hot Water Supply	Pump configurations	1	3	4	5	5	32
48	Refrigeration Optimisation	Refrigeration	High efficiency motors	1	4	3	5	5	32
49	Demand Reduction	Utilities	Compressed air management, leak, hours, operation etc.	1	4	3	5	5	32
50	Rendering Preparation	Rendering	Raw materials moisture removal	2	4	3	4	4	32
51	Refrigerant Change	Refrigeration	CO_2 as a refrigerant	1	5	3	4	4	31
52	Chemical Cleaning	Hot Water Demand	Bobby calf chemical carcass wash	2	3	3	4	4	30
53	Chemical Cleaning	Hot Water Demand	Carcass chemical wash - intervention	2	3	3	4	4	30
54	Demand Reduction	Processing	Lights	1	1	5	5	5	30
55	Refrigerant Change	Refrigeration	Natural refrigerants	1	4	3	4	4	29
56	Refrigeration Optimisation	Refrigeration	Air purgers	1	3	3	5	4	29
57	Rendering Optimisation	Rendering	VSEP (vibratory shear enhanced processing)	2	4	4	2	3	29
58	Refrigerant Change	Refrigeration	Absorption coolers	1	4	4	3	3	28
59	Rendering Optimisation	Rendering	Disc dryer (vs continuous)	1	3	3	5	3	28
60	Demand Reduction	Hot Water Demand	Electric hook wash	1	4	1	5	5	28
61	Rendering Optimisation	Rendering	Electric blood coagulation	2	4	1	4	3	27
62	Rendering Optimisation	Rendering	Fat screw press	1	4	1	5	3	26
63	Refrigeration Optimisation	Refrigeration	Underfloor heating optimisation	1	1	4	5	1	24
64	Refrigerant Change	Utilities	Organic rankine cycle	1	3	3	3	2	23
65	Rendering Optimisation	Rendering	Spin flash dryer	1	3	2	3	3	22

Biomass Fuel Types

Extracted from: Biomass boilers for industrial process heat (2023) | EECA

Type of Biomass Fuel	Advantages	Disadvantages
Wood chips *Wood that has been resized by passing through a chipper and at least partially dried.* 	• Less costly than wood pellets • Often compatible with existing handling systems • Easier to produce and scale production than pellets	• Higher volume, lower energy density • Variable moisture content • Harder to handle
Wood pellets *Wood that has been dried, ground up and pressed into cylindrical pellets.* 	• Highest energy density biomass fuel • Most uniform biomass fuel • Easier handling options • Less operator intervention • Lower transport costs and fewer truck movements	• More expensive • May require specific feed technology
Sawdust *Dust from sawmilling operations.* 	• Cheap if you are a sawmill	• Harder to get unless you are a sawmill • Hard to handle and transport • Generally very high moisture content >50%
Hog fuel *Ground up tree stumps and branches. Often very high moisture >50%.* 	• Generally the lowest cost biomass fuel • Easiest to produce, which may make it more available	• Higher volume, lower energy density • Variable/high moisture content • Harder to handle • May clog machinery

Innovation in Downstream Meat Processing

Several innovations and advancements in various technologies have emerged in the downstream processing of meat products.

Although not presently applicable to meat processors, the meat industry should monitor these developments closely to assess how similar technologies could potentially be implemented to enhance or replace existing processes in meat processing plants in the future. Trade and market access requirements should be factored into any assessment of these technologies.

Suppliers

pulsemaster

elea

Shockwave Tenderisation

- Shockwave tenderisation can currently tenderise meat on a small scale, with the goal of replacing long aging processing.
- Appears to be more ecologically benign and economical, however further research is required.

High Pressure Processing

- Used as a cold pasteurisation technique that extends shelf life without degrading meat quality.

→ What is High Pressure Processing?

Pulsed Electric Field

- A low-energy procedure that uses direct electric energy to destroy living cells in the meat without degrading the quality.
- Can enhance the quality of lower-value cuts.

Ohmic Heating

- Uses direct electric heating to reduce microbial load and has the potential to be a cost-effective and efficient technology for treating meat products.