Renewable Energy for Process Heat Opportunity Study

Project Report

May 2020

AUTHORSHIP OF THIS REPORT

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1 Introduction

The *A2EP & Climate-KIC Renewable Energy for Process Heat Opportunity Study* commenced in February 2019 and was completed in May 2020. The recipients of ARENA funding for this project were Australian Alliance for Energy Productivity Limited (A2EP) and Climate-KIC Australia Limited. The project partners were Sustainability Victoria and Office of Environment and Heritage NSW (OEH NSW). ARENA provided $428,956 in funding towards the total project value of $851,269.

Process heating accounts for the largest share of fossil fuel use in Australian manufacturing[1] and historically, alternative renewable process heat technologies have been commercially uncompetitive. During the course of the *Renewable Energy for Process Heat Opportunity Study* 10 pre-feasibility and four full feasibility studies were undertaken. These studies evaluated the technical and commercial feasibility of applying renewable energy, or electric technologies supplied by renewable energy, to displace fossil-fuelled process heating in manufacturing.

The *Opportunity Study* established that renewably powered alternatives to fossil-fuelled process heating are technically feasible and close to, if not actually, commercially viable, particularly if businesses are willing to accept paybacks of 4+ years or existing equipment is at its end of life and requires replacement. Greenfield sites are expected to be more commercially attractive.

Before this program commenced there was little understanding in Australian industry of the potential of renewably powered process heating solutions. However, the strong response to the second round of the program, which commenced in late 2019, and other feedback received, indicates Australian industry is increasingly aware of and interested in exploring the potential of renewable alternatives to fossil-fuelled process heating. The primary drivers of uptake are likely to be a business's desire to reduce energy costs and carbon emissions, with improving energy security and productivity also major considerations.

This report provides an overview of the *Renewable Energy for Process Heat Opportunity Study* project and is structured as follows:

- Section 2 sets out the purpose of the *Opportunity Study*.
- Section 3 discusses project activities, setting out: the milestone schedule; the process by which the steering committee decided which proposals would proceed to subsequent stages of the project; summaries of the pre-feasibility and feasibility studies; and, knowledge sharing activities that occurred during the course of the project.
- Section 4 contains the lessons learned from the project.
- Section 5 provides a brief outline of the recently commenced second round of the *Renewable Energy for Process Heat Opportunity Study*.
- Appendix A contains case studies from the feasibility stage of the project.

[1] https://arena.gov.au/assets/2019/11/renewable-energy-options-for-industrial-process-heat.pdf

2 Project purpose

Process heating accounts for the largest share of fossil fuel use in Australian manufacturing[1] and alternative renewable process heat technologies have historically been commercially uncompetitive. The purpose of the *Renewable Energy for Process Heat Opportunity Study* was to evaluate the technical and commercial feasibility of applying renewable energy or electric technologies supplied by renewable energy to displace/replace fossil-fuelled process heating in manufacturing.

The ultimate aim of the project was to assist in accelerating the adoption of renewables for process heating at temperatures up to 95°C and improve energy productivity in manufacturing. The project focused on process heating at temperatures up to 95°C as temperatures in this lower temperature range are the temperatures at which renewable alternatives are most likely to be viable. The food and beverage industry in particular has many applications where process heating below 95°C is required.

3 Project activities

The work in the *Renewable Energy for Process Heat Opportunity Study* was staged, from pre-feasibility investigations, through to full technical and commercial feasibility studies for selected proposals. The pre-feasibility and feasibility studies were conducted by engineering consultants with energy and process heating expertise.

Funding was provided for 100% of the cost of 10 pre-feasibility studies, up to a maximum of $19,200 excluding GST per pre-feasibility study. The pre-feasibility studies involved physical inspection, data collection and process heat mapping to assess process heat demand requirements against existing supply capacity and develop the case for alternative renewable technologies to meet process heat demand requirements.

Five pre-feasibility proposals were selected to proceed to the feasibility stage of the project. Funding was provided for four full feasibility studies of 50% of the study cost up to a maximum of $20,000 excluding GST per study. The balance of the cost of the feasibility studies was contributed by the participating businesses. Funding was also provided for 50% of the total cost of $3,200 for one partial feasibility study, which did not progress to a full feasibility study due to operational issues at the site.

The feasibility studies entailed detailed analysis of the renewable process heating technologies recommended in the pre-feasibility studies. The purpose of the feasibility studies was to develop a sufficiently comprehensive analysis of the technical and commercial feasibility of the proposals, including detailed costings, to inform investment decisions by participating businesses. The studies may be used to support applications for external funding support. At the time of writing, no final investment decisions to implement the proposals evaluated in the feasibility studies had been announced.

The sub-sections below set out: the schedule of activities for each Milestone of the *Opportunity Study;* the process by which the steering committee decided which proposals would proceed to subsequent stages of the project; and, knowledge sharing activities that were undertaken during the course of the project.

3.1 Milestone schedule

The schedule of activities conducted during each Milestone period were as follows:

Milestone and activities	Completion
1. Market scan: • A2EP prepared a review of the market potential for application of renewable energy to process heating. • A2EP, Climate-KIC, Sustainability Victoria and the Department of Planning, Industry and Environment (NSW) disseminated information about the program to potential participants. • Steering committee reviewed 19 expressions of interest (EOI) from businesses to participate in the program. EOI's included a description of the fossil-fuelled process heating technologies currently in use and a proposal to evaluate a renewable alternative. • Steering committee selected 10 businesses to participate in pre-feasibility studies to evaluate the technical and commercial feasibility of the proposals contained in those business's EOIs.	Feb 2019
2. Pre-feasibility (a): • A2EP entered into agreements with participating businesses and engineering consultants related to conduct of 10 pre-feasibility studies. • Consultants conducted the first batch of six pre-feasibility studies and submitted draft and final pre-feasibility reports. • Steering committee reviewed draft and final prefeasibility reports.	May 2019
3. Pre-feasibility (b): • Consultants conducted the second batch of four pre-feasibility studies and submitted draft and final pre-feasibility reports. • Steering committee reviewed draft and final pre-feasibility reports. • Steering committee evaluated the proposals in the 10 pre-feasibility reports and selected five to proceed to the feasibility stage of the project.	Jun 2019
4. Feasibility: • A2EP entered into agreements with participating businesses and engineering consultants related to conduct of five feasibility studies. • Consultants conducted four full feasibility studies and submitted draft and final feasibility reports. In addition, a partial feasibility study was conducted, but did not proceed to a full feasibility study due to site operating constraints. • Steering committee reviewed draft and final feasibility reports. • A2EP and ARENA conducted close out meetings with businesses that participated in the feasibility stage of the project to discuss their experience of participating in the project and plans for implementation of the proposals evaluated in the feasibility studies.	Jan 2020
5. Project finalisation • Conduct of final knowledge sharing activities. • Preparation of final project reports.	May 2020

3.2 Assessment process

Day to day project management of the *Opportunity Study* was overseen by A2EP, with major decision making the responsibility of the project steering committee. The steering committee was made up of one person from each of the project recipients and partners: A2EP, Climate-KIC Australia, Sustainability Victoria and the Department of Planning, Industry and Environment (NSW). An ARENA representative also attended steering committee meetings as an observer.

Regular steering committee meetings were held throughout the project. Meeting agenda items included: updates on project progress; review and approval of reports generated during each Milestone period; and selection of sites to proceed to subsequent stages of the project. The initial proposals contained in the expressions of interest were assessed to select participants for the pre-feasibility stage of the project. The refined proposals contained in the pre-feasibility reports were assessed to determine which sites would proceed to the feasibility stage of the project.

Factors which were considered as part of the assessment process included:

- The technical feasibility of the proposed solution, including ability to integrate renewable energy.
- The potential for the proposal to result in significant displacement of fossil fuel used for process heating up to 95°C.
- The potential financial and productivity benefits of the proposal.
- The replicability of the proposal at other sites.
- Risks associated with implementing the proposal.
- The level of management support in the business for participation in the *Opportunity Study* and intention to implement the proposal if feasibility was demonstrated.

3.3 Pre-feasibility studies

Ten pre-feasibility studies were conducted in the pre-feasibility stage of the project. A confidential report was provided to the participating business and the steering committee.

The table below contains a summary of the sites that participated in the pre-feasibility stage of the project including: site activity; site location; fossil fuel process heating technology currently in use; the proposed solution i.e. the renewable process heating alternative being evaluated in the pre-feasibility study; and, the consultant responsible for undertaking the pre-feasiblity study.

Table 1: Summary of pre-feasibility study sites

Activity	Location	Existing technology	Proposed solution	Consultant
Vegetable processing	Regional TAS	5MW natural gas boiler for cleaning, peeling, blanching, defrosting	a. 1.5 MW heat pump b. 5 MW biomass boiler	pitt&sherry
Brewing	Urban SA	2 x 10 MW natural gas boilers for brewing	2 x 350 kW CO2 transcritical heat pumps, solar PV	pitt&sherry
Food processing	Regional VIC	25MW natural gas boiler for heating water	250kW ammonia heat pump, solar PV	DETA
Wine production	Riverina NSW	1MW boiler for heating water	Co-join ring mains + 100-900kW heat pump, solar PV	2XE
Food & beverage manufacturing*	Regional NSW	10MW + 4MW natural gas boilers	2MW heat pump	Northmore Gordon
Food & beverage manufacturing	Western Sydney NSW	4 x 1.25MW boilers + 2 x 740kW Raypak hot water generators	80kW heat pump, PV + 250kW heat pump, RE PPA	2XE
Pet food processing	Regional NSW	1.8MW natural gas steam boiler + 1.1MW natural gas dryer	2 x CO2 heat pumps, PV + 1 x boiler flue stack economiser	2XE
Steel wire manufacturing	Regional NSW	3.125 MW natural gas fired boiler	Co-fired waste heat steam generator, heat from fluidised bed furnace flue	Northmore Gordon
Confectionary manufacturing	Regional VIC	1 x 4MW boiler + 2 x 2MW boilers for additional loads	2 x heat pumps to remove moisture from air used for drying, RE PPA	pitt&sherry
Beverage manufacturing	Urban NSW	2 MW natural gas boiler that produces 7.5 bar steam	Ammonia heat pump powered by PV and condensing hot water boilers	Northmore Gordon

Bold text denotes sites that progressed to the feasibility stage of the project

*Partial feasibility work conducted only due to operational constraints

The spread of characteristics of the 10 pre-feasibility sites can be summarised as follows:

- Regional/metropolitan mix: 6 regional and 3 metropolitan
- State distribution: 1 Tasmania, 1 South Australia, 2 Victoria, 6 NSW
- Industries: 5 food processing, 1 pet food processing, 1 brewing, 1 wine production, 1 alcoholic beverage manufacturing, 1 steel wire manufacturing
- Technologies evaluated: 9 heat pumps, 1 biomass boiler, 1 waste heat steam generator.

The scope of the project was limited to evaluating proposals to displace fossil fuelled process heating at temperatures below 95°C as this is the temperature range where the greatest opportunities to deploy renewable process heating lies. Food and beverage businesses were the most commonly selected to participate in the project as that industry, in particular, has many applications where process heating below 95°C is required.

Figure 1: Heat pump

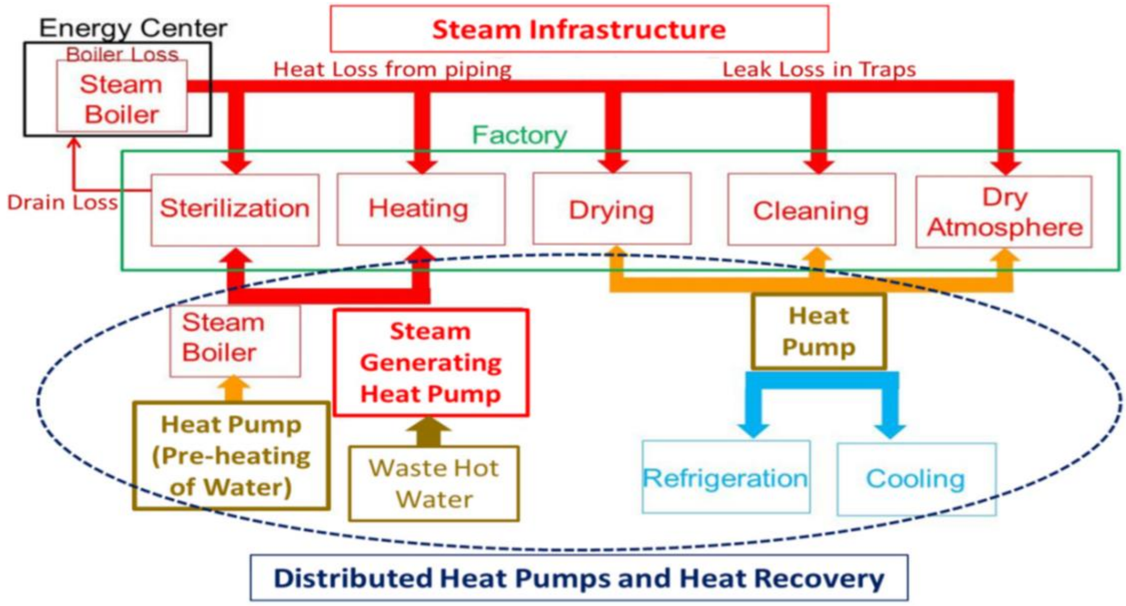
Heat pumps were the predominant type of technology considered in the pre-feasibility studies.

This was because they are a technology that is suited to efficiently creating process heat in the target temperature range and can be renewably powered. Heat pumps are technically mature but rarely deployed in Australian industry mainly due to lack of awareness of their capabilities, cost and less developed supply chains compared to commonly used process heating technologies such as gas-fired boilers.

A common scenario evaluated in the pre-feasibility studies was replacing gas-fired boilers with heat pumps to heat water. As the sites participating in the program were operational, the scenarios generally focused on an incremental change to a specific process at the site, rather than a whole of site system change.

However, as can be seen in the figure below, for a greenfield site, or site where complete replacement of the process heat system is being considered, an inefficient centralised gas fired boiler system with high distribution losses (top of diagram) could potentially be fully or partially displaced with heat pumps distributed to the point of application.

Figure 2: Replacement of gas boiler with point of end use heat pumps



See Section 4 for a discussion of lessons learned during the course of the project and Appendix A for case studies of the feasibility studies.

3.4 Feasibility studies

Four full feasibility studies and one partial feasibility study were conducted in the feasibility stage of the project. The partial feasibility study did not progress to a full feasibility due to operational constraints at the site. A confidential report of each feasibility study was provided by the consultant conducting the study to the participating business and the steering committee .

The table below contains a summary of the sites for which full feasibility studies were conducted including: business name; site activity; site location; fossil fuel process heating technology currently in use; the proposed solution i.e. the renewable process heating alternative being evaluated in the feasibility study; the benefits of the proposed solution; and, the consultant responsible for undertaking the feasibility study.

Table 2: Summary of feasibility study sites

Business	Activity	Location	Existing technology	Proposed solution	Benefits of proposed solution	Consultant
Simplot	Vegetable processing	Devonport TAS	5MW natural gas boiler for cleaning, peeling, blanching, defrosting	a. Heat pumps, PV b. Biomass boiler	↓ energy & operating costs, wash & defrost time, boiler softener use, pumping loads ↑ product quality & brand image	pitt&sherry
Lion	Brewing	Adelaide SA	2 x 10 MW natural gas boilers	CO_2 heat pumps, PV	↓ energy use & costs, steam transmission losses, boiler softener use, pumping loads ↑ demand response	pitt&sherry
McCain	Food processing	Ballarat VIC	25MW natural gas boiler for heating water	Heat pump, PV	↓ energy use & costs ↑ refrigeration capacity, resilience to gas price restrictions/price increases	DETA Consulting
De Bortoli	Wine production	Riverina NSW	1MW boiler for heating water + hot water generator	Ammonia heat pump, PV	↓ energy use & costs, water use ↑refrigeration system efficiency, boiler life	2XE

The spread of characteristics of the four full feasibility sites are as follows:

- Regional/metropolitan mix: 3 regional and 1 metropolitan
- State distribution: 1 Tasmania, 1 South Australia, 1 Victoria, 1 NSW
- Industries: 2 food processing, 1 brewing, 1 wine production
- Technologies evaluated: 4 heat pumps, 1 biomass boiler

See Section 4 for a discussion of lessons learned during the course of the project and Appendix A for case studies of the feasibility studies.

3.5 Knowledge sharing

A key objective of the project was to increase awareness and understanding of renewable alternatives to fossil-fuelled process heating, particularly within the manufacturing sector and the engineering consultancies that service the sector.

Participating in the project clearly resulted in an improved understanding of these alternatives for the businesses and consultancies involved. Additional support for the consultants conducting feasibility studies was provided in the form of a workshop and mentoring with a focus on process heat integration and pinch analysis. The workshop, funded by ARENA, was held in Sydney in July 2019 and was attended by the consultants plus staff from some of the participating businesses. The workshop was presented by Dr Martin Atkins of Waikato University and Mr Stephen Drew of SRD Consulting.

Dr Atkins subsequently provided mentoring to the consultants, holding meetings with each consultant to discuss their approach to the feasibility study and provide guidance, particularly in relation to process integration, pinch analysis and solutions optimisation.

It was also the aim of the project to disseminate information more widely than just to the direct project participants. The primary forum for this broader knowledge sharing was A2EP's regular Innovation Network meetings. These meetings were held "virtually" using the Zoom conferencing system at least once during each Milestone period. A typical meeting involved around 40-50 participants from across industry, consulting, government and research/educational institutions.

At each Innovation Network meeting held during the project period, an update of project progress was provided and results and lessons learned during the pre-feasibility and feasibility stages were presented.

4 Lessons learned

Valuable lessons were learnt during the course of the project. These learnings will be used to improve the process and outcomes of the second round of the *Opportunity Study*, which commenced in late 2019.

Major lessons learnt include:

- Renewably powered alternatives to fossil fuelled process heating are technically feasible and close to, if not actually, commercially viable, particularly if businesses are willing to accept paybacks of 4+ years or existing equipment is at its end of life and requires replacement. Greenfield sites are expected to be more commercially attractive. This will be tested in the second phase of the program which includes two greenfield sites.
- Short (less than 3 years) payback period requirements and conservative attitudes towards implementing innovative solutions are a significant barrier to uptake of renewable alternatives to fossil-fuelled process heating, though some companies are willing to relax hurdles for investments that meet sustainability objectives.
- Before this program commenced there was little understanding in Australian industry of the potential of renewable process heating solutions. However, the strong response to the second round of the program, and other feedback received, indicates Australian industry is

increasingly aware of and interested in exploring alternatives to fossil-fuelled process heating. The primary drivers of uptake are likely to be a business's desire to reduce energy costs and carbon emissions, with improved energy security and productivity also major considerations.

- Lack of metering/data was the biggest challenge for consultants conducting the studies.
- Understanding site-particular process heat flows and the specific temperatures required to achieve desired outcomes is essential. Mass energy balance analysis should be conducted at the pre-feasibility stage and it is essential to differentiate between utility demand and process demand.
- Retrofitting proved to be more complex than expected for large sites.
- Greater training of site staff and consultants to industry in process integration and pinch analysis is required for optimisation of solutions.
- Consultants need to have a clear view of the site's longer-term energy and production plans, priorities, resource constraints and decarbonisation goals to optimise solutions.
- Local equipment suppliers are at the thin end of a long supply chain and not all on-market options are available in Australia. Some overseas equipment suppliers have advised they do not currently wish to enter the Australian market, which they consider to be small and a long way from their base. This project, and the second phase of the project, are making a contribution towards demonstrating the potential size of the Australian market. A2EP has and continues to engage with overseas suppliers with a view to increasing the range of renewable process heating technologies available in Australia.
- The participating businesses recognised the value of the independent technical experts (consultants) as 'honest brokers' and a source of upskilling on new technologies for site staff. Overall, the sites concluded that participating in the program was a worthwhile learning experience and changed the way they looked at process heating.

5 Forward plan

The second phase of the *Renewable Energy for Process Heat Opportunity Study* commenced in late 2019. There was a strong response to the issue of a request for expressions of interest to participate in the second round of the *Opportunity Study*, with 27 submissions received. Ten sites were selected to progress to the pre-feasibility stage in March 2020.

The format of the second phase of the *Opportunity Study* largely replicates that of the first phase, with refinements based on the lessons learnt from phase one, as discussed in Section 4. The second phase also targets a broader range of temperatures requirements, industries, locations and technologies than the first phase. Two greenfield sites are included in the second phase.

The parties collaborating in the second phase of the *Opportunity Study* remain the same as the first phase: Australian Alliance for Energy Productivity Limited (A2EP) and Climate-KIC Australia Limited, Sustainability Victoria and the Department of Planning, Industry and Environment (NSW).

The schedule for the second phase is as follows:

Milestone	Completion
1. Market scan: selection of 10 sites to participate in pre-feasibility studies	Mar 2020
2. Pre-feasibility: conduct of first batch of pre-feasibility studies	May 2020
3. Pre-feasibility: conduct of remaining pre-feasibility studies and selection of up to 5 sites to proceed to feasibility	Jul 2020
4. Feasibility: conduct of feasibility studies	Jan 2021
5. Final knowledge sharing activities	Apr 2021

Appendix A: Case studies

Please see the following pages for case studies of the sites for which full feasibility studies were prepared.

Case study 1: De Bortoli Wines

Case study 2: Lion – Beer, Spirits and Wine

Case study 3: McCain Foods

Case study 4: Simplot Australia

Case study 1: De Bortoli Wines

Renewable Energy for Process Heat
Feasibility Report - Case Study
De Bortoli Wines

SITE DETAILS

Company:	De Bortoli Wines
Site:	Bilbul, Riverina, New South Wales
Application sector:	Winery
Technologies featured:	Heat pump
Consultant engaged for this study:	2XE | 2xe.com.au

This feasibility study was conducted as part of our Renewable Energy for Process Heat Opportunity Study – Phase 1. This project was undertaken in partnership with Climate-KIC Australia and in collaboration with Sustainability Victoria and the Department of Planning, Industry and Environment (NSW). The project was part-funded by the Australian Renewable Energy Agency (ARENA), more information here. A second phase of the project was commenced in early 2020, more information here.

The purpose of the feasibility study was to determine the technical and commercial feasibility of replacing some or all of the current fossil fuel process heating on the site with renewably powered alternatives, and to detail a pathway to implementation including technical and financial specifications and a business case for investment.

This case study summarises the findings of the study and is published with permission of the proponent. For more information about A2EP and the project, go to a2ep.org.au.

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Context

- Wine production
- Site has both winery and packaging operations with a large, low temperature (<100°C) heat demand driven by packaging process heating, CIP, sanitisation and regeneration filters.
- Heat demand is primarily serviced by two individual hot water ring mains each with unique hot water generation technologies including a solar thermal array (~200kW), condensing boilers (2 x 280kW) and a Raypak hot water generator (960kW). Some heat recovery is obtained from air conditioning systems.

Proposal

- Ammonia heat pump recovering waste heat from DBW's refrigeration system to generate hot water for process heating requirements. Mycom HS4 reciprocating compressor. Heat pump output can be modulated between 100kW and 900kW within a few minutes. Electrical consumption of the heat pump is to be offset with a 270kW solar PV system.
- This heat pump will dramatically offset gas consumption of existing boilers used for process heat in the packaging hall and cellar.
- CAPEX: ~$950,000
- Payback of 4.8 years, excluding potential Energy Saving Certificates generation or ARENA funding.
- Productivity benefits: cooling tower water savings, reduced maintenance costs, reduced plant downtime/increased plant reliability, improved refrigeration efficiency.
- Project benefits:

Net case	Capital cost ($)	Net energy savings		Fossil fuel displacement				
		Cost savings	Energy reduction	Fossil fuel savings	Additional electricity use	GHG saving (tCO2-e)	Renewable energy fraction (total)	Renewable energy fraction (thermal)
Heat pump w/ solar	~$950,000	11.2%	28.6%	86.0%	1,354 GJ/year	8.6%	11.6%	87.1%

Case study 2: Lion - Beer, Spirits and Wine

Renewable Energy for Process Heat
Feasibility Report - Case Study
Lion – Beer, Spirits and Wine

SITE DETAILS

Company:	Lion – Beer, Spirits and Wine
Site:	West End Brewery, Adelaide, South Australia
Application sector:	Brewery
Technologies featured:	Heat pump
Consultant engaged for this study:	pitt & sherry | pittsh.com.au

This feasibility study was conducted as part of our Renewable Energy for Process Heat Opportunity Study – Phase 1. This project was undertaken in partnership with Climate-KIC Australia and in collaboration with Sustainability Victoria and the Department of Planning, Industry and Environment (NSW). The project was part-funded by the Australian Renewable Energy Agency (ARENA), more information here. A second phase of the project was commenced in early 2020, more information here.

The purpose of the feasibility study was to determine the technical and commercial feasibility of replacing some or all of the current fossil fuel process heating on the site with renewably powered alternatives, and to detail a pathway to implementation including technical and financial specifications and a business case for investment.

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Context

Lion – Beer, Spirts and Wine Pty Ltd is one of the largest brewers in Australia, with iconic beers and ciders such as West End, Boag's, James Squire, Little Creatures and 5 Seeds as part of their portfolio. The business also has a strong focus on sustainability and corporate leadership, with recently announced commitments to be Australasia's first large-scale carbon neutral brewer by 2020. Lion has also pledged to use 100% renewable electricity in its operations by 2025.

The site at Thebarton, Adelaide is a large brewery that produces West End and a variety of other beers and ciders based on business needs.

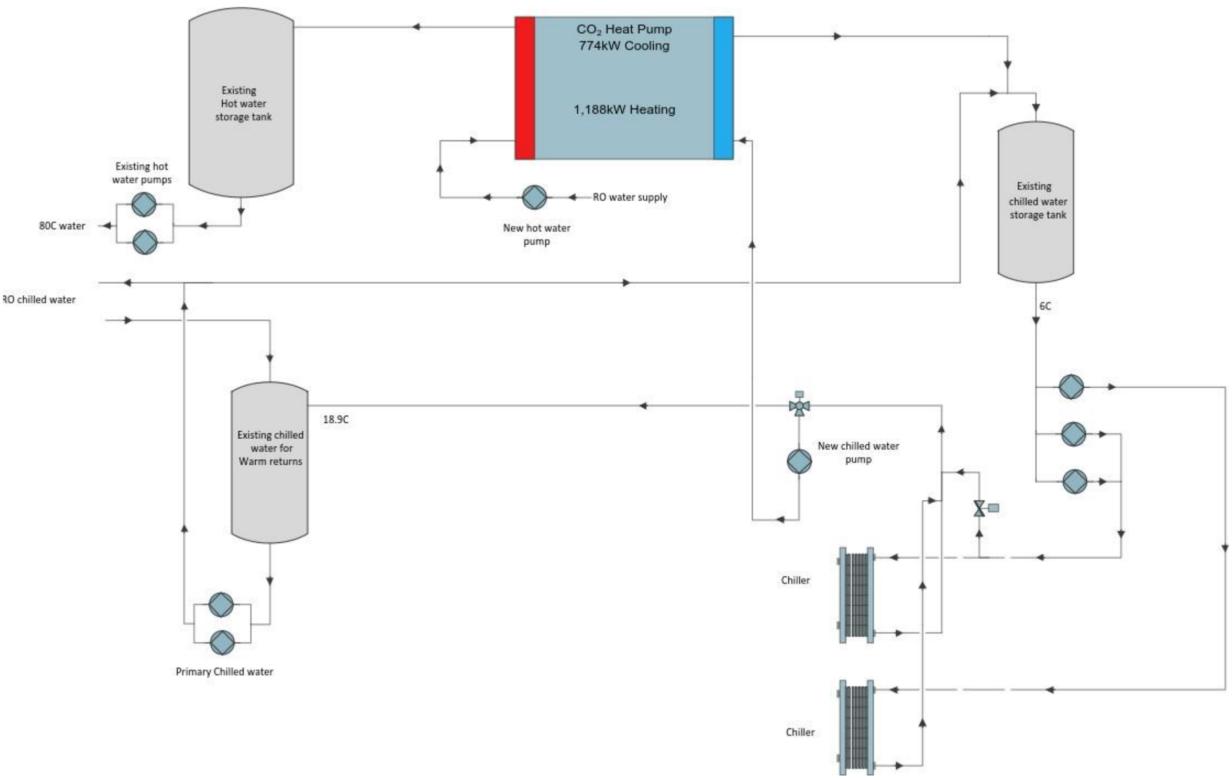
The site has a single heat utility system serviced by two (2) 10MW firetube boilers in a centralised steam plant that provides process heat for beer production, pasteurisation, as well as equipment cleaning. This classic type of brewery setup has been the standard for many years and can be found in breweries across the world. Whilst highly functional, this type of design does not respond well to the changing demands of the modern beer market and its shift to more craft beer that is produced in smaller batches. This results in low system efficiency and poor system utilisation. Addressing these issues is Lion's primary driver to investigate new and innovative technologies to replace their existing process heating needs with a more efficient, electrified and renewably sourced energy supply.

This feasibility study is centred on determining the operational and financial viability of the replacement of some or all of the existing gas fired boiler steam and heating supply with electric heat pump technology and consolidating the boiler heat demand to just a single unit.

Proposal

The proposed project will utilise two large scale CO_2 heat pump systems:

1. A 357 kWe system providing 1188 kWt of heat and 774 kWt of cooling to the brewhouse operations. This system will use the chilled water (used for wort cooling) as the heat source and produces hot water for all brewhouse heating and cleaning needs with the exception of wort boiling and mashing. As this is a water sourced heat pump, the cooling side will benefit the system by producing chilled water on location, reducing the duty cycle for the ammonia refrigeration plant.



2. A 350 kWe system providing 1155 kWt of heat for the Clean in Place system at the bottling plant. This system will be air sourced due to the lack of refrigeration needs.

Whilst the CO2 heat pumps proposed do replace most of the boiler duty, they do not replace all of it due to the high capital costs involved. The brewing process requires heating of the wort to over 100°C which is difficult to achieve using heat pumps. Direct electric heating can be used for this purpose though brewing equipment with this type of heating technology would need to be custom built.

However, the technical feasibility of replacing all other Clean in Place systems on site (which are the other large steam user at this facility) is established and is limited only by cost. We envisage that a brewery of the future would be built with these renewable, electrified, on demand heating systems with a biogas boiler to provide redundancy and additional peak heat demands.

This project's financial performance (excluding the planned installation and subsequent use of renewable energy) is as follows:

Capital cost ($, ex GST)	$3,430,000
Simple payback period (years)	4.4
Net energy savings (GJ/year) and % of site total	>43,000 (32%)
Net energy savings ($/year) and % of site total	~(24%)
Additional renewables deployed (GJ/year)	~3,000
GHG reduction (T CO2-e) and % of site total	>4,800 (27%)

Productivity benefits: Reduced boiler standby losses by using only a single boiler. Reduced maintenance costs due to lower boiler run times. Greater ability of the site to respond to partial loading of production levels. Reduced run times of refrigeration equipment.

Case study 3: McCain Foods

Renewable Energy for Process Heat
Feasibility Report - Case Study
McCain Foods

SITE DETAILS

Company:	McCain Foods
Site:	Ballarat, Victoria
Application sector:	Food processing
Technologies featured:	Heat pump
Consultant engaged for this study:	DETA Consulting | deta.global

This feasibility study was conducted as part of our Renewable Energy for Process Heat Opportunity Study – Phase 1. This project was undertaken in partnership with Climate-KIC Australia and in collaboration with Sustainability Victoria and the Department of Planning, Industry and Environment (NSW). The project was part-funded by the Australian Renewable Energy Agency (ARENA), more information here. A second phase of the project was commenced in early 2020, more information here.

The purpose of the feasibility study was to determine the technical and commercial feasibility of replacing some or all of the current fossil fuel process heating on the site with renewably powered alternatives, and to detail a pathway to implementation including technical and financial specifications and a business case for investment.

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Context

McCain Foods operates a manufacturing plant in Ballarat, Victoria. The plant is split into two sites - Potato Plant and Prepared Foods Plant. The Potato Plant prepares potato products such as French-fries, wedges, roast potatoes and hash browns. The Prepared Foods Plant prepares meal products including prepared frozen meals, pizzas and lasagne. McCain has operated at the site since 1974.

The Plant is committed to reducing its carbon footprint and improving its operational resource efficiency as part of its overall strategic "*Be Good Do Good*" initiative and McCain's Global response to climate change.

Heat, in the form of high, medium, and low-pressure steam is used for a variety of food preparation purposes including:

- washing;
- peeling;
- blanching;
- fryer oil heating; and
- drying.

Steam is generated at a single natural gas-fired boiler. As much of the steam is used in direct steam injection (DSI) application, it is currently not amenable to reuse as a heat-containing condensate. This represents both a water use reduction and heat capture opportunity.

Refrigeration services represent a significant electricity use for the Plant with a combined 3 MW of installed compressors consuming approximately 10% of the Plant's electricity. The majority of heat rejection is via evaporative condensers, with some heat recovered elsewhere (to underfloor heating in freezers).

Proposal

An opportunity was identified to recover heat from the large refrigeration system, rather than rejecting it at the evaporative condensers, by installing a high-temperature heat pump (HTHP) to take available heat from the refrigeration compression-cycle and upgrade it, through further compression to a higher temperature, where it's heat could be given up to process water at up to 85°C.

The heat sink proposed for the resulting HTHP heat was the preheating of make-up water to the boiler-house feed-tank, with the aim of reducing steam requirement for this service to practically nil. Heat available over and above that required at the feed-tank further holds the potential to pre-heat potable water for process and cleaning services.

The steam boiler was to remain in service, continuing to supply the main site steam requirements, and as a back-up supply for feed-tank heating when required.

Cost

The total project cost was estimated at approximately $1.5 million, with around $900,000 of this being for the supply and electrical/mechanical installation of the heat pump itself. The HTHP would produce a hot-water discharge temperature of up to 85°C.

Simple payback was projected to be approximately 7 years. This was calculated on the basis of a potential future solar plant (under feasibility) generating the required electricity for the HTHP.

Benefits

A key factor in the consideration of this proposal was the potential for significant reductions to the site's energy related carbon emissions. Two particular elements combined to create this potential; are:

- Solar electricity generation – the site is undertaking a feasibility study regarding the installation of a solar plant. Solar power has effectively zero carbon emissions, compared to grid electricity in Victoria which has emissions of 1.02 $kgCO_2e/kWh$ (2019 figures).
- HTHP Efficiency – the HTHP would offer a coefficient of performance (CoP) of up to 5 (effectively an efficiency of 500% on an electricity -in to heat-output basis), as compared to the existing boiler efficiency of 82%. So even on grid electricity, the net carbon emissions per kWh of heat delivered to site would be lower (0.204 $kgCO_2e$) for the HTHP compared to the existing boiler set-up (0.226 $kgCO_2e$).

Assuming the project could be delivered in a manner where electricity is sourced from an on-site solar plant, the overall CO_2 emissions from the Plant could reduce the Plants CO_2 emissions and energy usage by approximately 2% and 4%, respectively.

At this stage the proposal requires further development to fully integrate with other energy efficiency projects under consideration. Given the anticipated benefits, McCain intend to develop the HTHP feasibility further once all feasibilities are completed.

Case study 4: Simplot Australia

Renewable Energy for Process Heat
Feasibility Report - Case Study
Simplot Australia

SITE DETAILS

Company:	Simplot Australia
Site:	Quoiba Plant, Devonport, Tasmania
Application sector:	Food processing
Technologies featured:	Heat pump and biomass boiler
Consultant engaged for this study:	pitt & sherry | pittsh.com.au

This feasibility study was conducted as part of our Renewable Energy for Process Heat Opportunity Study – Phase 1. This project was undertaken in partnership with Climate-KIC Australia and in collaboration with Sustainability Victoria and the Department of Planning, Industry and Environment (NSW). The project was part-funded by the Australian Renewable Energy Agency (ARENA), more information here. A second phase of the project was commenced in early 2020, more information here.

The purpose of the feasibility study was to determine the technical and commercial feasibility of replacing some or all of the current fossil fuel process heating on the site with renewably powered alternatives, and to detail a pathway to implementation including technical and financial specifications and a business case for investment.

This case study summarises the findings of the study and is published with permission of the proponent. For more information about A2EP and the project, go to a2ep.org.au.

Australian Alliance for Energy Productivity (A2EP)
A2EP is an independent, non-partisan, not-for-profit coalition of business, government and research leaders promoting a more energy productive economy. We advocate for the smarter use of energy for improved economic outcomes.

Context

Simplot's Devonport factory processes a large variety of vegetables and this makes it quite unique. The plant produces for the Birds Eye and Edgell frozen vegetable brands. The main activities on site are categorised as cleaning, peeling, cutting, blanching, cooling after blanch, freezing, and cold storage.

Heating is used for blanching and peeling and for hot water. Hot water is used widely around the plant for cleaning and for defrosting freezer tunnels. This heat is provided by a natural gas fired 5MW boiler. The boiler produces steam at high pressure (1500kPa) and is reduced immediately above the boiler to 500kPa. Steam is delivered around the plant using well insulated piping. In all cases steam is used only after a final pressure reduction to 20kPa.

The natural gas boiler is nearing the end of its life and is likely to be replaced in the next 3-5 years. The boiler is a rebuild of what was once a briquette fuelled boiler, and then for a period a coal fired boiler, before being converted to natural gas. The boiler has a bespoke economiser.

There are advantages for the plant production processes if more hot water can be made available. Cleaning would be quicker with warmer water. Most importantly the defrosting of the freezer tunnels will be faster. Freezer tunnels run for a considerable time before ice builds up on the internal surfaces, and this eventually needs to be removed. Warm water is used to melt and wash away the ice during a freezer tunnel shut down. At the moment the supply of warm water is limiting and the shutdown time of the freezer tunnels is longer than it needs to be.

Simplot can produce more warm water very simply by increasing the use of natural gas at the boiler. However, the heat required for warm water does not need to be produced at the high pressures and temperatures of the steam boiler. There are other more efficient sources of this lower grade heat on site.

The project proposes two stages of development:

1. 0-2 years - Create extra hot water on site by capturing rejected heat from the very significant refrigeration system. This is waste heat and using it elsewhere increases plant efficiency and does so with no additional carbon footprint.
2. 3-5 years - Remove the carbon footprint of the remaining boiler operations by replacing natural gas with locally available bio fuel such as wood waste or woodchips.

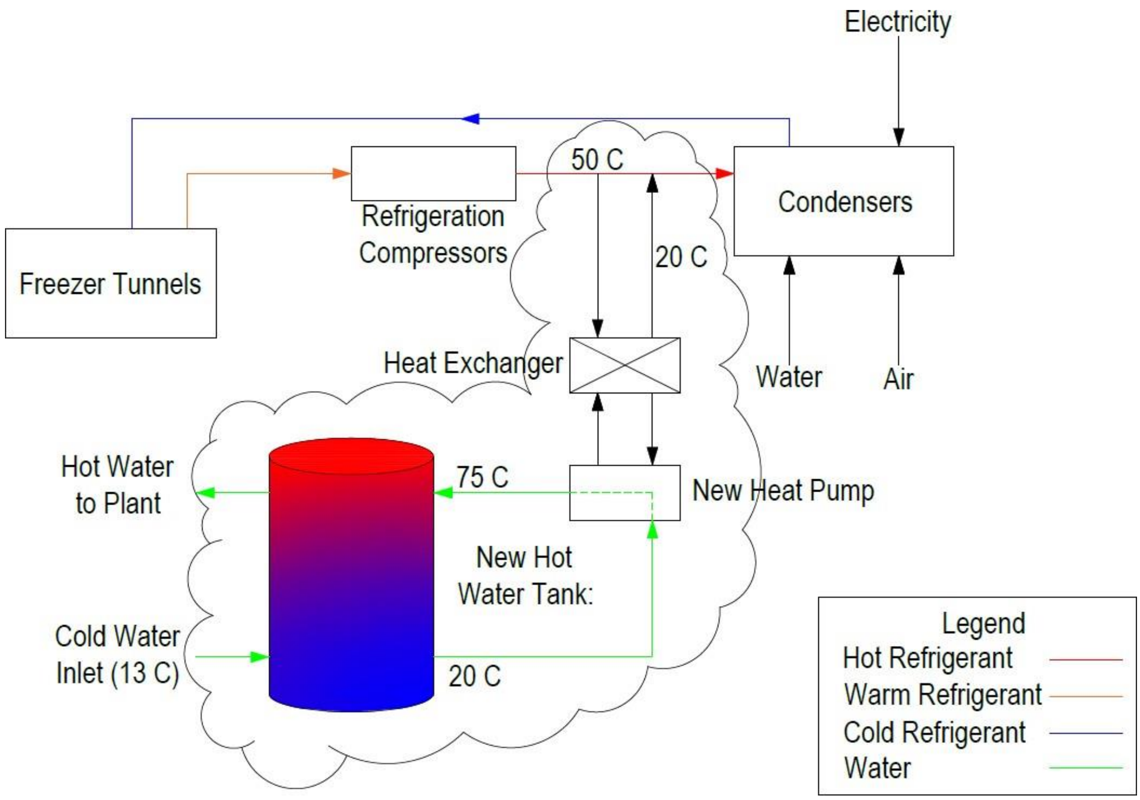
Proposal 1

Refrigeration on site is significant with 4 blast freezing tunnels in relatively continuous operation. The site runs an ammonia refrigeration system with typical water-cooled condensers on the roof. These condensers reject the heat that is extracted from the vegetables. This rejected heat can be captured by extracting it from the condenser circulation line (ammonia gas) prior to the existing condensers. This will be achieved with a new high temperature heat pump that can upgrade the heat from the condenser ammonia line from 50C to produce hot water at 70C. The heat pumps to be used have a conventional refrigerant and are very efficient having a high coefficient or performance (COP). There are two possible manufacturers and models in mind at this time, either would use a single ~1600kW unit producing heating for hot water uses.

This replaces the hot water that is currently produced by the boiler. This system also provides the desired new hot water to the factory. The additional hot water has several benefits around the plant in reducing time to defrost tunnels and reducing time for cleaning. It will also reduce the amount of water used for cleaning, the amount of water used by the boiler and water use at the condensers. The energy benefits include the reduction in boiler gas usage, a reduction in electricity used at the condensers and a reduction in chemical usage at the boiler.

An additional benefit of the increased freezer tunnel running time is greater opportunity to process local vegetables during peak season. This better use of local vegetables is a significant saving in transport and logistics costs, and the reduction in transport is another greenhouse gas improvement.

The project effectively takes what is a waste heat stream - one that currently demands electricity and water use in the condensers - and upgrades it to a useful heat stream that significantly reduces the load on the condensers and boiler. The drawing shows the new equipment in the clouded area.



The nett cost of the installation is $1.3m (or $1.8m if site solar PV is installed to provide electricity to run the heat pumps). Annual benefits total around $0.2m for a relatively long payback period.

The reduction in fossil fuel use is 790tCO2e, or around 13% of the site footprint.

Proposal 2

The second phase of the project involves replacing the existing natural gas boiler with a biomass boiler at the time of replacement of the boiler.

The biomass boiler would be 5MW at an installed capital cost of $5.2m (current prices). The boiler would use a dedicated woodchip supply at fuel quality (not export quality). This biomass boiler option results in the provision of all steam to the remaining processes on site and has an annual benefit of $300k.

The business as usual replacement of the natural gas boiler with another new natural gas boiler is $4.8m. Thus, the difference between the two – new biomass boiler versus a new natural gas boiler – is $400k. So, there is a benefit of $300k per annum for this additional small extra cost. The reduction in fossil fuel use is 2500tCO2e, or around 46% of the site footprint.