HARDWICK PROCESSORS PROPRIETARY LIMITED

HEAT PUMP PROJECT:2021/ARP021

FINAL REPORT

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EXECUTIVE SUMMARY

This Project has demonstrated the use of heat pump technology in managing industrial process heat demand powered by renewable energy to support decarbonization of the industrial sector.

The report covers the operating experience over the last year (May 24 to current) following the initial operating phase of the Project during early 2024.

As previously reported Hardwicks became a HV customer on the 3rd of December 2022, with commissioning of the system heat pump following.

The heat pump and oil heat recovery system are running continuously providing combined thermal energy output in the range 900 kW to 1500 kW when operating during the production week. During the period Oct 23 to Sept 24 the plant run hours typically operated at 5 x 24 (annualized at 5512 hours; or 63% capacity factor) which was a little lower than anticipated. This was due to a production decision not to operate the heat pump for hot water inventory built during weekends.

The heat pump and the oil heat recovery systems is providing around 61% of the energy required to produce process hot water for the site (45% heat pump and 16% oil heat recovery). The remainder is still provided by natural gas for elevation to the final process temperature required

Show in the following table is the combined outputs from the systems during the October 23 to September 24 performance logging period.

Description	Total	heat pump	oil cooler	units
Combined output of heat pump and oil recovery	1266	932	334	KW
Annualised operating hours from log sheets	5512	5512	5512	hrs
Output	4.6	3.355	1.2	GJ/h
Annualised total savings	29550	21758	7792	GJ/y

Typically, the heat pump itself operates between 900 and 930 KW (frequency set at 43Hz on drive) however the unit could operate at its' thermal capacity of 1000KW if required. The higher-than-expected output from the oil heat recovery units has prioritized this free heat recovery over the heat pump operating at its maximin possible rating. It also means the heat pump is operating at a lower compression pressure which is likely to increase its operating life between overhauls.

Subsequently to the above, due to the current drought and supply availability the plant has significantly reduced production (reduced shifts for beef production and overall daily processing rates). This drop in production has reduced demand for process hot water which has meant the requirement for the heat pump was diminished during this period. The

running hours for the heat pump from Oct 24 to May 25 is annualized at 4,277 hours (or 49% capacity factor).

Show in the following table is the combined outputs from the systems during the October 24 to May 25 performance logging period.

Description	Total	heat pump	oil cooler	units
Combined output of heat pump and oil recovery	1088	901	187	KW
Annualised operating hours from log sheets	4277	4277	4277	hrs
Output	3.9	3.2	0.7	GJ/h
Annualised total savings	19711	16323	3396	GJ/y

It is expected that production levels and consequently hot water demand will return to previously seen levels over the next year, which will enable running hours for the system to return to at least 5 x 24-hour basis weekly operations.

The other major change made to the heat pump and heat recovery system has been the flow and temperature set points chosen for the operational system. It was found that it was more appropriate to operate the heat pump outlet water temperature in the range 68 to 74C range with combined flows for the heat pump and the oil cooler in the range of 54 to 64C. The overall preheat temperatures are slightly lower than projected for the project, however this is more than offset by an increase in flow through the system.

The HV transition is now in place with both the plant and the PV/ battery operating satisfactorily on this new system.

In summary, technical outcomes have been achieved, although some optimization is still to be undertaken, and operational interface factors remain to be finalized.

INTRODUCTION

This report covers the operating experience for the project since commissioning during the period May 2023 to May 2025.

The total project scope included:

The installation and operation of 1 MW (thermal) capacity heat pump and associated heat recovery infrastructure to deliver hot water at a planned 75°C to satisfy most of the heat demand for the 82°C hot water circuit required for process water.

The heat pump and oil heat recovery system are now running continuously providing combined thermal energy output in the range 1088 to 1266 kW when operating during the production week. This is in line with the designed combined output of 1056 kW for the project. The major variance from design currently is the thermal mix between the heat pump and the oil heat recovery system with the heat pump providing around 83% of thermal energy generated (17% from oil recovery) compared to design projected of 95% from heat pump and 5% from oil heat recovery. This is due to higher-than-expected performance from the oil heat recovery systems as well as operational decision to operate the heat pump at lower than its full capacity (speed set at 43Hz compared to 50Hz. The current mix maximizes the low-cost heat from the oil system as well as delivering an appropriate heat balance for the current plant hot water loads.

Show in the following table is the combined outputs from the systems during the October 23 to September 24 performance logging period.

Description	Total	heat pump	oil cooler	units
Combined output of heat pump and oil recovery	1266	932	334	KW
Annualised operating hours from log sheets	5512	5512	5512	hrs
Output	4.6	3.355	1.2	GJ/h
Annualised total savings	29550	21758	7792	GJ/y

During the period Oct 23 to Sept 24 (5,059 hours) the plant typically operated at 5 x 24 per week (is annualized at 5,512 hours) which was a little lower than anticipated. This was due to a decision not to operate the heat pump for hot water inventory built during weekends.

Subsequently due to the drought and supply availability the plant has significantly reduced production (reduced shifts for beef production and overall daily processing rates). This drop in production has reduced demand for processed hot water which has meant the requirement for the heat pump was diminished during this period. The running hours for the heat pump from Oct 24 to May 25 (2,461 hours is annualized at 4,277 hours).

The Project has demonstrated the use of heat pump technology in managing industrial process heat demand powered by renewable energy to support decarbonization of the industrial sector. It has reduced the perceived risks associated with industrial heat pump installation and should aid further uptake in the industry.

A significant upgrade to the electrical supply system in addition to the heat pump installation. This upgrade results in Hardwick Meat Works becoming a High Voltage customer, taking supply at 22 kV from the Powercor network and upgrading total supply capacity from 2 Mega Volt-Amp (MVA) to 4 MVA. Hardwicks became a HV customer on the 3rd of December 2022, with commissioning of the heat pump following this during late December 2022-February 23 period.

The power upgrade and HV interface to the existing 2.5MW solar array resulted in the previous site power constraint to be overcome. This allowed the 250KW electrical load of the heat pump to be catered for as well as providing incremental electricity for plant expansion. The integration of the solar array into the HV upgrade will also streamline the installation of future incremental PV arrays on site.

Currently the existing 2.5MW solar array provides about 36% of total power used at the site (including the heat pump power loads). Therefore, in evaluating the heat pump project the reduced cost of the solar power was apportioned using the same percentages (i.e. 36%) to derive overall running costs for the unit.

Currently there is no export from the PV system and BESS on site so there is no incentive to use any surplus renewable power to preheat water using the heat pump or direct resistance heaters. However this may change if and when further PV and/or battery capacity is installed. *

**Since the installation Kilcoy Global Foods (Hardwick's new owner), has in November 2024, had the Kyneton site certified Carbon Neutral by Climate Active. This followed on from their certification of the Kilcoy site in late 2023.*

PROJECT STATUS

The heat pump is fully operational and is now operating reliably during weekday production.

The Project interfaces with Mycom compressors within the existing ammonia loop. This is a low technology solution compared to other advanced systems such as CO2 and two stage systems; however, it does reduce gas usage by about 61% and fits in with the rugged requirements of a typical Meat Works.

The combined heat pump and oil recovery system is currently operating at 1088 to 1266KW thermally, producing hot water between 55-70C at typically 5.5 to 7.5 litres/sec. Hot water is transferred to large thermal storage tanks, with the final additional heating using the existing gas hot water heaters to heat final process water to 85C.

The heat pump has been in operation since December 2022. During the commissioning period, various issues were rectified or refined:

- Air lock in the oil cooling lines rectified.
- Heating of the compressor oil sump rectified.

- Higher pressure-drops across oil separator than planned.
- Vibrations on the heat pump skid were rectified.
- Optimizing control operation on the expansion valve and level probe.
- Mains water supply limitations to the site restricted operations (outside of our control, now rectified).
- Modifications to the system to eliminate ammonia liquid condensation from the compressor oil sump when the heat pump is idle; and,
- All distribution fluid pipes were insulated with 25mm of closed cell foil pipe insulation to minimize heat loss.

The transition from LV to HV is now in place with both the plant and the PV/ battery now operating satisfactorily on this new system. The Heat Pump and HV upgrade required the PLCs installed as part of the project to communicate and integrate with existing refrigeration PLC's, Hot Water Plant Room PLC's, Renewable Energy PLC's and external communications for the Electrical Network Provider. In-depth understanding of the existing controls was required to integrate the Heat Pump. This has been completed satisfactorily and is a critical input into achieving the required Project outcomes.

Approvals and Sign offs

All technical approval requirements have been signed off for both the heat pump and LV to HV upgrade works. These included:

- Energy Safe Victoria's Certificate of Electrical Compliance for the power and switchboard upgrades.
- BESS HV Customer Island Testing (for interface into Powercor distribution system).
- HV Upgrade Protection reports.
- Hoctors refrigeration verification reports.

Shown in the following table are the overall project economics updated for current gas, power and water costs and adjusted for actual performance achieved during the October 23 to September 24.

Potential Savings Opportunities	Gas savings	Power increase	Power increase	Greenhouse Gas Savings	Energy Expenditure Savings	Water savings	Total Savings	Capital Investment
	GJ pa	kWh pa	GJ pa	tonnes CO_2 -e pa	($ pa)	($ pa)	($ pa)	
Heat pump and compressor heat recovery								
Install condenser based HTHP on refrigeration circuit for process hot water heating	21,758	730,480	2,630	640.2	$288,793 pa	$50,147		
Heat recovery from screw compressor oil cooling circuits	7,792	0	0	400.0	$141,036 pa	$0 pa		
Sub total	**29,550**	**730,480**	**2,630**	**1,040**	**$429,828**	**$50,147**	**$479,975**	**$1,457,471**
Network tariff reduction move from LV to HV Supply								
Network tariff reduction at projected consumptions					**$235,598**		**$235,598**	**$1,129,491**
TOTALS							**$715,573**	**$2,586,962**
ARENA CONTRIBUTION (Payment schedules to be determined)								**$838,000**

KNOWLEDGE SHARING DELIVERABLES

Since the practical completion of the project there have been several presentations and case studies produced aimed at promoting the technologies demonstrated. Hardwicks, Hoctor's and A2EP have been proactive in these initiatives. They include:

1. Presentation made by Eujin Tan (Hoctor Refrigeration) and Mark Hardwick (Hardwicks) at the 'Australian Alliance for Energy Productivity Forum' in October 2022.
2. ARENA and A2EP site visit for their members and other interested parties to review the project (November 2023).
3. The case study of Hardwicks heat pump project was prepared and distributed by A2EP and sponsored by RACE 2030.
4. Cited as a case study in 'The Australian Industrial Process Heat Market, Towards Zero Emissions April 2025 'published by ITP for CSIRO.

The project has also been promoted by participation in the following two award events:

1. Australian Renewable Energy Award 2024 for Outstanding Electrification Project.
2. Finalist in the National AIRAH 2024 awards, Nov 2024.

Whilst to our knowledge this heat pump project has not been replicated to date there have been several food processing plants that are currently reviewing commercial proposals presented to them. It is expected that at least some of these will proceed as economic conditions improve and electrification for processing heat becomes more viable.

There have also been a few sites that have implemented oil cooler heat recovery technology.

OUTCOMES

In summary, technical outcomes have been achieved with the heat pump now operating reliably.

The following are comments from both the plant operator and the refrigeration contractor on their experience in the operation of the heat pump to date.

- There have been no significant operational issues with the heat pump once initial commissioning problems were sorted.
- The system is designed to operate 24hrs x 5 days/ week all year round. There are some limited operations at week- ends if there is sufficient capacity in the preheat tank to absorb the heat pump and refrigeration oil heat recovery units.
- During commissioning some changes to control reporting pages and set points were made to improve integration into the existing plant refrigeration system and plant's hot water demand profiles.
- Changes were made to the main discharge pressure settings and valve configuration to swing more of the load through the heat pump as a priority over the cooling tower condensing circuits. This ensured that most of the hot gas is extracted via the heat pump rather than the cooling tower system.
- The heat pump outlet temperature typically ranges from 68 to 77C depending on a number of factors including supply water temperature (12 to 18C), head pressure set points of the heat pump and flow settings. The heat pump is capable of operating at higher exit water temperatures (highest achieved to date is 81C) however with current water demand and available heat from oil cooler heat exchangers, the temperature setpoints for heat pump has been set lower for operations.
- The fans on the cooling towers now operate sparingly reflecting both the loads taken off them by both the heat pump and the refrigeration oil recovery systems now employed.
- The oil cooler heat recovery systems also exceed their expected performance when operated in conjunction with the heat pump system. Although their operation could be extended to weekends currently the automation and recirculation system is not there to allow for effective preheating water inventory prior to Monday production starts. This constraint could potentially be overcome by installing a pump and hot water pipe to recirculate warm water from the preheat tank back through the heat pump and oil heat recovery units so that when water demand diminishes on weekends the water can be continually heated in the preheat tank. Further control upgrades would need to be incorporated into the existing system to cater for higher recirculating temperatures entering all heat exchanges (i.e. oil coolers and heat pump).
- Hoctors Refrigeration have advised that when they install similar oil cooler heat recovery systems, they now install control temperature sensors in the oil circuit rather than the cooling water circuit as used in the current system. This would improve reaction time and provide more uniform return oil temperatures from the oil coolers. This would also allow

preheat water flows to be steadier improving average heat exchange over the waste heat preheaters.

- For future projects Hoctors advise that pressure, temperature and flow metering should be installed on all primary flow circuits prior to implementation as this would then allow for improved sizing and control of the heat pump and the integration of it with the existing refrigeration and hot water heating equipment.
- There is scope to improve the control of water levels within the new pre-heat tank. Currently it is controlled purely on high water level in the tank (on/off switching of the heat pump) however this could potentially be improved by changing flow rates to more closely match the variable plant hot water demand.
- The hot water inventory starts at 70/75% in the morning and typically drops to around 16 to 20% by lunch time on a production day. This drop in water storage inventory is due to the very high hot water demand compared to the existing water tanks and pump capacities to keep up.
- Due to capacity constraints and drought conditions the current production at the site has dropped significantly over the last six months and is now running one shift beef and two shifts lamb. This has significantly impacted the water flow and associated heat pump run hours. It is expected that production will, at a minimum, return to the previous levels over the next year or so, which will allow the heat pump operating hours to revert to full 24 x 5 operation duties.
- Heat pumps and oil coolers are operating satisfactorily, however both are switched off at weekends and are not used to heat water in the pre-heat tanks. The reason for this is that heat would be lost from water prior to the startup resulting in excessive cold water on Monday morning startups. This could potentially be avoided through the use of return loops and associated controls to circulate preheat water during non-production periods.
- On very cold days start-ups the heat pump sometimes trips due to low discharge pressures on the refrigeration system. This could potentially be avoided by incorporating control logic to better control pump operation during very cold ambient and low discharge pressures.
- Discharge pressures for the plant now typically operate at up to 1200kPag but can float down to 950kPag. These higher pressures are driven by the requirement of lower chiller temperatures of 2C. The higher head pressures for the main refrigeration plant also results in potential for higher heat pump outputs due to higher pressure lift. Currently this extra output capacity is not utilized due to the current hot water balances previously discussed.

The site plans to further refine the system to extract maximum performance from the heat pump and at the same time find the best system operating point (in conjunction with water consumption and boiler operating temperatures). In conjunction with this, the control of the pre-heat thermal store still needs to be optimized to ensure the heat pump continuously supplies heat to satisfy the plants' hot water demands (i.e.: building pre-heat water inventory to match demand draw.

JOBS

The number of direct jobs attributed to the Project during this phase was 8 FTE. Since the plant has become operational it is estimated that 0.2 FTE has been required for ongoing operation (daily performance monitoring, operational checks, resets and minor adjustments).