Final Report

AMPC
AUSTRALIAN MEAT PROCESSOR CORPORATION

Solar Assisted Refrigeration

Solar Assisted Refrigeration for large Commercial Refrigeration Systems

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Prepared by
Tynan Coles

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1.0 Executive Summary

With the rising cost of electricity, and push towards reducing CO2 emissions, refrigeration systems need to become more energy efficient. Generally, refrigeration systems were designed and installed to maintain temperature no matter how much electricity was used. This means there is a need to find new technologies to improve the efficiency of these electricity thirsty refrigeration systems.

One of the main consumers of power within a refrigeration system, is the compressors. They are needed to create heat which is a vital part of the refrigeration process. As more compressors are on within the system, more heat is created. Our technology substitutes the compressor load to create heat, with solar thermal collectors, utilising the free energy from the sun. In turn this means less compressors are required to operate to achieve the same cooling output equating in less power consumption within the refrigeration system.

Now that we are substituting the compressors load with thermal energy collected from the sun, we are providing many benefits to the system. A reduction in runtime, on each compressor is the main benefit. Our control system, will even the load runtime across all compressors so that they are used evenly, and also limit the maximum number of compressors required as the additional load now comes from the solar thermal collectors. This leads to demand charge savings, a large component of the electricity bill. So, we are not only reducing the electricity used by their system, we are also reducing their demand charges and ongoing maintenance and repair costs.

The importance of what our technology provides commercial refrigeration systems, is vital in achieving a more efficient solution. It can be retrofitted to most refrigeration systems, without disturbing the existing functioning of the system. This is important as most sites have critical loads that are being cooled by their refrigeration system, so any downtime is potentially catastrophic. As long as there is reasonable roof space for our solar collectors, then this technology should be retrofitted to all compatible refrigeration systems.

2.0 Introduction

This new technology creates a Substitution and/or additional thermal energy via of a secondary FREE source, the sun. The Thermal Collectors are Retrofitted to an existing system, only to replace an element of the thermal energy normally generated by the compressors on a variable speed, or RACK type system. In an open cylinder circuit with sensors, compressor loads are reduced dramatically.

The capabilities and efficiencies of our solar thermal solution, have exceeded and continue to exceed expectations across a range of industries. It has the ability to provide a significant number of benefits, to most if not all organisations, within the Red Meat Industry, through the use of our new solar thermal collection technology.

3.0 Project Objectives

Data Validation phase pre and post installation. A report will be provided to prove the following:

- Saves vast amounts of energy (saving of water if used to cool condensers during hotter months).

- Considerably reduces Co2 emissions.

- Eliminates failure of compressor due to overheating.

- Has shown Demand Reduction at source of the trail

- Lowered maintenance costs during and predicted post trail.

- Probability of increased lifespan of the compressor itself.

4.0 Methodology

Inception meeting

- Initial meeting to discuss the project scope and outcomes.

Milestone Report Site Plan & detailed design

- System design
- Roof design
- OH&S Policies

Onsite Install and Commissioning

- Delivery of thermal panels and materials to complete the project
- Delivery of scissor lift and any other safety equipment
- Installation of the panels and copper piping
- Pressure and system testing

Final Site Plan and Design

- Signing off on all designs as per the actual installation
- Confirm efficiencies are already being achieved
- Monitor system for 48 hours to ensure existing system is operating as per normal

6 Monthly Data Review

- Correlate all the raw data and display them in the interim 6 monthly report

12 Monthly Data Review and Final Report

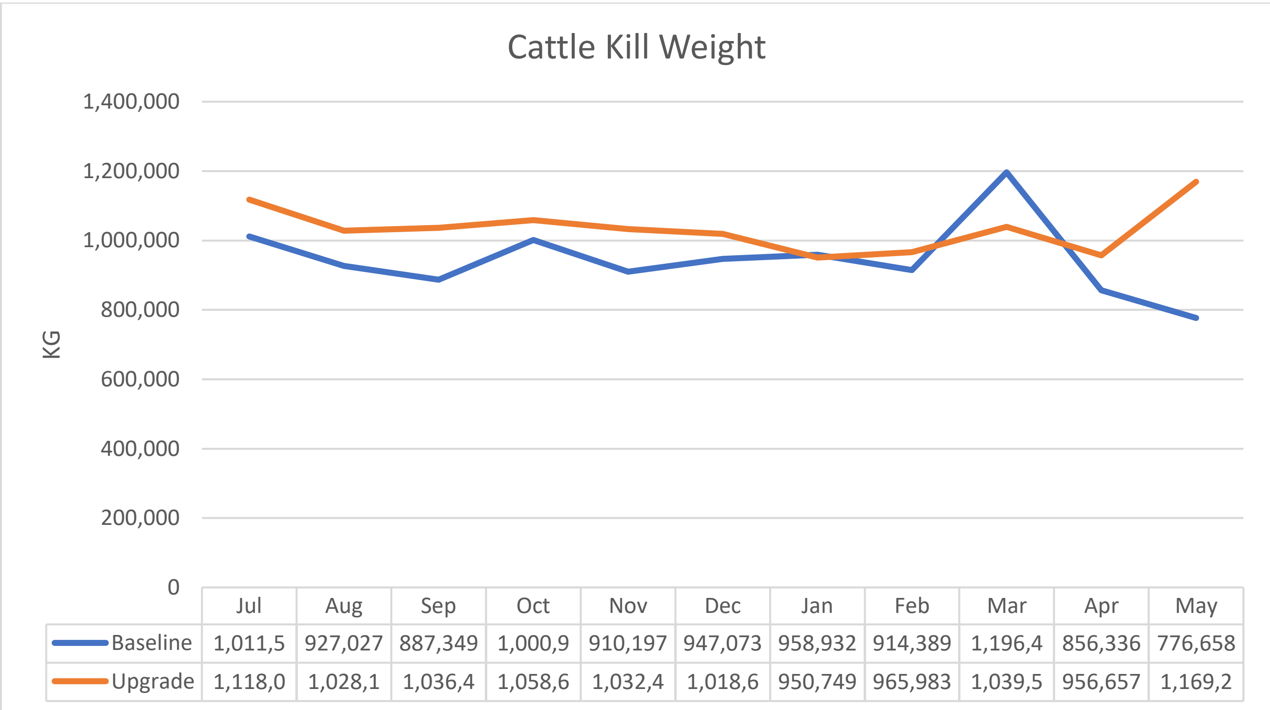
- Correlate all the raw data and display them in the final 12 monthly report
- Compare data to project projections and scope
- Summarise the project confirming the technology as a great option for energy efficiencies for refrigeration applications

5.0 Project Outcomes

The baseline data was from July 2019-May 2020. The comparison data was from July 2020- May 2021.

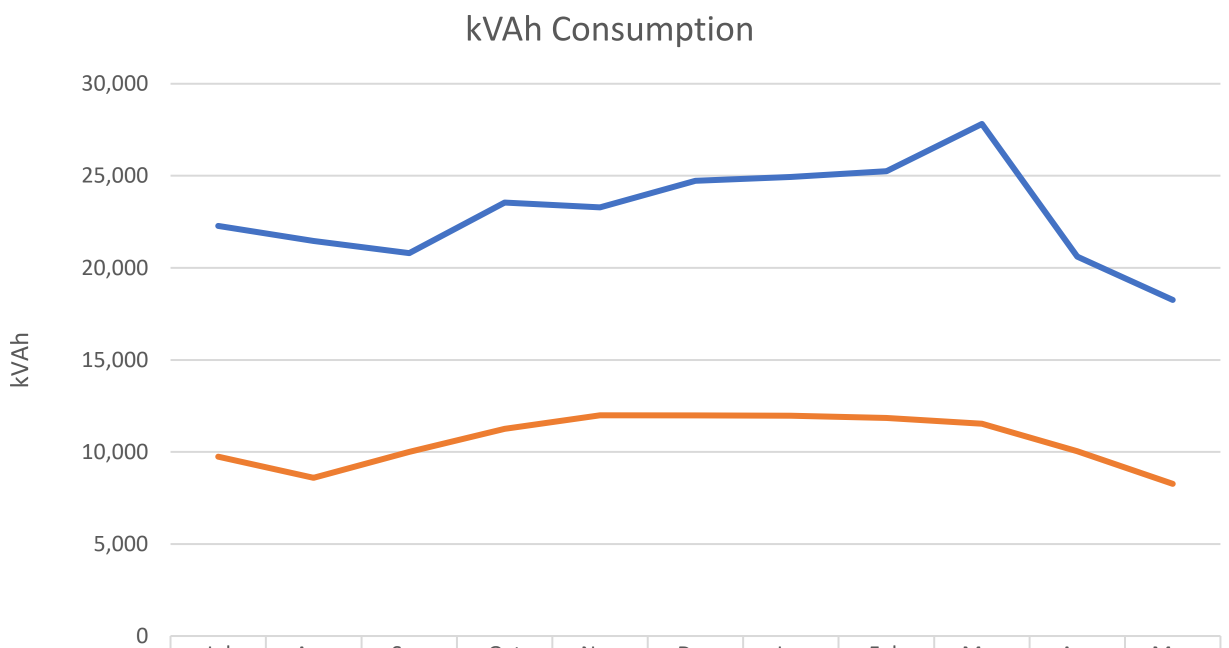
Cattle kill weights

Month	Cattle Weight Total (Kgs)	Month	Cattle Weight Total (Kgs)	Difference	%Increase
Jul-19	1,011,575	Jul-20	1,118,017	106,442	10.5%
Aug-19	927,027	Aug-20	1,028,180	101,153	10.9%
Sep-19	887,349	Sep-20	1,036,438	149,089	16.8%
Oct-19	1,000,990	Oct-20	1,058,687	57,697	5.8%
Nov-19	910,197	Nov-20	1,032,447	122,250	13.4%
Dec-19	947,073	Dec-20	1,018,639	71,566	7.6%
Jan-20	958,932	Jan-21	950,749	-8,183	-0.9%
Feb-20	914,389	Feb-21	965,983	51,594	5.6%
Mar-20	1,196,462	Mar-21	1,039,521	-156,941	-13.1%
Apr-20	856,336	Apr-21	956,657	100,321	11.7%
May-20	776,658	May-21	1,169,268	392,610	50.6%
Total	10,386,988	Total	11,374,586	987,598	9.5%



kVAh Consumption

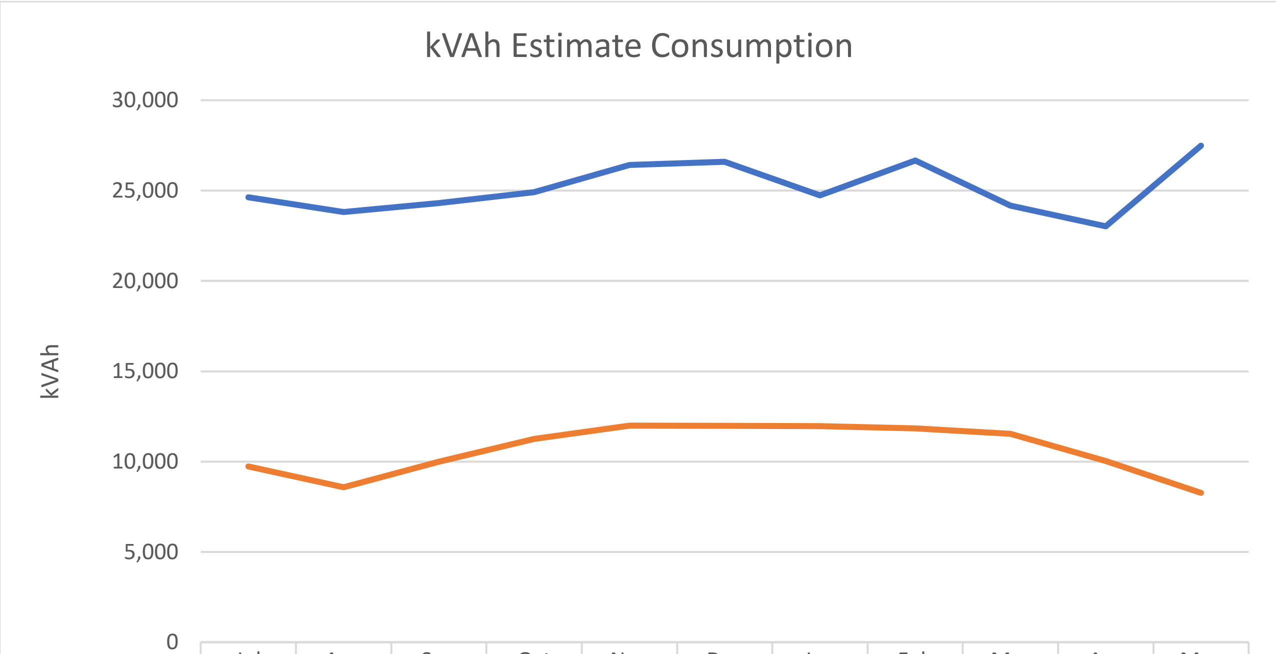
Month	ThermX Data Total	Month	ThermX Data Total	kVA Savings	% Reduction
Jul-19	22,281	Jul-20	9,736	12,545	56.3%
Aug-19	21,463	Aug-20	8,586	12,877	60.0%
Sep-19	20,807	Sep-20	10,000	10,807	51.9%
Oct-19	23,552	Oct-20	11,261	12,291	52.2%
Nov-19	23,294	Nov-20	11,990	11,304	48.5%
Dec-19	24,724	Dec-20	11,985	12,739	51.5%
Jan-20	24,942	Jan-21	11,965	12,977	52.0%
Feb-20	25,248	Feb-21	11,839	13,409	53.1%
Mar-20	27,817	Mar-21	11,537	16,280	58.5%
Apr-20	20,608	Apr-21	10,032	10,576	51.3%
May-20	18,258	May-21	8,266	9,992	54.7%
Total	252,994	Total	117,197	135,797	53.7%



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Baseline	22,281	21,463	20,807	23,552	23,294	24,724	24,942	25,248	27,817	20,608	18,258
Upgrade	9,736	8,586	10,000	11,261	11,990	11,985	11,965	11,839	11,537	10,032	8,266

kVAh Estimate Consumption

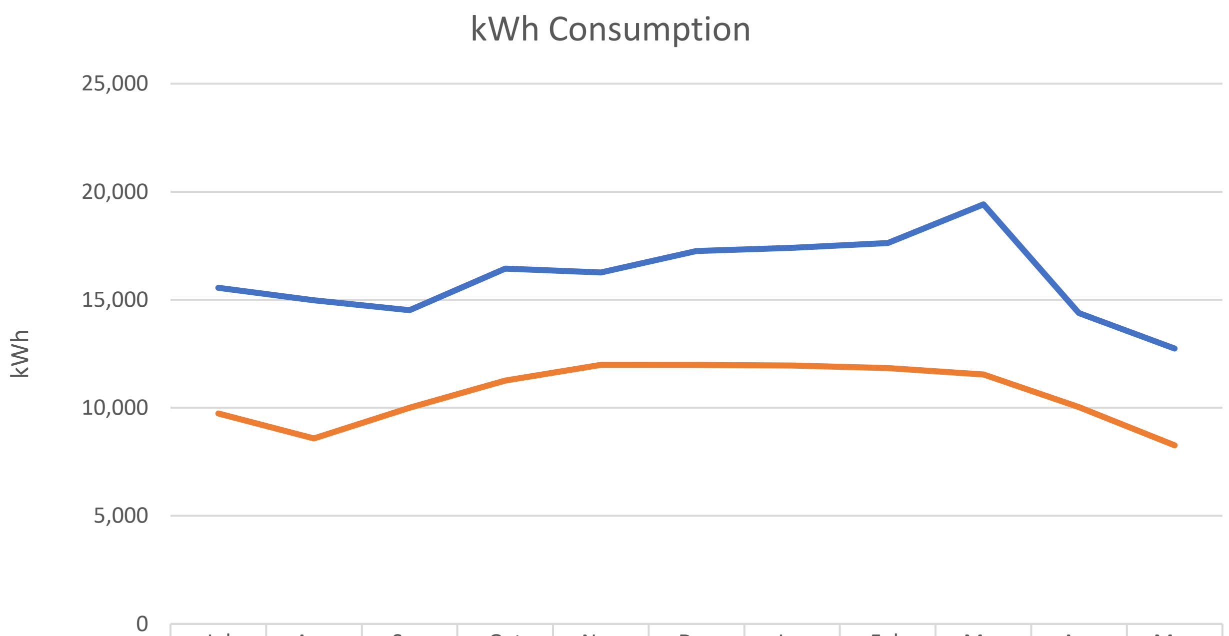
Month	ThermX Data Total	Month	ThermX Data Total	kVA Savings	% Reduction
Jul-19	24,625	Jul-20	9,736	14,889	60.5%
Aug-19	23,805	Aug-20	8,586	15,219	63.9%
Sep-19	24,303	Sep-20	10,000	14,303	58.9%
Oct-19	24,910	Oct-20	11,261	13,649	54.8%
Nov-19	26,422	Nov-20	11,990	14,432	54.6%
Dec-19	26,593	Dec-20	11,985	14,608	54.9%
Jan-20	24,729	Jan-21	11,965	12,764	51.6%
Feb-20	26,673	Feb-21	11,839	14,834	55.6%
Mar-20	24,168	Mar-21	11,537	12,631	52.3%
Apr-20	23,022	Apr-21	10,032	12,990	56.4%
May-20	27,488	May-21	8,266	19,222	69.9%
Total	276,738	Total	117,197	159,541	57.7%



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Baseline	24,625	23,805	24,303	24,910	26,422	26,593	24,729	26,673	24,168	23,022	27,488
Upgrade	9,736	8,586	10,000	11,261	11,990	11,985	11,965	11,839	11,537	10,032	8,266

kWh Consumption

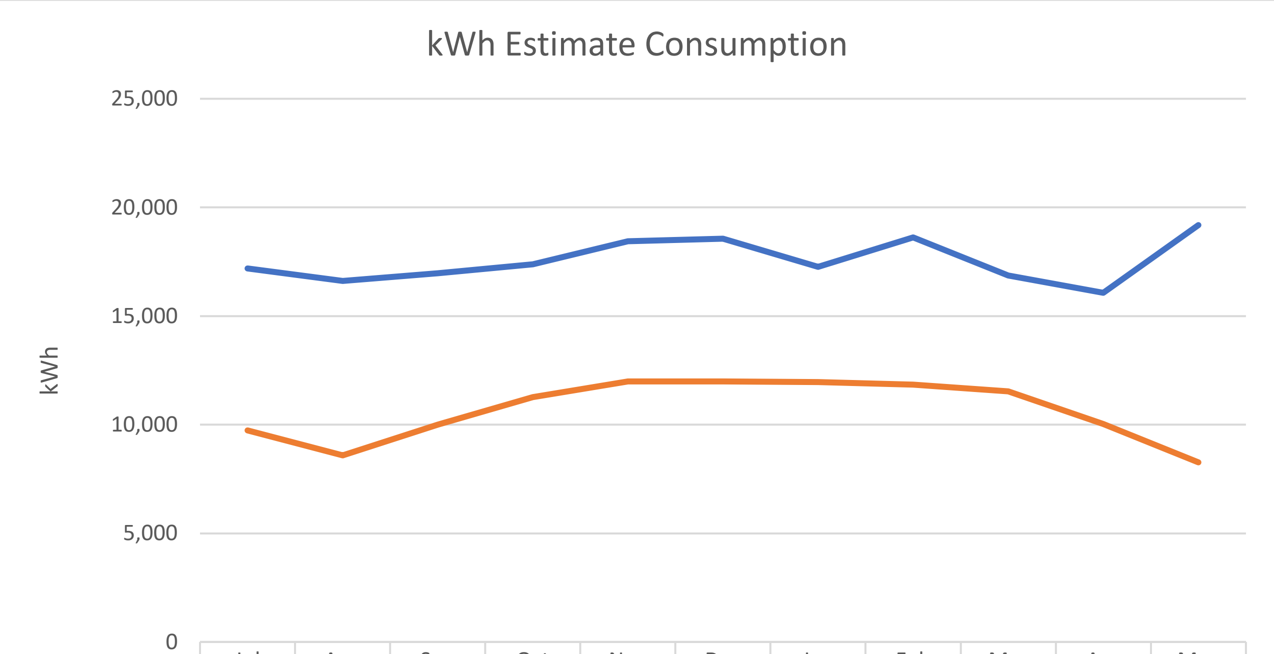
Month	ThermX Data Total	Month	ThermX Data Total	kWh Savings	% Reduction
Jul-19	15,552	Jul-20	9,736	5,816	37.4%
Aug-19	14,981	Aug-20	8,586	6,395	42.7%
Sep-19	14,523	Sep-20	10,000	4,523	31.1%
Oct-19	16,440	Oct-20	11,261	5,179	31.5%
Nov-19	16,259	Nov-20	11,990	4,269	26.3%
Dec-19	17,258	Dec-20	11,985	5,273	30.6%
Jan-20	17,410	Jan-21	11,965	5,445	31.3%
Feb-20	17,623	Feb-21	11,839	5,784	32.8%
Mar-20	19,416	Mar-21	11,537	7,879	40.6%
Apr-20	14,384	Apr-21	10,032	4,352	30.3%
May-20	12,744	May-21	8,266	4,478	35.1%
Total	176,590	Total	117,197	59,393	33.6%



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Baseline	15,552	14,981	14,523	16,440	16,259	17,258	17,410	17,623	19,416	14,384	12,744
Upgrade	9,736	8,586	10,000	11,261	11,990	11,985	11,965	11,839	11,537	10,032	8,266

kWh Estimate Consumption

Month	ThermX Data Total	Month	ThermX Data Total	kWh Savings	% Reduction
Jul-19	17,188	Jul-20	9,736	7,452	43.4%
Aug-19	16,616	Aug-20	8,586	8,030	48.3%
Sep-19	16,963	Sep-20	10,000	6,963	41.0%
Oct-19	17,387	Oct-20	11,261	6,126	35.2%
Nov-19	18,443	Nov-20	11,990	6,453	35.0%
Dec-19	18,562	Dec-20	11,985	6,577	35.4%
Jan-20	17,261	Jan-21	11,965	5,296	30.7%
Feb-20	18,617	Feb-21	11,839	6,778	36.4%
Mar-20	16,869	Mar-21	11,537	5,332	31.6%
Apr-20	16,070	Apr-21	10,032	6,038	37.6%
May-20	19,186	May-21	8,266	10,920	56.9%
Total	193,163	Total	117,197	75,966	39.3%



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Baseline	17,188	16,616	16,963	17,387	18,443	18,562	17,261	18,617	16,869	16,070	19,186
Upgrade	9,736	8,586	10,000	11,261	11,990	11,985	11,965	11,839	11,537	10,032	8,266

Demand Charge Savings

The main challenge with getting the demand charges down, is that it takes up to 12 months for the lowest demand to reset to the new demand. This is a standard electricity retailer requirement if you are on a 12 monthly demand charge tariff.

By increasing the capacity of the rack system through our solar thermal panels, we were able to limit the maximum number of compressors running at any time from 5 to 3. This meant that we were able to target their total demand at the site with the reduction being the power input of 2 compressors. Throughout the period after the upgrade the maximum demand was 451kVA until March when it spiked to 463kVA. This was a total reduction of 42kVA before the spike in March. I have been made aware that a new evaporative cooler has been installed which uses approximately 12kVA which would explain the increase against what we were seeing throughout the early upgrade period.

Below is the actual savings now seen on the bill.

Pre-Upgrade

Demand Charge		491 kVA	$9.99917/kVA		$4,909.59

Post-Upgrade

Demand Charge		465 kVA	$9.36917/kVA		$4,356.66

Power Factor Savings

When we monitored the compressors prior to the control system and compressor drive upgrade, the power factor was approximately 69.9%. This is now at 100% which means that the overall power supply to the compressor has been reduced significantly. When we first did the site survey and bill analysis, the site did not have any Power Factor Corrector devices. This was only found out when we had completed the upgrade and started evaluating the NMI data. If this site had not had this PFC device installed then we would have achieved approximately another 30kVA worth of demand charge savings.

Maintenance and Repairs

Since the upgrade, there has been no maintenance requests on the upgraded refrigeration system. This includes no requirements for maintenance and repairs on all the other components within this system. This is very common for our solar thermal solution as it using thermal heat from the sun to substitute compressor load.

Also, the control system and VSDs that were installed on each compressor is limiting the compressor startup load through soft starting each compressor and also varying the frequency of the compressors to ramp up and down depending on the thermal heat provided by the sun. Our control system is optimized to avoid as much short cycling in the compressor meaning that the compressor runtime is minimized to achieve temperature without the constant starting and stopping of each compressor.

The compressor life across the rack will be increased as the runtime has been drastically reduced. The runtime was not measured during the baseline period but the fact that the maximum number of compressors that run at any given time has been reduced from 5 to 3 and still able to maintain temperature means the compressor runtime is much less than before.

Finally, the water sprayers for the condensers were switched off even during the summer period. This not only provides a saving on water costs, but also reduces maintenance costs on the condensers due to rust and water corrosion.

Monetary Savings

Annual Energy Savings:	$13,446
Annual Demand Savings:	$6,635
Total:	$20,081

The $20,081 savings are under the initial proposal stating $24,763. This was due to the additional demand charge savings that should have been provided if there was no PFC device on site. If we were made aware of this change, then we could have adjusted our projections accordingly.

Also, the system we upgraded was oversized for what was needed. if the system was only a 4 compressor system instead of 5, we would only have needed 14 solar thermal panels rather than the 18 that was installed. This would have achieved similar savings at a reduced capital expense.

Further to this, there is going to be an ongoing water usage, maintenance and repairs cost. These have not been quantified in this report.

Summary

Kill Weight Increase	9.5%
kVAh Consumption Decrease	53.7%
kVAh Consumption Adjusted Decrease	57.7%
kWh Consumption Decrease	33.6%
kWh Consumption Adjusted Decrease	39.3%
Demand Charge Savings	26kVA
Power Factor Savings	30.1%
Maintenance and Repairs	$0
Monetary Savings	$20,081

6.0 Discussion

Our intentions were to provide an energy savings report based on the NMI data provided by their energy retailer. The modelling that was done was not conclusive and did not show the sub-metered energy savings that have been provided within this report. The main reason for this is that being an abattoir, the power consumption can come from various sources throughout the site. The rack system we upgraded was initially using approximately 11% of the total electricity consumption at that site. Post-upgrade its now down to 7% so any changes to the operations on site could be absorbed in these energy savings.

The COVID-19 pandemic has seen an increase in kill weights. It has also introduced many additional operational requirements. Density limits for Abattoirs were changed considerably throughout the Victorian lockdowns so to achieve a higher kill weight with these density limits would have been a significant increase in the operational energy usage that could have absorbed most of our savings we saw through the sub-metered data.

NMI data energy savings are good when most of the site load is coming from the refrigeration load. For example, cold storage facilities, their refrigeration load is approximately 80% of their total site load. Therefore, our solutions energy savings can easily be seen post-upgrade through the NMI data. Any future projects will use third party sub-metered only data as it’s the only way to achieve the exact energy savings that our solar thermal solution has achieved.

7.0 Conclusions / Recommendations

As you can see, our solar thermal solution, is a great option for any refrigeration compressor system. There is no other product out there that can deliver 57.7% kVAh and 39.3% kWh savings for refrigeration compressor systems. The overall project costs could have been lower if the compressor rack was according to the required load as discussed previously in this report.

During the project lifetime, there has been some significant changes in the costs of our solution. We now have a solar thermal panel partner that can deliver the same thermal energy at a more competitive price. Our control system has also been further refined to decrease the overall project costs. This project would now only cost $106,700.

The VEECs are also much higher than when we started the project. Today’s market VEEC Price is $58. This would increase the rebate amount to $30,914 bringing the total out of pocket cost for the customer to $75,786 Ex GST. This is a total reduction of $25,965. Based on the savings this project has delivered, the payback of this particular project would 3.77 years. This does not take into consideration any increases in power prices and any of the other benefits discussed in this report where the costs savings cannot be quantified.

For any future projects, we will make sure that the independent energy measurement and report will be at a refrigeration system level so that any other site variables are not interfering with the overall energy savings.

Overall, the project was a great success. The COVID-19 pandemic did make things tricky for an installation and commissioning point of view but this is now the new normal practice that we are all dealing with. The changes in operational practices on site did lead to a change in power usage but ultimately, we were able to verify the overall savings through our sub-metered data. I believe with a decrease in project costs, as well as the increase in the rebate amount, it becomes an even better investment for sites that have considerable amounts of refrigeration energy usage.

8.0 Bibliography

No references required for the final report.

9.0 Appendices

9.1 Appendix 1 – Sub Metered Raw Data

Sub metered data that was recorded on the 5 individual compressors.

9.2 Appendix 2 – Production Data

Kill weights provided by the Abattoir.