MAKRO STRUBENS VALLEY

11/1/2016	CASE STUDY

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This document was prepared as an account of work done by Commercial Refrigeration Services for Makro Strubens Valley. This case study illustrates some key focus areas or points our client has measured and manages in order to improve the store's overall efficiency.

The phase out of CFC and HCFC refrigerants and the unknown future of their replacement refrigerants has led the supermarket industry having to look to alternative, long term, energy efficient solutions. Carbon dioxide (R 744) is rapidly becoming the industry choice for an alternative refrigerant due to its favorable environmental properties (ODP = 0, GWP = 1).

This case study will explore how CRS has successfully installed a CO2 refrigeration system for Makro Strubens Valley. The challenge for the refrigeration industry is to create a system that meets the energy consumption levels of today's efficient HFC machines.

For the past few years, CRS have been developing alternative solutions to the conventional refrigerated systems available on the market. Conventional systems that are inefficient, with high energy consumption and high maintenance costs.

The objective to be achieved, was to provide an efficient, sustainable and reliable CO2 solution that would be cost efficient in terms of initial cost (equipment and installation) as well as operating cost (energy, maintenance and gas).

In order for CO2 to work as a viable refrigerant today, where energy efficiency, cooling capacity, power consumption, and quick pull down are necessary starting points, components and systems that can better control capacity and temperature using CO2 should be developed. To be successful, refrigeration equipment manufacturers must work to combine the best of these components into a carefully designed system. The goal of these new systems should be to achieve a GWP equal to one, minimize environmental impact from materials used, and improve energy efficiency at the same time.

There are a range of alternative gasses when considering the transition from a traditional system to an alternative refrigerant with low GWP. In the table below a list of some alternative refrigerants and their properties can be seen.

Refrigerant	Critical temperature (ºC)	Critical pressure (bar)	Ozone depletion potential	Global warming potential (100 years)	Flammable or explosive	Toxicity
CFCs and HCFCs						
R12	100.9	40.6	0.9	8100	No	No
R22	96.2	49.8	0.055	1500	No	No
Pure HFCs						
R32	78.4	58.3	0	650	Yes	No
R134a	101.1	40.7	0	1200	No	No
R152a	113.5	45.2	0	140	Yes	No
HFC mixtures						
R404A	72.1	37.4	0	3300	No	No
R407C	86.8	46.0	0	1600	No	No
R410A	72.5	49.6	0	1900	No	No
Natural refrigerants						
Propane (R290)	96.8	42.5	0	3	Yes	No
Isobutane (R600a)	135.0	36.5	0	3	Yes	No
Ammonia (R717)	132.2	113.5	0	0	Yes	Yes
Carbon dioxide (R744)	31.0	73.8	0	1	No	No

Using CO2 requires a different system design than the traditional HFC system. There are mainly two standard design CO2 refrigeration types that exist in the application of commercial food retail refrigeration systems:

1. Transcritical systems
2. Cascade (Subcritical) systems

1 PROJECT BACKGROUND

Makro has a preferred refrigeration design they use on their larger format stores. The system has been designed to minimize refrigerant leakage, reduce the energy consumed, whilst ensuring progress towards lowering their CO2 footprint. The store was upgraded from a Freon to a CO2 store in 2016.

Medium Temperature - Triple packs were fitted with Danfoss variable speed drives, floating condensing and electronic expansion valves. The liquor store was operated by a simplex system.

OLD SYSTEM	MEDIUM TEMPERATURE
Unit type	2 x Triple Packs (3 x 4G-20.2Y Bitzer Compressors)
Refrigerant	R507A
Evap. Temperature	-8°C
Refrigeration Load	201.02 kW

Low Temperature - Simplex units were fitted with Danfoss variable speed drives, floating condensing and electronic expansion valves.

OLD SYSTEM	LOW TEMPERATURE
Unit type	4 x 6G-30.2Y Bitzer Simplex unit 1 x 4J-13.2Y Bitzer Simplex unit
Refrigerant	R507A
Evap. Temperature	-30°C
Refrigeration Load	88 kW

2 ABOUT THE NEW SYSTEM

Makro worked alongside CRS to develop a more environmentally conscious system for the Makro Strubens Valley store that combined the lower GWP and improved energy efficiency of a new CO2 refrigeration system. Makro chose to upgrade the existing system to a CO2 system to control future operating costs and to meet energy and sustainability goals. Within this system CO2 levels are monitored for leakage, however, because CO2 is a natural gas, this system do not pose the same risk to the environment as traditional HFC systems.

The system used for Makro Strubens Valley is a Transcritical Booster system with parallel compression. The advantages of a parallel compression system is instead of expanding the flashgas to the Medium Temperature Section pressure and then compressing the flash gas to the gas cooler pressure, a parallel compression system directly compresses the flashgas to the gas cooler pressure. Therefore the power used to create a lift for the flash gas between the MT-suction pressure and the receiver pressure, is saved on a parrallel compression pack, making it energy efficient. Especially for high ambient temperatures.

Electricity for refrigeration makes up 50% of the total energy consumption of the store. Makro has an ambition to cut down this consumption year by year as part of their sustainability program. Another goal is to switch to natural refrigerants like CO2 to cut the carbon footprint.

The new system consists of 2 x Transcritical Booster systems with parallel compression.

NEW SYSTEM	MEDIUM TEMPERATURE	PARALLEL	LOW TEMPERATURE
Unit type	1 x 4HTC-20K 2 x 4FTC-20K	1 x 4HTC-20K 1 x 4MTC-10K	2 x 2DSL-5K
Refrigerant	CO2	CO2	CO2
Evap. Temperature	-5°C	NA	-30°C
Refrigeration Load	300.46 kW	NA	88.45 kW

3 CHALLENGES

Challenges that need to be overcome in applying CO2 systems include designing for the high operating pressures, absorbing increased system costs and implementing system controls. Perhaps the most significant challenge is using new and innovative technology, especially in high ambient climates where CO2 becomes more challenging to make energy efficient. Makro has been a commendable company in pursuing their green values and looking for improved, energy efficient environmental solutions to their refrigerant needs with a transcritical system.

"We are very proud to be BIG on running our stores on a sustainable basis. Not only is it important for us to exhibit superior stewardship when it comes to the environment, but it assists us to channel savings to our customers allowing them to save more, live better and trade more profitably." – Makro South Africa

4 ADVANTAGES

CO2 is a low GWP refrigerant and an excellent choice when it comes to reducing greenhouse gas emissions. CO2 provides high performance and exceptional properties for heat reclaim, due to its high heat transfer capabilities. CO2 has excellent volumetric efficiency (more than 5 times the cooling effect per volume as R22), resulting is reduced compressor and pipe sizes for the same cooling effect, low consumption ration (the ration between inlet and outlet pressures at the compressor), low viscosity (making it easier to pump). CO2 is widely available as a by-product in a number of industries and the price of CO2 is very low. Another advantage to using a Transcritical CO2 system is that it operates on one gas as oppose to a Cascade system.

5 DISADVANTAGES

Higher investment costs due to expensive components capable of operating safely in such high pressures. The COP of the system is reduced when operating in transcritical mode. It is difficult to obtain components at present. The disadvantages can be overcome with time and competitiveness in the market.

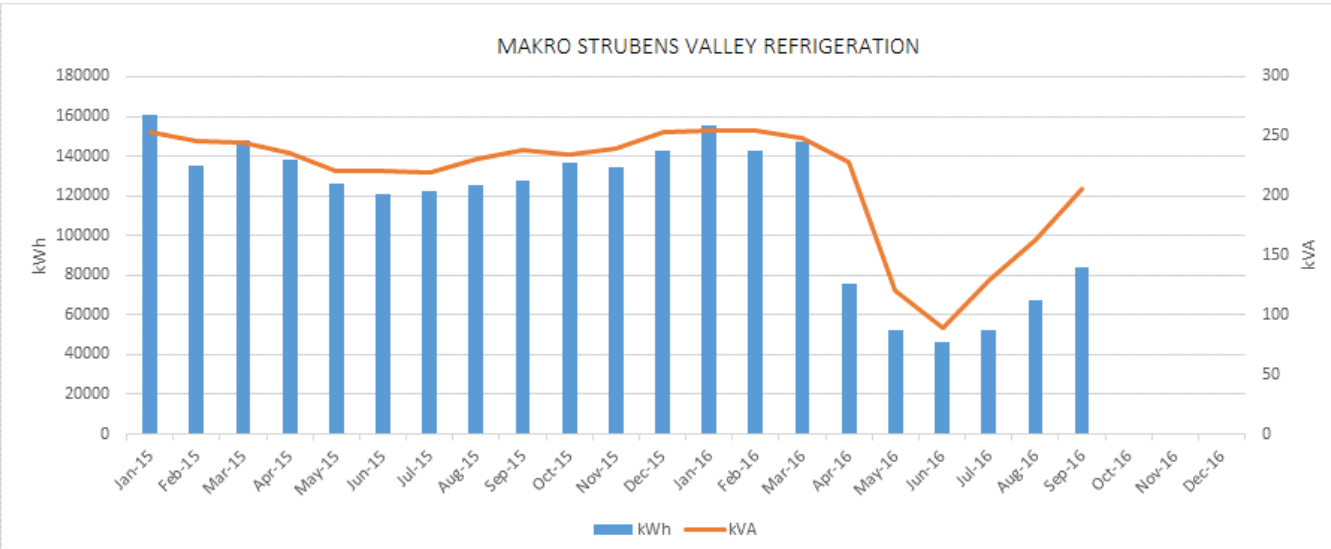
6 ENERGY SAVINGS SUMMARY

The purpose of this case study is to summarize the situation and give a rough estimate of what energy savings have been made since changing/upgrading from the old system to the new system. The energy saving really depends on the outdoor ambient temperature. High outdoor temperatures give less energy saving. The knowledge of energy conservation on store operation was obtained from using data captured during 2015 compared to data at present (2016). Overall and more accurate energy savings can be obtained after a full year has passed to see a yearly average saving.

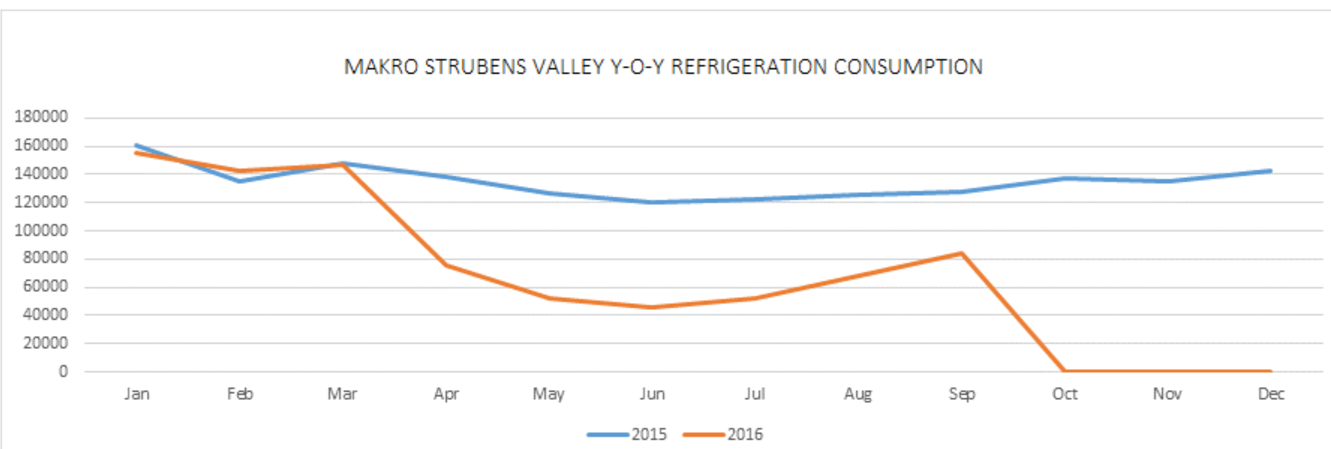
In order to manage the simultaneous energy demands and to maximize the energy savings further the system must be put onto a monitoring system. To keep track of temperatures reached and that no downtime of the refrigeration are met that can create product loss. Real-time monitoring can have great financial implications for future energy savings.

7 ELECTRICITY COMPARISON BETWEEN 2015 AND 2016
(DATA RECEIVED FROM MAKRO)

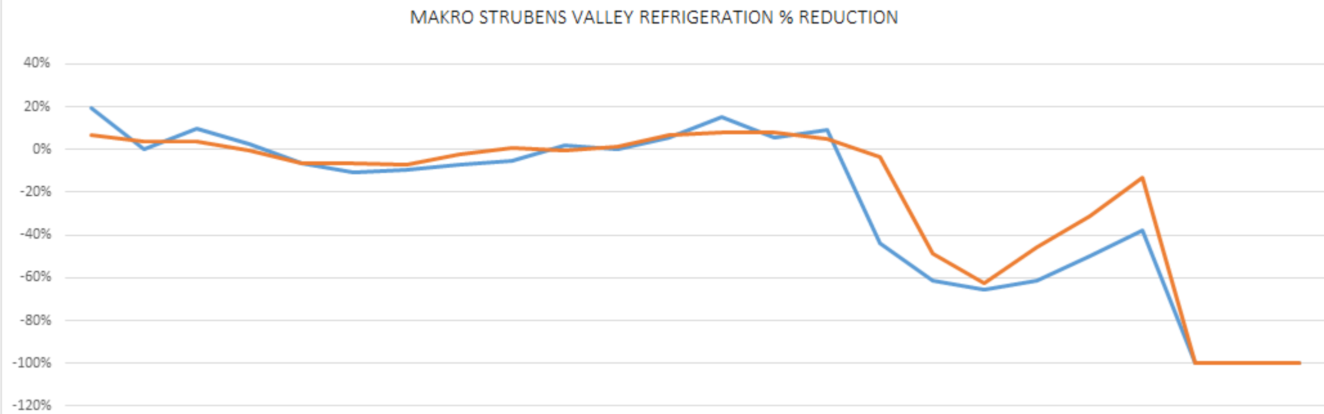
From the graphs below we can see the electricity comparison between 2015 and 2016 for Makro Strubens Valley. The new CO2 system was implemented in April 2016. CRS added 100 kW additional refrigeration capacity on the medium temperature and they are seeing a 40% reduction in energy usage.



Graph 1: Energy usage



Graph 2: Refrigeration Consumption



	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
kWh %	19%	0%	10%	3%	-6%	-11%	-9%	-7%	-5%	2%	0%	6%	15%	6%	9%	-44%	-61%	-66%	-61%	-50%	-38%	-100%	-100%	-100%
kVA %	7%	4%	4%	0%	-7%	-7%	-7%	-2%	1%	-1%	1%	7%	8%	8%	5%	-4%	-49%	-62%	-45%	-31%	-13%	-100%	-100%	-100%

Graph 3: Refrigeration Reduction

8 CONCLUSION

Although the store has only been operating on the new CO_2 system for a few months, the refrigeration system is exceeding expectations. While performance data is just an indication the system is giving great pay back on electricity costs.

Looking at the new system upfront costs were roughly 15% higher than a standard Freon system. Refrigerant costs are expected to be 80% lower than the previous system. Maintenance costs are also expected to be lower. From a financial perspective, the store cost more upfront to upgrade, but is expected to save money over time. Overall operational savings from energy use, refrigerant use, and maintenance costs are expected to offset the initial capital cost, resulting in only a small cost if taken into account the lifetime of the system.

Following the revamp, Makro experienced an average energy consumption reduction of 40% for their combined medium and low temperature systems. Due to the lower energy consumption, the average return on investment for these systems are about 3-4 years.

For any other information regarding this case study please do not hesitate to contact CRS with any questions or queries.