

COLES PUTTING CO₂ ON THE MAP

A world-first CO₂ transcritical system combining 100% of the store's air conditioning and refrigeration requirements in the one plant design is at the heart of Coles' long-term strategy to slash its operating costs and eliminate direct emissions.

– By James Ranson and Jan Dusek

 That would be the end game for us - to deliver an all natural solution for our stores."

Stuart Saville is a man of purpose. Charged with the task of driving Coles' sustainable agenda, one of the two dominant food retailers in Australia with Woolworths, Saville is measured in his thoughts but knows he is sitting on a good thing.

Decked out with "all the bells and whistles," Coles' first CO₂ transcritical installation at its recently opened flagship store in North Coburg, Melbourne, has so far performed above and beyond expectations. Management were hoping for energy reductions of 10%, but since the store opened in August 2015 the refrigeration system has so far seen an impressive 15% and up to 22% efficiency improvement during the cooler months, compared to its baseline CO₂/R134a systems.

It's little wonder industry figures and rival retailers have been keeping their ears close to the ground for news on one of Australia's five commercial transcritical installations, which include three at Metcash IGA stores.

Accelerate Australia & NZ was invited inside to see it in the flesh and strolled through the bustling store with Saville, Coles' National Engineering Refrigeration Manager and Brian Toulson, Senior Project Engineer for UK-based City Refrigeration Holdings, whose Australian arm City Facilities Management partner with Coles on all its installations.

Described as a 'concept' store, the 3,700m² premises includes and adjacent Liquorland and is as close as you can get to an all-natural solution. Only one back-up compressor is running on HFC R134a. Coles is eager to implement CO₂ transcritical systems in two more stores as early as 2016 and is all but convinced ejector technology will accompany one or both. "At Coles we think, from an efficiency and emissions point of view, that it [transcritical] is the right way to go, but there are just a couple of steps we need to take before we make a blanket commitment to the technology."



Coles National Engineering Refrigeration
Manager Stuart Saville

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→ The installation in Melbourne's north is striking to say the least. Little was left to the imagination with the booster system including parallel compression, two Bitzer CO₂ centralised racks for all temperature ranges, adiabatic cooling, hot gas defrost, 250 kilowatts (kW) chilled water capacity to supply all store air conditioning, heat reclaim supplying store hot water and heating and four solar inverters generating up to 100kW.

Toulson, who has been in the engine room and seen the system under stable operation on a 43°C day, said no stone had been left unturned in ensuring the store was as advanced as possible. "We looked at everything that would help the energy profile and we really wanted to get rid of synthetic refrigerants and also to hit the optimum energy savings that we could."

Following efficiency monitoring starting last autumn, through spring and now summer, Toulson recalls the collective interest from technical staff, who would scurry to the plant room to monitor the operation of the system on the first 30°C and 32°C days. "That's no longer the case and in fact on the 43°C day, the operation

of the [CO₂ transcritical] system was very stable. We've got to the stage now where our mechanics and technicians don't even bother coming here on the hot days, they go to the stores which have heat issues on hot days."

That's high praise for technology previously questioned in high ambient regions like Australia's. "When we opened it, ironically, it was a 6°C day so we were actually trying to get heat into the store just to get it started," Toulson said. "Once we started monitoring efficiencies, during the cooler climate months, we found that we were able to save 22% on power consumption compared to our baseline stores."

Toulson said the savings during those cooler periods couldn't be accounted for by the parallel compression as the system would have been operating in subcritical mode for the majority of that time, while the adiabatic cooling would have had been under minimal operation, too. "That was a unique challenge: we've built this system designed to handle a 45°C day and we were operating it in a 6°C climate!"

Coles measured the transcritical system against one of its benchmark stores fitted with a CO₂/R134a cascade system using all the key metrics considered to be pertinent to get a true measure: overall refrigeration capacity, sales floor area, climatic region, case length. "We were expecting to see in the vicinity of a 10% reduction in power consumption but after a full six-month period (August-January) we found that the consumption has actually come in at about 15% under one of our benchmark stores," Saville said.

"The critical time for us to find a firm footing and be able to go back to the business is the summer months so that we can clearly demonstrate what the savings have been. Hopefully then we can seek endorsement for two further stores," Toulson said.

A SIMPLE SYSTEM

Avoiding the intricacies involved with installing any HVAC&R system is imperative for end users like Coles. The company ideally wants to use the technology as a template. "We'll trial another couple of stores with transcritical, we'll take the learnings that

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→ we've had, take some of the complexity out of what we've done here and try to simplify it and drive down the capital cost," Toulson said.

The entire process from design to installation took roughly six months with the system eventually craned into the store. "We spent a lot of time on the fixtures in the plant so that it could essentially be 'dropped in' to avoid installation time and hassles." The full installation alone took 14-16 weeks.

"The remit initially was for a standard store but it wasn't until about halfway through planning that we decided to go for CO₂ transcritical because we realised it was very feasible and we wanted a 100% natural refrigerant store solution," Toulson said.

Bitzer and Danfoss were chosen as key suppliers due to their "experience and excellent track record in Europe," Saville said. Bitzer and Danfoss helped both Coles and City with the design and installation. "We had buy-in from both of them [Bitzer

and Danfoss] to ask for their assistance to ensure our technicians were fluent in installation, servicing and maintenance of the system."

The two booster systems each contain four mid-temperature (MT) and three low-temperature (LT) Bitzer compressors, supplying a total fixture load of 610kW. Two Alfa Laval heat exchangers facilitate the heat reclaim and supply hot water and heating for the store, while the 250kW chilled water from the racks is re-circulated to power 100% of the store's air conditioning. Four solar inverters linked to 399 roof-mounted panels were supplying 40kW of additional power capacity on the day *Accelerate Australia & NZ* toured the store, but they can supply up to 100kW.

The adjacent Liquorland store, one of parent company Wesfarmers' many franchises, which include Bunnings Warehouse, Target, K-Mart and Office Works, runs on a closed-loop condenser waterloop system with three hydrocarbon R1270 showcases (850g charge) from UK-based supplier Carter

Refrigeration, and includes adiabatic spray systems.

Even though Saville and Toulson are restrained in their appraisal of the system's performance, there is an undeniable sense of achievement so far. Reining in higher capital costs remains the major barrier to tackle and ensuring the technology is transferrable to Coles' more remote stores in higher ambient temperatures. The addition of ejector technology will no doubt help in that regard.

"Probably if [the installation] had been six months later we would've run ejectors in unison with parallel compression in this plant, but we'll definitely be looking at ejectors in our next iteration of a transcritical plant," Saville said. "We've had initial discussions with quite a few primary producers who are saying that they could look at this for us if we're to take the next step."

Although the southern city of Melbourne can reach temperatures of 45°C in summer, the other seasons are typically

AUSTRALIA'S LARGEST COMPANIES BY TOTAL REVENUE (FY 2014/15)

NEW POSITION	PREVIOUS POSITION	CHANGE	COMPANY	TOTAL REVENUE (\$M)	CHANGE (%)
1	3	2	Wesfarmers	62,777.00	3.9
2	2	0	Woolworths	61,149.40	-0.1
3	4	1	Rio Tinto	60,276.61	-6.9
4	1	-3	BHP Billiton	59,342.24	-21.3
5	6	1	Commonwealth Bank of Australia	45,310.00	2.3
6	5	-1	NAB (9/15)	43,650.00	-2.8
7	7	0	Westpac Banking Corporation	39,670.00	2.7
8	8	0	ANZ Banking Group	36,356.00	3.1
9	9	0	Telstra	26,764.00	1.2
10	10	0	Caltex Australia	24,240.16	-2.0

SYSTEM SPECS

Coles' CO₂ booster system in Coburg North has the following specifications:

- 3,700m² store/sales floor
- Total fixture load of 610kW
- 2 centralised CO₂ Bitzer racks supplying three temperature ranges: LT, MT and HT
- Booster system with parallel compression into the flash gas bypass
- 320kW MT display cases and rooms
- 40kW LT fixtures (-27.5°C and -35°C)
- Bitzer compressors: 4 MT, 3 HT and 2 LT compressors per rack
- Hot gas defrost for all LT fixtures
- 2 x 90kW Alfa Laval heat exchangers for heat reclaim used for potable water and store heating
- 250kW chilled water from racks recirculated to power 100% of store AC through plate heat exchanger
- ARNEG hydrocarbon (R290) display cases
- 108 evaporators connected to MT, LT
- 4 solar inverters generating 100kW power capacity
- 2 Alfa Laval (Bitzer/Buffalo Trident supplier) roof-mounted adiabatic gas coolers
- Gas coolers fitted with K65 copper/steel heat exchanger

LIQUORLAND STORE:

- Closed-loop condenser waterloop system with adiabatic spray systems
- Supplying 3 water-cooled Carter HC plug-ins with 850g R1270 charge
- R290 display showcases containing 80-100g charge (supplier ARNEG)
- Each showcase fitted with 2 variable speed scroll compressors
- Carter Retail Equipment (R1270) open showcases
- Buffalo Trident roof-mounted dry cooler fitted with Carel adiabatic cooling system



much cooler than in the northern states, which pose CO₂ transcritical a more consistent challenge in terms of high ambient temperatures.

The team estimates that initial capital costs of their first CO₂ transcritical store are around 27-28% higher than their 'business as usual' cascade CO₂/R134a system, noting that it took Coles around two years when it installed its first cascade system in 2005 to reach cost parity with its now obsolete all-HFC model. "We would expect to see the same kind of timeline for the transition to transcritical once it's up and running," Saville said. "[In 2005] we were able to simplify the systems and saw the added interest in CO₂ in retail in Australia, there were more end users actually using the technology. The market penetration of CO₂ in Australia is really quite deep."

"With some of the global suppliers entering the Australian market we'll definitely see, and we're already starting to see, costs come down. If [ejectors] enable us to simplify the design and

maybe drop some compressors off the rack, there's big capital savings when we start looking at those."

ENVIRONMENTAL CONSCIENCE A HEAVY BURDEN

A father of two young boys, Saville has over 21 years experience in the HVAC&R sector, starting out with now defunct domestic turnkey solution provider Frigrite, who at a time accounted for around 50% of Coles' and Woolworths' business. "They were a pioneering company as far as CO₂ technology in the Australian market. They developed one of the first CO₂ (subcritical) stores for Coles back in 2005, in Gisborne."

From there Saville spent over four years with construction firm CBES Limited before landing the job at Coles in 2009. Following a transition period Wesfarmers has now leapfrogged rival Woolworths and mining conglomerate BHP as the largest Australian company by total revenue ([see graphic, page 24](#)).

"From an environmental and energy efficiency perspective Coles is very progressive when it comes to technology like this; we can see the benefit [of being] able to deploy a store that has very little by way of direct emissions. It is of great importance to the Coles business; it's good for our customers, it's good for the business, and it's good for the environment."

Saville has seen wave after wave of synthetic refrigerants fall by the wayside and sees them for what they are: a short-term solution. "I've always paid attention to what's going on both domestically and internationally and the effects of our industry on the environment from the time when it was found that CFCs were having a damaging impact and there was a hole above the ozone layer, so it weighed very heavily on everyone during that time. When industry started to mobilise to look for alternatives I think that kind of brought that environmental element into everything that we do."

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Brian Toulson, Senior Project Engineer for City Facilities Management



SELF-SUFFICIENT TRAINING

Like Woolworths, Coles has a dedicated team of technicians and servicing staff at its disposal as a by-product of its partnership with City. Contractor Melbourne Refrigeration Services also helped with the installation and design of Coles' first transcritical store, in effect, upskilling multiple parties already very familiar with CO₂ as a working fluid.

"They're all competent with the operation of CO₂ in the subcritical operation and we know now that there needs to be a step change in the level of expertise in the field to be able to maintain our first CO₂ transcritical store. We didn't enter into this without considering that transition - it's very important for us to be able to seamlessly integrate all those parties to a come up with a sustainable solution."

With City, Coles has dedicated 'clusters' made up of four or five technicians each responsible for a set of stores, including 24-hour support. Before the first Coburg North store was completed Toulson engaged with industry and Box Hill TAFE (Technical and Further Education) in Melbourne to put an internal course together that would upskill the team in

CO₂ transcritical refrigeration so "that [Coles] could walk away from the store with the knowledge that there would be no issue," Saville said.

Coles/City conducts similar training for hydrocarbon systems and would like to adapt the courses in each location new technology is implemented: in a sense, staying one step ahead of the curve to avoid training deficiencies. "We wouldn't have gone to this effort with the capital outlay, training and time investment if we didn't see it as the solution for us moving forward," Saville said.

HERE COMES THE COMPETITION!

"It's really exciting to see the scope of increase as far as what CO₂ looks like from everything from full-line supermarkets right down to the CVS. It's exciting to be a part of it," Saville said. From predominant showcase suppliers ARNEG and Hussmann to rack and heat exchanger suppliers Bitzer and Heatcraft, Coles and the broader market are now seeing a wave of new natural refrigerant technology make its way to Australia from Europe and other regions.

COLES' NATURAL REFRIGERANT BREAKDOWN

- Gross revenue FY14/15: Coles \$38.2 billion; Wesfarmers (\$62.8 billion)
- Number of stores in Australia: 780 supermarkets
- Types of natural refrigerant equipment: R134a/CO₂ Hybrid DX, R134a/CO₂ hybrid liquid recirculation, R717/CO₂ cascade, hydrocarbon showcases
- Number of subcritical CO₂ installations: 120
- Number of transcritical CO₂ stores: 1
- Number of hydrocarbon showcases: 20+ (Coburg North store)
- Number of ammonia installations: 1 (R717/CO₂ cascade supermarket)
- Number of stores converted to natural refrigerants/year: 25-30 stores





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Showcase supplier Carter, Hillphoenix (Advansor), Green & Cool and the EPTA Group have either moved or are moving into the market, while Beijer Ref Group are working with SCM Frigo in New Zealand. In addition, Panasonic’s acquisition of Hussmann will open the door for packaged transcritical units with further potential to transition the market.

“Other manufacturers wouldn’t like that because it forces you to be more competitive,” Saville said. “It opens us up to other trials and innovations that these manufacturers can bring to the table. We’re really looking forward to working with these new companies and seeing what they bring, we’ll never stop looking for new solutions that are cost-competitive and perhaps simpler.”

“The packaged units would be very interesting to see, we’ve already asked the question of Hussmann to get visibility on what they are doing in that space to see if it’s a suitable solution for our smaller format stores and we’re keen to see the offer.”

AUSTRALIA ALWAYS LOOKING TO CO₂

Coles’ journey with CO₂ started in 2004 while Saville was still in his role at Frigrite. “At that stage Frigrite was playing very close attention to what was happening on the international market and they could see that there was an emerging trend in the EU to move towards this technology and looking at what we were going to be able to do to future-proof our plant designs,” Saville recalls.

Coles’ ‘business as usual’ standard CO₂/R134a cascade systems installed in around 120 stores nationally all include integrated cooling, handle over about 250kW of cooling duty and use CO₂ as a refrigerant on the LT side. Importantly, Coles’ 11-year association with the refrigerant has laid a solid bedrock to transition to all-CO₂ systems from a technology, installation and servicing perspective.

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END USERS STANDING TALL

As a region, in many ways Australia makes a much more compelling case for the viability of CO₂ technology given the absence of strong policy and subsidies. There are few handouts given here, paving a clear course for self-sufficiency.

“There’s an element of shadow boxing going on in Australia as to which way the chips are going to fall in terms of policy,” Saville said. “All we can do as a company is put our best foot forward and deliver a result that we think is the most efficient, like the great offering you can see on our site here. There are no regulations that made us do this.”

Australia’s Carbon Tax was in place for just under two years until it was famously scrapped in the Australian Senate on 17 July 2014. Designed to encourage Australia’s largest emitters to increase energy efficiency and invest in sustainable energy, Saville said it did start to have a flow-on effect.

“The price of our HFC refrigerants accelerated considerably during that period, but I think more importantly [our] business was forced to look at the way it conducted itself from an engineering and maintenance point of view. It put a spotlight on some of [our] failings as a business.”

Irrespective of the tax, Coles has been able to reduce its overall (direct) emissions by 50% and its refrigerant leakage rate to 7% (the global average is 12-13%). “Whether it [the tax] had an effect, it may have instigated it but I think the Coles business is very focussed internally on these issues.”

Bitzer CO₂ compressors

→ “When you look at our current hybrid plant design, the intent of these has always been with the knowledge that one day we will be able to retrofit that HFC out,” he said. “It will definitely help us to transition. We know that what we’ve done here with the transcritical plant is another step along that road, not without challenges. For quite some years we’ve been watching the global trends with transcritical refrigeration with an understanding that once the technology evolves to suit our climatic conditions we will be in a great position.”

“Initially when CO₂ came onto the market there was a lot of concern in the industry about the skill level to be able to maintain these plants and the intricacies involved with keeping them operational: general repair and maintenance. It’s quite some years ago that we managed to overstep that hurdle, now it’s a very stable platform for us. The CO₂ is very well insulated against ambient conditions, it’s tried and tested.”

Although CO₂ transcritical will be a major focus for Coles, Saville sees the continued use of hydrocarbon plug-ins from suppliers like Carter and ARNEG as essential to the business’ equipment portfolio. Indeed, hydrocarbons are

used for all plug-in showcases at the Coburg North store. “From a retail perspective they are very important at point of sale and the flexibility they offer as opposed to having something that’s hard-plumbed into the plant and the services required to support that.”

Concerns over the practice of ‘retrofitting’ systems with hydrocarbon refrigerants in Australia don’t bother Saville and his team, simply because their staff are trained professionally to handle the refrigerants, install, and maintain the systems. They set a good example for others in the industry. “We comply with the A2 flammable refrigerant restrictions with the amount of charge we have in them and if you approach them in the right way and you’re instilling the skill set into your staff then where’s the risk? It’s pretty much a maintenance-free system.”

From an industrial point of view, the company’s distribution centres are deployed with direct expansion ammonia systems as standard but are run by a separate arm of the business. “It’s something that we’ll definitely be looking into in the future, it will be a focus for us.”

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GREEN STAR ARBS SUBMISSION

In 2014, Coles’ Hallam store in southeast Melbourne was awarded the first Green Star rated supermarket in Australia. The store was awarded a 4 Star rating for reducing its energy consumption by 20% compared to an equivalent supermarket of the same size.

The Coburg North store has also been submitted for a Project Excellence award at ARBS 2016 in Melbourne, one of three contenders in line to achieve a 4 Star plus Green Star rated supermarket.

On top of the refrigeration systems mentioned above, the store includes an air-conditioning system that automatically adjusts based on the number of people in the store, natural refrigerant technology, combined cooling for more efficient temperature control, LED lighting and extra ceiling insulation.

“Because our business is so energy intensive with such a high power demand on all the equipment, refrigeration and mechanical services, we actually worked with them [Green Building Council of Australia] to develop a rating tool,” Saville said.

Saville said the company continues to look to major European retailers like TESCO, Carrefour, METRO and Sainsbury’s for engineering inspiration, but the biggest competition remains internal. “I think I’m more in direct competition with the last store that I built and how can I do that better. How can we deliver a better solution than what we’ve already got?”

“You can see the amount of change that we went through when we deployed our first [CO₂ transcritical] store, there’s a lot of initiatives that we’re conducting that will be used in our other stores. We’re always striving to provide a better offer for our customers and a better environment.”