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# Thrills and chills

The Bend Motorsport Park  
leads the way with refrigeration technology

# THRILLS AND CHILLS



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The recently completed Bend Motorsport Park in South Australia is a world-class racing circuit with a world-class refrigeration system to match. **Sean McGowan** reports.

In late August more than 35,000 motorsport fans flocked to the second running of the OTR SuperSprint at The Bend, stamping the venue as one of the highlights of the Australian Supercar Championship calendar.

Considered one of the most significant developments in Australian motorsport history, The Bend Motorsport Park at Tailem Bend – an hour's drive south-east of Adelaide – is a state-of-the-art facility catering for all motorsport disciplines.

As well as hosting the Australian Supercar Championship and the Australian Superbike Championship, The Bend features circuits for drift, karting, rallycross, drag racing and rally/off-road racing events. 4WD adventure and driver training is also supported.

And The Bend is setting its sights even higher for the future.

In early January, international motorsport will return to South Australia, with The Bend hosting Round 2 of the 2019/2020 Asian Le Mans Series – the only regional pathway into the World Championships.

It will be the first event to race on The Bend's purpose-built 7.77km GT Circuit – the second-longest permanent racetrack in the world.

It will also host the opening round of Enduro Cup in the 2020 Supercars season.

Inspired by some of the world's most iconic race circuits, the track is the only circuit in Australia to comply with the FIA Grade 2 and FIM Category A standards set by the governing bodies for world motorsport and motorcycling respectively.

"As far as a permanent circuit goes, this has got to be number one – this is our best circuit by a long shot," says 2017 Australian Supercar Championship winner and current Red Bull Holden Racing team driver, Jamie Whincup.

"Just the quality of it – it's an F1-style circuit."

Needless to say, The Bend has put the small town of Tailem Bend on the world motorsport map.

## BEYOND THE TRACK

Off the track, visitors and spectators to The Bend are well served by a purpose-built central Welcome Centre.

Those who wish to stay onsite have a choice of accommodation options ranging from the 100-room hotel located in the four-storey pit building, to a caravan and camping tourist park. An airstrip suitable for light aircraft and helipads for fast commuting between Adelaide and the park are also being built.

The Bend was developed and primarily funded by the Peregrine Corporation – South Australia's largest privately owned company, with annual revenue of over \$2 billion.

A key part of the group is the On The Run (OTR) convenience store operations, with over 135 sites across South Australia. Combined with the group's other retail and property interests, Peregrine's operations consume a large amount of electricity. Many of its refrigeration systems are also being affected by the HFC phase-down.

In 2016, Glaciem Cooling Technologies – a senior industry partner of the University of South Australia (UniSA) – approached Peregrine to explore an alternative refrigeration platform for the OTR sites.

"Due to the significant increase in the price of energy in South Australia, more and more businesses are turning to renewable energy as a way of controlling their energy cost," says Glaciem's managing director Julian Hudson, M.AIRAH.

"Peregrine's commitment to sustainability meant the corporation had already begun an internal process aimed at reducing overall energy costs across its OTR operations. And because Glaciem has a proven track record of providing innovative, energy efficient cooling solutions – as well as being SA-based – it seemed a natural fit."

It was during these discussions that Peregrine identified The Bend as an ideal candidate for a commercial trial of Glaciem's new refrigeration platform, Dew Point Carbon Dioxide-only (DP-CO<sub>2</sub>) refrigeration.

“We were looking for an opportunity to install this newly developed technology platform on a large, greenfield site and The Bend – being under construction at the time – ticked these boxes.”

The system was designed to be installed within the pit building to serve the 10m<sup>2</sup> freezer and coolrooms used by the commercial kitchen, dining rooms and hotel.

For Peregrine, the ability of the proposed system to meet the group’s sustainability objectives while addressing life-cycle costs and mitigate environmental risks were key to the project proceeding.

## RESEARCH DELIVERS

Glaciem has conducted research and development targeted towards the HVAC&R sector for many years as a senior industry partner of UniSA.

Among its more recent projects has been the commercialisation of a phase-change material and thermal energy storage (PCM TES) system.

The system installed at The Bend integrates Glaciem’s DP-CO<sub>2</sub> refrigeration system with the more recently developed PCM TES system to provide highly efficient energy storage.

“Each component, on its own, represents a significant technical advancement for the industry, but when coupled together, they are well placed to leave a measurable and long-lasting legacy” says Hudson.

The combined DP-CO<sub>2</sub> and PCM TES refrigeration system deployed at The Bend operates entirely on natural refrigerants. R744 (CO<sub>2</sub>) is used as the primary refrigerant for the medium temperature system, which cools a heat transfer liquid, HC30.

“CO<sub>2</sub> was selected to demonstrate the advantages of using dew point (or indirect evaporative) cooling in high ambient conditions,” says Hudson. “This is particularly salient given summer daytime temperatures in Tailem Bend regularly exceed 45°C.”

The low temperature (LT) side of the system is a CO<sub>2</sub> cascade system, and the medium temperature (MT) side is “more or less” a standard CO<sub>2</sub>-only system.

“The difference is that a heat transfer fluid (HTF) is circulated between the two LT and MT loops to enable the CO<sub>2</sub> systems to exchange heat with the thermal energy store (TES).”

The HTF performs several functions.

The facilities at The Bend got a serious workout when the OTR SuperSprint was held in August.

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When the TES requires charging, the MT CO<sub>2</sub> system cools the HTF to -9°C, which in turn freezes the -6°C phase change material. When the TES is required to discharge, the MT system is cycled off and the energy stored in the TES is used to cool the coolroom and to condense the LT CO<sub>2</sub> cascade system. Peak power consumption is therefore dramatically reduced.

The system also takes advantages of onsite solar PV power generation, with algorithms developed to optimise the generation of this renewable energy and offer a “hedge” to users exposed to spot market electricity pricing fluctuations.

But to enable the MT system to operate sub-critical, even in ambient temperatures above 45°C, it has been designed with the addition of indirect evaporative cooling installed in series with its main condenser.

## COMPLEX CHALLENGES

Identifying a cost-effective refrigerant with high efficiency to charge the PCM store proved challenging to the research team. Synthetic refrigerants were ruled out due to their environmental impact and long-term sustainability performance.

This left natural refrigerants only. CO<sub>2</sub> was adopted due to being non-toxic and non-flammable.

But as CO<sub>2</sub> systems have low efficiencies in ambient temperatures above 25°C, the solution adopted by Glaciem and UniSA integrates indirect cooling technology to allow it to operate in high ambient conditions.

“To achieve this, the incoming air is indirectly cooled close to the dew-point temperature of the air,” says Hudson.

“Tests show that with ambient dry bulb air temperatures above 40°C, condenser air inlet temperatures of below 20°C could be achieved, thereby allowing the CO<sub>2</sub> to condensate at 25°C.”

The indirect evaporative cooling uses existing technology – found in commercial systems – that has been integrated in series with the main condenser coil (see Figure 1).

“This integration turned out to be quite complex – particularly around the balance between low condensing temperature and fan power,” says Hudson.

To allow the system to operate at sub-critical, an automatic bypass valve is installed around the high-pressure expansion valve, thereby simplifying the cooling cycle. Hudson says from a pressure enthalpy diagram perspective, it is identical to a standard HFC DX cycle.

The application of this technology was developed with the assistance of Tech in SA – a South Australian government funding program. Research and development was carried out at UniSA Mawson Lakes over an 18-month period.

It has resulted in a worldwide patent, as well as the creation of a new control algorithm.

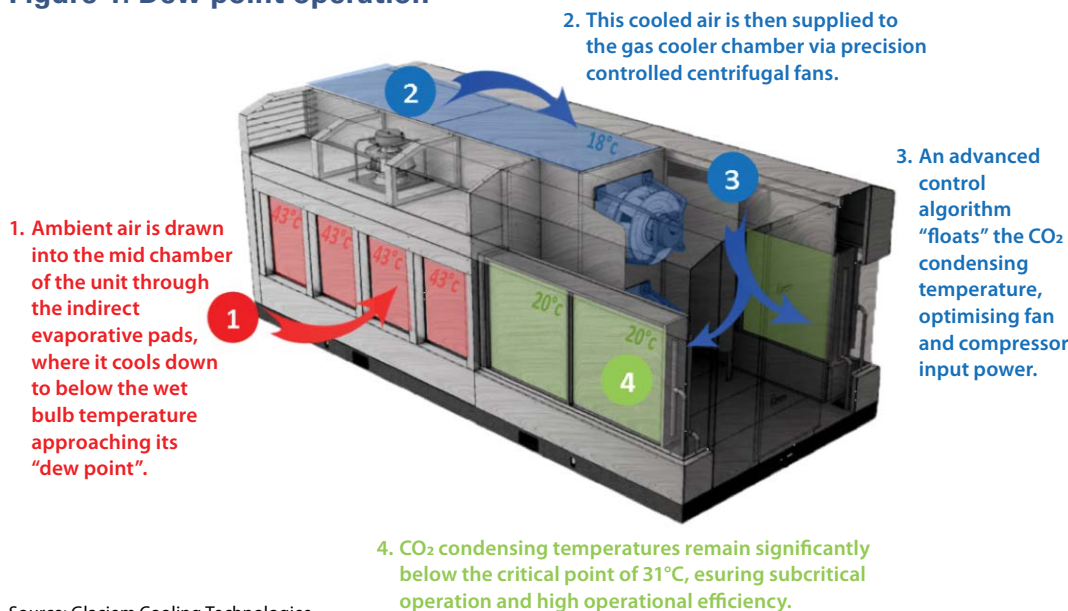
## CHANGING PHASE

Although water in the form of ice has been used in the HVAC&R industry for many years to provide chilled water at 6°C, it has had limited use in refrigeration applications due to the fact that ice melts at 0°C.

“A lot of research has taken place into chloride-based salt solutions for refrigeration applications, but due to the corrosive nature of chlorides the PCM is usually encapsulated within a ball,” says Hudson. “This encapsulation brings several prohibitive aspects – namely cost and poor heat transfer characteristics.”

Although researchers at UniSA had already overcome these issues by developing a -11°C PCM suitable for -6°C process cooling, it was only suitable for use with an ammonia or R404A system.

Figure 1: Dew point operation



Source: Glaciem Cooling Technologies

“We identified the need for a new PCM with a higher freezing point because R404A has no real longevity due to its high GWP. And not everyone is comfortable using ammonia either.”

This led to the development of the -6°C PCM by the Barbara Hardy Institute at UniSA – as part of an Australian Renewable Energy Agency (ARENA) research and development project. A low-cost, non-chloride-based salt solution, it enables ice to be built up directly on coils, thus eliminating the need for encapsulation and reducing the overall cost of the TES tank.

When used in the system installed at The Bend, this new coil and dynamic melt design increases the efficiency of the TES system by allowing more of the latent heat to be extracted, and thereby reducing the installed footprint.

“The system has to cope with a very diverse load profile – from extremely low loads where there are no events on and the kitchen is only serving hotel guests and general visitors, to large events when they have over 1,000 covers to cater for,” says Hudson.

“The use of PCM TES means that the system handles these diverse loads extremely well. Having the PCM TES fully charged before an event acts as a boost to the main system, while during low loads the refrigeration system is charging the ‘battery’ at a high Coefficient of Performance (COP) such that this charge can be trickled out at the required rate.”

## THE FINAL STRAIGHT

Since being commissioned in April 2018, the DP-CO<sub>2</sub> refrigeration system at The Bend has been considered a resounding success. It breaks new ground for the performance of CO<sub>2</sub> systems operating in warm climates.

“The performance of the DP-CO<sub>2</sub> system and control algorithms has met expectations,” says Hudson. “In fact, the design and nature of the system has proven to be extremely reliable.”

Such was the reliability of the system last summer, when temperatures in the region exceeded 47°C, that The Bend was the only one of Peregrine’s sites to not have a call out for refrigeration during the period.

“Initial analysis of the first year’s operating data by UniSA suggests that it is the world’s most efficient air-cooled refrigeration system,” says Hudson.



The main circuit combines technical corners and fast-flowing sections for good racing.

Source: The Bend Motorsport Park.



Initial analysis of the first year’s operating data by UniSA suggests that it is the world’s most efficient air-cooled refrigeration system

The data has also shown significant improvements in system performance with smart algorithm control, and the major impact on energy savings when dew-point cooling is integrated with a CO<sub>2</sub>-only system compared to the use of an adiabatic gas cooler.

As well as now offering the Peregrine Corporation with a tried and tested platform to roll out across the OTR convenience stores, the technology has also attracted interest from a supermarket group and smaller retailers.

In this way, the collaboration between Glaciem and UniSA is achieving its objectives.

“These kinds of partnerships targeted at finding important solutions for real problems are part of what makes UniSA Australia’s university of enterprise,” says UniSA deputy vice chancellor of research and innovation, Professor Tanya Monro.

“We want to deliver research that makes an impact, that meets industry at the coalface and helps them to deliver great outcomes for the environment, for society and for business.”

The Bend refrigeration project won the 2018 AIRAH Excellence in Refrigeration Award, and the 2017 Carbon Neutral Adelaide Award for Applied Innovation. ■

## PROJECT AT A GLANCE

### THE PERSONNEL

- ▲ Builder: **Romaldi**
- ▲ Client: **Peregrine Corporation**
- ▲ Data analytics: **UniSA Ventures**
- ▲ Funding (in part): **Tech in SA Early Commercialisation Grant**
- ▲ Refrigeration contractor: **Glaciem Cooling Technologies** (sub-contractors)
- ▲ Refrigeration engineer: **Glaciem Cooling Technologies**

### THE EQUIPMENT

- ▲ Compressors: **Bitzer**
- ▲ Controls: **Schneider**
- ▲ Electrical Panel PLC program: **Electric Solutions**
- ▲ Indirect Evaporative Cooler: **Seeley**
- ▲ Integrated Cooling System: **Glaciem Cooling Technology**
- ▲ PCMs: **Barbara Hardy Institute, UniSA**
- ▲ PCM Tank: **Glaciem, AR Industrial**
- ▲ Pumps: **Grundfos**
- ▲ Sensors: **IFM Effector**
- ▲ Thermal Energy Storage (TES): **Glaciem, Sinobaron**

Source: Glaciem Cooling Technologies



The main building also houses Rydges Pit Lane Hotel.  
Source: The Bend Motorsport Park.