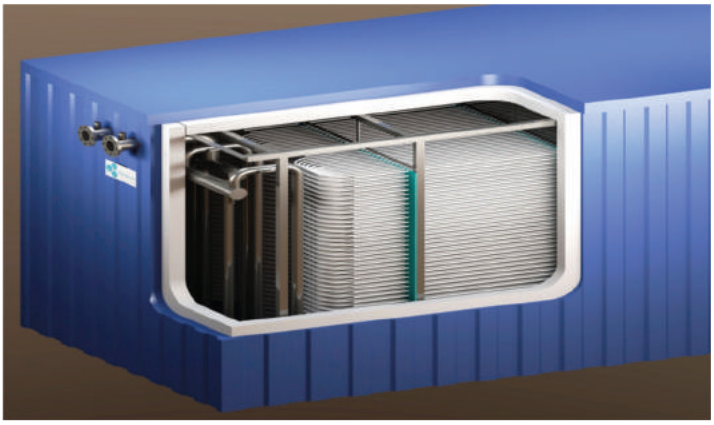
GLACIEM
COOLING TECHNOLOGIES

# THERMCOLD®

## *Thermal Storage Systems*



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Innovative Natural Solutions

# THERMCOLD® by Glaciem Cooling Technologies

Glaciem Cooling Technologies thermal storage system Thermcold provides a revolutionary breakthrough that can significantly reduce energy costs for medium temperature refrigeration applications.

Thermal Storage in the form of simple ice banks and slurries have been used successfully in air conditioning and systems for many years. Typically these have been used in systems requiring +6˚C secondary fluid temperatures. However use in medium temperature applications (-6˚C to +4˚C) has been difficult due to the relatively high temperature that ice releases latent heat.

Glaciem Cooling and the University of South Australia have developed new phase change materials capable of achieving lower freezing temperatures and a thermal storage system that efficiently stores thermal energy and then releases that energy when required. Thermal energy storage allow refrigeration plants to run and store energy during off peak times at cheaper electricity rates, and then to release energy during peak periods, minimizing running costs. The system can be retrofitted into a current medium temperature refrigeration systems or included in designs for new installations.

If there is a cooling requirement, the Thermcold thermal storage system is very competitive when compared to electric battery solutions. It is important to note these technologies are complementary, each offering certain advantages. When cooling counts though, Thermcold is the answer!

| **ThermCOLD is very cost effective!** | | |
|---|---|---|
| ThermCOLD | <$178 kWh installed* | Up to a 20 year life @ high efficiency |
| Electrical Storage | $502 kWh installed* | 10 year life @ reducing efficiencies |
| *Electrical equivalent. Costs contingent on unit selected. | | |

## Demand Response Management

In May 2017 the Australian Renewable Energy Agency (ARENA) and the Australian Energy Market Operator (AEMO) jointly announced plans to pilot a demand response initiative to manage electricity supply during extreme peaks. This involves paying consumers to reduce their energy consumption on request during peak periods or emergencies, freeing up electricity supply.

Energy users who subscribe will receive incentive payments to be on standby in emergencies or peak demand days funded by ARENA. During an emergency or extreme peak, those who participate could be called upon by AEMO to switch off or reduce their electricity use temporarily, and would receive a further compensation payment. Currently limited to those customers involved in the pilot, this initiative nevertheless highlights future policy direction and the importance of the load management technology provided by Thermcold.

## Energy Management made possible by ThermCOLD

## 1. Manage Your Purchased Power!

The energy management options provided by the Thermcold system are extensive.

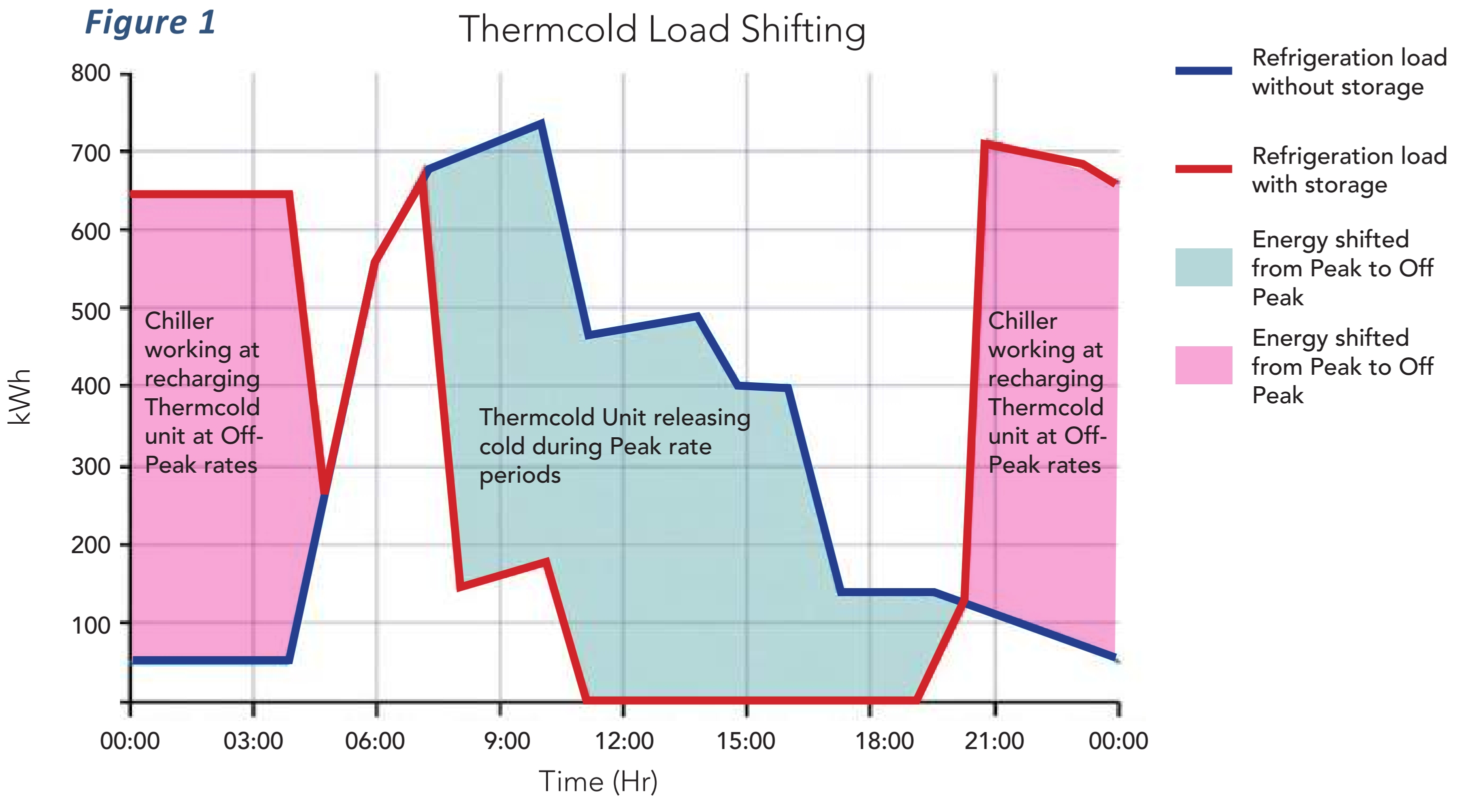
Figure 1 overleaf shows a typical daily refrigeration profile for a dairy process plant without thermal storage (blue line) and with thermal storage (red line).

In this example, the Thermcold unit is sized to provide all cooling requirements from ~ 9:00 am until after 6:00 pm, allowing the facility to effectively avoid peak electricity rates during this period, instead using the Thermcold charge that was provided by, in this instance, off peak grid power.

Additionally, the facility has realised a reduction in peak demand of 200 kVA by smoothing the load.

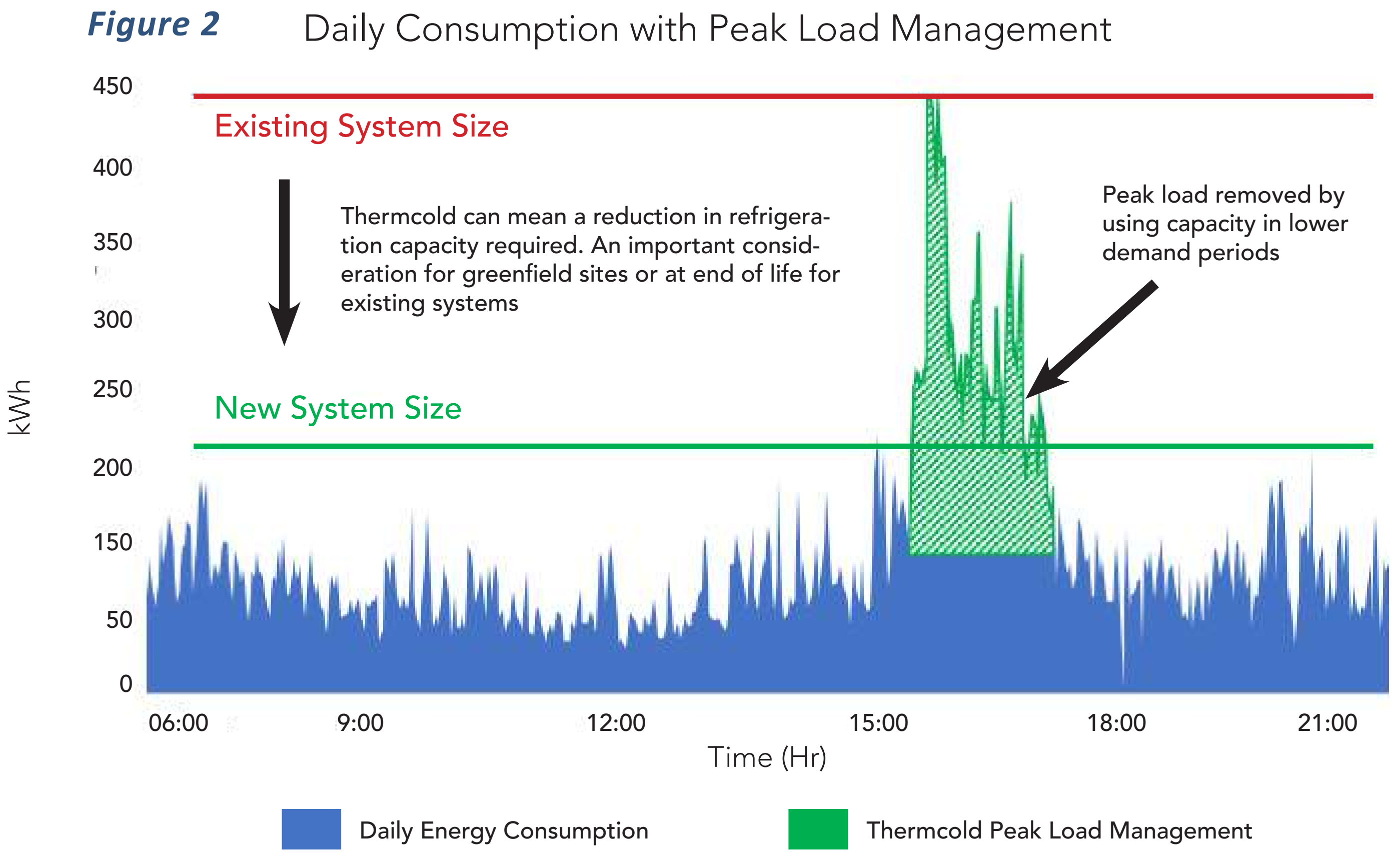
Thermcold units can be sized to achieve the peak demand reduction that suits the end user. Figure 2 shows the ‘peak lopping’ that can be achieved by an appropriately sized installation.

***Figure 1***




In the example highlighted in Figure 2, the Thermcold unit has been sized to supplement energy usage at a particular time in the day, allowing the site to avoid both the majority of peak costs during the afternoon, but also significantly reducing Peak Demand when energy usage is at its highest.

***Figure 2***




The Glaciem Engineering team specialise in working closely with clients to properly understand energy management priorities. This ensures the Thermcold system installed is providing the ultimate in site productive capacity and energy cost management.

# 2. Maximise the benefits of Renewables

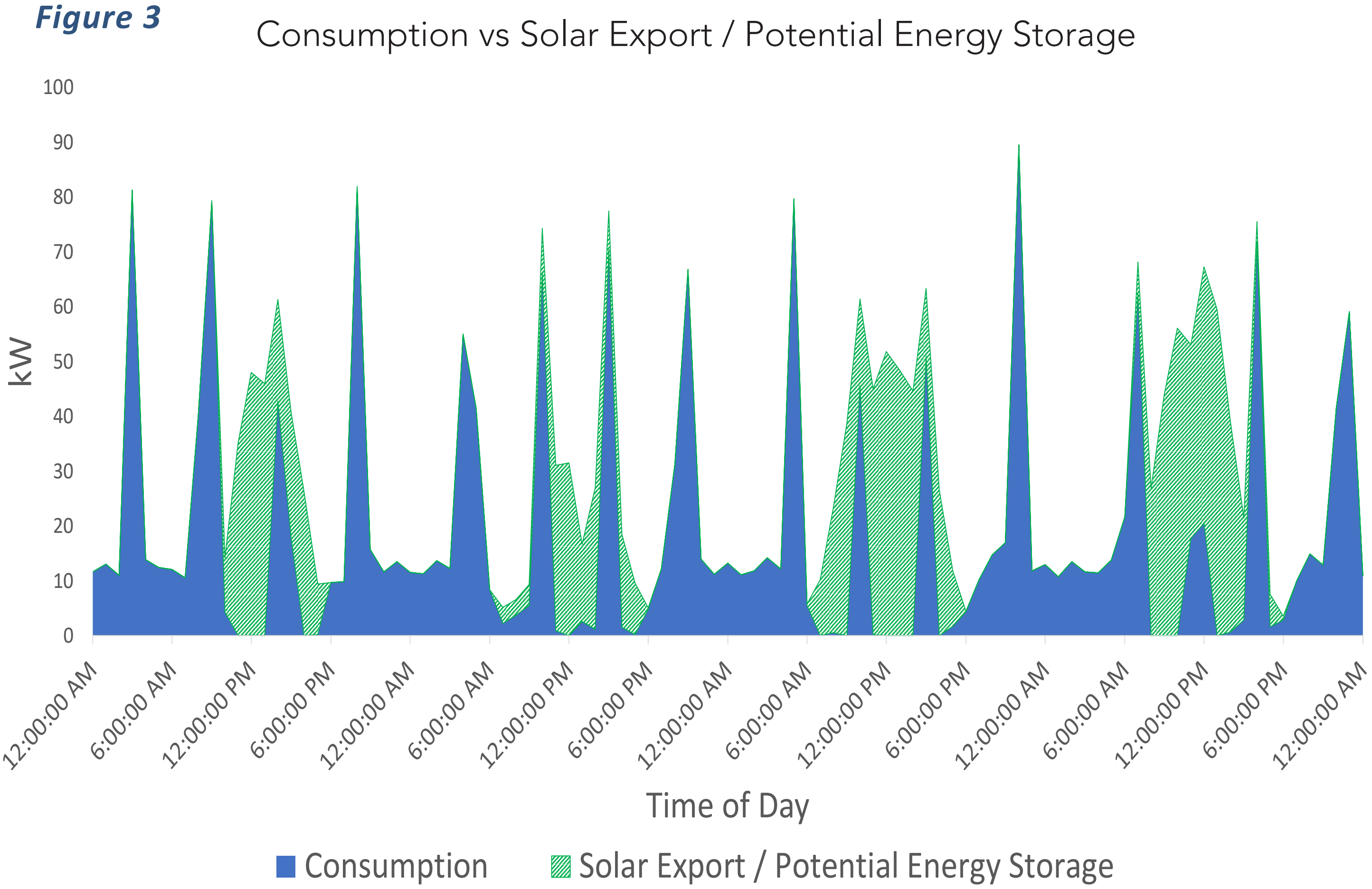
Thermcold also allows the end user to capture surplus energy from renewable sources, for use when renewables are not generating power.

Too often Australian customers are required to sell surplus renewable energy they have generated to the grid at low prices, or in many cases, are forced to stop generating this energy for a given period of time. Ironically these customers are often then buying grid power at peak rates later in the same day! Recent changes by the Australian Energy Regulator are likely to drive peak power prices up, meaning Australians will pay much more per kWh during times of peak demand.

Thermcold technology changes the paradigm, putting control over energy management squarely in the hands of the user. Systems can be sized to help end users on 'time-of-use' tariffs store just the right amount of surplus energy from their renewable source to ensure they are not paying premium rates for electricity at peak times in the day.

For many users, this represents a huge saving as the energy provided by Thermcold is essentially 'free' from the renewable source, and certainly cheaper than peak premium rates. Figure 3 shows a typical solar PV consumption / export trend across a 4 day period. The green highlighted areas show zones of potential energy storage via Thermcold.

***Figure 3***



# How does it work?  Charging the Thermal Storage

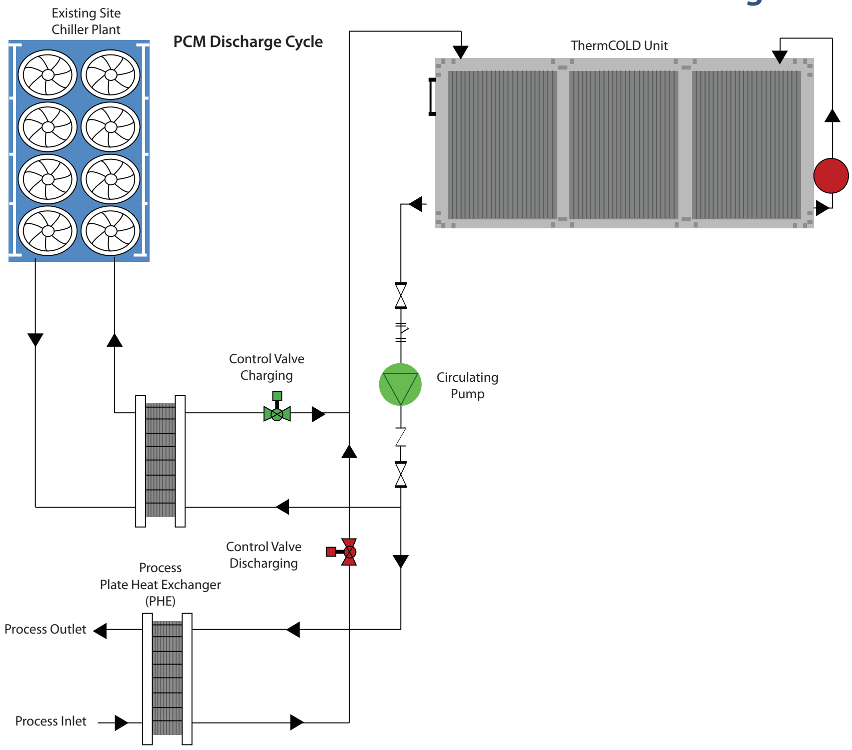
The system uses a salt solution which freezes or changes phase at below zero, thus storing and releasing latent heat at a lower temperature than ice. Figures 4 & 5 illustrate the Charge and Discharge cycles respectively.

The Charge Cycle starts with a primary refrigeration chiller plant, which operates at night at lower ambient temperature using less power and cheap off peak electricity, or with solar PV during the day throughout periods of peak power generation, and releasing at night.

The existing site or primary chiller plant cools the secondary heat transfer fluid (HTF) using a Plate Heat Exchanger (PHE) ,the HTF is then pumped through the Thermcold Unit, freezing the salt PCM solution.

During the Charge cycle the control valve to the Process PHE is closed and the charging control valve is open. A series of probes situated in the Thermcold unit feed information back to the PLC, allowing the charge cycle to be terminated on time or temperature.

**Figure 4**




# How does it work?  Discharging the Thermal Storage

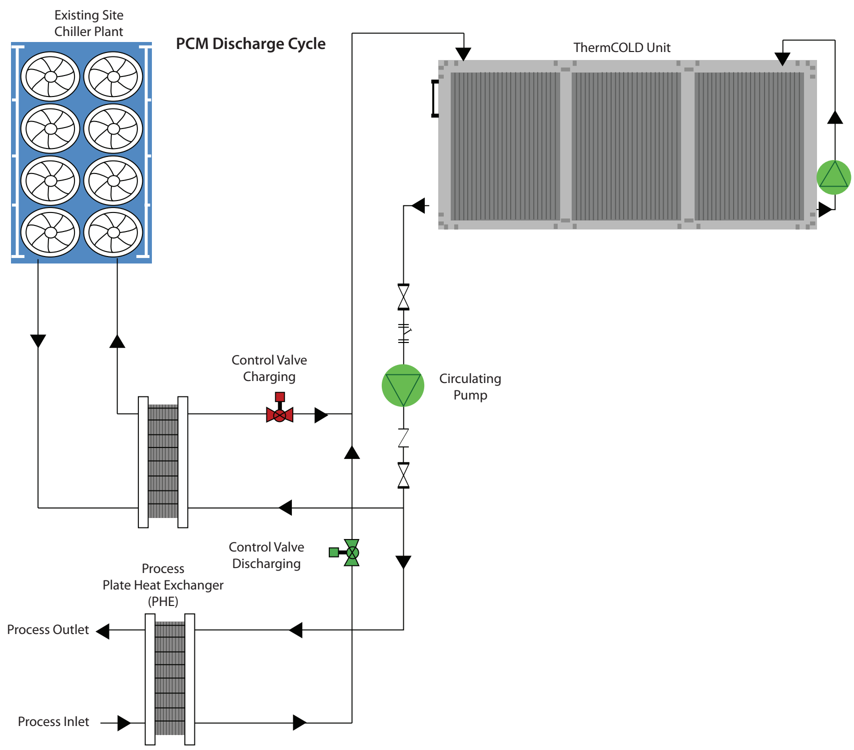
The Discharge Cycle operates when required and uses only minimal energy for the circulating, process pumps and dynamic melt pump.

During the Discharging cycle the primary refrigeration chiller plant is cycled off, the charging control valve is closed and the discharge control valve is open.

The HTF is pumped through the Thermcold unit and cooled, it then flows on to the process heat exchanger and cools the process fluid (typically glycol based fluid).

The Thermcold unit incorporates Glaciem's Dynamic Melt Technology on the discharge cycle which provides intensive turbulence to ensure a perfect defrost heat transfer and low HTF temperatures.

**Figure 5**



# System Specifications*

| Model | Unit | DYN 840 | DYN 1120 | DYN 1200 | DYN 1360 | DYN 1504 | DYN 2200 | DYN 2640 |
|---|---|---|---|---|---|---|---|---|
| Thermal Storage Capacity** - 11˚C PCM | kWh | 658 | 835 | 988 | 1101 | 1177 | 1763 | 2124 |
| Thermal Storage Capacity** - 0˚C PCM (Water) | kWh | 1001 | 1270 | 1502 | 1674 | 1790 | 2680 | 3230 |
| Length | mm | 3950 | 4950 | 4950 | 5550 | 5950 | 6600 | 6600 |
| Width | mm | 2200 | 2200 | 2200 | 2200 | 2200 | 2500 | 2500 |
| Height | mm | 2050 | 2050 | 2200 | 2200 | 2200 | 2500 | 2500 |
| Tank Shell | 304 Stainless Steel | | | | | | | |
| Distribution Header | 304 Stainless Steel | | | | | | | |
| Coil Supports | Polyethylene | | | | | | | |
| Coil | 16mm HDPE (Polyethylene) | | | | | | | |
| Volume | Liter | 690 | 880 | 1050 | 1200 | 1320 | 1280 | 1900 |
| Inlet/Outlet Connections | DN | 80 | 80 | 100 | 100 | 100 | 125 | 125 |
| Shipping weight | Kg | 1450 | 1860 | 2080 | 2360 | 2560 | 3540 | 4530 |
| Operating Weight*** | Kg | 16160 | 21472 | 23750 | 26680 | 28890 | 42450 | 51300 |
| Max Operating Pressure | kPa | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| Test pressure | kPa | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 |
| Operating Temperature | -15°C to 50°C | | | | | | | |
| HTF Discharge Temperature | -9°C to 9°C | | | | | | | |

** Specifications subject to change without notice*
*** Thermal storage capacity based on 8hrs of continuous discharge*
**** Operating weight will change depending on PCM used, refer to Glaciem for further details. Weights for -11˚C PCM included above.*

# The next phase

Every PCM system is different.

**Understanding a substance's "phase" or "state" change has been the cornerstone of refrigeration for more than 150 years. Yet recent technological advances have seen new materials developed that enhance this concept even further. Sean McGowan looks at the next phase of refrigeration.**

As the single largest electricity-consuming technology in Australia, refrigeration equipment accounted for more than 22 per cent of all electricity used nationally in 2012 (according to Cold Hard Facts 2).

And just as our society's demand for refrigeration has grown, so too have the price and availability of electrical energy.

Big consumers are encouraged (and for this read rewarded) by utilities companies to help reduce peak electrical demand on the grid through cheaper off-peak tariffs and alternative tariff structures.

Naturally, this has led the refrigeration industry to seek new methods and technologies that can satisfy the growing demand for refrigeration, all the while taking advantage of cheaper tariffs.

It really has become an industry onto itself.

One technology that has been recognised as a game-changer in this space is phase change material (PCM). In a relatively short time, and with just a few real-world trials under its belt, PCMs have shown to be more than capable of shifting refrigeration-related electricity loads from peak to off-peak, or from high cost to low.

Still in its infancy, significant research and development work continues to take place to help PCMs step out of the laboratory and into the real world.

Take for instance the use of PCM thermal storage at Parilla Premium Potatoes in South Australia (HVAC&R Nation, February 2015).

Faced with the prospect of replacing its 14-year old R22 refrigeration system, the family-owned company's isolated farm near the South Australia/Victoria border became ground-zero for the use of a low temperature PCM in a real-world refrigeration application.

The design is based on a 12kW thermal storage system researched and developed by Glaciem Cooling Technologies (formerly Quik-Cool) in partnership with the Barbara Hardy Institute at the University of South Australia.

Exactly 20-times larger than its test counterpart, the Parilla PCM system uses a central ammonia plant to operate only during evening off-peak times to cool a secondary refrigerant (HC30) to a lower temperature of -15°C.

> "PCMs have shown to be more than capable in shifting refrigeration-related electricity loads from peak to off-peak"

This cooled secondary refrigerant is then pumped through stainless steel coils located in four PCM storage tanks, each with a capacity of 720kWh, where it freezes a salt-based PCM before flowing back to a holding tank.

During the daytime operations of the farm, the ammonia plant is cycled off and the HC30 is circulated back through the PCM storage tanks. There it is cooled by the phase change that occurs – this provides cooling to the farm's six large coolrooms.

According to Glaciem's managing director Phillip Henshall, HC30 was selected for its viscosity at low temperatures.

"In the early days of our development, we needed to find a fluid that was still able to be pumped efficiently at temperatures from 20°C to -20°C," he told AIRAH's HVAC&R Nation earlier this year.

> The role of PCMs may also take on even greater significance in the future as energy markets change

"Other glycol-like fluids were considered, but HC30 was by far the most energy-efficient fluid within the temperature range."

The PCM used at Parilla is a specialised salt-based product developed by the Barbara Hardy Institute and Glaciem Cooling Technologies.

It has undergone years of testing, with the necessary tank-sizing algorithm model for refrigeration loads developed using a pilot plant.

It provides secondary refrigerant temperatures of around -8° to -6°C, making it ideal for use in food-storage applications where coolroom temperatures are typically held between -1°C and 3°C.

## RESEARCH MARCHES ON

The University of South Australia's detailed analysis of the system performance at Parilla has revealed positive results.

The analysis was able to demonstrate the capability of the PCM thermal storage system to charge and discharge near its rated capacity, as well as achieve a peak-demand reduction over the summer period.

**The PCM tanks at Parilla Premium Potatoes in South Australia use a specialised salt-based product.**

In addition, testing after one year has shown that the PCM in use has not degraded.

"We took a vast number of lessons away from the Parilla project," says Julian Hudson, M.AIRAH, director of JCH Refrigeration Consulting and Glaciem Cooling Technologies.

"Working on a small R&D system and then scaling it up to real-life brings up issues that you would not expect or see in a smaller test unit. And this is particularly true of controls and system integration.

"On the face of it, PCM systems appear to be very similar to a hydronic system, or any secondary fluid system. However, system integration, controls and the selection of pumps and valves during the charge and discharge cycles are quite complex. Experience with these challenges can only be gained by being involved with PCM projects."

Another limitation of PCM technology is the availability of suitable phase-change materials to suit various applications.

The salt-based material used at Parilla has unique characteristics, with a freezing point of -11°C and a melting point of -9°, making it suitable only for specific purposes.

Research therefore continues to find a material that will have broader appeal in the Australian market.

"The University of South Australia is currently developing a PCM with a freezing point of -6°, which will broaden the market for PCMs in Australia," says Hudson.

Hudson says there is R&D work under way to integrate solar PV with PCMs – a combination that promises to further reduce refrigeration's dependency on the electricity grid.

The role of PCMs may also take on even greater significance in the future as energy markets change and we arrive at a point where electricity consumers exist off the grid, on micro-grids.

"This is especially true in thermal energy storage (TES) where PCMs can be used with solar PV in the form of thermal batteries," Hudson says.

"Current lithium-ion batteries have a cost of around $500kW/h, whereas low-temperature PCMs are around $180kW/h, making them an extremely attractive option – especially when you have a cooling demand on site."

## STICK AND CARROT

One company extending the reach of PCMs beyond commercial applications is Perth-based Phase Change Products (PCP).

Specialising in the manufacture of PCMs with a phase change point ranging from -21°C to 29°C, the company is currently working with major electronics manufacturer LG, with refrigeration in India.

The Ammonia plant at Parilla, which was a finalist in 2014 AIRAH Awards' Best HVAC&R Retrofit or Upgrade category.

According to PCP technical manager Gavin Colbourne, the application of PCM in the freezer compartment of domestic refrigerators achieves the aim of keeping both the fridge and freezer stable during long periods of power outages.

PCP has successfully developed a PC-7 material and, over the past two years alone, has implemented its PC-11 material into over one million refrigerators in the Indian marketplace.

This has significant benefits in developing nations, where electricity grid infrastructure is underdeveloped and supply is unreliable.

The company is also conducting tests on commercial refrigerators, with a view to using PCMs to reduce the number of compressor starts as well as maintain temperature stability when the refrigerator door is opened.

"Applications that require temperature stability, or have a product sensitivity or value, are applications where the use of PCM is evolving," Colbourne says.

He also points to locations where extreme weather can impact the performance of equipment; as can cases of intermittent power supply or restrictions on availability.



## CONSIDERING PHASE CHANGE

**Julian Hudson, M.AIRAH, director, JCH Refrigeration Consulting & Glaciem Cooling Technologies says those considering the use of phase-change material in refrigeration applications must keep three things in mind.**

1. Every project has to be individually analysed to determine if PCMs are suitable, including in-depth analysis of the end user's electricity supply agreement.
2. A clear understanding of the customer's current and future refrigeration requirements needs to be addressed, especially on greenfield sites, where the refrigeration plant infrastructure needs to be installed at the beginning in order to accommodate future expansion of the PCM part of the system.
3. There is much written in the media of the lack of Australian will to tackle global warming, reduce $CO_2$ emissions and move to a clean-energy future.

But little is said of the work being done by Australian research institutions like the Barbara Hardy Institute, and the fantastic work being done in the RAC sector that is at the forefront of innovation in refrigeration technology, sustainability and in reducing $CO_2$ emissions.

These factors were behind PCP also dipping its toe into the agricultural industry when it retrofitted a PCM thermal storage system to a 405-hectare carrot farm about 100km north of Perth (Ecolibrium, August 2012).

Requiring increased cooling capacity, but unable to add more chillers to its existing plant due to restrictions with electricity delivery to the farm, PCP retrofitted a 1,600kW/hr thermal storage system that was charged at night to take advantage of off-peak tariffs.

This also provided the advantage of operating chillers during the lower night-time ambient temperature experienced in this part of Western Australia.

PCP's design used the farm's existing chiller set by connecting it to two large, insulated thermal storage tanks via a plate heat exchanger.

Each tank holds a proprietary PCM – in this case PC-4, which is a non-hazardous, inorganic hydrated salt solution –

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