LESSONS LEARNT REPORT ON THE TECHNOLOGY

Advancing Renewables with PCM Thermal Energy Storage Project (2019/ARP025)

Authors:
Julian Hudson, Glaciem Cooling Technologies
Dena Hadian, Glaciem Cooling Technologies
Peter Pudney, University of South Australia

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Executive summary

In 2019 the Australian Renewable Energy Agency (ARENA) awarded Glaciem Cooling Technologies Pty Ltd $2 million in funding to demonstrate the technical and economic value of integrating thermal energy storage with renewable energy into Heating, Ventilation, Air Conditioning and Refrigeration (HVAC&R) applications.

The innovative new cooling technology developed in South Australia integrates renewable energy sources with low-cost thermal energy storage batteries controlled by a newly developed cloud-based forecasting algorithm to optimise the system's operation based on weather forecasts, electricity price forecasts, and customer demand forecasts to optimise the storage system in order to maximise customer savings.

All three projects utilise natural refrigerants ither ammonia or carbon dioxide heat pumps to provide cooling to the thermal batteries rather than commonly used synthetic refrigerants which are harmful to the environment. The systems have been installed in food, agriculture and tourism sectors and are now commissioned. All three projects are in their monitoring and optimisation phase.

This Lessons Learnt report provides insights on the development, installation, and commissioning of thermal energy storage (TES) and advanced control and forecasting algorithm (ACFA) integrated with solar PV, existing refrigeration infrastructure and the optimal control system.

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Key Lesson/s

Risk Management and Contingencies

- Ensure the original budget and project schedule contains contingency for a force majeure in this case, a global pandemic. Without this contingency, the risk of major changes to the initial budget, resources and the schedule can impact the terms contained in the funding agreement.

Project Planning

- Prior jumping into the design and execution phase, ask suppliers and project partners to explain their Project Management methodology and to submit a comprehensive project plan for designing and execution of their work. Without the project plan, they struggle to identify desired goals, reduce risks, avoid missed deadlines, and ultimately deliver the agreed product, service, or result.

Supply Disruption and Local Manufacturing

- To avoid the COVID-19 pandemic impact on the duration and cost of the procurement and shipping, Glaciem shifted to build the Thermal Energy Storage (TES) system in South Australia. By local manufacturing not only we have reduced the impact of procurement risks, but also, we have cut down on shipping costs.

Sub-Contractor Management

- Although Glaciem designs the TES Tanks, some of the smaller parts such as lifting logs for the TES frames was left for the manufacturer to design. Glaciem must check and approve the manufacturer's designs to reduce the risk of any rebuilding or alterations at the time of installation.
- The Installation work that has been performed by the subcontractors must be checked prior to commissioning. Although suppliers check their work, we have experienced some undetected issues that caused excessive delay in the commissioning process.

Design Review

- Rainwater seeps through the roof panels into the TES tank and caused the Phase Change Material (PCM) level to rise and deteriorate the charge level reading. This shows that the insulation panels are not completely weatherproof and need additional measures such as suitable flashing on the joints for weather proofing when TES units are installed outside of plantrooms.

- Air or water vapor accumulate at the sensing end of the level sensor on TES tanks. The pressure sensors on the TES tanks must be mounted such that the sensing diaphragm is pointing upward. This way air cannot be trapped and will be purged automatically.

Advanced Control Forecasting Algorithm (ACFA) Control Strategies

- Electricity charges based on annual peak demand are difficult to handle, because we cannot predict which half-hour period during the year will determine the demand charge. If we are running a strategy designed to minimise the contribution to a possible peak demand charge, then we may not store as much thermal energy as we would if we were just minimising energy costs. A practical way to overcome this dilemma is to minimise energy costs as the default strategy, and switch to a demand management strategy only during periods when there is a high risk of setting the annual demand peak.

ACFA Optimisation

- The optimisation considers solar generation and unrelated electricity use at a site so that it can predict whether the site will be importing energy from the grid or exporting energy to the grid, since this determines the value of electricity—if the site is importing energy from the grid, electrical energy is generally more valuable than if the site is exporting. However, it may not be feasible to predict the other electrical loads with sufficient accuracy to determine whether the site will be importing or exporting at any instant. If the other loads are large enough that the site rarely exports, then just the import price can be used. If the difference between the import price and the export price is small, then incorrectly estimating the other site loads should not have a significant impact on cost savings.
- In situations where the thermal load sometimes exceeds the cooling capacity of the compressors, it is possible that ACFA will use the store to achieve better cooling but not achieve any cost savings.
- Underestimating the load can result in the system melting all the ice while electricity prices are still high. It may be better to overestimate the load so that the system will not run out of ice—the disadvantage is that the system will not take advantage of the entire store capacity.

System Controls Integration

- When the Glaciem chiller is in parallel with the site's current chiller circulating chilled water to and from the same points that the existing secondary loop pump is circulating water, the operation of the existing pump impacts the pressure at the suction of Glaciem pump. As a result, the discharge pressure can vary and following a setpoint ends in a variable chilled water flow. Best is to read the flow from the recently installed

chilled water flow meter and use it as the input. Alternatively, a differential pressure sensor instead of a pressure transducer can solve this issue.

Implications to Future Projects

- Glaciem will continue manufacturing the Thermal Storage in South Australia using the lesson learns on design and planning. We believe by manufacturing in South Australia we have more control on the quality of the finished product. Also, local manufacturing means supporting other small businesses as well as having the ability of performing routine quality inspections.