DeCalon Trial

Lakes District Health Board

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SAVING CALCULATION SHEET

DCI DATA SHEETS

1. Executive Summary

1.1 Introduction

The DeCalon (DCI) is a new approach to eliminating scale in condenser water systems. It uses electro-chemistry to remove the hardness salts from the water eliminating the need to add anti-scalant chemical treatment. By reducing and eliminating scale within the condenser water system and particularly chiller condenser water tubes, savings are made in electricity, water and chemical treatment.

1.2 The Trial

A trial was initiated at Lakes District Health Board Rotorua Hospital to test the DCI in the field. Power Solutions Ltd were engaged to carry out the independent monitoring of all system parameters to demonstrate the results of the trial. This report outlines the details of the trial and the analysis of the results.

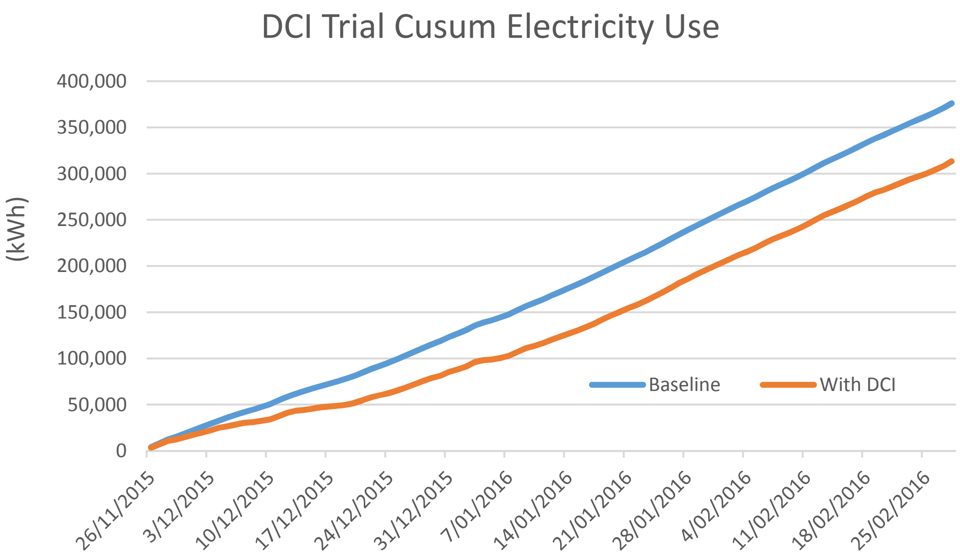
The system parameters to be logged and recorded were determined. The boundary of the monitoring was deemed to be the electrical load of the chillers and cooling tower loads. To achieve this data loggers were installed on the chillers, cooling tower fans, and the DCI units along with obtaining regular data from the Building Management System and logs for chilled water and condenser water temperatures, pump status, water meters etc.

Pre-trial monitoring began on 26 November 2015 and ran for 12 days to set a baseline energy consumption. The DCI unit was installed and operational from 17 December 2015 and the trial ran from then through until 4 March 2016 with continuous monitoring of the key parameters. A second DCI unit was installed in parallel on 7 January 2016.

1.3 What are the Benefits

The trial showed that savings were achieved in electricity use, water and chemical treatment. A reduction in electricity consumption of ≈15% for the chillers, condenser water pumps and cooling towers has been achieved. The projected reduction in electrical load equates to approximately 197,000 kWh/year providing an annual saving of $15.5k/year including network demand savings.

Figure 1 below shows the accumulated electricity use using the evaluations of the baseline energy and the projection of energy use based on the end of trial energy use calculations.



Water consumption from the system was reduced due to reducing the blowdown from the cooling towers. A small amount of blowdown occurs from the DCI units. The total makeup water consumption was recorded throughout the baseline and trial periods and demonstrated a reduction in water consumption of approximately 4.5 m^3/day providing an annual saving of $3,900/year.

During the trial the current chemical dosing system was isolated as the antiscalant chemical is not required with the DCI removing the hardness salts. Biocide dosing was replaced with testing and shock dosing of hydrogen peroxide at 30ppm. The net result is a significant reduction in annual chemical and treatment cost that is projected to be approximately $7,300/year.

The following table presents the total annual savings projected for Lakes DHB for electricity, water and chemical treatment.

Utility	Projected Annual Reduction (Unit/year)	Projected Annual Cost Saving ($/year)
Electricity - energy	196,830 kWh	$12,400
Electricity - demand	Variable	$3,120
Chemical		$7,310
Water	1643 m^3	$3,900
Carbon emissions	27 Tonnes CO_2-e	
	Total Projected Annual Saving	**$26,730**

There is an annual cost required to maintain the DCI units that equates to approximately $3,000/year therefore the net savings are projected to be $23,732/year.

1.4 Investment required and Funding opportunity

The full investment required to install two DCI units for Lakes DHB is approximately $95,000. Therefore the Simple Pay Back equates to 4.00 years.

The Energy Efficiency and Conservation Authority has a Technology grant that may be applied for that could provide up to 40% of the funding potentially reducing the actual investment to $57,000 and also reducing the Simple Pay Back to 2.4 years.

2. Project Summary

2.1 The Chilled water and Condenser water system

Rotorua Hospital has four water cooled chillers located in the basement of the Clinical Services Block supplying chilled water at 6°C that is distributed throughout the hospital for cooling and dehumidification purposes. Chillers No 1 and 2 were largely ineffective and in the process of being replaced therefore have been excluded from this evaluation.

Chiller Nos 3 and 4 are both Carrier Model 30XW0552P water cooled with screw compressors that use R134a refrigerant and have a cooling capacity of 571kW each.

The condenser water pumps positioned adjacent to the chillers and circulate the condenser water through to four cooling towers located on the roof of the CSB Mechanical Services plant room.

2.2 Condenser Water system maintenance

Condenser water systems require constant management to ensure that the system is maintained biologically safe and also to minimise scaling so that the heat transfer surfaces are kept clean and clear of obstructions to ensure optimising chiller energy performance.

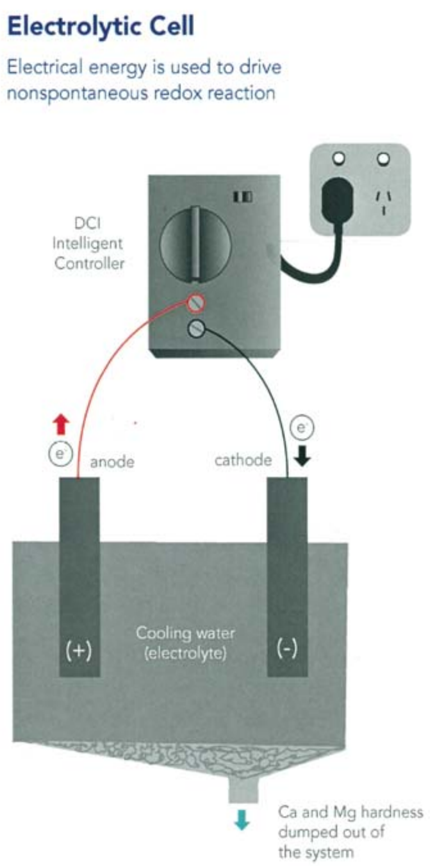
The management regime entails constant blowdown of water from the cooling towers to manage the concentration of hardness salts that build up as water is evaporated out of the towers. The salts precipitate out of the water and typically get deposited on cooling tower media, pipework and in particular chiller condenser tubes that can significantly reduce heat transfer and increasing energy consumption. In conjunction with blowdown the water is chemically treated with anti-scalant chemical and biocide.

The water treatment management is typically contracted to a specialist building services or chemical company which is an on-going maintenance cost. This process can be reduced through the use of the DCI units therefore contributing to the return on investment.

The DCI units replace the requirement to add anti-scaling chemical treatment however the biological treatment is still necessary particularly to manage the risk of legionella.

2.3 The DCI Unit and how it works

The DCI process uses an electrolytic cell to alter the chemical balance of the condenser water and removes the hardness salts by controlled blowdown. Condenser water is constantly passed through the DCI cell where the chemical balance is altered to be below equilibrium. The hardness salts are removed from the makeup water and once circulated, the water endeavours to return to the equilibrium state by dissolving existing scale within the condenser water system. This means that the DCI units will progressively clean up a fouled system.



The DCI units are sized according to the system refrigeration load. One unit has the capacity to process the condenser water for a cooling load of 350 tonnes of refrigeration. The units are installed at the cooling towers with water drawn from and treated water returned to the cooling tower basins.

2.4 DCI Unit Maintenance and operating cost

The DCI units have two electrodes that degrade over time and do need to be regenerated. This is an annual maintenance requirement estimated to cost $1,500/DCI unit.

There is also another very small operating cost associated with the electrical load of the DCI units that has been recorded to be 13kWh/day/DCI unit.

2.5 The Trial process

The evaluation methods for the trial were predetermined along with processes for data capture. As soon as agreement was given for the trial, logging was initiated for the baseline period. The actual trial period was finite as the hospital were replacing the two old and ineffective chillers Nos 1 and 2 in early February 2016. For this reason these two chillers have been excluded from the evaluation.

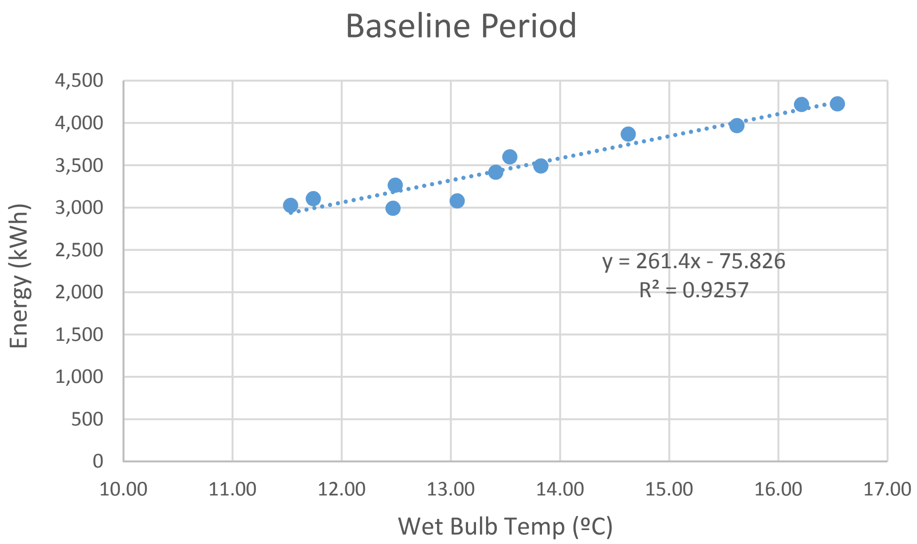
The baseline period commenced on 26 November 2015 and extended for a 12 day period.

The DCI unit was installed and operational from 17 December 2015. A second unit was installed on 7 January 2016 and the two continued in operation until the trial ended on 4 March 2016.

The load on the system was been evaluated against the outside air wet bulb temperature using regression analysis.

Electrical load was monitored on each chiller, cooling tower fans and the DCI units. Data was downloaded from the Building Management System (BMS) regarding condenser water flow and return and chilled water flow and return temperatures. Manual logging of numerous other parameters was also initiated such as cooling tower makeup water, and simultaneous liquid refrigerant temperature and leaving condenser water temperature that provides a condenser approach temperature (CAT). The CAT measurement is an indicator of condenser tube cleanliness. A high CAT can indicate dirty or blocked condenser tubes impacting on the ability to reject refrigerant heat into the condenser water.

The baseline energy data was evaluated against the outside air wet bulb temperature data to derive a baseline formula. The results are shown below.

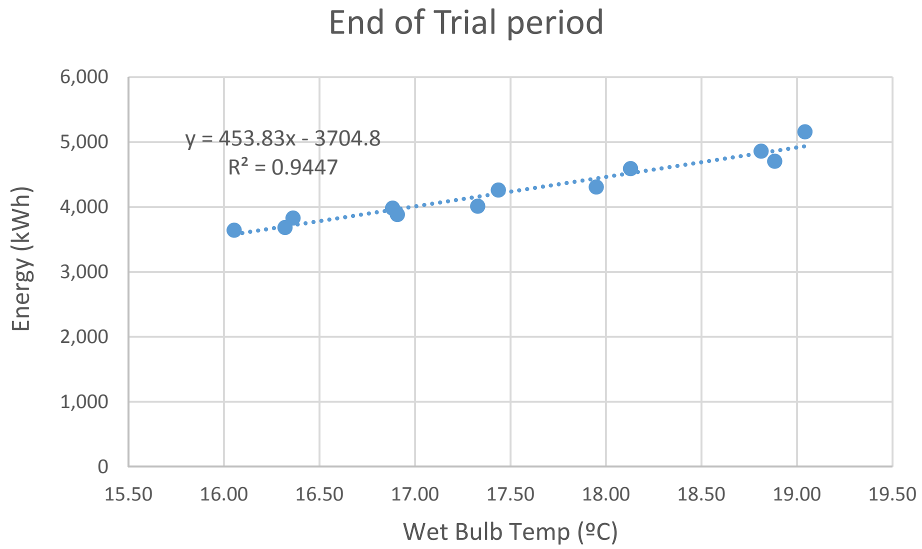


Throughout the trial the existing chemical treatment system of the cooling towers was isolated as the descaling process was taken over by the DCI units. The biological treatment was performed manually by shock dosing 3 times per week using hydrogen peroxide.

During the trial the condenser water was regularly tested to ensure strict chemical management of the entire process. In particular the pH is maintained to be between 8.5 and 8.8 along with the total dissolved solids. Another factor that was closely maintained was the Oxidation Reduction Potential which is an indicator of corrosion. This was kept under 150 mV being below the previous chemical treatment system level.

The trial period was continued for as long as possible so that as much data could be gathered.

Intermediate data downloads were analysed to determine when the system might be deemed clean and a plateauing of improvement experienced. The trial was continued as long as possible and the last 12 days of energy data was again analysed against the outside air wet bulb temperature to derive a new energy use formula using a regression analysis. The results are as fiollows.



By using the baseline and end of trial regression analysis formula the differences in energy consumption can be evaluated. The formulae were used to calculate the baseline and end of trial energy consumption.

3. Trial Findings

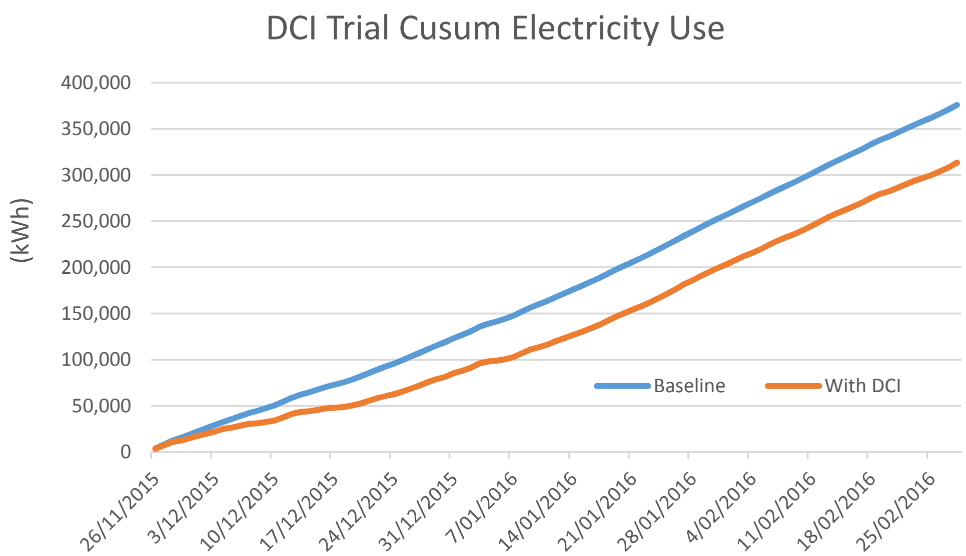
3.1 System cleanliness

It was noted as the trial progressed that scale was being loosened and falling off into the condenser water. It is thought to have largely come from the cooling tower media. The loose scale was passed through the system and settling in the sump of the cooling towers and being caught in the strainers prior to the condenser water pumps. At one time the strainer became blocked to the point of impeding condenser water flow causing the chiller to trip on high head pressure. The strainers were then regularly checked and cleaned throughout the course of the trial.

The loosening and removal of this scale is seen as a positive step in the overall system cleaning and it is predicted that this may continue for some time but should progressively reduce to eventually have a clean system. As the DCI process reduces the condenser water chemical equilibrium, this loose scale along with any scale evident on the condenser tubes will be dissolved. It would be preferred however to have the loose scale removed from the system as regularly as possible as this will also be dissolved by the DCI treated water. Removing the loose scale will expedite the removal of the scale in the condenser tubes which is where the greatest energy saving will be achieved. The loose scale will still continue to be removed as the trial period was brought to a close.

3.2 Energy

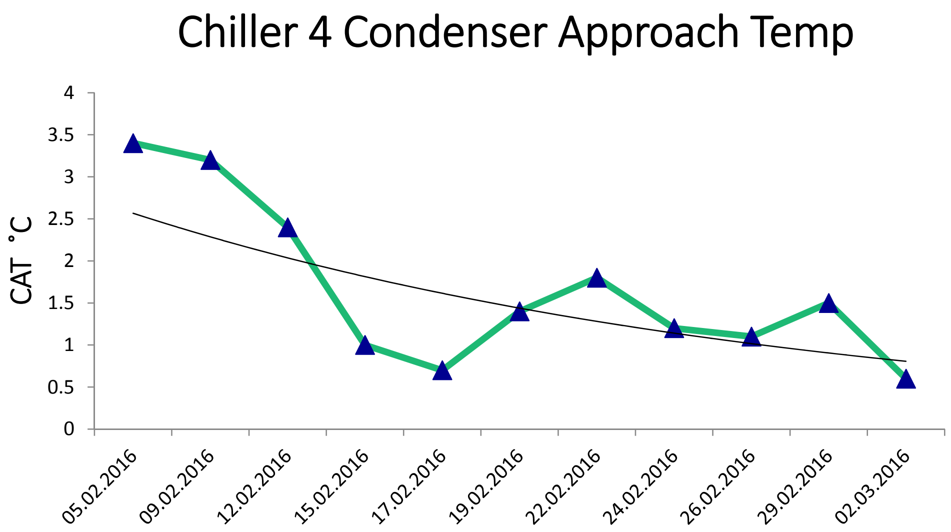
Using the baseline and end of trial regression analysis formula the energy consumption was evaluated. The cumulative sum of the baseline energy calculations has been projected against the end of trial calculation. The results are shown below.



This evaluation has shown that the accumulated electrical load of the overall system reduced throughout the trial period by 17%.

This result is in line with performance evaluations for the DCI units installed in Singapore.

The main electricity savings will be achieved at the chillers through cleaning of the condenser tubes that improves the heat rejection from the liquid refrigerant into the condenser water. A measure of this improvement is given by monitoring of the condenser approach temperature (CAT) that is the difference in temperature of the liquid refrigerant and the leaving condenser water temperature. The CAT was not being recorded from the very beginning of the trial however there is a marked reduction from early February 2016 when readings were initiated.



The variations in the CAT readings are expected to result from a combination of load fluctuations along with times when the condenser water strainer was becoming partially blocked. Accurate CAT results are taken when chillers are fully loaded. The Chiller 4 results provide the best indication of improvement.

A "rule of thumb" for chiller compressor load reduction based on CAT is a saving of 3% for each 1°C reduction in condenser approach temperature.

The CAT has clearly reduced since February by ≈3°C equating to approximately 9% reduction in compressor load. This has occurred in the last month of the trial. It is reasonably assumed that the reduction in CAT could have been 4-5°C based on the DCI's having been installed over a month prior and also the rate of reduction in CAT at the beginning of the logged period. This being the case the gain in compressor efficiency would have been approximately 12-15%.

To determine the actual cost saving associated with the system energy reduction the overall energy saving has been taken conservatively as 15%. The annual system load has been estimated by taking a peak summer daily load projected throughout a typical year with a load reduction factor applied through the seasons. The actual electricity rates for Lakes DHB have then been applied. This has resulted in an estimated reduction in annual electricity consumption of 197,000kWh/year that will provide a saving of $12,400/year.

In addition to reducing the electricity costs, there will also be an associated reduction in the demand component of the network charges. This has been calculated to be $3,100/year.

The total electricity related savings are therefore estimated to be $15,500/year.

3.3 Water

A reduction in water consumption is immediate. The DCI units eliminate the need to constantly bleed water to manage the hardness salts concentration in the condenser water. The DCI units have a much smaller and controlled blowdown so water loss from the system is greatly reduced.

During the pre-trial baseline monitoring, the water consumption from the cooling towers was recorded at 8.5m^3/day and this reduced immediately to 4m^3/day. Annually this projects to a reduction in water use of 1,642m^3. The Lakes DHB are charged for both water use and trade waste therefore the total savings that the reduction in water will provide is $3,900/year.

3.4 Chemicals

The use of chemical treatment in the condenser water system can be significantly reduced as the DCI units replace the requirement to add antiscalant chemical. There is an on-going need to maintain a biological treatment and a new requirement to manage ph.

The existing chemical treatment process can be ended and replaced with a simple shock dosing system along with the regular water analysis testing. The cost to provide this service has been estimated to be $1,946/year.

The annual saving in the condenser water chemical and treatment regime is approximately $7,300/year

3.5 Carbon Emissions

Carbon emissions are reduced commensurate with the reduction in electricity consumption. The annual electricity consumption will be by an estimated 197,000kWh/year and using an emissions factor of 0.137kg CO_2-e this equates to a reduction in carbon emissions of 27,000kg CO_2-e.

4. Financial Results

This following financial analysis has been carried out based on the evaluation methods and findings from the DCI trial at Lakes DHB and are specific to this site.

Electricity - The estimated reduction in system load of 15% will result in a reduction in annual electricity consumption of 197,000kWh/year that will provide a saving of $12,400/year. In addition there will also be an associated reduction in the demand charge component of the network charges. This has been calculated to total $3,100/year. The total electricity related savings are therefore estimated to be $15,500/year.

Water - Water consumption will reduce by 4.5m^3/day equating to 1,642m^3/year. Based on the Lakes DHB water and trade waste charges, the total savings will be approximately $3,900/year.

Chemicals - The existing chemical treatment process can cease and be replaced with a simple shock dosing system along with the regular water analysis testing. The cost to provide this service has been estimated to be $1,946/year.

The annual saving in the condenser water chemical and treatment regime is approximately $7,300/year.

Utility	Projected Annual Reduction (Unit/year)	Projected Annual Cost Saving ($/year)
Electricity - energy	196,830 kWh	$12,400
Electricity - demand	Variable	$3,100
Chemical		$7,300
Water	1643 m^3	$3,900
Carbon emissions	27 Tonnes CO_2-e	
	Total	$26,700
	Annual Cost to maintain DCI Units	$3,000
	Total Projected Annual Saving	$23,700

5. Investment

The full investment required to install two DCI units for Lakes DHB is approximately $95,000 therefore the Simple Pay Back equates to 4.0 years.

6. Potential Funding

The Energy Efficiency and Conservation Authority have a Technology grant that could be applied for that could provide up to 40% of the funding therefore potentially reducing the actual investment to $57,000 and also reducing the Simple Pay Back to 2.4 years.

7. Acknowledgement and thanks

Power Solutions Ltd wishes to acknowledge the valuable assistance and cooperation provided by the Facilities staff and management at the Rotorua Hospital especially:

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