CHILLED WATER PRIMARY – SECONDARY
&
THERMAL ENERGY STORAGE DIGITAL CONTROL SYSTEM FUNDAMENTALS

Presented by : Ben Macdonald – QLD Sales Manager
Innotech Control Systems Australia

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Northern Beaches State High School Case Study – (NBSHS)

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Agenda:

- HVAC Terminology
- NBSHS Chilled Water Plant overview
- NBSHS Control System Overview
- Chilled Water Plant Control System Methodology
- Field Equipment Selections
- What made the project successful
- Things to be considered

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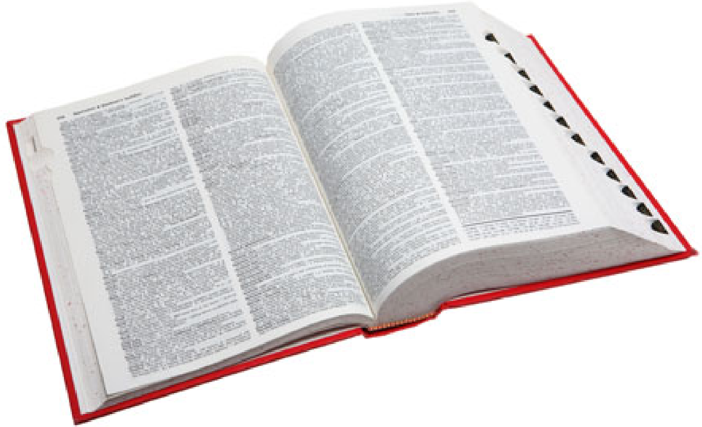
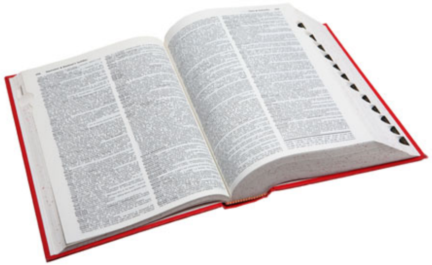
HVAC & Control System Terminology:

- **VSD –** Variable Speed Drive. (Electric motor speed controller)
- **CH -** Chiller
- **MV –** Motorised Valve
- **PICCV –** Pressure Independent Characterized Control Valves
- **D.P –** Differential Pressure
- **C.S –** Control Strategy
- **PCHWP –** Primary Chilled Water Pump.
- **SCHWP –** Secondary Chilled Water Pump.



HVAC & Control System Terminology:

- **DDC -** Direct Digital Controller. Programmable Controller with it's own Central Processor Unit (CPU)
- **BMS** – Building Management System. A network of DDC's and Building Services Software
- **HMI** – Human Machine Interface (Controller or Network Display)
- **Web-Server** – A network device that provides local or remote monitoring of a DDC / BMS via a Web Browser
- **HLI** – High Level Interface. The ability to send and receive large amounts of data over a single communications BUS
- **Integration** – The process of translating from one protocol to another



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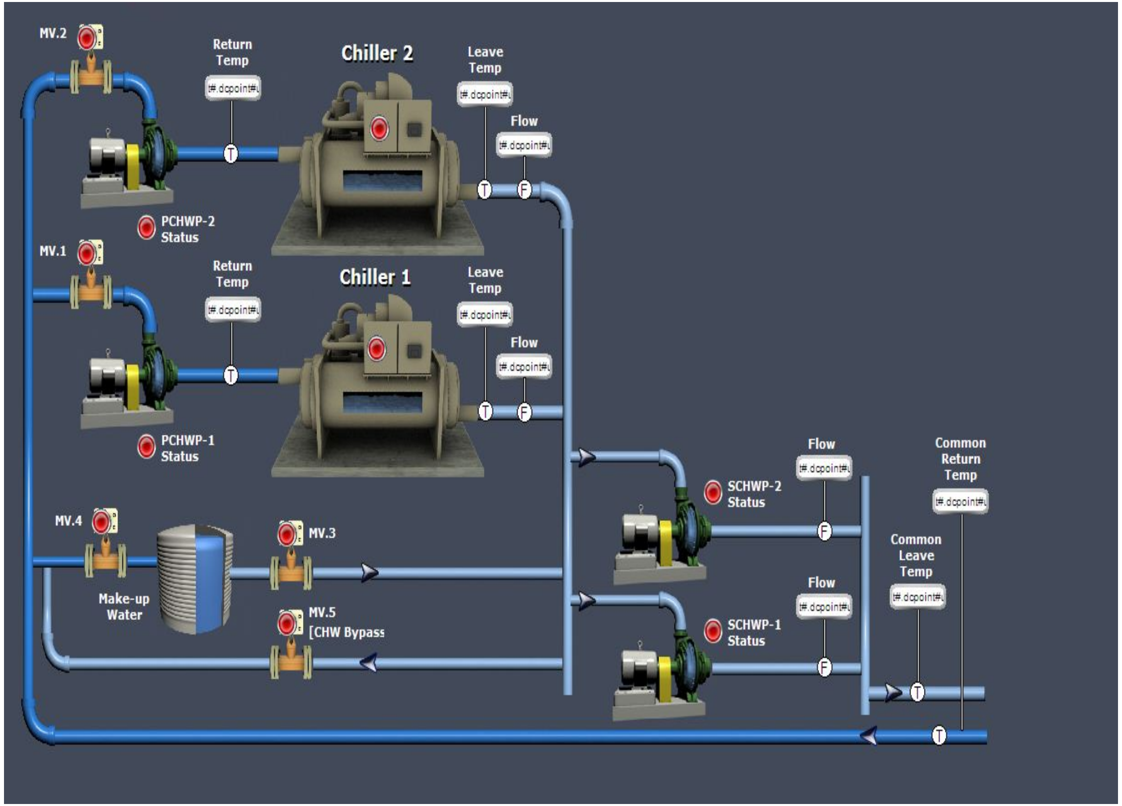
CHW Plant Overview:

- 2 x 270 kW Air Cooled Chillers
- 2 x Primary Chilled Water Pumps
- 2 x Secondary Chilled Water Pumps plus 1 Standby Pump
- 1 x 440,000 Litre Thermal Energy Storage Tank
- 46 x Chilled water Fan Coil Unit's
- 5 x MAGflow meters
- Pressure Independent Characterised Control Valves



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Building Management System Overview:

- 25 Direct Digital Controllers installed in 12 Separate Building
- 750 Hardwired Points & 20,000 BMS Software Points
- 500 High Level BACnet points from other vendors equipment
- 4.5Km of RS485 Network Cabling
- BACnet High Level Interface to Chillers, VSD's & Energy Meters.
- Webserver for Remote Access and monitoring.
- BMS Computer with Dynamic Graphics, Energy & Alarm Management Software.

Plant Control System Strategies:

The goal for the project was to provide chilled water cooling for the school to maintain conditions, but also to ensure this was achieved using the most economical measures. Due to the physical size of the school, and the climatic conditions experienced in this area during summer, the system has been designed using a large chilled water thermal energy storage tank. The tank is charged with cold water during off-peak electrical times to minimise the time that the chillers run during peak electrical tariff periods.

A variety of strategies were implemented to achieve the clients outcome. A couple of these strategies will be further explained in the following slides:

- Standard Cooling Mode
- Recharge Cooling Mode

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The chilled water plant has 6 control system strategies that are automatically selected in relation to:

- The time of Day
- The time of Year
- Off Peak electrical tariff availability
- A Fault in an item of equipment

Control Strategy	Description	Period (adjustable)
CS1	All Central Plant is Off	Terms 2,3 (Winter)
CS2	Standard Cooling mode	Terms 1,4 (Summer) Operating Hours
CS3	Recharging mode	Terms 1,4 (Summer) Overnight
CS4	After Hours Demand	Terms 1,4 (Summer) Weekends & Holidays
CS5	Safety recharging mode	Any night
CS6	Tank Offline	Anytime
System Flush	All Valves Open	Anytime

Control Strategy - Standard Cooling Overview

Stored chilled water produced from the previous evening is used to provide air conditioning to the buildings.

Secondary Pump Control:

- The Secondary Chilled Water pump VSD is controlled by the Differential Pressure from eight (8) field mounted Differential Pressure sensors to maintain the required flow setpoint
- Proportional and Integral Control is used for close control of the chilled water pumps
- Lead / Lag Control of these pumps is utilised to cater for varying loads
- The pump control logic incorporates a pressure reset loop that also uses valve position calculations
- BACnet Integration to Variable Speed Drives is used for monitoring, whilst hard-wired points are used for fail-safe control
- Chilled water pumps are not initiated until any FCU's chilled water valve is opened to a pre-set setpoint. This ensures that there is sensible load before starting pumps. This reduces pump starts and reduces energy waste.

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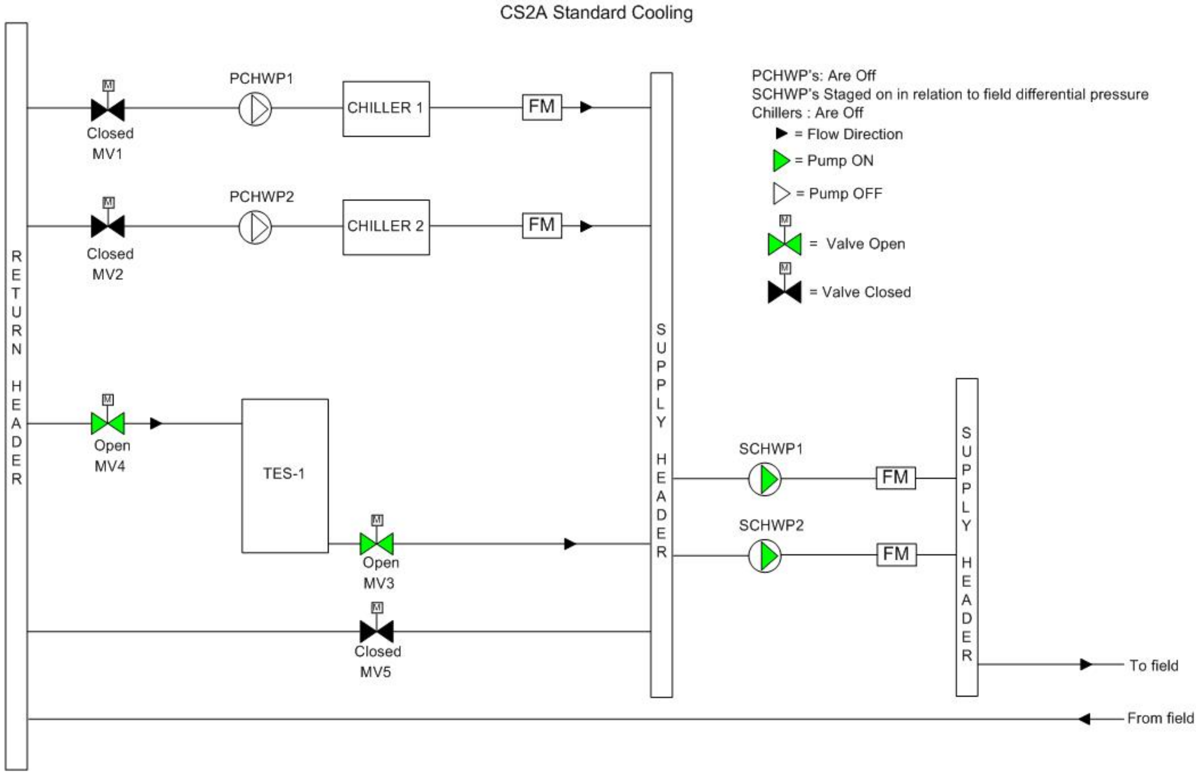

Control Strategy – Re-charge Mode Overview

The chillers run to charge the thermal energy storage tank based on the following parameters:

- The times for the off-peak energy tariff (between 11pm and 7am)
- Lowest overnight ambient temperature
- The highest energy-efficient operating point of each chiller

As the lowset overnight ambient temperature generally occurs in the early morning, this is the best time to start the re-charge mode as it will give the best efficiency from the chiller. Historic information for the time taken to recharge the system is used to reset the re-charge timer, the chiller start time is adjusted to finish as close to 6:30am as possible.

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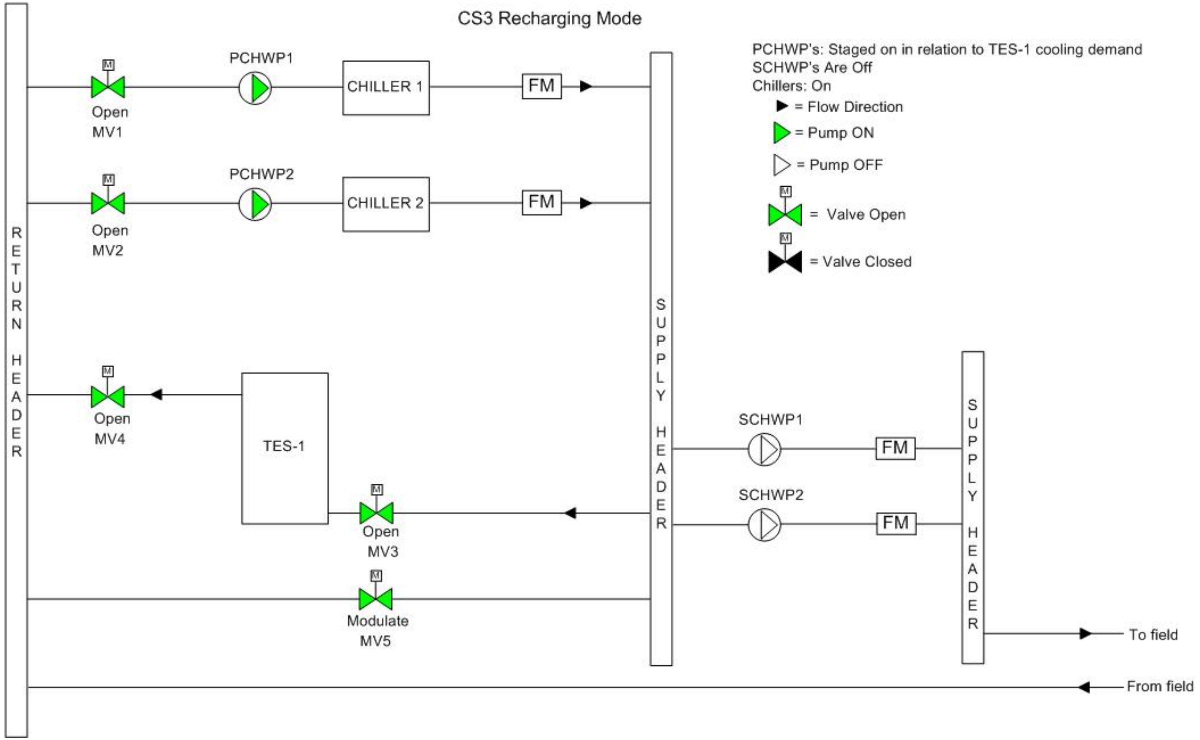

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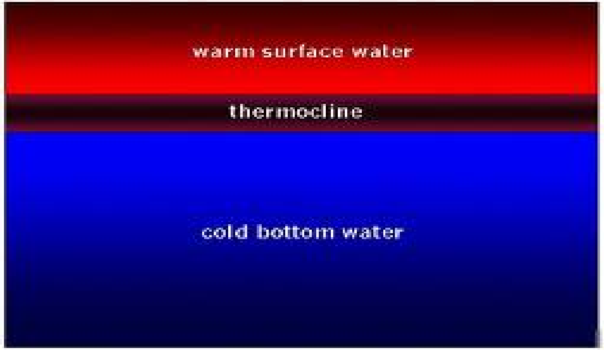
Tank Re-Charge Setpoint

The flow of the secondary chilled water pumps are measured, accumulated and totalised each day. This figure is then used in the calculation to determine the actual re-charge setpoint.

Thermocline

The chilled water storage tank is fitted with twenty-two (22) equally spaced temperature sensors mounted vertically in the tank. These are used to determine the location of the thermocline. The volume of cold water below the thermocline is used to calculate the percentage of stored charge (kWhR) available.



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Chiller Temperature Control:

- The chillers operate on a variable primary flow principle.

- The intent of this is to maintain a wide temperature difference between the chiller entering and leaving water, thereby maintaining a higher efficiency within the chiller. (Design entering and leaving chilled water temperatures are 15.0°C and 6.0°C respectively)

- To minimise the inherent losses associated with two chillers operating in a low-load condition, the HLI percentage load output from the chillers are used to determine when one chiller can shut-down.

- The BMS initiates each chiller and the chiller function under their on-board controls.

- BACnet Integration to the Variable Speed Drives is used for monitoring only.

- If the total chiller demand is less than the 70% of one chiller for a pre-defined period, one chiller will be disabled.

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Chilled Water Plant Intelligent Energy Meters

Intelligent Energy Meters monitor various items of the plant components:

- The instantaneous live data, including Power, Current, Voltage, Power Factor and Frequency is viewed through the Innotech BMS.

- The live data is stored in the Innotech Energy SQL database for historic analysis, review and reporting.

- The metering information is also used in the control of the chilled water plant, as well as load shed control for situations where the chillers are required to run during daylight hours. (To reduce peak demand charges)

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What made the project a "Success:

Using quality equipment that is fit-for-purpose (not just standard HVAC sensors) ensured that the outcomes were achieved. Standard HVAC sensing elements may have worked, but would likely not last on a project of this nature. Sometimes these items may cost more initially, however there were savings in setup and commissioning that offset some of these costs. The client also has the benefit of guaranteed ongoing savings due to limited/no failures.

Using a combined BMS and Energy package (BEMS) allowed real-time data analysis, historic data analysis, and a combination of both. As changes were made, the reaction to the changes could be determined immediately and altered if necessary.

Working with companies and individuals with a common goal to succeed for the client. The expertise of each company ensured the best outcomes were achieved, and if there were issues, the resolution of these things were done as a team.