Podium

Barangaroo South

District Cooling Plant

lendlease

Project Overview

Barangaroo is Sydney's largest urban regeneration project since the 2000 Olympics and can be considered one of the most significant waterfront CBD transformations being undertaken anywhere in the world.

Lendlease is developing the southern third of the 22 hectare former container port, known as Barangaroo South. The Barangaroo South precinct will have a mix of uses including three commercial towers, 1,000 apartments (including high-rise), the Crown Integrated Hotel Resort, shopping, dining and public places.

The environmental targets set for the precinct challenged the team to design a world's best practice District Cooling Plant (DCP), incorporating a harbour water heat rejection system (HHR). This key piece of infrastructure forms one of the cornerstone elements in achieving carbon neutral and water positive outcomes in operation for Barangaroo South.

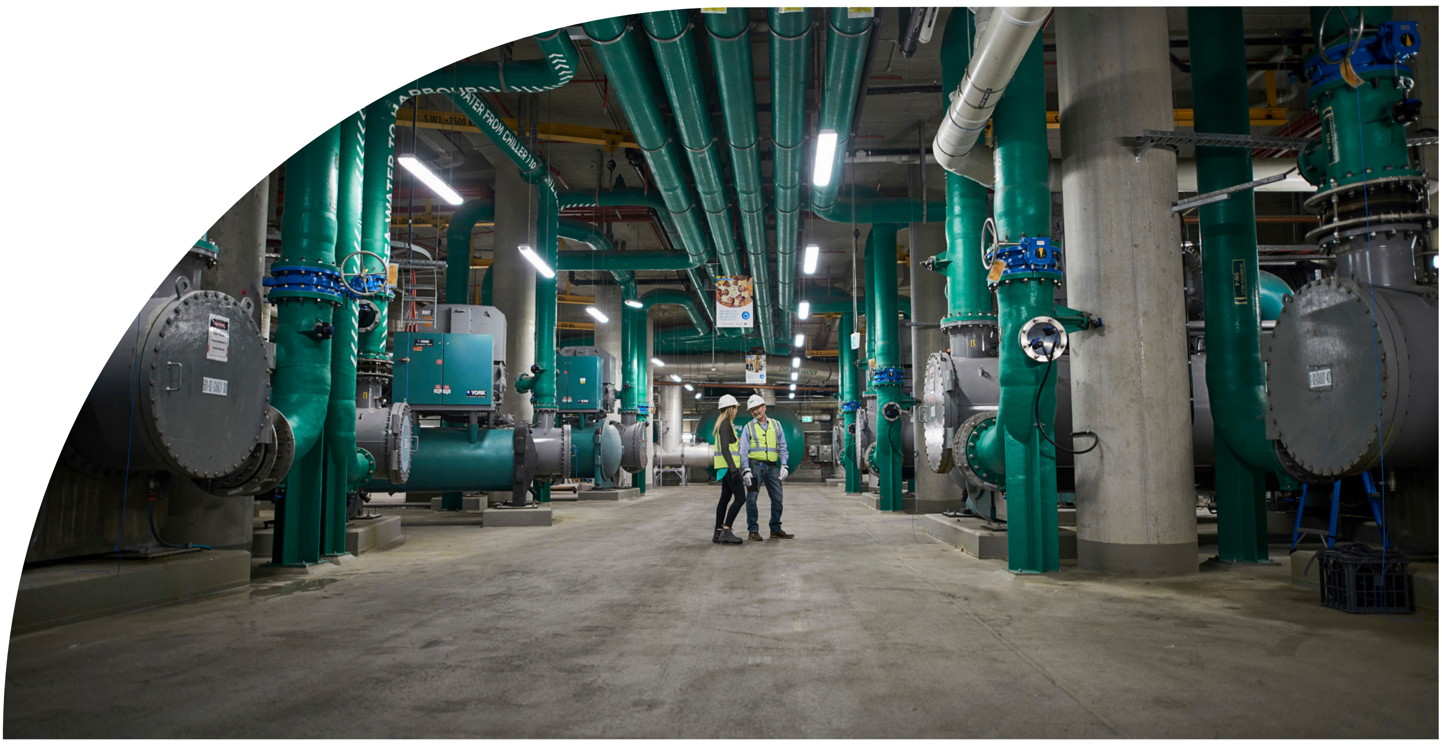
The Opportunity

The scale of the Barangaroo South project provided an opportunity to replace numerous, standalone, building cooling systems with a single centralised system, providing significant water saving, spatial and efficiency benefits.

The new DCP located in the Barangaroo Basement, will provide chilled water for cooling of the buildings in Barangaroo South and consists of the following three main elements:

- Central District-Wide Chilled Water Plant (DCP)
- Harbour Water Heat Rejection System (HHR)
- Building Specific Energy Transfer Stations (ETS)

District Cooling as a utility service is not commonly used within Australia and DCP's utilising harbour heat rejection are not common globally. The use of harbour heat rejection means Barangaroo's buildings have no cooling towers, improving the amenity of the development while also significantly reducing the water usage across the precinct – a key element in achieving the development's water positive commitment.



Key Challenges

Barangaroo South is a mixed use precinct consisting of multiple buildings with differing tenancy usage and cooling requirements.

Some of the key challenges included:

- Co-ordination between the DCP project team and each individual building design and delivery team, to ensure an integrated solution against differing building project requirements and timeframes.
- Innovation in the design of the plant, systems and controls to achieve the highest coefficient of performance possible based on variable flow condenser and chilled water circuits.
- To provide a level of service that exceeds that typically provided by a conventional single building solution.
- Extensive time phased thermal modelling of the heated water rejected to Sydney Harbour by the HHR, ensuring compliance with Australian and international environmental protection policies and guidelines.
- Develop filtering and anti-fouling approach to minimise maintenance, maximise plant life and system reliability.
- Managing multiple project and government stakeholders including the Barangaroo Delivery Authority (BDA - the state government entity responsible for the delivery of the Barangaroo development), Department of Planning and Environment (DoPE), Environmental Planning Authority (EPA), Sydney Harbour Foreshore Authority (SHFA), Roads and Maritime Services (RMS) and other state and local authorities.

Approach

Lendlease Millers Point (LLMP) Infrastructure Team took the lead role in the project, with Lendlease Design in the principle role for the design and development of the plant utilising in house capabilities.

Lendlease Design for Mechanical Services (Plant Design Lead), Sustainable Design and energy modelling, Architects, Structural, Electrical, Hydraulic, Fire, Environmental and ArchEng design services.

Lendlease Building's Project Management Team.

Lendlease Building's Project Delivery and Construction team.

Whilst the plant was being procured and built, Lendlease created a new business, Podium Asset Services (formerly Living Utilities), to own and operate the plant. This included setting up supply agreements with each building owner and billing for the cooling energy provided.

In addition to Lendlease Design designing the plant and Lendlease Building managing the design and construction of the plant the following was carried out to verify the DCP was designed to world's best practice:

- Extensive benchmarking and due diligence studies by Lendlease completed in Australia and internationally.
- Extensive thermal load modelling of the development taking into consideration the varying ambient conditions and dynamic variable cooling loads.
- Peer Review of DCP design by an internationally recognised Consulting Engineering organisation, with extensive large scale DCP experience in both the Middle East and North America.
- International Study Tour(s), including inspection of DCPs in Europe, Middle East and Asia.
- Design review by Australian and internationally based Operating and Maintenance companies.
- Design input and reviews from local and internationally based suppliers on key equipment items utilised in the plant.
- Separate Peer Review of DCP controls system design by an internationally recognised Consulting Engineering organisation and Australian based expert.
- Internal design review completed by Lendlease Design and Podium Asset Services (formerly Living Utilities).
- Completion of Lendlease DCP ROAD (Risk, Opportunity at Design) review process.
- A rigorous pre-qualification process for chiller suppliers followed by close engagement with shortlisted chiller suppliers. This resulted in a 5-10% lift in normal chiller performance.
- Testing of the chillers setup on a specially designed test rig so as they could be tested in series counter flow arrangement. This was the first time this had been done in the world.

During the delivery of the project the DCP plant has had the following undertaken:

- On site review of the DCP plant's construction and quality by external consultants independently appointed by LLMP.
- On site commissioning witness testing of the plant by an independently appointed (by LLMP) commissioning agent.

The new DCP plant will undergo a 24 month verification period that will involve Lendlease Design's engineers and Sustainable Design team in conjunction with Podium Asset Services (formerly Living Utilities) and its appointed operator to monitor and tune the plant.

Features

The final completed DCP will have the following features:

- Cooling provided via 14 high efficiency electric chillers (6 duty sets and 1 low load set) in a paired series counter flow arrangement.
- Space in the DCP plantroom for the future addition of 2 chillers (1 additional duty set).
- The use of non ozone depleting refrigerants, variable speed chillers, pumps and an insulated chilled water piping system.
- On completion, the DCP chillers and chilled water pipework will be capable of providing 72MWr of cooling to the precinct's buildings. To meet project staged opening requirements the plant currently has the capability to provide between 20kWr to 52,000kWr
- Chilled water is distributed to energy transfer stations located in the basement of the connected buildings to transfer cooling from the DCP to the buildings via heat exchangers.
- Dual 70% capacity chilled water reticulation pipework.
- A single stage of cooling transfer to minimise pumping energy and system losses.
- The DCP chillers will reject heat using a Harbour water heat rejection system (HHR). The chillers use sea water directly drawn from and returned to Sydney harbour without interposing heat exchangers.
- An industrial grade PLC based control and monitoring system with Lendlease Design developed control strategies to optimise plant operation. The plant is designed for automated unmanned operation.
- An extensive thermal and energy metering system to monitor the production and distribution of chilled water to each building.
- The exchange information between the Buildings and DCP control systems for both control and optimisation of plant efficiency.
- All connected customers (including residential) are billed for chilled water cooling based on their thermal energy (kWh) usage, not volume (kL) of water provided.

The HHR System has the following features:

- The use of a harbour heat rejection system enabled zero consumption of potable water for heat rejection purposes typically required for cooling towers, saving around 100 million litres of water per year.
- The HHR's seawater intake is drawn from the harbour through a concrete intake structure made up of 3 intake chambers. These are separated from the discharge pipe by a distance of approximately 100m to reduce the risk of recirculation.
- The seawater intake is a positive suction system. It is positioned at a depth of -5m. This depth was determined by the Lendlease team using more than two years of harbour temperature monitoring to identify the optimal level for consistently cooler water temperatures.
- A primary screen (100mm spaced vertical bars typical) and a secondary screen (mesh with approximately 30mm square opening) is installed at each intake chamber connection to the harbour as the initial filter system to prevent large object fouling.
- The primary screen is positioned outside maximum velocity streams above 0.15m/s to prevent impingement as per USEPA requirements.
- The intake structure includes the installation of three penstock valves that provide isolation from the harbour and manually installed drop boards when required for double isolation during maintenance.
- A macerating sea water strainer is provided before each pump to filter out any debris larger than 800 microns before it enters the pump.
- A sea water jet filter is provided on the discharge of each pump to further filter the sea water to less than 200 microns.
- Glass reinforced piping (GRP, approximately 500m per chiller set) in combination with HDPE piping, super duplex stainless steels, titanium and other specially selected materials and coatings are used to minimise maintenance, maximise plant life and system reliability.
- The use of individual chiller set piping systems to maintain pipe velocities that minimise fouling whilst minimising any energy penalty.
- The use of an authority approved surfactant as required in combination with the design features noted above to help minimise fouling of pipework and chiller condensers.
- Use of maintenance strategies to minimise the use of the surfactant.
- The seawater cooling water discharges into the harbour at a short distance below the low tide mark (RL 2.0m) and mixes with the harbour water.

Outcomes

The advantages of a district cooling system vs conventional individual building cooling plants are as follows:

- Economies of scale from optimisation of the plant's spatial requirements across the development.
- Capitalises on the building usage diversity across the precinct (residential vs commercial vs retail vs hotel) to optimise chiller plant capacity and efficiency.
- The use of multiple chiller sets improves plant redundancy and reliability and ability to deal with staged variable cooling demands.
- Offers tenants high grade chilled water for supplementary cooling.
- Removal of the need for cooling towers allows space at the tops of buildings for green roofs and/or renewable energy systems.

The DCP is estimated to consume 12% to 16% of the site wide electricity use, inclusive of tenants.

The energy efficiency of the plant has played a critical role in meeting the climate positive benchmarks for the precinct including:

- Carbon neutrality
- 6 Star Green Star Office Design for the commercial buildings.
- 5 Star Green Star Multi-Unit Residential for the residential buildings.
- Providing buildings with the potential to operate at better than 5.5 NABERs Energy rating

A traditional in-building cooling system would constitute 30-40% of the commercial office base building greenhouse gas emissions. The DCP design developed for Barangaroo South is targeting to reduce that to 25-30% of the commercial office base building greenhouse gas emissions, a substantial reduction from business as usual.

Lendlease created a new business, Podium Asset Services (formerly Living Utilities), to own, operate and manage this plant and other infrastructure at Barangaroo South (A Blackwater treatment plant and a 33kV triplex embedded electrical network).

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