Project Background

The CEEP1167: Trigeneration at The Concourse project was developed to design, install and commission a combined heat and power system (tri-generation), supplying electricity and hot and chilled water to Willoughby City Council's performing arts and civic centre, 'The Concourse'.

An initiative of Willoughby City Council, The Concourse is the cultural home of the North Shore. The Concourse is one of Sydney’s leading entertainment venues home to a dynamic range of live arts and entertainment. Council has created a landmark building which is a vibrant hub of culture, entertainment and information right in the heart of Chatswood’s CBD.

Innovative sustainable design has been integrated into The Concourse to reduce its impact on the environment and provide comfort for users of the building. The building has been designed to minimise water and energy consumption, incorporate the use of recycled products, reduce building emissions and improve air quality inside the building. The Concourse provides a central place for the Chatswood CBD and includes quality outdoor environment to meet, a theatre, concert hall, function rooms, library, art gallery and retail space.

The tri-generation system was proposed to provide low carbon energy for The Concourse. Preliminary studies showed the project may save an approximate 25% in energy costs and an immediate reduction in greenhouse gas emissions. Decreased reliance on the local power grid would be further benefit of the use of tri-generation at this site if properly designed and commissioned.

Project Timeline

An application for funding under the Community Energy Efficiency Program was submitted on March 23rd 2012 and the Funding Agreement was executed on June 12th 2013.

On June 24th 2013, SLR Consulting Australia Pty Ltd was engaged to undertake a full and detailed feasibility and design for the installation of a tri-generation system at The Concourse. SLR Consulting were provided with all historical building data relevant to energy usage, heating and cooling loads and gas consumption on which to base their assumptions and design. SLR Consulting was also given full access to The Concourse’s building management system, energy management system and plant room during the design and feasibility process and worked closely with The Concourse’s on-site staff to gain a thorough understanding of the building.

In late August 2013, SLR Consulting presented their feasibility report to Willoughby City Council, followed by a draft design in September. Both the design and feasibility report were reviewed by Council and relevant changes were made where applicable. Final tender issue design drawings were provided to Willoughby City Council in December 2013.

On receipt of the final detailed design, the decision was made by the WCC internal Project Control Group to commission a peer review of the design. Engineering consulting company ‘Cundall’ were selected to undertake the review and submitted their findings in February 2014.
After careful consideration by the Project Control Group, the decision was made by Willoughby City Council in April 2014 to not proceed with the project.

**Budget**

The below table outlines the approved budget, as per the executed Funding Agreement, for the project, split into the proportion of Department Funding versus the anticipated contribution by Willoughby City Council:

<table>
<thead>
<tr>
<th>Expenditure Item</th>
<th>Dept. Funding</th>
<th>Other Contributions (cash)</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cogeneration System</td>
<td>$274,601</td>
<td>$274,601</td>
<td>$549,202</td>
</tr>
<tr>
<td>Absorption Chiller</td>
<td>$104,640</td>
<td>$104,640</td>
<td>$209,280</td>
</tr>
<tr>
<td>Install and plant room costs (including thermal storage)</td>
<td>$187,842</td>
<td>$187,846</td>
<td>$375,688</td>
</tr>
<tr>
<td>Maintenance Contract</td>
<td>$11,387</td>
<td>$42,613</td>
<td>$54,000</td>
</tr>
<tr>
<td>Energy Monitoring</td>
<td>$36,615</td>
<td>$36,615</td>
<td>$73,230</td>
</tr>
<tr>
<td>Education &amp; Communication Program</td>
<td>$37,100</td>
<td>$37,100</td>
<td>$74,200</td>
</tr>
<tr>
<td>Energy Assessments</td>
<td>$1,500</td>
<td>$1,500</td>
<td>$3,000</td>
</tr>
<tr>
<td>Administration support</td>
<td>$46,200</td>
<td>$46,200</td>
<td>$92,400</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$699,885</strong></td>
<td><strong>$731,115</strong></td>
<td><strong>$1,431,000</strong></td>
</tr>
</tbody>
</table>

As the project did not proceed past the design and feasibility stage, the overall expenditure for this project was far less than outlined in the Funding Agreement. As a result, the below table outlines the actual expenditure for the project at the time of execution of the Deed of Termination as well as the contribution from the Department of Industry:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Project Expenditure</td>
<td>$157,127 (ex GST)</td>
</tr>
<tr>
<td>CEEP Contribution</td>
<td>$78,563 (ex GST)</td>
</tr>
</tbody>
</table>
Public Communication

During the early stages of the project, the project was promoted throughout the local community in order to promote awareness of tri-generation and the proposed installation at The Concourse.

WCC issued a press release, detailing some of the preliminary details of the project, including the commissioning of a feasibility study into the use of tri-generation at The Concourse, as well as notice of undertaking a detailed design. This story was picked up by the local print media and featured both in private newspapers and Willoughby City Council produced newsletters. Examples of these are shown below.

![The Concourse to produce its own Power](image)

In addition, WCC produced an informative video which explained both the concept of tri-generation and how it would be used in The Concourse. By using easy to understand infographics and facts, the video was posted to Willoughby City Council’s YouTube channel.

Finally, a fact sheet was produced which outlined the potential benefits of tri-generation to The Concourse, including anticipated financial and environmental savings. Copies of this fact sheet were placed in the Sustainable Living Section of the Willoughby City Council library, located in The Concourse. A digital copy of the fact sheet was also available for download from the Willoughby City Council website.
Feasibility & Design

It was crucial that the design of the tri-generation system allowed for total integration into The Concourse including the following elements:

Size

Sizing of the tri-generation system was a key element of the design process. SLR Consulting presented two options in their feasibility report; a 200kWe system and a 400kWe system (comprised of two 200kWe engines).

The first 200kWe option was sized on the base electricity load during peak and shoulder hours for The Concourse. As a tri-generation system is typically sized based on the ratio of heat to power required by a site, this option was recommended as the optimal size, based on the highest achievable efficiency allowing the system to be utilised at 100% load.

The proposed 200kWe system was designed to generate 750,000 kWh/year, assuming that the proposed tri-generation plant is operated on 100% electricity load for 50 weeks per year, 15 hours per day, 5 days per week. This may have been slightly ambitious given the nature of the building’s operation, but it is likely these hours would be balanced out given the afterhours and weekend usage of The Concourse.

The above sizing would cater for approximately 28% of the total energy consumption for The Concourse. Based on this design, SLR Consulting projected that the building could produce 200 kW cooling and 291 kW heating from tri-generation heat that was previously going unused.

Location

The Concourse comprises of one central plant room, located on the top floor of the main building, directly above the concert hall. The plant room was efficiently designed, with each mechanical element having adequate room for access and maintenance. However, the plant room was designed to minimise wasted space, therefore the installation of additional large plant and equipment proved to be problematic.

As a result, SLR Consulting designed the tri-generation system to sit on top of a steel platform, to be constructed above the two existing chillers. An obvious concern with this design feature was the additional structural load to the plant room floor. Taylor Thompson Whitting, the original structural engineers engaged during construction of The Concourse, were engaged to analyse the design of the platform and the additional load required in this part of the building.

After a few minor design changes, Taylor Thompson Whitting approved the proposed structural load for the plant room, however, identified the weight of the hot water storage tanks to be problematic. The solution in this case was to install two smaller tanks, located in different areas of the plant room, spreading the weight across two structural columns.
Project Risks/Challenges

The unviability of proceeding with the installation of the tri-generation system extends to all key areas of this project. These risks have been highlighted and discussed throughout the feasibility and design process and it has become apparent that the mitigating measures discussed by the Project Control Group will not satisfy full confidence in investing in this system.

Design Risks

- There were clear conflicting views between the two engaged consultants as to the suitability of the design of the tri-generation system. As Council intended to retrofit this system into an existing plant room, it was essential that the design does not adversely impact any of the building’s existing plant and machinery. Whilst both consultants agree that the sizing of the system is correct, the connections, positioning and pipework are all disputed. Both consultants have sound reasoning for their approach to the design of the system, however, the uncertainty of correctness for Council was far too great to accept the position of either firm.

- A major design issue from the outset of this project was the lack of use for the excess waste heat. The nature of The Concourse’s day-to-day operations does not fulfil the need for distributed hot water, closed loop or otherwise. The lack of a use for this element of the tri-generation system required the need for Council to find a way to distribute the waste heat offsite. After an exploration of all options, Council has concluded that the surrounding buildings do not require any additional heated water and the cost of distributing the water via insulated underground trenching to a building further than the immediate neighbouring properties would far outweigh any benefit of doing so. As one of the key elements of the system cannot be utilised effectively, the efficiency of installing such a system is strongly compromised.

- The initial projections for greenhouse gas savings by SLR were based on unachievable engine efficiency. Cundall’s report indicates that various factors, including lessened efficiency, no allowance for parasitic loads and the assumption of outlet for the utilisation of waste heat skews the overall projections for carbon savings for this system.

Financial Risks

- The cost of running and maintaining the system is far higher than the potential financial savings. As the value of the system decreases steadily over time and the ongoing maintenance cost increases, it is projected that the system will cost Council approximately $1.9 Million over the life of the machinery.

- The price of natural gas over the life of this system is unpredictable and could compromise the effectiveness of running the system. Any dramatic increase in the price of natural gas would leave the system, coupled with high maintenance costs, as a more expensive way to generate electricity. This was an unacceptable variable to Council.
Operational Risks

- As more information came to hand about the daily operation of the tri-generation system, it has become clear that many of the resources do not exist within Council to ensure the tri-generation plant operated correctly. The Concourse lacks onsite staff with experience in this type of technology. As this system will require a great deal of fine tuning over the first few years of operation, it is essential that a staff member with a mechanical engineering background oversees this process. The increased cost of employing an engineer simply to oversee this piece of machinery further diminishes the potential financial savings of the system. For example: even at the best predicted savings of $100,000 per annum, a mechanical engineer on staff would cost in the order of $100,000, removing all financial benefit from the system’s operation.

- It is unclear how effectively the tri-generation system will interact with the existing plant, machinery and building services. The system is designed with the intent of integration; however, given the current process for day-to-day operation of our asset, the tri-generation system would likely be run manually until it can be optimised to run in sync with the new building management system. It is clear, based on past experiences within the building, that there may be many teething problems with such a migration, leaving the operation of the plant and machinery in an uncertain condition.

Building Risks

- The lack of historical load data for electricity, heating and cooling within The Concourse makes it difficult to accurately predict peak loads and building requirements. This project allowed Council to install the appropriate metering equipment at The Concourse, however, to fully understand this new and complex building, additional years of monitoring (especially over hot summer periods) must be carried out in order to have a detailed and accurate spread of data as the building becomes better optimised.

- Vibration and noise emitted from the system continued to present an unacceptable risk to Council. Although the system was designed to absorb the majority of vibration and noise as best as possible, the nature of the building operations (theatre, concert hall etc.) dictate that any uncertainty with this risk is unacceptable. The delicate nature of the equipment within the building must have the assurance that any vibration from this large, volatile engine must be contained with 100% certainty, an assurance that the design cannot provide.
Project Successes

Knowledge of The Concourse

As Council’s flagship building, The Concourse was designed to incorporate numerous passive and active energy saving measures to not only achieve environmental and financial savings, but to act as an example for the Willoughby community.

As The Concourse is a mixed use facility, the building must cater for an ever changing schedule and varying building load and occupancy rates. As a result, Council is still learning how the building can be best optimised through both summer and winter, taking into account the various events held at The Concourse.

A significant obstacle to the design and feasibility stages of this project was the lack of historical energy consumption data for the building. The project allowed Council to install the appropriate metering on the relevant plant and equipment to understand exactly how the building operates and allow WCC to capture data into the future. From the data already obtained from the metering, as well as the installation of a new and more detailed energy management system, our on-site facilities team was able to fine tune our automated plant and equipment, realising instant efficiencies in mechanical operations.

Understanding of Tri-Generation

The feasibility and design process of the proposed tri-generation installation at The Concourse has allowed significant research to be undertaken by Council, exploring and analysing this technology in depth.

It has become apparent that huge efficiencies can be gained if a building is designed with tri-generation as a core element of on-site power generation, rather than retrofitting this technology into an existing building. Willoughby City Council is in the fortunate position of currently planning the development additional sustainable property landmarks within the local government area, covering a variety of uses and sizes. The knowledge gained regarding both the advantages and risks of designing a tri-generation system into some of these future developments will lead to informed and experienced analysis integrating tri-generation into a new building – a discussion that may have been unlikely if this project was not undertaken.

Conclusion

CEEP1167: Tri-generation at The Concourse was an ambitious project that aimed to enhance and already efficiently designed property asset and sought to position Willoughby City Council as a leader in this emerging technology.

After detailed analysis of the risks and challenges associated with progressing with this project, the decision was made by Council to discontinue the project. As discussed in this report, it was determined that the design, operational, installation and financial risks of the project present an unacceptable level of uncertainty to Council.

Despite not continuing with this project, the grant from CEEP has allowed Willoughby City Council to better understand our flagship building and has given Council a base on which to possibly incorporate this technology into future Council property developments.