The University of the Sunshine Coast in Queensland, Australia, has a Carbon Management Plan with a target to achieve carbon neutrality by 2025. Committing to such a target requires major capital investment. Due to current tertiary sector budget constraints the University looked for a strategic alliance to deliver innovative solutions to meet CO2 Zero targets.

Veolia presented a concept solution via a *Market Led Proposal* to partner with USC to achieve their goals. It offered the customer the following elements of the partnership:

- Highly innovative concept.
- Zero client capital outlay.
- Avoiding the simple practice of purchasing carbon credits as a way to reach carbon neutrality.
- Transparent, open book, partnership model, providing guaranteed value for money.
- Teaching, learning and research integration.

This project delivers large-scale renewable energy and maximises energy efficiency, reducing carbon emissions on the University's main campus by 42%. It was implemented as a collaborative partnership between the University and Veolia. The outcome is a sophisticated and innovative system which integrates the existing cooling network, solar PV with thermal energy storage. To tackle the engineering design, financial and legal complexity of the project, the University and Veolia agreed on a transparent, open book arrangement whereby they would share all relevant information. This arrangement was based on trust – but it also contributed to even more solid understanding – and was an essential ingredient enabling the project to succeed.

The project was developed as a DBOOT contract (Design, Build, Operate, Own, Transfer), whereby:

- Veolia, already operating the University energy facilities, including the cooling network, designed and built the infrastructure, in close collaboration with USC.
- Veolia owns, operates and maintains the infrastructure for a period of ten years, after which ownership will transfer to USC.
- USC purchases electricity and chilled water from Veolia at an agreed price for 10 years.

Key engineering highlights of the project are summarised as follows:

- 8.2 MW cooling network peak flow rate of 140L/s in summer
- 1.6km of piping serving 15 buildings
- 2.1MW solar PV across rooftop and car-park structures
- the installation of two highly efficient and environmentally-friendly HFO chillers
- the construction of a 4.5ML chilled water tank (which effectively acts as a thermal battery)
- the development of a high-end plant room, which not only incorporates innovative engineering solutions but is also designed to function as a teaching and learning space for current and future students.
- the implementation of an advanced Building Management Control System (BMS), allowing sophisticated and real-time management of the PV solar output to create chilled water (for air-conditioning purposes), to use in building energy consumption or to export to the electricity grid.

The key technical synergy is ensured by the integrated approach to monitoring and control of energy to determine, in real time, which is the best use for green electricity coming from the solar installation. In this way, the system seamlessly reacts to the changing load and weather conditions on campus and selects the best use of the renewable energy generated.

In order to utilise the Thermal Energy Storage System, new Heat Transfer Plant was required. This new plant uses Plate Heat Exchangers and circulating pumps to allow the chilled water production (Chillers), Chilled Water Storage (Tank), and chilled water usage (Field Loop) systems to be hydraulically decoupled.

The New Heat Exchanger Plantroom consists of six Parallel Plate Heat Exchangers, each with associated characterised control valves, in order to precisely control the desired temperature and flow of chilled water being supplied to the Field. These Heat Exchangers are hydraulically configured in parallel on both the Field (consumption) side, and the Tank (storage) side. The closed loop consumption circuit and open loop storage circuit each have four circulating pumps, hydraulically connected in parallel, each with an associated Variable Speed Drive (VSD), allowing precise control of the required Heat Exchanger Flows. The parallel arrangement of pumps and Heat Exchangers provide redundancy of components, allowing any pump or heat exchanger to be taken out of service, without limiting system performance.

A new mechanical services switchboard (MSSB) was installed to serve Chiller 3 and its associated chilled water pump, condenser water pump and cooling tower. The new MSSB also serves the primary plate heat exchanger pumps, secondary plate heat exchanger pumps and lake water treatment plant.

Veolia constructed a new lake water treatment plant in order to utilise the lake water as cooling tower makeup. The plant draws water from the lake via a low velocity screened intake arrangement, ensuring no flora or fauna are detrimentally affected by the water extraction process.

The water treatment plant consists of feed water pumps, holding tanks and various filtration components – complete with a filter backwash cycle.

The capacity of the water treatment plant is sized for a peak flow of 15 kL per hour to the cooling towers, and an overall processing capacity of 10 kL per hour. These values have been selected so as to deliver the full amount of cooling tower makeup water during high cooling requirements likely to be experienced.

It is the combination of the sophisticated engineering design, the close partnership, and the innovative financial and legal agreement that have delivered an ‘out-of-the-box’ industry-leading solution to reduce the University’s carbon footprint and provide renewable cooling to students and University staff.

Why the programme was implemented

Keeping average global temperatures within 2°C of pre-industrial levels, as articulated in the Paris climate agreement, will require a reduction in carbon emissions of 40-70% from 2010 levels by 2050, and near-zero emissions by 2100. At the same time, by 2050, energy use for

cooling is projected to triple and global energy demand for cooling will be more than it is for heating. This rising energy demand will generate even more CO2 emissions.

The motivation to implement the programme is related to this reality and stems from both Veolia and its customers environmental ambitions to help achieve Paris agreement goals as set out in Veolia's sustainable goals as well as both in the University's Strategic Plan and Carbon Management Plan.

The project carries significant emissions reductions potential, and directly contributes to the achievement of those objectives.
Veolia has committed to combat climate change with 2020 objectives of:

- 100 million CO2 equivalent tons of emissions reduced over the period 2015- 2020;
- 50 million CO2 equivalent tons of emissions avoided over the period 2015- 2020;
- Capturing more than 60% of methane in the waste disposal facilities the group manages.

As for the University, it is worth mentioning that the energy and carbon footprint of large organisations, who manage and maintain numerous buildings, is considerable. Because of local climate in Australia, air conditioning and ventilation are one of the most significant contributors to that footprint. Universities fall into this category and are increasingly finding innovative ways to improve processes, reduce energy usage, and develop renewable energy sources. The University of the Sunshine Coast's Carbon Management Plan has set the benchmark to achieve carbon neutrality by 2025.

As part of the Carbon Management Plan, the University aimed to achieve maximum in house energy abatement on campus (rather than purchasing carbon off-sets). This meant focusing on both energy efficiency measures and the implementation of renewable energy-based solutions. Given the University's location in southern Queensland, Australia, where the climate is hot and sun exposure abundant, the most appropriate source of renewable energy has been solar energy. Thus the programme implementation involved the installation of a 2.1MW PV solar array (over 6500 panels), spread across multiple rooftops and some car park structures of the University's main campus (having a gross floor area of 73,854m2 and a usable floor area of 45,738m2).

Energy efficiency was also important and was achieved through a multiplicity of different factors. The University uses chilled water in the air-conditioning process. Given that air-conditioning uses up to 55% of the University's electricity use, the focus was also on increasing efficiency of the air-conditioning process itself.

Prior to upgrading the cooling network, the system was over 37% less efficient and emitted in excess of 2000 tonnes of CO2 emissions per annum.

The implemented technology controls load shifting the cooling production to the best energy source and time of day available. One unique aspect of this project has been the flexibility gained by combining thermal storage with PV production. It has enabled the use of the PV when it sun energy is available; and when it is unavailable, the thermal storage tank can be used to supply the site and the cooling demand. Subsequently, the thermal battery is charged

in off peak times and during the cooler night time to gain operating efficiencies. This innovation reduces electrical consumption and carbon impact.

The coefficient of performance (COP) of the cooling system has improved from 4 to 5.5. 2609 MWh of primary energy annually has been saved from grid electricity through the implementation of renewable source of cooling compared to use in 2018.

Moreover, Veolia and the University have been keen to demonstrate leadership in sustainability throughout the region and beyond. Indeed the University's Strategic Plan 2019 – 2022 includes the following priorities:

- Implement strong USC environmental sustainability deliverables.
- Partner with industry and government to contribute to the development and sustainability of the region.

In keeping with these priorities, the project was developed in partnership with Veolia, an international company specializing in the management of energy, water and waste.

Finally, the Veolia and the University are committed to contribute to knowledge and skills development and exchange, in particular demonstrating feasibility of renewable district cooling, through the development of a living laboratory on-campus. Thus, it was important not only that the University saves emissions, but also that its students learn about sustainability, innovation and energy efficiency as part of their degrees, so that they in turn are able to demonstrate leadership in sustainability when they graduate.

Professor Greg Hill, USC's Vice-Chancellor and President:

"USC recognises that our sustainability legacy will be realised primarily through the impact of our teaching and research, including the contribution of graduates as active, informed citizens and leaders who are knowledgeable about sustainability and its practices. USC will raise public awareness through stewardship of the environment and proactively engage through collaborative approaches with staff, students and partners in the broader community to promote sustainability in the local region and beyond."

Additional Information - How the program was implemented

The program was implemented as a collaborative partnership between the University (USC) and Veolia. Veolia and USC had a long-standing relationship which started approximately 20 years ago when Trane equipment was installed as part of the first district cooling system on the campus. Veolia, then Trane, were acting initially as contractor to the University for chiller maintenance services. Over time, as USC and Veolia worked closely together to implement energy efficiency measures, the relationship deepened and a mutual trust and respect developed between the partners, to enable further projects and endeavours.

In 2016 the University and Veolia were in discussions to develop an idea to build an innovative system which would integrate large-scale solar PV with the storage of chilled water, which would be distributed to final customers through an upgraded version of the existing cooling network, for air-conditioning purposes. This would allow the University to chill the water

using electricity from the solar PV (instead of electricity from the grid), and thus reduce considerably its carbon footprint. The construction of a large chilled water tank would also allow the University to decouple the production of chilled water from the demand for air-conditioning. This in turn would create many efficiencies, allowing the chillers to run at an optimal efficiency until the tank was chilled, instead of ramping up and down to match site demand.

Initially it was intended that Veolia would work with the University to design and implement the project. However, once the feasibility study began, and the scale of the project became apparent, it became clear that the University was not in a position to fund the project.

Veolia and the University then worked together to develop a business arrangement under which the project could continue. Using a Queensland government procurement guideline (the Market Led Proposal), the University granted Veolia a six-month exclusivity period to design the system and develop the economic modelling.

Veolia's proposal was based on a shared vision for the continual sustainable development of the Sippy Downs Campus by providing a technical and value for money energy solution. Innovation is embedded into the cultures of both USC and Veolia. The two associates' values aligned and the partnership progressed through an open and trusted relationship. As part of this process, the parties agreed on a transparent, open book arrangement whereby Veolia and USC would share all information relevant to the project. This arrangement was based on trust – but it also deepened mutual understanding – and this was an essential ingredient enabling the project to succeed.

As for all projects of this scale, the engineering design, financial and legal aspects were quite complex. Both parties were keen to work on a sophisticated and innovative system, resulting in maximum efficiencies and using existing infrastructure, including local cooling network. To this end, the system was designed to include:

- the installation of two highly efficient and environmentally-friendly HFO chillers
- the construction of a 4.5ML chilled water tank (which effectively acts as a thermal battery)
- the development of a high-end plant room which not only incorporates innovative engineering solutions but is also designed to function as a teaching and learning space
- a sophisticated building management system which operates in real-time to maximise efficiencies in the system
- New efficient chillers to service 15 buildings on campus, via existing cooling network, with the potential to expand
- And one water rerouting mentioned in the following section

In addition to designing the system itself, it was also necessary to develop a business model under which the project could effectively proceed. To this end, the partners agreed to develop the contract as a DBOOT model (Design, Build, Operate, Own, Transfer), under which:

- Veolia designed and built the infrastructure;
- Veolia owns, operates and maintains the infrastructure for a period of ten years, after which ownership will transfer to USC;
- USC purchases electricity and chilled water from Veolia at an agreed price for 10 years.

Ultimately, it was the strength of the partnership between USC and Veolia that guaranteed the success of the project. It is the combination of the sophisticated engineering design, the close and solid partnership between parties involved, and the innovative financial and legal agreement that have delivered an 'out-of-the-box' industry-leading solution to reducing the University's carbon footprint and demonstrate the feasibility of distinct network based renewable cooling.

Additional Information - Achievements

The project has delivered world-class infrastructure, which:

- reduces emissions of the University's main campus by 37% or 0.41 tonnes CO2 per full-time student - from an original base of 1.1 tonnes;
- reduces consumption of electricity from the grid for the University's main campus by 42%;
- will decrease the University's CO2 emissions by 100,634 tonnes over the 25-year project life;
- will result in a reduction by 802,104 Kilo Litres of main water consumption over the 25-year project life; and
- will ensure provision for 40 electric-vehicle charging bays within the car-park infrastructure.

On the financial side, the University's second largest ongoing operational expense (after salaries) was the purchase of electricity required for its operations. As a result of the project the University will save:

- $7.3 M in energy consumption costs in the first 10 years (whilst the system is owned and operated by Veolia), and;
- a total of $111.4 M in savings of energy purchase costs over the 25-year design life of the project.

These figures are compared to the business-as-usual case.

The project goes beyond helping USC achieve its sustainability goals. It actively contributes to the University's primary purpose - that is of education through providing a living laboratory with hands-on practical application for USC's business and engineering students. As more than just the infrastructural innovation and savings, this initiative also forms the basis for teaching engineering, sustainability and business students. Indeed, Dr Graham Ashford, Deputy Head, School of Science and Engineering has said that:"*The University practices what it preaches. In making these changes that we've been advocating in the wider world, it is proof that we are leading the way in sustainability initiatives*".

Additionally, the project is in line with Veolia's strong commitment to the mission of strengthening the teaching, learning, research and development areas.

Last but not least, the project demonstrates the feasibility of using renewable intermittent energy to ensure sustainable cooling delivered through district network, on a University campus setting.

Additional Information - Innovation

This project is innovative in three main ways:

- it is based on the high-end engineering solutions
- it applies the innovative business model
- it entails academic and knowledge sharing dimensions

The engineering solution ensures maximum efficiencies:

- The key technical synergy throughout the design is the smart and seamless integration between all the individual elements of the system. A sophisticated Building Management System directs the electricity from the solar PV array to (i) the creation of chilled water, (ii) the use in building energy or (iii) for export to the external electricity network. In this way, the system seamlessly reacts to the changing load and weather conditions on campus and selects the most efficient and cost-effective way to use the renewable energy generated.
- The first environmentally-friendly HFO Refrigerant chillers in Australia.
- The use of comprehensive system monitoring, including irradiance sensors adjacent to the solar panels, sensors every ½ metre from top to bottom throughout the chilled water tank, sensors in the heat exchangers and in the flow and return water for the chillers. These combine to enable comprehensive understanding of system operation and fine-tuning for maximum efficiency.
- 8.2MW district cooling system servicing 15 buildings via 1.6km of piping.

The business model was innovative in that:

- Both parties agreed on an internal rate of return on the investment carried out by Veolia, which allowed them to agree on systemic and dynamic improvements during the build process rather than to be limited by a fixed contract arrangement.
- It embodied trust and transparency between the parties, allowing any difficulties to be openly discussed and eventually overcome.
- It incorporated the use of the DBOOT (Design, Build, Own, Operate, Transfer) contract between USC and Veolia

The academic focus of the project is innovative as it has also delivered a teaching and research vehicle for academics and students so that they could have exposure to an industry-leading engineering, business, innovation and sustainability solution:

- the plant room has been designed in a way that enables teaching and learning to take place in and around the equipment,
- the plant control room includes large-screen monitors and allows extensive view of the plant room for visiting groups and classes,
- the extensive data, collected as part of the monitoring system, is stored in data lakes for use by academic researchers, including for student projects and more in-depth research by staff, and
- Veolia offered to undertake guest lecturing and project work with students.

- Through the interactive character of the learning process, students can acquire knowledge regarding the development of renewable energy sources, storage of intermittent RES and their use in the framework of a local district cooling network.

Additional Information - Replicability

The project in its entirety, or aspects of it, can be replicated within another University, public institution or commercial environment.

For sites which already utilise centralised and distributed chilled water within the air-conditioning system, the learnings from this project could be used on a broader scale, both to help develop the business case for energy reduction projects, and in the optimization of the technical design of these projects.

Other sites could also implement the integrated, real-time monitoring and control of energy to determine, in real time, whether it is most economically beneficial to use the electricity from renewable sources for reduced building energy consumption or export to the grid.

The renewable-energy-fed thermal-energy-storage model, now proven, is transferable to other sites, locations, universities, technical and further education (TAFE) institutes and organisations, with good rooftop or ground-mounted solar resource, and high air-conditioning, heating (the tank could as easily store heated water) or even refrigeration needs. In addition, it demonstrates the efficient use of local, small scale cooling network (which could also be a heating network) for the purpose of local energy planning and management.

The other component that could be replicated would be the business framework for engagement of a private company for major infrastructure projects, including private funding, provision of elaborate expertise and guaranteed delivery.

Having a baseline, and using the responsiveness and data captured from the BMS during the operation will enable the results of this initiative to be measured in great detail, enabling accurate return of experience This will serve as an example for other organisations in terms of the cost and benefits associated with this approach.

Extensive data was gathered in the development of the business case such as electrical and cooling loads and weather variation. The data collection is continuing and is saved in a “data silo” for access in the teaching and research arena into the future.

Impact on employment and local jobs created:

The project created 56,800 man-hours in local employment, and resulted in significant upskilling of local industry. Over 30 contractors were involved in the project. 92% of the project’s costs have gone to local companies or branches and 74% of companies by number were local.

Additional Information - Impact on customers:

With the project, the USC will save: (i) AUD $7.3m in electricity costs in the first 10 years (whilst the system is owned and operated by Veolia), and (ii) AUD $111.4m in electricity costs in the entire 25-year project life. There was no upfront capital cost for the University. Veolia funded the project build and implementation costs.

So far, the customer, USC has demonstrated its satisfaction with both the concept of the project and its implementation, as it reduces the carbon footprint of USC's main campus by 42%, saves money, and provides a living laboratory on-campus, enabling students to gain first-hand knowledge of sustainability, innovation and energy efficiency applied to a concrete setting.

The transparent, open book arrangement for communication between USC and Veolia resulted in enhanced trust between the parties and underpinned the project's success.

Veolia and USC have shown leadership in sustainability and inspired other institutes and businesses to consider a similar concept.

Additional Information - Videos

News video announcing the project
https://cdn.intelligencebank.com/au/share/EXd9/WJz/RGB6r/mp4/Veolia-vid-1-FINAL
Video on the educational outcomes
https://cdn.intelligencebank.com/au/share/EXd9/WJz/09pG6/mp4/veolia-eng.

Inside the plant control room:

Views of the solar car park structure, plant room and chilled water tank:

Opening Ceremony: