Co-generation and tri-generation is in itself not a new technology, nor is it a newly adopted one. Rather, it has been employed successfully in many projects where the opportunity for waste heat recovery, particularly in industrial applications, has made it a very viable proposition.

But the concept of tri and co-generation in the commercial office building sector is one which, while perhaps considered, has rarely if ever been adopted. It’s often been considered financially untenable from a purely commercial perspective.

That was until now.

According to Glenn Ralph, M.AIRAH, managing partner and principal mechanical engineer with Floth Sustainable Building Consultants, the advent of climate change has thrown new light on a technology largely deemed unsuitable for commercial buildings.

“In commercial office buildings where the operating times are restricted and the load profiles significantly vary, tri or co-generation from a purely commercial perspective has generally not been viable,” Ralph explains.

“However, with the challenges now presented by climate change, and carbon dioxide being identified as a major contributor to the global warming component, tri or co-generation has in recent times presented itself from an emissions perspective to be a technology which inherently delivers significant reductions in CO₂ emissions.”

In typical commercial office building design, Ralph identifies that any reduction in CO₂ emissions is directly related to the primary energy source of the local electricity generator. In Queensland, that source is black coal.

With the burning of black coal responsible for a CO₂ emissions output five times greater than that of natural gas, the employment of natural gas as a primary energy source immediately reduces CO₂ emissions significantly, while offering the ability to recover waste heat from this process to power air conditioning systems and further reduce emissions.

Although sound in theory, the question was, could the designers of Brisbane’s Green Square North Tower make co-generation in a commercial office building viable?

The answer was a resounding yes.
**GREEN SQUARE**

Located in Brisbane’s Fortitude Valley, just 1km from the city’s centre, Leighton Properties’ $220 million Green Square commercial office development is the largest mixed-use corporate office park to be developed in Brisbane in the past 15 years.

Green Square, which is also a major component of Brisbane City Council’s ongoing Urban Renewal Plan, comprises two office towers – the six-storey South Tower and the larger North Tower – with the latter comprising 24,000 sq m of office space over 12 levels, as well as 600 sq m of retail space, an adjacent plaza area and two levels of basement car parking.

Having enjoyed a long-standing relationship with the developer, and closely following other successful projects such as the 5 Star Green Star 400 George Street Brisbane, Floth was appointed to the project as the ESD, mechanical and electrical consultants.

From the outset, Leighton Properties was determined to develop the North Tower as a market leader in environmentally sustainable development. It immediately set about achieving a 6 Star Green Star – Office Design (V2) rating, and a 5 Star NABERS rating, both the highest possible achievements in the respective rating tools.

It was the challenge of becoming Queensland’s first 6 Star Green Star commercial office building, and delivering these ratings in a commercially sustainable manner, that brought about the adoption and implementation of co-generation in the project.

“"If the fundamentals of the HVAC system design are correct then good sustainable outcomes can be achieved without the unnecessary expense of ESD bling””

The project team (which included the mechanical services contractor, Triple M and the electrical services contractor, Q Electrical) then set about developing the concept of co-generation into an operational reality.

**CO-GEN AND SCR**

Having set its sights on co-generation, the design team was quickly faced with the challenge of achieving approval from the Brisbane City Council, which had never received an application for a gas-fired co-generation plant, let alone had guidelines on which to base its approval.

It was both a challenge and an opportunity to break new ground in one of the country’s fastest growing cities.

According to Ralph, the team was able to refine the development application for co-generation by working together with the council and the local community.

“Under the leadership of Leighton Contractors and working with the air quality consultants MWA, we provided the necessary performance requirements for the proposed co-generation plant, enabling the Brisbane City Council to develop a Tri/Co-generation Emissions...
Standard,” he says, adding that this set the standard for future sustainable developments in the city.

To meet these new standards and further enhance the project’s environmentally sustainable credentials, selective catalytic reduction (SCR) generator exhaust emission technology was adopted, again a first of its kind to operate in an Australian commercial office building.

"Selective catalytic reduction technology involves the injection of an ammonia solution into the exhaust gas stream, where it reacts with a rare earth catalyst in an exothermic chemical reaction to reduce the percentage of nitrous oxide below the local authority emissions requirements," explains Ralph.

In simpler terms, the SCR is a form of post-combustion control that reduces nitrogen oxide (otherwise commonly referred to as smog) by 85 per cent while also reducing carbon monoxide emissions by 85 per cent. Independent NATA-certified laboratories have subsequently confirmed levels are below mandatory requirements.

“SCR technology was the optimal solution to meet the council’s emission standards, and as such will continue to be employed depending on specific requirements of the local authority,” Ralph says.

SUSTAINABLE HVAC

With the co-generation plant approved, Floth looked at a wide range of HVAC solutions before adopting a design with separate variable air volume (VAV) air-handling plant dedicated to each building façade and internal office zones, with all incorporating economy cycle operation.

The design supply air temperature delivered to the occupied zone is in the region of 8°C, and delivered through high-induction swirl diffusion grilles.

According to Ralph, this design offered a cost-effective method of delivering an HVAC system that met both inherent long-term ownership and sustainability objectives.

“Low-temperature VAV systems also provide a long-term sustainability benefit not often recognised, through the minimisation of material use and the associated embodied energy components, compared to more exotic alternatives that are available,” Ralph says.

He says low-temperature VAV is an evolution of traditional VAV systems designed to deliver energy efficiencies through a reduction in fan power and spatial efficiencies. It delivers excellent indoor air quality while providing a highly flexible system that can meet a wide range of office fit-out requirements.
Incredibly, Ralph says this system alone is so energy efficient, it is able to deliver a 5 Star NABERS Energy rating in its own right, without the benefit of the co-generation plant.

Notwithstanding that the co-generation plant employs a water-cooled absorption chiller, the low-temperature VAV system is supported by the use of water-cooled electric chillers, selected primarily for their energy-efficiency benefits and their long operational life. It’s also supported by a Floth-developed “modified variable flow” primary chilled water system, which operates in conjunction with auto adaptive condenser water optimisation control strategies.

Each air handling unit also features outside air volume control and CO₂ monitoring.

**MODELLING TO 6 STARS**

With Floth having undertaken all modelling associated with the project’s Green Star submission using the latest CFD, building energy simulation and lighting design software, the significance of this building becomes plainly obvious.

Computer-based numerical modelling revealed the building to use 53.3 per cent less energy (MJ) than an equivalent 4 Star NABERS Energy rated building. It will also deliver a significant reduction in CO₂ emissions — 73 per cent or 1,645,000kg when also compared to an equivalent all-electric grid 4 Star NABERS Energy rated building. According to Ralph, this is the equivalent of removing 721 Toyota Prius cars from the road (although Toyota has done a reasonable job of that itself).

Similarly, through the use of the SCR generator exhaust emission control technology, Green Square North Tower’s nitrous oxide emissions are just 1 per cent of the emissions of a typical natural-gas engine city bus.

Such is the achievement here that at the time of the GBCA Green Star Office Design submission, Green Square North Tower was the first project to achieve maximum points (15 out of 15) for the Ene-2 credit “Energy Improvement”.

**ECONOMICALLY SUSTAINABLE**

From the outside, Green Square North Tower, like many of its most recent peers, remains rather devoid of any overtly green characteristics you would come to expect from a building that has set such benchmarks. Rather, it appears its design has been built around maximising traditional technologies and achieving synchronicity to deliver outstanding performance.

“We believe that if the fundamentals of the HVAC system design are correct then good sustainable outcomes can be achieved without the unnecessary expense of ESD bling,” explains Ralph.

Rather, the building’s design is such that efficiency is achieved without fanfare.
Along with the co-generation, SCR and low-temperature VAV systems, the building’s incredible efficiency is also achieved through a reduction in heat load through the use of sun shading, a number of different roofs and glazing on 10.38mm glass.

“A holistic approach should be applied to sustainability in that the project needs to be economically sustainable as well as ecologically sustainable”

Daylighting and the use of high-frequency fluorescent ballasts also contribute to the building’s overall performance and indoor environment quality.
Water efficiency is treated no differently, with 1.4 megalitres of water saved annually through the use of AAAA-rated water fittings, a 90,000 litre rainwater storage tank, and the harvest and reuse of condensate from the air conditioning system.

Furthermore, throughout the building’s construction, a focus was placed on recycled materials, with 40 per cent recycled concrete, 90 per cent recycled steel and 100 per cent plantation or recycled timber in use. The development also committed to recycling all of its onsite construction waste.

Amenities for the tower’s occupants also encourage environmentally sustainable practices, with a dedicated recycling room, and more than 150 bike racks and change room facilities provided in an attempt to reduce car dependency. This is further enhanced by the building’s location, which is in close proximity to the city centre, and public transport.

Having been completed and operational for a little more than a year, Ralph says the building is now fully occupied and is exceeding its design intent, with energy consumption below the predicted energy simulations.

“Green Square North Tower provides an excellent example of an ecologically sustainable development that avoided the exotic and expensive solutions such as sewer mining, grey water treatment, large photovoltaic arrays and air to air heat exchangers to name but a few,” says Ralph.

“We believe that a holistic approach should be applied to sustainability in that the project needs to be economically sustainable as well as ecologically sustainable.”