

ESD REPORT

HURSTVILLE PRIVATE HOSPITAL



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1 Executive Summary

Investigations of various sustainable initiatives were conducted to identify opportunity to incorporate them into the Hurstville Private Hospital redevelopment.

A number of the initiatives provided define ongoing savings in term of utility cost, electricity, gas or water. The implementation would have impact on some spatial requirement on the roof and around the building, and also additional infrastructure to cater for the new initiatives.

Sustainable initiatives investigation included a feasibility study for a co-generation (tri-generation plant) to efficiently service the electrical, heating, and cooling requirements for the redevelopment of Hurstville Private Hospital.



The proposed configuration and optimal sizing of the tri-generation plant is based on estimates of the thermal and electrical loads for the development. An estimate of the electrical load profile for the building was developed in order to size the generation plant using equipment specifications developed as part of the building design process.

To maximise the financial return from the tri-generation system the plant size has been selected to maximise the operating hours for the generator set and absorption chiller. A preliminary life cycle cost assessment was undertaken to test the feasibility of the proposed system.

The life cycle cost assessment assumes a fixed electricity price of 0.06 \$/kWh (as per current HPH electricity bill) and natural gas of \$0.019/MJ, which is typical of a medium to large size commercial development.

For each of the system configurations, the capital and operating cost of each of the systems was estimated. In addition to the various technology options three possible outcomes for utility price escalation were also developed.

The proposed size of the tri-generation system and the most likely outcomes from operation of the system are detailed in the table below.

Item	Value
Generator Set Capacity	230 kW
Waste Heat Capture	360 kW
Absorption Chiller Capacity	125 kW
Capital Cost	\$920,000
Annual Savings	\$33,400
Estimated Payback Period	10.5 – 20.7 years

2 Introduction

Erbas Engineers has been engaged to assess the use of sustainable resource and technologies and to incorporate into the redevelopment of Hurstville Private Hospital (HPH).

A comprehensive study and assessment of various ideas, technologies and methodologies will be reviewed in this report.

Technologies such as:

- Solar power
- Solar hot water system
- Gas generator
- Water utilization
- Building Services equipment
- Benchmarking
- Co-generation & Tri-generation

The purpose of this report is to show the various sustainable initiatives that will be incorporated by the hospital to deliver a well thought through design to provide the world class medical services, while utilizing the technology of today and tomorrow to limit the impact of the development and its operation to the environment.



1.1 LIMITATIONS OF STUDY

This report presents the results of a study into the feasibility and cost analysis of various technologies to service the building. In order to arrive at the conclusions identified, it has been necessary to estimate various quantities, including:

- Thermal Loads and Profiles
- Electrical Loads and Profiles
- Water estimation
- Capital and Operating Costs and Future Cost Escalation etc.

At all times, these estimates have been produced for the purpose of comparison between options and as an indication of the order of magnitude of each of the relevant parameters. The final design and operation of the hospital may have results that are differing to the proposed modelling.

It should also be noted that at the time of this report, the project was still in the preliminary design stage. Thus much of the design has not been finalised.

3 Sustainable Initiatives

As part of the early phase of the hospital design, sustainable initiatives have been reviewed and assessed for their feasibility to be incorporated into the HPH redevelopment.

These initiatives are:



- Solar power
- Solar hot water system
- Co-generation & Tri-generation
- Gas generator
- Water utilization
- Building Services equipment
- Benchmarking

Each initiative has been assessed in their own merits, and the reasoning for their inclusion and exclusion will be reviewed in this report.

3.1 Solar Power

Solar power has its natural cause for consideration, as Australia is one of the sunniest continents. In addition, their commercialisation and utilisation in domestic and commercial projects across Australia has also brought greater attention in the 'Green' vision.



Solar panels also help to conserve energy and natural resources, specifically non-renewable fossil fuels. The majority of conventional electric power is generated by the burning of coal, natural gas or petroleum. Generally only 35% of fossil fuel energy is actually converted to electricity. Solar panel systems are designed to be much more efficient.

Applied to this project, solar power is a great utilisation of a natural resource. The ability to generate electricity onsite for a facility that will be operating 24/7 would greatly reduce the electricity demand during the daytime. As it reduce the electricity demand from the grid, this would also reduce the operating cost of the hospital by having a renewable source of power generation.

The typical solar PV is generally 10m² in surface area per kW capacity. So for a typical system to generate 20kW of electricity, it would require about 200m² of surface area. With an average weight ranging between 12-16kg, a 20kW system would weight 680kg. This means that for a relative small amount of electricity generation, this would take up quite a sizable footprint and impose weight on the building.

A preliminary review of the proposed available space indicated that there could be potential over 800m² gross roof area in the new building. Some of this area would be needed for plant space, which not been finalised yet, however there will still plant space available to harvest solar energy on the roof given the structure can be strengthen to support the additional load on the building.

The table below shows a simple estimate of the payback period solar panel. The information is based on data provided by Clean Energy Council of Australia.

Solar system Cost per 1kW (\$)	\$3,500
Proposed Solar system capacity (kW)	10 kW
Total cost (\$)	\$35,000

Table 2.1 Solar Panel Payback Estimate

Average ratio for electricity generate per day per 1kW Solar system	3.9
Total power generate (p/day)	39 kWh
Current electricity cost (\$)	\$0.07
Electricity cost saving per day (\$)	\$2.61
Electricity cost saving per annum (\$)	\$953.75
Payback period	37 years
Roof area	
Area per panel	100 m ²

The relatively long payback period would make this a less attractive initiative to consider. It could be more practical to have solar PV to supplement a percentage of the total electricity demand for the hospital. This way, a balance can be struck between utilising renewable energy without the additional burden on the structure load and roof space.

3.2 Solar Hot Water System

Similar to Solar PV, Solar hot water system utilises solar energy to heat water for domestic hot water usage, such as washing and showers. Generally, solar hot water utilises much of the same methodology as solar PV where solar energy is transferred to a useful medium to harness the energy radiated from the Sun. Water is heated by the sun through water tubes located within panels that are installed on the roof of the building.



The benefit is renewable free energy that can be harnessed to heat up the domestic hot water. This would reduce the hot water energy required to heat the domestic hot water.

However, there are a several limitations with the use of a solar hot water system in a hospital.

A hospital requires constant supply of hot water and to fully meet the needs it would require a significant amount of surface area on the roof.

Secondly, there will be times particular in winter where hot water cannot be generated by a solar hot water system. Therefore, there is still the need for reliable backup system to support the solar hot water system.

Thirdly, a solar hot water system requires storage tanks to maintain reliable hot water supply. This would affect the spatial limitations of the hospital particular due to its unique location within a residential area. The hospital requires space to maximise medical facilities for ensure care for patients.

It is proposed that the development will incorporate a solar hot water system to supplement the proposed central hot water system. The solar hot water will be preheating hot water and assisting the central hot water plant.

3.3 Water Utilization

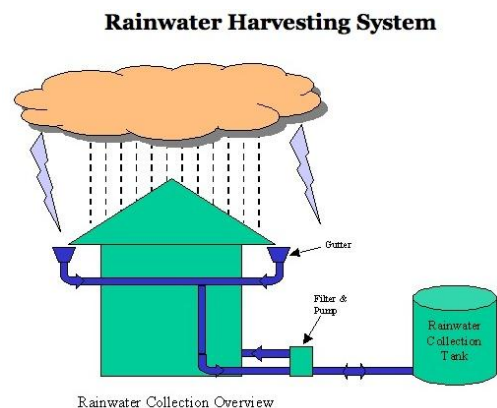
Water utilisations under consideration are rainwater harvesting and recycle water. Both have their sustainability credentials, and they are widely used in both commercial and domestic applications.

3.3.1 Rainwater Harvesting

Rainwater harvesting is a very simple way to capture a nature resource that is essential to sustain life. Rainwater can generally be used for toilet flushing and landscape irrigation without further treatment.

For toilet flushing, additional infrastructure would be needed. This is considered not practical for the existing part of the building. The use in the new building will be considered, as design element such as the size of storage tank, location for the storage tank, and the water quality will need to meet the current hospital cleaning regime etc.

The proposed size of the storage tank (s) will be considered as a minimum of 15,000L and is subject to final water usage calculation during design stage of this project.



3.3.2 Recycle water

With the volume of people visiting and working in the HPH, it is anticipated that there would be a high volume of water would be used and discharged from site. Therefore, we believe it should be considered utilising recycled water for this facility. The following summarises our feasibility study.

Generally, hospitals have large sites and produce water that can be recycles and also have large landscape areas to utilise the water. By comparison this site has very limited landscape area to utilise recycled water. If recycled water would be utilised for hospital use it would demand a very high level of filtration, large spatial requirements for storage and filtration plant.

With hygiene, ongoing maintenance requirements for the filtration plant and given the size of the hospital and the landscape areas a recycled water system is not recommended for this project.

3.4 Building Services Equipment

Commercial buildings are responsible for approximately 10 per cent of Australia's greenhouse gas emissions and those emissions have grown by 87 per cent between 1990 and 2006.

Improving the energy efficiency of commercial buildings has the potential to deliver savings on energy bills and building maintenance costs, happier and more productive workers and increased building value.

Energy efficient building services are critical in reducing energy usage. The services design of this project has incorporated efficient equipment and fittings to minimise the energy to reduce the impact on the environment.

The following three (3) major areas have been identified with the greatest impact on energy efficiency.

3.4.1 Mechanical Ventilation and Air Conditioning

As air conditioning and ventilation is critical part in creating a comfortable environment for patients to encourage recovery and provide the correct environment for medical treatment. Therefore it is critical to select reliable and efficient systems to serve the hospital.

Below is a list of major plant considered in this project:

- Electric drive chiller(s)
- Gas fired boiler(s)
- Air handling units
- Fans and pumps



The proposed design will incorporate:

- high efficiency chiller
- high efficiency boiler
- variable speed drive motor control on fans and pumps to optimise operation (where suitable)
- economy cycle - where permissible by hospital operation
- building management control system to monitor and control the operation of all mechanical system to optimise efficiency

3.4.2 Electrical Services

3.4.2.1 Lighting

The hospital is operation 24/7 and therefore internal lights are considered as major energy consumer.

An efficient lighting strategy will be incorporated including:

- efficient lights fittings such as LED down lights and recess T5 florescent are being proposed for majority of the areas
- lighting control strategy such as zoning opportunities; this ensures that different areas can be lit separately.

Initiatives to ensure that lights turn off when spaces are not being used for example movement sensors. This could apply to frequently used spaces such meeting rooms.



3.4.2.2 Gas Generator

Gas fired generator allows the building to generate its own electricity. Gas power generator utilise an alternative fuel source to power the hospital either as the main power source or as a backup. Natural gas has a lower greenhouse gas emission than coal or diesel which is the traditional source of power generation from coal fire power station and diesel backup generator. Additionally, in combine with the use of absorption chiller, the heat rejected from the generator can be fully utilised to generate air conditioning to the space.

The principle of using gas generator has a number of benefits to both the user and the environment.

Electricity generated locally reduces the efficiency loss through long distance of transmission from coal fired power plant to the end user. This method maximise the power conversion from fuel to electricity. In effect, for the same amount of

fuel that is used to generate electricity, there is more of it is available instead of loss through transmission. Therefore this reduces the overall carbon footprint as there is more electricity available from the same amount of fuel used.

3.4.2.2.1 Main or Backup Power

Following factors would need to be considered by the hospital and the design team for to the use gas fired generator.

- Is it suitable as the main power supply away from the traditional grid supply
- Is it suitable to cater for the base heating/ cooling requirements
- And/ or would it be used as a backup power source.

There are benefits associated with the use of a gas fired generator as a power source. As discussed earlier, the fuel source has less impact to the environment in terms of the emission level.

Financial benefit is another factor for considering an onsite gas generator. With current gas supply price at lower rate than electricity, it provides an opportunity to reduce the operating cost of the hospital.



	Electricity	Gas
Average cost per unit	\$0.067 / kW	\$0.019 / MJ

Table 2.5.2.1 Utility cost comparison, based on current site charge rate and industry information.
Conversion 3.6MJ Gas = 1kW Electricity

The unit price comparison in table 2.5.2.1 suggested that the gas price can be 3.5 times lower than electricity. The power generation efficiency is about 3 to 1 for gas generator. This means that 1kW of power equate to \$0.067 for grid electricity supply or about \$0.057 for gas supply. This equate to around 17% saving based on the above estimates.

Utilising a hospital electricity bill for November 2013, the saving on the consumption would equate to approximately \$1,300 for one month.

Whilst the gas generator has positive attributes to both the users and the environment, there are a number of limitations that will need to be considered.

1. The current hospitals electricity rate is very low.
2. Using onsite generation as the main electricity source requires a reliable source of fuel supply and equipment would need a very high level of care and maintenance to ensure the system operation. Reliable source of fuel supply cannot be guaranteed at this stage.
3. The flue emissions from the generator are constantly discharged into the atmosphere and may have an impact on the air quality in the local residential area.
4. A gas generator has a time lag when starting up and therefore it is not deemed suitable to provide backup power in a critical building such as a hospital. Reliable electrical back up power supply is critical for the hospital operation.
5. Noise emissions by the generator are generally high and need to be treated. This is considered critical due to its close proximity to residential dwellings.
6. Control sequence between the switch over of primary and backup power source will need to be carefully assessed to avoid any lag between the changeovers.

The above elements will need to be assessed during detail design and its viability for use in this hospital.

3.4.3 Tapware

With a significant amount of tapware proposed to be fitted throughout the hospital, the use of efficient tapware can provide a significant saving over the year. It is anticipated that most of the amenities would be fitted with 5 Stars efficiency tapware.

3.4.4 Building Fabric and Facade



The building fabrics plays a vital role from reducing and delaying the impact of the solar heat gain by developing a well-insulated structure to reduce the impact of the solar load to spaces and air conditioning operating hours.

The design team, in particular architect, mechanical engineer and the ESD consultant, will work closely to identify potential areas that would be affected by the solar gain. Solution to modified internal or external shading as well as improving insulation would be analysed to provide an optimum outcome.

3.5 Benchmarking

A method to present the performance of a building is by comparing to other building of similar nature. Two (2) approaches are proposed to compare energy performance:

- In order to rate HPH in term of energy performance amongst its peers, a benchmark of it performance via the energy data can be compared to hospital with similar operation and size.
- HPH can use computer simulation to predict the energy performance and greenhouse gas emission of the building and compare that again an industry rating tool such as Green Star Healthcare v1 Greenhouse Gas Emissions Calculator.

The process will involve the simulation of the all the design element of the building such as structural, architectural, and building services designs. This simulation will generate an in-depth detail of the building energy consumption. This result is then compared against a reference building as described by the Green Star Healthcare V1 – Greenhouse Gas Emissions Calculator Guide.

This involves the development to two (2) energy models for the building. The first model is the proposed building as per the architectural details, materials and equipment selected by the design team. The second model is the reference building. The reference building is a representation of the proposed building in terms of the architecture of the building, however it utilise a predefined services requirement and efficiency to determine the energy consumption of the building using a generic Green Star reference building.

The comparison of the two building energy models will provide a guide of the performance and how it is rated against other buildings in the industry.

This benchmarking exercise will be conducted in the later part of the design stage. This would allow time for each of the disciplines to develop their design strategy and be able to provide some indicative data of the provide equipment selected for the project.

It is anticipated that the building will achieve a similar performance to the conditional requirement of Green Star energy conditional requirement.

4 Cogeneration Feasibility Study

Co-generation plant has become a common topic for the design team and the developer to consider. The common perception of the system is that it is sustainable, as it generates energy, and utilizes any waste heat for generation of other system. An in-depth study of the plant and its feasibility for this project will be examined.

4.1 Commercial Building Tri-generation System Configuration

In a typical commercial building cogeneration or tri-generation system a gas engine driven electric generator would generate electricity which would in turn drive electrical loads, including electric chillers.

The waste heat from the gas engine would be recovered and used for space heating, domestic hot water heating and in the case of tri-generation in a Heat Recovery Absorption Chiller to generate additional cooling. A typical flow diagram for a commercial building tri-generation plant is shown in Figure 1 below.

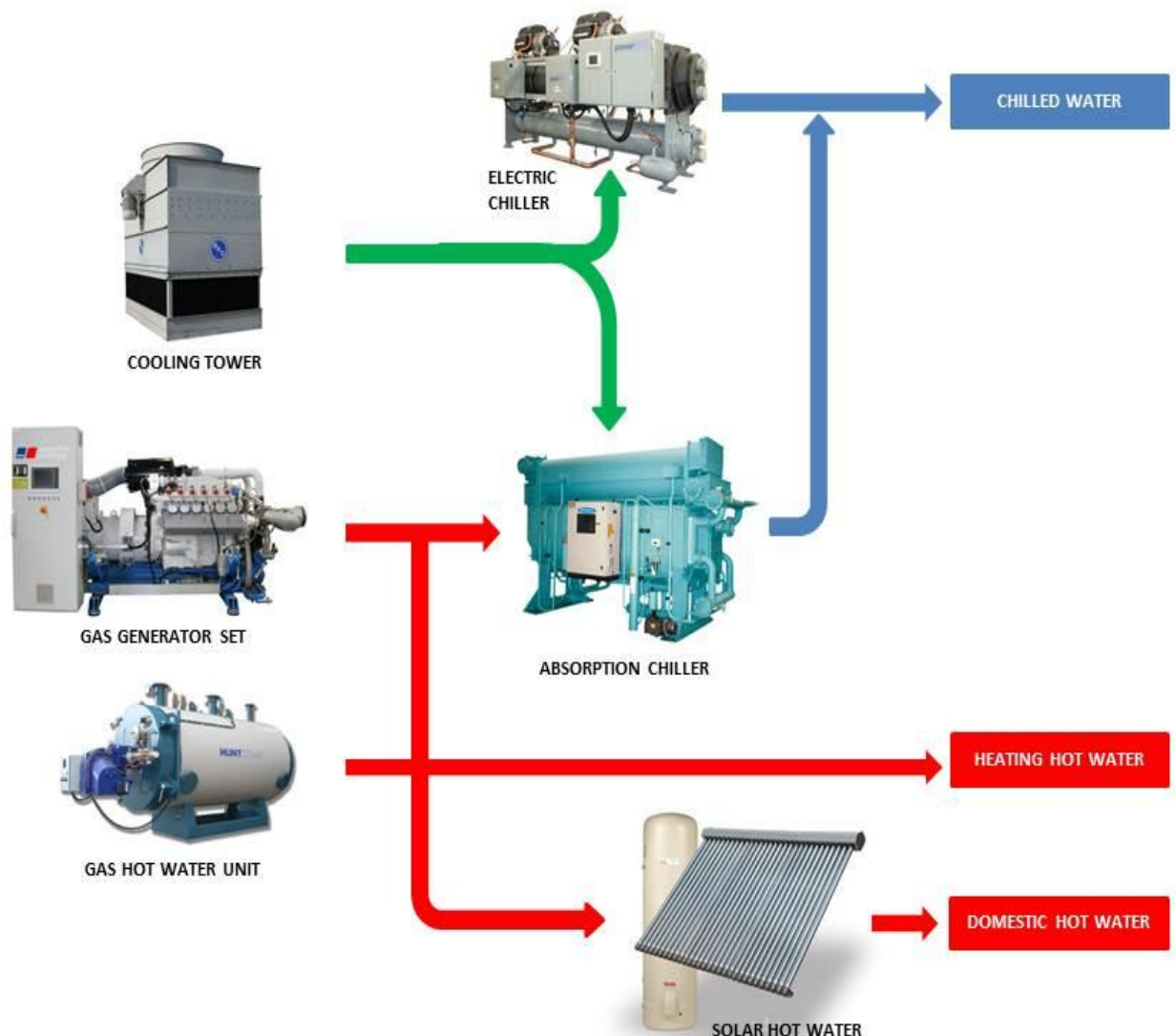


Figure 1: Typical Commercial Building Tri-generation Plant Flow Diagram

4.2 Electrical Load Profile

In order to size the generating plant an electrical load profile for the building needs to be developed. The load profile was calculated using equipment specifications developed as part of the building design process.

Of the total installed load only those that operate frequently throughout a typical day were included in the electrical load profile. The electrical loads considered include:

- Lighting
- Power ("plug loads")
- Ventilation fans
- Plant and equipment
- Common area services

4.3 Optimal Generation Capacity

To maximise the financial return from cogeneration and tri-generation systems it is generally accepted that operating the plant for the highest number of operating hours per annum provides the greatest return on investment.

The other critical point for consideration is how the co-generation system is utilised. Would the co-generation system be running all the time to deliver the minimal building consumption? Or would it be used to supplement the grid power with the generator as the lead power supply and the main grid power as the lag power supply. The answer to this question will determine the method to size this co-generation plant.

4.4 Waste Heat Recovery Capacity

In order to ensure maximum utilisation of the recovered waste heat from the generator set it is proposed that the system supply heat to the following services:

- Hot water absorption chiller
- Space heating
- Domestic hot water

The absorption chiller will be sized to utilise all of the waste heat from the generator set, however should the buildings cooling load fall below the output of the absorption chiller excess waste heat will be diverted to the other building uses.

A 230kW_e gas fuelled generator set will provide approximately 360kW_{th} of waste heat depending on the efficiency of the generator and associated heat recovery equipment. A single stage hot water absorption chiller sized to utilise this waste heat would provide approximately 175kW_r of chilled water.

4.5 Life Cycle Cost Analysis

The feasibility of the proposed tri-generation plant has been assessed through a life cycle cost assessment comparing the capital and operating costs between the tri-generation system and the conventional plant. The following parameters and assumptions have been used to complete the life cycle assessment:

- Capital cost
- Maintenance cost
- Utility costs
- Utility price escalation
- System assumptions

4.6 Capital Cost

The life cycle cost assessment is based on the additional capital cost over and above the capital cost of the conventional thermal plant.

The additional capital cost for an 230kW_e Tri-generation System with heat recovery and 175kW_r Absorption Chiller is estimated at \$920,000.

4.7 Maintenance Costs

Additional maintenance costs for the tri-generation plant have been allowed for at the rate of 0.05 \$/kWh of generation.

4.8 Utility Costs

The life cycle cost assessment assumes a fixed electricity price of 0.067 \$/kWh. This is the current electricity charge rate that the hospital is paying. Demand charges and variable time of use charges have not been accounted for in this preliminary assessment.

Natural gas costs have been assumed to be at a fixed price of 0.019 \$/MJ. This is typical of a regulated retail costs for a medium size commercial development. Significant reductions in gas costs can be obtained by entering into a supply contract with an energy retailer.

4.9 Utility Price Escalation

For each of the system configurations (base case and tri-generation), the capital and operating cost of each of the systems was estimated. Three possible outcomes for utility price escalation were also developed, these being:

- Business as Usual
- Low Price on Carbon
- High Price on Carbon

Electricity escalation factors were estimated using wholesale electricity price forecasts contained in the Australian Federal Government's Treasury document "Australia's Low Pollution Future: The Economics of Climate Change Mitigation". The factors developed in this report assume that 50% of a typical retail electricity bill is directly affected by increases in wholesale electricity prices, with the other 50% being attributed to network and administration costs.

The "low price on carbon" scenario uses prices modelled under the CPRS 5 emission trading scheme, whilst the "high price on carbon" scenario uses price modelled under the Garnaut 25 emissions trading scheme.

Natural gas escalation factors were estimated using Australian domestic gas price forecasts contained in the Australian Federal Government's Treasury document "Australia's Low Pollution Future: The Economics of Climate Change Mitigation". The escalation factors take into account gradual depletion of south eastern gas supplies, and the development of Liquefied Natural Gas (LNG) facilities in Queensland.

Business as Usual

This scenario represents no change to current electricity prices due to emissions trading, or a carbon price. No electricity and gas price escalation other than due to inflation has been allowed for.

Low Price on Carbon

This scenario is representative of the likely outcomes from the Government's current commitments to reductions in emissions.

High Price on Carbon

This scenario is representative of the likely outcome should the government commit to a more ambitious cut in emissions in line with the Copenhagen Accord (i.e. 2020 emissions 25% below 2000 levels).

4.10 System Assumptions

The life cycle models make the following operational and plant assumptions:

- The tri-generation plant operates at base load for 12 hours per day, 7 days per week, and 52 weeks per year.
- All electricity generated is utilised within the building.
- All cooling generated by the absorption chiller is used to offset cooling that would be otherwise be produced using electricity
- Cooling produced using electricity at a Coefficient of Performance (COP) of 6
- Cooling generated by the single stage absorption chiller at a COP of 0.7
- Electricity is generated by the natural gas generator set at a conversion efficiency of 32%
- Thermal energy is recovered from the waste heat of the natural gas generator set with an effectiveness of 70%
- Each of the plants has an economic life of 20 years
- Inflation rate on maintenance and utility costs is 2.5% p.a.
- Discount rate for Net Present Value (NPV) calculations is 7% p.a.

4.11 Results

Operation of the cogeneration plant results in a reduction in annual operating costs of approximately \$18,000.

This results in a payback period of 10.4 to 20.7 years depending on the extent of utility price escalation over the life of the plant. The most like outcome being a payback of over 12.5 years resulting from the adoption of a “low price on carbon”. As the hospital current electricity cost is quite low compare to industry standard, this makes the payback period longer than other business.

The operation of the proposed tri-generation plant would result in an annual reduction in greenhouse gas emissions of approximately 440 tonne CO₂-e.

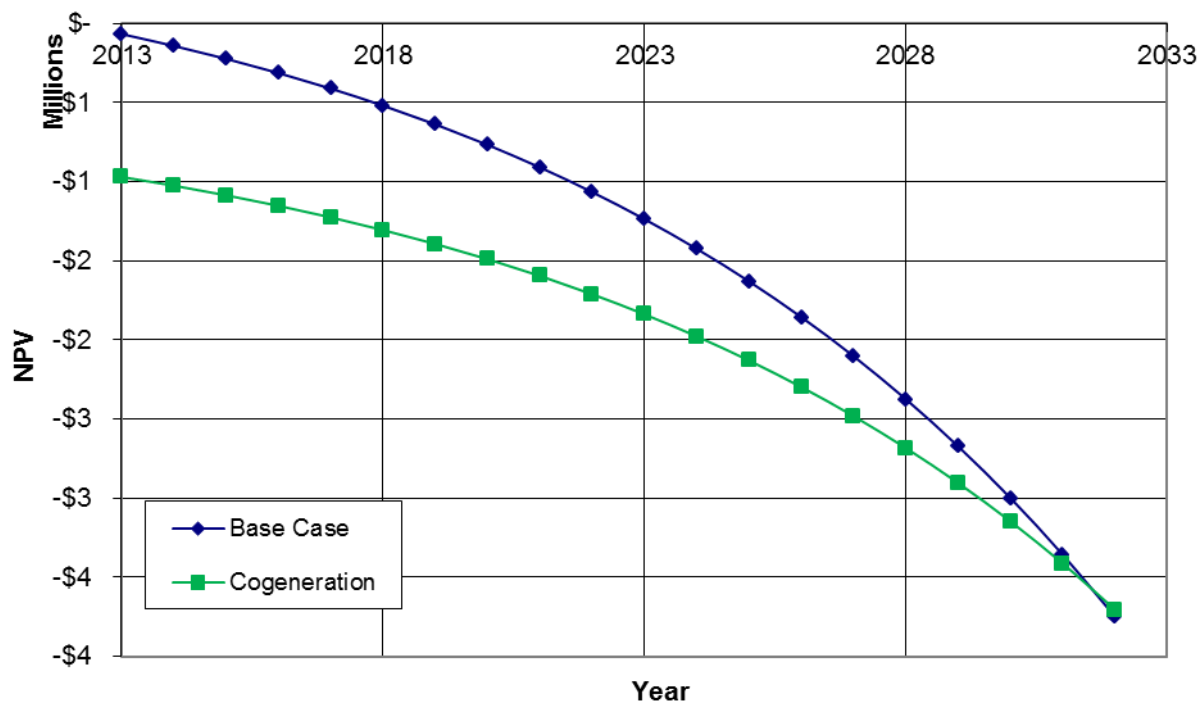


Figure 4: Discounted Cash Flow “Business as Usual” Price Escalation

Figures 4 to 6 show the cumulative Net Present Value (NPV) of both the base case conventional system and the proposed tri-generation system over the life of the plant. The NPV costs are only for the portion of costs influenced by the tri-generation system.

It can be seen in Figures 5 and 6 below that utility price escalation has a large effect on the life cycle costs for the base case conventional system but has very little effect on the life cycle costs for the tri-generation system

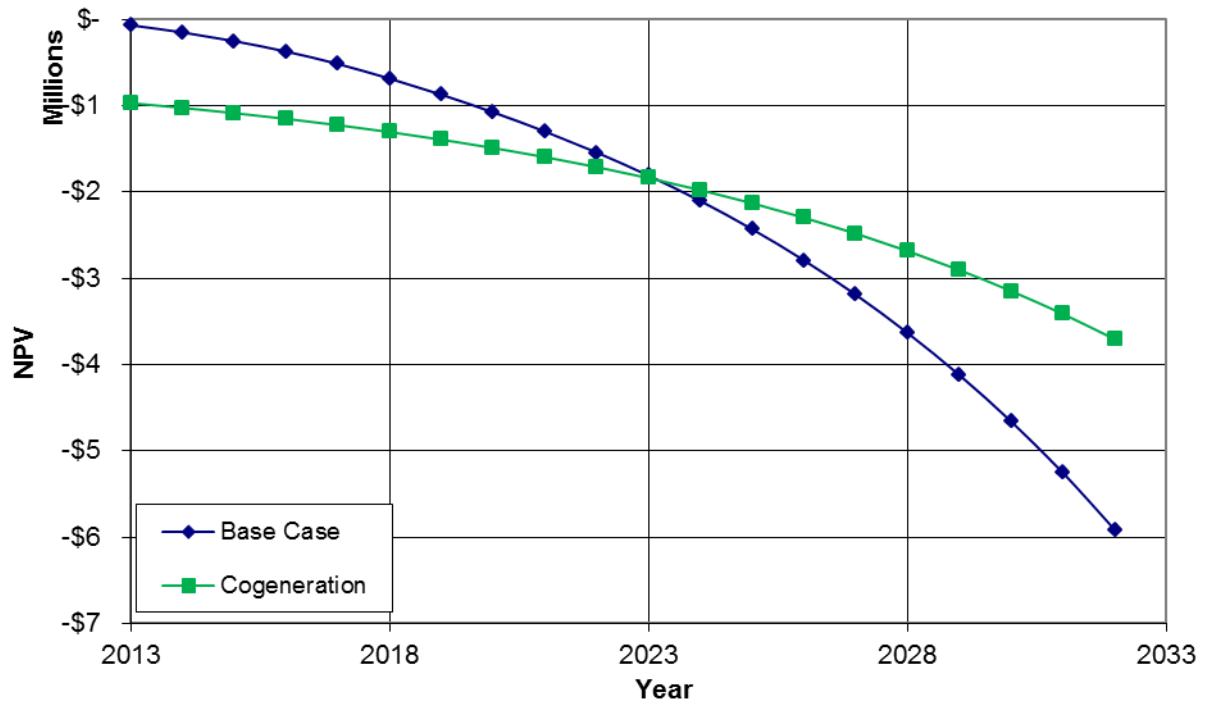


Figure 5: Discounted Cash Flow “Low Carbon Price” Price Escalation

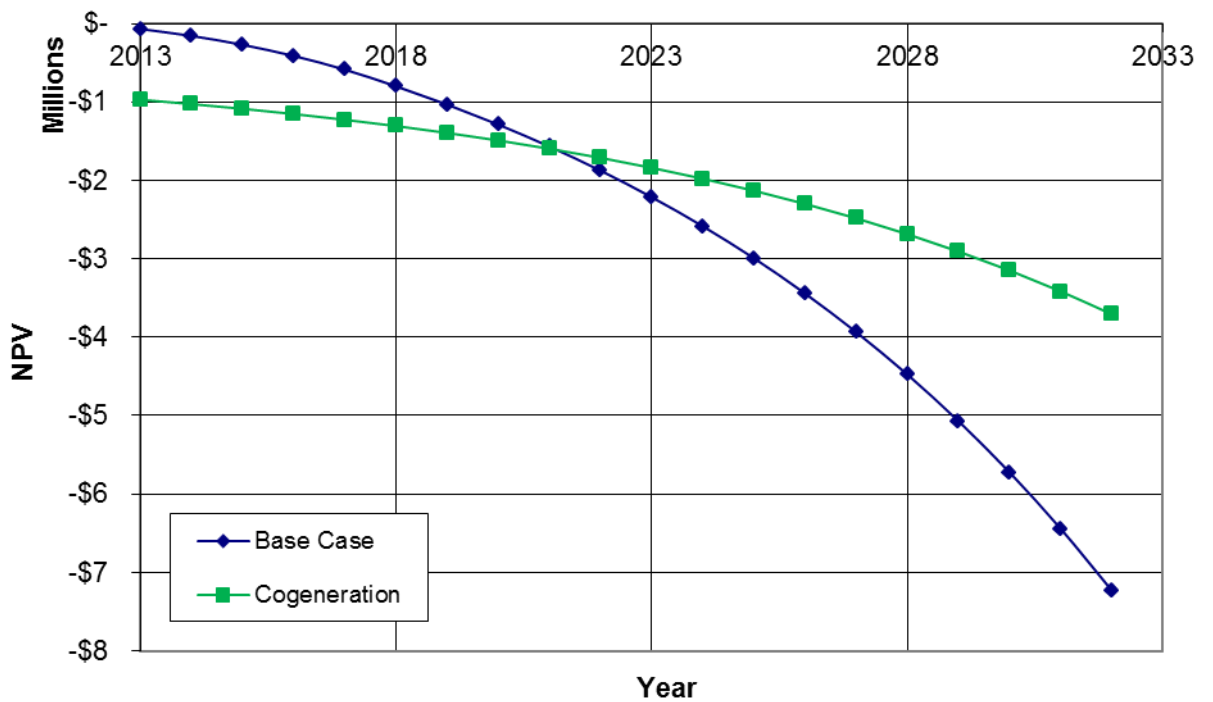


Figure 6: Discounted Cash Flow “High Carbon Price” Price Escalation

4.12 Conclusion

The analysis and feasibility study in this report has provided a list of building sustainability initiative for the hospital to consider.

Initiatives such solar hot water system, solar power generation, and rainwater harvesting, they all have their own unit benefit to both the site and the environment with their utilisation of natural resources. However, their physical foot print on the site would have a significant impact either on the structure of the building and also reduce the useful space for the hospital. The hospital will need to consider whether the benefits from these initiatives would outweigh the impact to the service of the building.

The recycle water would also be a worthwhile consideration, as the hospital generally discharges large volume of waste water. The hospital will need to consider where this water can be used and the level of filtration required to meet that requirement.

For general building services, the design team has incorporated efficient tapware, lighting fittings, equipment and plants into the current design.

An energy model of the hospital will be model to compare against an industry reference such as Green Star Healthcare energy calculator. This will be carried out in the later part of the design phase so the information can be incorporated from the design to develop an energy model that is a close representation of the final design.

In addition to the sustainability initiatives, a feasibility study for co-generation (tri-generation) was also investigated. Based on some preliminary assumption for the system and selection tri-generation system for the Hospital would consist of:

- 230kW_e Natural Gas Generation Set
- Waste Heat Recovery providing heating for absorption cooling, space heating, and domestic hot water
- 175kW_r Hot Water Single Stage Absorption Chiller

The tri-generation system would operate at base load for approximately 19 hours every day of the year

The tri-generation system would cost an additional \$920,000 over and above the cost of the conventional thermal plant proposed for the building, and would result in annual operational cost savings of approximately \$18,000 depending on utility rates.

The likely payback for the system would be approximately over 12.5 years depending on the escalation rate for electricity and natural gas.