TITLE

St ANDREW'S HOSPITAL, A JOURNEY FROM A FAILED CO-GENERATION PLANT TO A NEW TRI- GENERATION PLANT.

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GOOD MORNING EVERYONE, I TRUST THAT YOU ARE ALL WELL.

THANK YOU FOR INVITING ME HERE THIS MORNING.

MY PRESENTATION IS FOR NO MORE THAN 10 MINUTES

I HAVE BEEN ASKED TO PROVIDE YOU WITH AN APPRECIATION OF THE FACILITIES THAT COMPRISE THE PHYSICAL ASSETS FOR St ANDREW'S HOSPITAL & OUR JOURNEY FROM THE ORIGINAL **CO-GENERATION PLANT** TO WHAT IS SOON TO BECOME OUR **NEW TRI- GENERATION PLANT.**

INTRODUCTION:

.St Andrew's Hospital is Australia's largest Stand Alone Not For Profit Acute Care Hospital, located on the southern fringe of the Adelaide CBD.

SAH MANTRA for selection of new Technologies

- Flexible
- Reliable
- Robust
- Efficient

CURRENT FACILITY CHARACTERISTICS -:

1. Building Stock ranging from (1865 – 1990's) & now 2018 (ECD

Current Issues -:

- Concrete Cancer
- Brick Growth
- Heritage Buildings
- Asbestos

- Box Gutters
- Salt Damp
- Termites
- AND AN AGING INFRASTRUCTURE (including but not limited to)
    - Hydraulics
    - Mechanical Services
    - Architecture
    - Lift Services
    - Electrical Services Upgraded 2011
    - VOIP Infrastructure (ITC Platform) Commissioned 2012

2. <u>Plant & Equipment stock</u>

- 5 Chiller Sets including an Absorption Chiller
- 2 Cooling Towers
- 8 Boilers including a Steam Boiler as part of the Tri Gen infrastructure.
- 2 Intelligent Diesel Generator Sets (800kWe) each
- 1 Tri generator Set (635kWe)
- 7 Elevators
- Multiple AHU's
- Wide array of Medical Surgical devices including
    - Da Vinci Robot
    - Cardiac Thoracic Theatres
    - Angiography Suite
    - 11 Theatres (Total of 16 Procedural Rooms)
    - Lasers
    - Image Intensifiers
    - Heart Lung Machines
    - Physiological Monitoring Systems
    - Organ Imaging including CAT Scanners & MRI Scanners
    - Heart Lung Machines
    - Linear Accelerators
    - In all well in excess of 5,000 Biomedical devices & assets.

The site is constantly undergoing renovations, Theatres, Patient rooms, en-suites, car parking facilities & the like.

MAJOR DEVELOPMENT OF **1990 -92**

The site underwent a major development that provided the new Central Wing which accommodated the ICU, Kitchen, Angiography Suites, Organ Imaging/ Nuclear Medicine/ Cat Scan & additional new 35 Bed Wards on each of the

- 2nd,
- 3rd &
- 4th Floors.

In Total an addition of 105 Beds.

CAPITAL INJECTION FOR PLANT & EQUIPMENT

As a component of the 1991 development of the Central Wing of the Hospital a significant capital injection was also undertaken for new & upgraded plant & equipment for the site.

At around this time St Andrew's Hospital installed the original Cogeneration Plant (This Cogen was commissioned in 1993).

(I was the Engineering Manager at the Adelaide Children's Hospital at this time and I can remember taking part in an IHEA Branch site tour, of the new co – generator plant at St Andrew's.)
Here in South Australia, - back in 1993 - it was considered some of the leading technology available to Hospital Facility Managers.)

At this point is may be appropriate to explain what the Co-Generation process is -:

- ***CO GENERATION,***

Google Definition -:

Description of the Co-generation Process (or Combined Heat & Power CHP)

- ***Cogeneration*** *is a thermodynamically efficient use of fuel.*
- *In separate production of electricity, some energy must be discarded as waste heat, but in cogeneration some of this thermal energy is put to use. All thermal power plants emit heat during electricity generation, which can be released into the natural environment through cooling towers, flue gas, or dump radiators. The CHP captures some or all of*

the by-product for heating to heat water for ablutions, pre heating for sterilization plant and heating water for the air conditioning utilization. Typically the hot water from the waste heat developed in co-generator plant will reach temperatures ranging from approximately (80 to 130) °C. This is also called combined heat and power

- ❖ **TRI GENERATION**
- ❖ ***Tri Generation*** *or Combined Heat Power & Cooling (CHPC) is the process by which some of the Heat produced by a cogeneration plant is used to generate chilled water for air conditioning or refrigeration. An absorption chiller is linked to the combined heat & power (CHP) to provide this functionality.*
- ❖ **QUAD GENERATION**
- ❖ ***Quad Generation*** *takes this process one step further with the addition of systems to sequester carbon dioxide from the engine exhaust for the consumption of the carbon dioxide for industrial use.*

The ORIGINAL Co-Generation Plant consisted of -:

The Engine -:

- Caterpillar 3508 Spark Ignited Engine
- It was initially designed as a Diesel Engine but was later converted to Gas Fuelled version
- It was Turbo Charged
- It was rated at 500kWe
- The synchronisation to ETSA was monitored by the site's BMS system managed by a Woodward 'easYgen-3000GenSet Control Platform, which in turn monitored the sinusoidal wave form of the incoming ETSA Supply.
- It operated on a 24 / 7 basis 365 days per annum (excluding downtime for servicing).

- ➢ **Commissioned 1993**
- ➢ **Decommissioned 2015 approximately a 22 YEAR Service Life**

TOTAL OF 146,992 Run Hours.

UPTIME & OUTPUT PERFORMANCE WAS MONITORED BY THE BMS

- Uptime for July 2013 Equated to 96.7 %
- However by September 2015 Uptime Equated to 83.5% (Less Programmed Servicing Downtime)
  THEREFORE WE HAD LOST 13% of the previously achieved uptime in approximately 2 years.

To further exacerbate this matter, the final 20 months of the life of the engine we had de-tuned it in order to extend the run life.

During that final 20 months the engine & controls were clearly showing signs of fatigue consistent to it reaching the end of its economical life-:

- There was a clear pattern of progressively failing components
- Parts were becoming increasingly difficult to source
- On the rare occasions that parts were sourced they proved to be extremely expensive.
  ❖

SO WHY LOOK TO INSTALLING A TRI GENERATOR SET?

In 2016 the Hospital was in the Planning Stage of the Eastern Wing.

The new Eastern Wing would consist of

- 196 bay underground car parking facilities.
- 2 Acute Digital Theatres
- 2 Angiography Suites
- 3 Endoscopy / Procedure Rooms (1 of which is serviced to provide Emergency Theatre status
- 28 Bed Cardio – Thoracic Ward

During the planning stages for the new Eastern Clinical Development the Hospital wanted to secure an additional SAPN electrical "Feeder" cable for the new building.

St Andrew's needed to be provided with a new "Feeder" that was capable of carrying the electrical load of the new ECD, as well as support some of the existing site electrical load.

In addition it was determined that in order to provide an extra level of electrical supply reliability, the new "Feeder" should be supplied from an alternative source to that of the existing "Feeders".

The Estimate figure we received for the provision of the "Feeder" cable was in the order of $5M au.

However that figure did NOT include-:

- Any Transformer
- Switchboards
- Distribution networks

For the $5M we would have a very large cable delivered to the boundary of the site, but NIL supporting infrastructures.

The Proposed St Andrew's Tri- Generation Plant -:

It was now time to commit to the planning for the successor to the previous Co generation Plant

It should include a Tri Generation approach in lieu of Co-Generation; this would require the addition of an Absorption Chiller & Cooling Tower, to assist with the management of the Hospital's existing heat load, plus the additional heat load of the new Eastern Wing of the Hospital.

In addition to assisting with the air conditioning load, it should also be capable of managing the increased thermal requirement for -:

- Steam – the Steam Header
- (Hot) Ablution Water
- Pre heated water for Sterilisation
- Heated Water for the Mechanical Systems.

All of this while at the same time generating the base load electrical energy requirement for the site

Tri-generation Plant

Mode of Operation for St Andrew's Hospital

Tri-generation is the production of -:

1. electricity,
2. heat and steam
3. Air Conditioning (Chiller provided cooling), ALL in the one process.

For St Andrew's Hospital this means a gas fired engine driving a generator producing thermal & electrical energy for the Hospital site.

Due to the reciprocating technology of the engine, heat energy, developed in the engine's exhaust & water jacket systems is developed as a waste product of the process. This heat energy is then transferred to an absorption chiller which produces chilled water for the cooling cycle of the air conditioning plant, (so when we have the highest demand for air conditioning Cooling in Summer, it is a perfect timing match for the high ambients that drive our maximum thermal output from the generator's exhaust and water jacket and still have enough thermal energy for ablution water, pre heating for steriliser water and to supply the Steam Header for distribution of steam around the hospital.

The ratio of electricity produced and exhaust heat for the absorption chiller and then the ratio of cooling to heating can be varied to meet the specific site requirements.

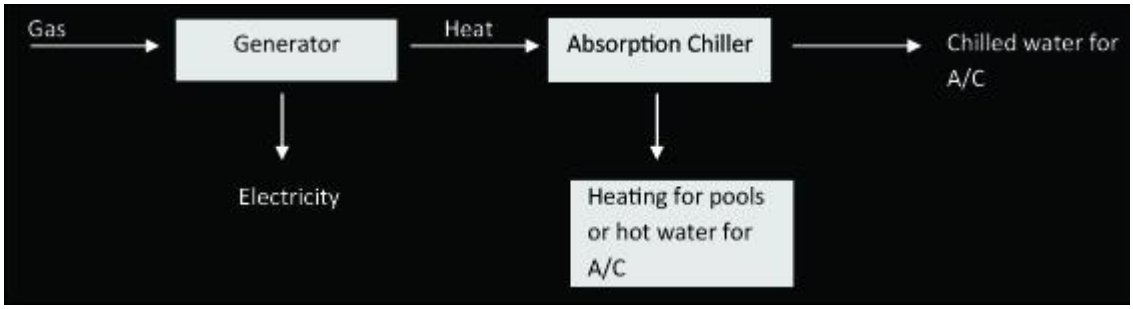

Figure 1 Heating for Pre heated Steriliser water feed, Ablution Water, Mechanical Systems occupied space

The Benefits of a Tri-generation System In a Hospital Application :

1) Provides the Hospital with an ALTERNATIVE ELECTRICAL POWER SUPPLY. – CAN CONTINUE TO SUPPLY ELECTRICAL AND THERMAL ENERGY TO THE HOSPITAL IN AN EVENT WHERE SAPN HAS FAILED.

2)

2. Savings on energy costs;
Using tri-generation to produce electricity, and specifically when using gas to run the engine & generator and produce heat for the absorption chiller instead of power from the grid to run the air conditioning plant, savings on energy costs in the order of up to 30% can be achieved, depending on the relative price of gas and electricity to the site.

3) Savings on Greenhouse gases;
Producing electricity on site using gas fuel produces approximately 30% less greenhouse gases than using power from the grid for an equal amount of power output.

4) Independence from the Grid;
Installing a tri-generation plant provides a site with a level of independence from the power grid. In some areas the capacity of the grid is constrained and in extreme conditions the grid may need to impose restrictions on use.

The configuration employed at St Andrew's is such that in the case of a power failure, the Trigen unit will stop, the Emergency Generators will power up to establish power to all the UPS units & essential medical & patient services. When the diesel generators have stabilised their load profiles the Tri-generator will start providing Thermal & Electrical Energy to the Hospital.

5) Free Thermal Energy as a Waste Product
The PRIMARY Energy REQUIREMENT from a well-designed Tri Gen Plant is the Thermal Energy profile. The Plant SHOULD be designed to match the THERMAL LOAD PROFILE, NOT THE ELECTRICAL LOAD AS IS OFTEN THOUGHT.

6) Energy costs are rising;
Worldwide the cost of energy from the grid is rising and will continue to rise into the foreseeable future. A tri-generation plant can be a buffer against some of this increase in energy costs.

FINANCIAL CONSIDERATIONS

A literature review highlighted the lack of clear & agreed upon methods for measuring an organisation's cost of capital & therefore the efficacy in investing in a project. For the purposes of our Project the

1. **Weighted Average Cost of Capital WACC**
2. **Net Present Value NPV**

were selected as the methodology to be incorporated in the financial decision making process. The analysis of

3. **Cash Flow**,
4. **Identification of Pay Back Period**, &
5. **Calculation of the Internal Rate of Return** were also factors in arriving at our final decision.
6. **The St Andrew's 40% Debt to Equity Ratio & preferred formulas** were also incorporated.

The results demonstrated a positive Net Present Value & an attractive Internal Rate of Return that when combined with the Pay Back Period (2.05 Years), c**oncluded that the Project is viable**.

GREENHOUSE GAS EMISSION CONSIDERATIONS

St Andrew's Hospital seeks to be a responsible corporate citizen at all times & therefore the impact of the Hospital's overall greenhouse gas emissions was also calculated.
The equivalent carbon dioxide emissions were calculated for each of the generator's fuel sources (Gas for the generator & electricity to operate the fan, radiator & fuel pump). This data was then compared to the greenhouse gas emissions saved by generating electricity on site & redirecting the waste heat from the generator for use as an energy source rather than purchasing the required gas & electrical energy.

The overall greenhouse gas emissions savings attributed to operating the current generator are approximately **435 Tonnes of CO^2 p.a.**

(From figures taken from the National Greenhouse Accounts Factors document for August 2015.)

CONCLUSION

The delivery of Private Health Care is a capital intensive industry with facilities to maintain, new technologies to be embraced to satisfy the needs of consumers & Health Funds. Stakeholders are demanding hospitals demonstrate social & environmental responsibility by monitoring & decreasing their carbon footprint. In addition the healthcare sector is expected to demonstrate sound financial practices to ensure affordable access to healthcare into the future. Calculating costs of investing in capital remains an imperfect science but it is necessary to sustain business growth. The very process does not always allow for possible changes in future trends or market activity. However until a concise methodology is developed St Andrew's will continue to use WACC & NPV calculations and some internally developed metrics, to aid in financial decision making.

TAKE AWAYS

1. *Contrary to the conventional assumption that any Co- Gen / Tri Gen Plant should be sized on the Electrical Load requirements , lessons learned in our experience suggest that the Plant should be sized to match the Heat load of the site with Electrical Energy being the bi – product. The economic success / failure of this type of Project is in the economies of the savings from the energy costs for the Thermal energy, while the cost of producing Electrical Energy is minimal saving at best (IF considered in isolation from the benefits from the Thermal Energy utilisation).*

2. *Due to the very nature of the Plant that comprises a Tri-generator the best fit is usually confined to 24 / 7 type industries.*

3. *For a Hospital application one of the significant benefits of Co-gen / Tri- gen Plant is that it affords the site an "Alternative" Power source. While it cannot be classified as an "Emergency Power Supply", such as our Diesel Generators it does afford a similar service while providing Thermal Energy & Electrical Energy simultaneously.*

4. *Do the Numbers*

THANK YOU