Glen Hadfield* – Australia

Cogeneration advantages highlighted

Benefits of cogeneration are discussed in this article, and detailed are experiences and conclusions gained through a number of recent projects at hospitals in New South Wales, Australia.

Sydney West Area Health Service (SWAHS) delivers healthcare services to residents of western Sydney from Auburn to Lithgow, and includes major teaching hospitals at Westmead, Blacktown and Nepean at Penrith.

To date SWAHS has implemented four cogeneration projects, three of which have been running for a few years, and one of which, at time of writing was being commissioned. In addition a small cogeneration project at Blue Mountains Hospital, Katoomba was at the tender stage.

Key drivers

Utility prices

One of the main drivers for cogeneration in SWAHS is mitigating the exposure to escalating utility prices.

Electricity prices under the new contract have risen steeply, costing SWAHS an additional A$2 million per annum (compared with the Service's existing contract).

Gas prices increased by 34% across SWAHS from April 2008, costing the Service an additional A$700,000 p.a.

The future carbon price

The future carbon price is projected to be between A$20 and $40/tonne, adding a further 2 c-4 c/kWh to the cost of electricity. There are still a number of uncertainties around the future carbon price, but the following factors will impact the value/price of carbon and its volatility:

- The nature of the future national carbon trading scheme, and the projected price of carbon, have changed, and been bounced around almost as frequently as members of the NSW Labour Cabinet.
- Prices for certificates under the NSW Greenhouse Gas Abatement Scheme (GGAS) have softened, to just over A$3 / tonne. A replacement scheme called the NSW Energy Savings Scheme, covering only projects accredited under Demand Side Abatement, have operated from July 2009. It is anticipated that the value of certificates created under this scheme should improve significantly due to supply/demand factors.
- The national Carbon Pollution Reduction Scheme has been discussed in the "Green Paper". Cogeneration will be included in the scheme, but not demand-side abatement projects.

Blacktown Hospital case study

Blacktown Hospital is a large metropolitan hospital of 400 beds in Western Sydney with utility costs that will soon eclipse A$1 m despite the completion of an Energy Performance Contract (EPC) that produced savings of A$200,000 p.a. The hospital's utility costs for 2007/08 totalled A$984,000 p.a. (electricity: 5.1 GWhrs, A$448,000; gas: 52 TJ, A$315,000; water: 92.9 mL, A$221,000). These figures represent the post-cogeneration consumption.

The thermal and electrical profiles are typical of a 400-bed hospital with a cool winter (5-18°C) and warm to hot summers (19-35°C).

In June 2005 a Waukesha VGF 36 GLD gas-fired generator set was installed with an electrical output of 550 kW and a thermal output of useful heat of 792 kW. The primary use of this heat is for space heating and domestic hot water. The original business case was prepared in 2002 as part of an Energy Performance Contract implemented by Total Energy Solutions. It was based on

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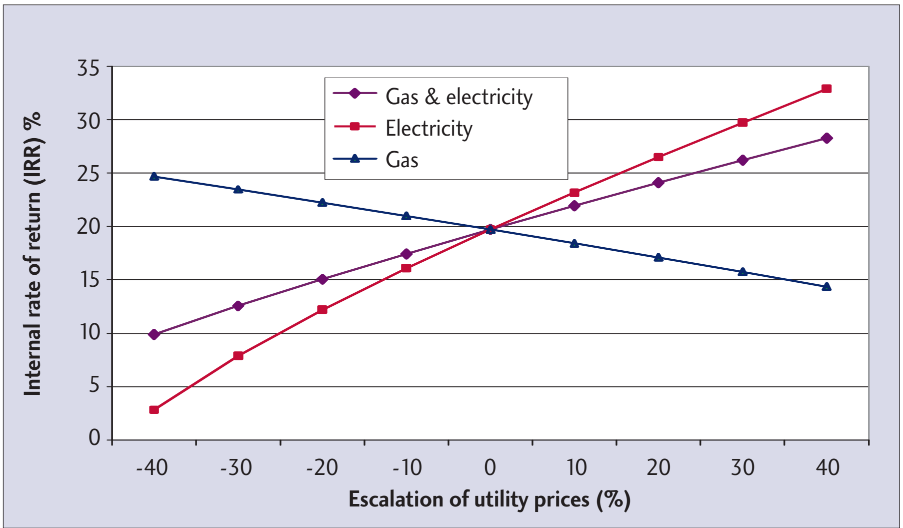


Figure 1: Blacktown cogeneration – sensitivity to electricity and gas prices rising concurrently.

tariff rates applicable at the time, with a capital cost of A$942,000, guaranteed savings of A$183,000, and greenhouse gas savings of 1,950 tons per year. The cogeneration plant provides approximately 50% of the electrical load and 80% of the average thermal load.

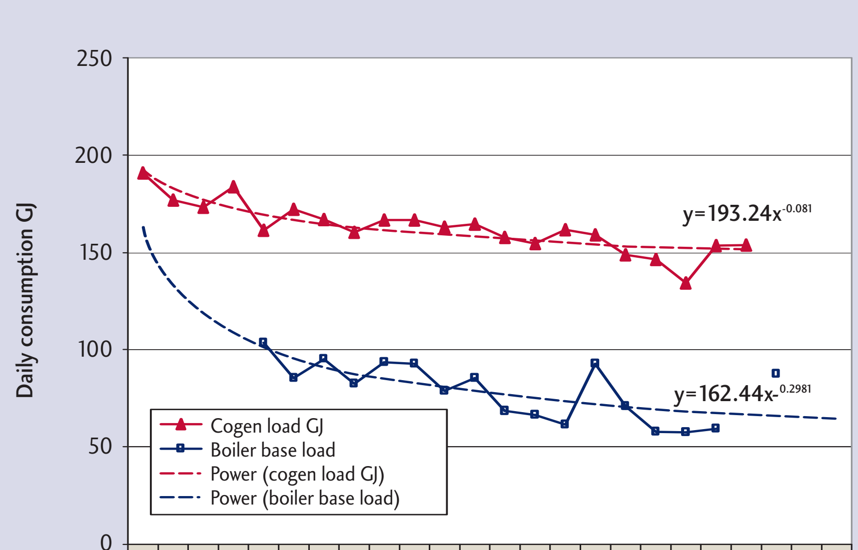
Reticulation challenges

The cogeneration plant is located on the ground floor, and the thermal plant on level four, so, in order to accomplish the heat transfer in the most effective manner, primary, secondary and tertiary hydraulic circuits were employed with heat exchangers between each circuit. The heat is dumped into the domestic hot water and heating hot water systems. Recovery of steam from the flue of the cogeneration plant was not considered cost-effective.

Commissioning issues can significantly delay the project's practical completion. Additional air release valves for bleeding the hydraulic lines, ensuring the right size heat exchangers, and installing a bypass line for engine warm-up, are all necessary features to enable smooth start-up and operation of the plant.

Control mechanisms/supervisory control

Thermal and electrical supplies and site demands are being logged by a SCADA system. This system provides energy logging as well as system fault information. The system is also monitored remotely by the energy service company, Total Energy Solutions, as well as providing access for remote diagnosis by the supplier, Gas Drive Systems.



	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29			
Cogen load GJ	191.0	176.8	173.3	183.8	161.4	172.3	167.1	160.2	166.6	166.6	162.9	164.6	157.6	154.7	161.6	159.2	148.8	146.3	134.3	153.5	153.8			
Boiler base load					103.6	85.5	95.2	82.6	93.5	92.7	78.9	85.4	68.5	66.5	61.4	92.8	71.0	57.8	57.6	59.4		87.6		

Average daily temperature

Figure 2: Blacktown Hospital gas consumption (weekday) *vs* average temperature.

'The important thing is not so much the electricity or gas price, but the relationship between the two.'

Electrical switchboard interface

Cogeneration plant also will have the effect of increasing the fault level on the electrical switchboard, so the switchboard fault rating should be examined to ensure that no additional switchgear upgrades are required. The designer needs to avoid the potential of harmonics developing between the power factor correction (PFC) units from the main switchboard and the generator, which can be done by careful tuning of the capacitors.

There are a number of factors influencing the business case for cogeneration, with the obvious influences being electricity and gas prices. However, the important thing is not so much the electricity or gas price, but the relationship between the two. If they rise at the same rate, and the capital remains constant, it will improve the business case.

Keeping all other parameters constant (gas price, maintenance costs, value generated by carbon certificates, level of heat recovery), the business case for cogeneration improves significantly if both electricity and gas costs rise concurrently (see Fig. 1).

Maintenance is also a significant determinant in the business case for cogeneration. The cost per kilowatt hour for the Blacktown unit was around 1.8 c/kWh over the 2007/08 year. The impact of maintenance on the business case is around a one percentage point drop in IRR for every 10% escalation in maintenance costs.

Aiming high

The amount of thermal heat recovery is critical, and it is important to aim for greater than 80% to make the project viable. Comparisons of the cogeneration plant operating and not operating over a period show that the plant is achieving around 80% utilisation of the waste heat. A heat reduction in heat recovery of 5% reduces the IRR of the project by about 1%.

The carbon saving generated from the unit running at 90% availability is

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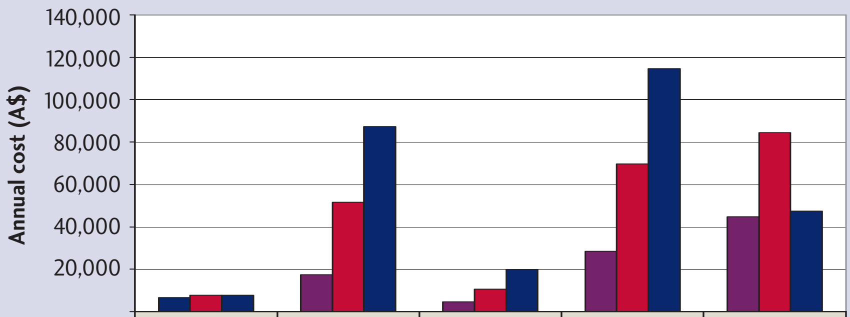

Year	Weekly	Major service	Breakdown	Total	Budget
2006	A$ 6,608.35	A$ 17,255.04	A$ 4,598.37	A$ 28,461.76	A$ 44,622.63
2007	A$ 7,730	A$ 51,522.91	A$ 10,431.55	A$ 69,684.46	A$ 84,321.68
2008	A$ 7,657	A$ 87,291.45	A$ 19,766.38	A$ 114,714.83	A$ 47,340.14

Type of service

Figure 3: Blacktown cogeneration plant maintenance.

approximately 2,700 tonnes per year. This represents a cut of 28% on the carbon footprint of the Blacktown Hospital site, far more than is likely to be achieved through energy efficiency projects. The volatile nature of the price of carbon certificates under the NSW GGAS scheme, and the uncertainty around the carbon price, make it difficult to predict the benefit to the business case for cogeneration, but the projected carbon price of greater than A$20/tonne would improve the business case quite dramatically.

If the plant is operating within performance guidelines of 90% availability, then using projected tariff rates and applying them to the Blacktown plant, escalating 20% to the capital cost, results in net savings of A$228,000 and a payback of around five years.

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Repair costs mitigated

In October 2007 the Blacktown engine experienced a major failure. The repair costs fortunately were mitigated by bringing forward a major service involving a head swing. The cause appears to have been that the engine had been run at extended periods with elevated jacket water temperatures. During the previous summer the cogeneration plant has been running with jacket water temperatures up to 99˚C, but was reduced later to a maximum of 95˚C by starting to run the dump radiator when jacket water reached 90˚C. Further protection is also being installed to shut down the unit if jacket water reaches critical levels above 95˚C. There have been no further issues with the plant since this time. This does not impact the level of heat recovery, as the heat generally would exceed the site requirements on hot days with temperatures of over 30˚C.

While the plant runs 24/7, the cost versus benefit is quite marginal during off-peak times. This, however, is offset by the improved reliability and the reduction in wear and tear of the engine via the elimination of frequent warm-up and cooling down cycles. The business case for running during off peak is also assisted by the generation of additional carbon certificates (currently called NGACs in New South Wales). During summer (November to March) the local electricity network authority has provided an additional incentive to run in hot weather over 30˚C. The incentive payment is worth up to A$12,000 per annum.

The Blacktown cogeneration plant performance was poor during the previous 12 months, with only 73% overall availability in 07/08, the worst of our three cogeneration units, mainly due to the major failure that put the unit out of action for over six weeks. Recently the settings that govern the control values of the cogeneration unit were being intermittently lost and having to be reset.

Sydney West Area Health Service has a service contract with the supplier of the cogeneration plant which includes weekly inspections, as well as the usual monthly, quarterly, and annual, services. However, the performance of the plant requires committed in-house staff who are willing to monitor the plant on a daily basis, including not just the central engine and generator, but also all the heat recovery components and the dump heat radiator, all of which are monitored by the SCADA system located in the hospital's maintenance department.

Conclusion

Government policy on climate change is now a major driver for consideration for cogeneration, with the price of carbon likely to have major impact on the cost benefits. Cogeneration represents a good opportunity to make major cuts in the CO_2e footprint of facilities (~30%). However, optimising the cogeneration plant thermally and electrically to site profile is critical to the business case, and there are significant maintenance and operational risks that need to be factored in to the case.

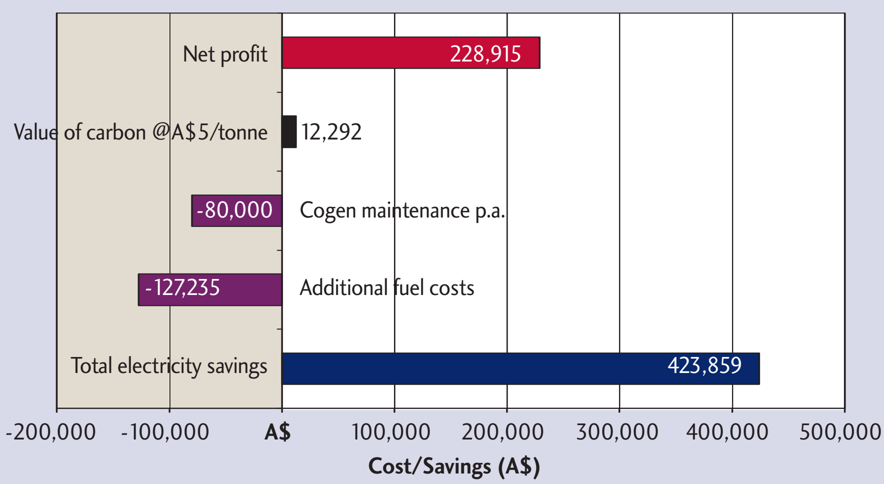

Figure 4: Blacktown Hospital cogeneration costs and savings.

This article is an adapted version of a paper presented at the 2008 National Conference of the Institute of Hospital Engineering, Australia (IHEA) – the contribution to the conference won the "Best Paper" award. The article has been published in *The Australian Hospital Engineer*, the journal of IHEA, and in *Health Estate Journal*, the publication of the Institute of Healthcare Engineering and Estate Management (IHEEM).