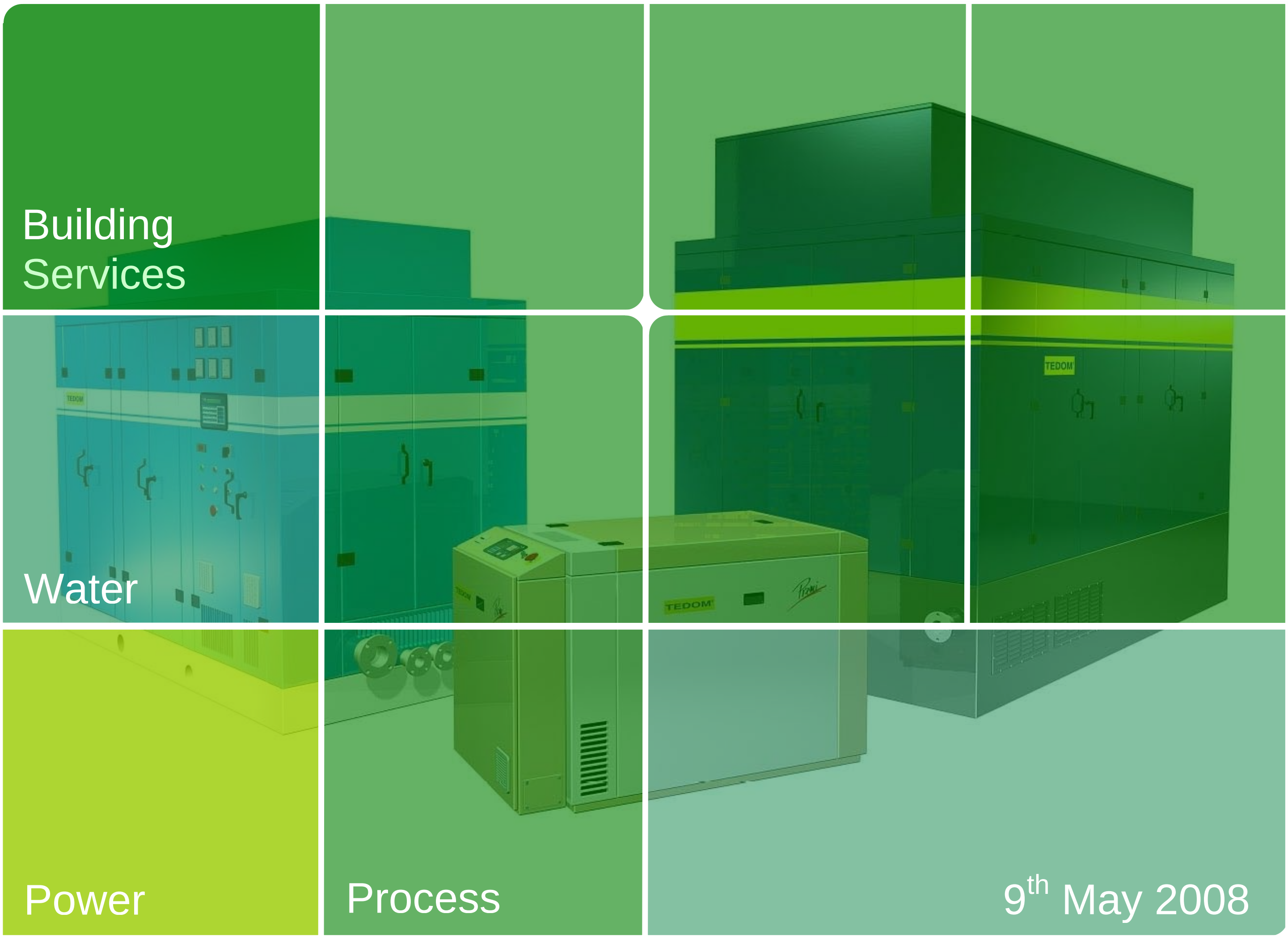

NSW Department of Planning – BASIX – Cogeneration Demonstration Project

Cambridge Apartments

Period Report:

Report 4 – 12th April 2008 to 9th May 2008

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Table of Contents

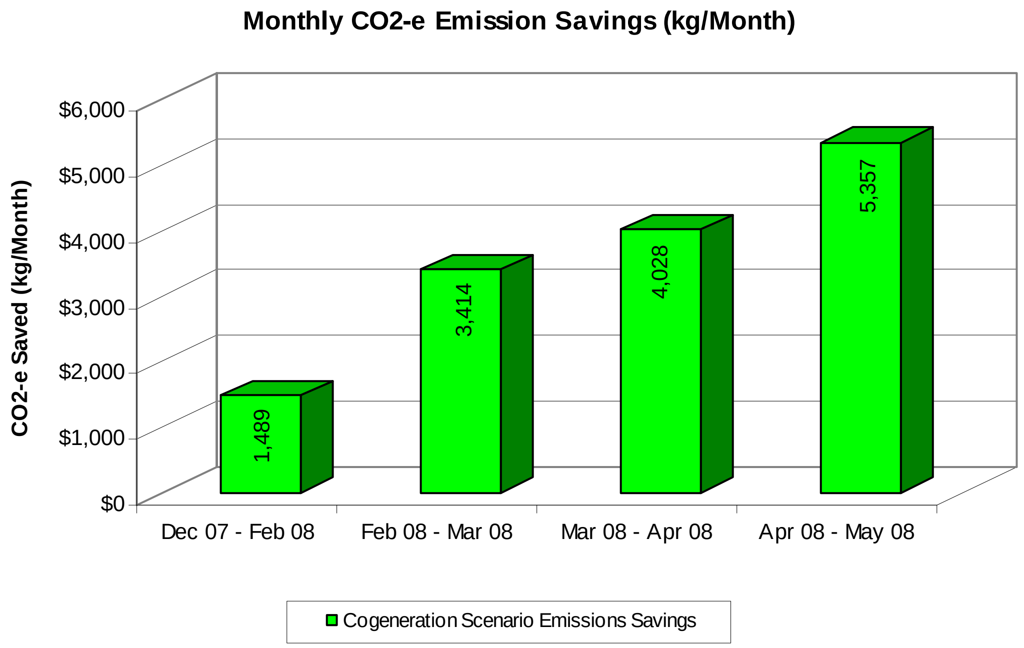
1 Executive Summary

This Report details the performance of the Tedom F25AP Cogeneration Unit installed at Cambridge Apartments, Chatswood for the period between the 9th of April and 12th of May, 2008 – a total of 28 days.

Building occupancy is close to 100%. However compared to the previous month the performance of the Cogeneration Unit has decreased, with Overall Efficiency (as a ratio of *fuel energy in* : *thermal* + *electrical energy out*) now at **76.71%**.

Use of the Cogeneration Unit during the Reporting Period saved a total of **4,932 kg CO2-e** as compared to a No-Cogeneration Scenario using solely Raypak Gas Boilers for Hot Water and importing Electricity from the grid.

Since Commissioning, the Cogeneration Unit has **saved a total of 15,612 kg CO2-e**. The Emissions Savings (kg CO2-e/month) of the Cogeneration Scenario compared to the No-Cogeneration Scenario is shown below:



For the Reporting Period, the Cogeneration Unit consumed a total of **2,427 m³** of Natural Gas and generated **6,402 kWh** of Electricity and **12,126 kWh** of Heat.

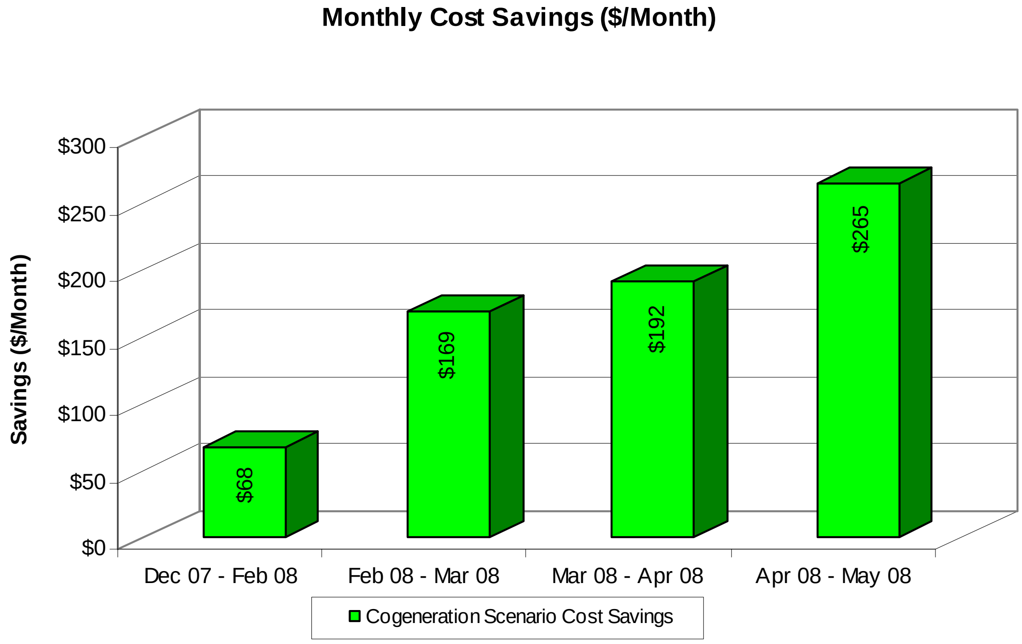
This gives the unit an **Electrical Efficiency** of **26.51%** and a **Thermal Efficiency** of **50.21%.** As stated earlier, the **Overall Efficiency** of the Cogeneration Unit is **76.71%**.

The electrical efficiency of the unit is consistent with previous months, however thermal efficiency has decreased from the previous month – but overall is reasonably consistent with previous months.

It is not wise to conclude on the nature of this decrease – and it is suggested that data is obtained for several more months to determine whether the previous month's thermal efficiency was erroneous or whether there are other factors at play.

In addition to Emissions Savings, the Cogeneration Unit also provides **Cost Savings** – saving a total of **$244** over the Reporting Period when compared to a No-Cogeneration Scenario.

Since Commissioning, the Cogeneration Unit has **saved a total of $753**. The Monthly Cost Savings of the Cogeneration Scenario compared to the No-Cogeneration Scenario is shown below:



With the current payback rate of **$265/Month**, it will take **58 Years** to pay back the $185,000 Installation Cost of the Tedom F25AP Cogeneration Unit. This is due to the Cogeneration Unit operating in the proportions of 8.70% Peak/50.72% Shoulder/40.58% Off Peak as well as the current price of Electricity (see **Data & Assumptions in the appendix**).

Since the previous month, the Hot Water setpoint temperature for the Cogeneration Unit has been altered to 65ºC – this has resulted in a slightly longer running time per day. Shortly, the Hot Water setpoint temperature for the Raypack boilers will also be altered – and this should hopefully yield efficiency gains for the Cogeneration Unit.

It should be noted **that if the Cogeneration Unit were to run** in the proportions of **80% Peak/15% Shoulder/5% Off Peak** and if the Electricity Price **were to increase** to 28c/kWh Peak (7c increase), 14.8c/kWh Shoulder (3c increase) and 8.1c/ kWh Off Peak (2c increase) – it would pay back the $185,000 Installation Cost within **13 Years** (less than the life of the unit).

Carbon Credits (including NGACs) have not been included in the analysis.

2 Analysis & Conclusion

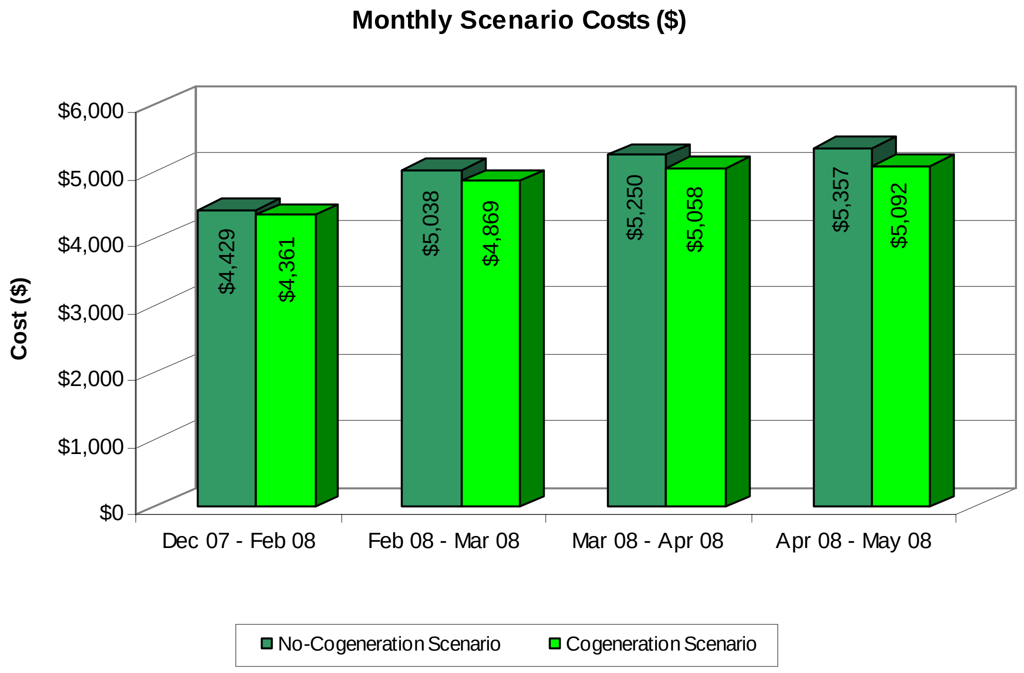
Due to improved data acquisition and more accurate figures, the Report Model has been improved and previous Report Figures have been adjusted.

This section analyses and concludes on the No-Cogeneration vs. Cogeneration Scenarios on the basis of Costs and Emissions. Analysis will be conducted on a Monthly timeframe using the Data from the Reporting Periods.

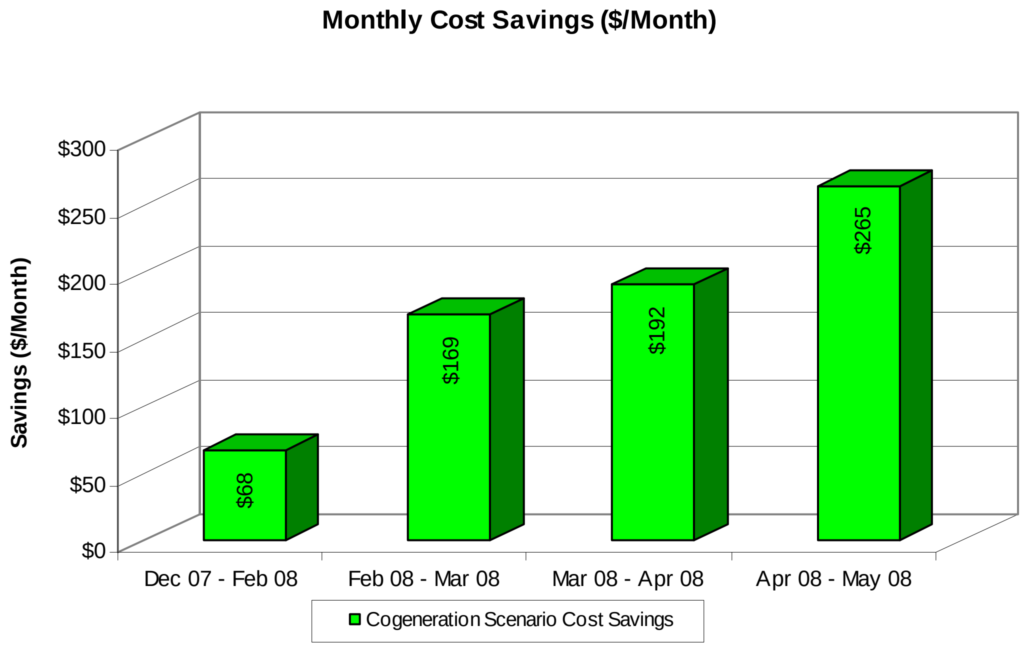
The costs, emissions and payback periods are shown on the subsequent pages.

2.1 Costs

Monthly Scenario Costs for the past three Reporting Periods are shown below.

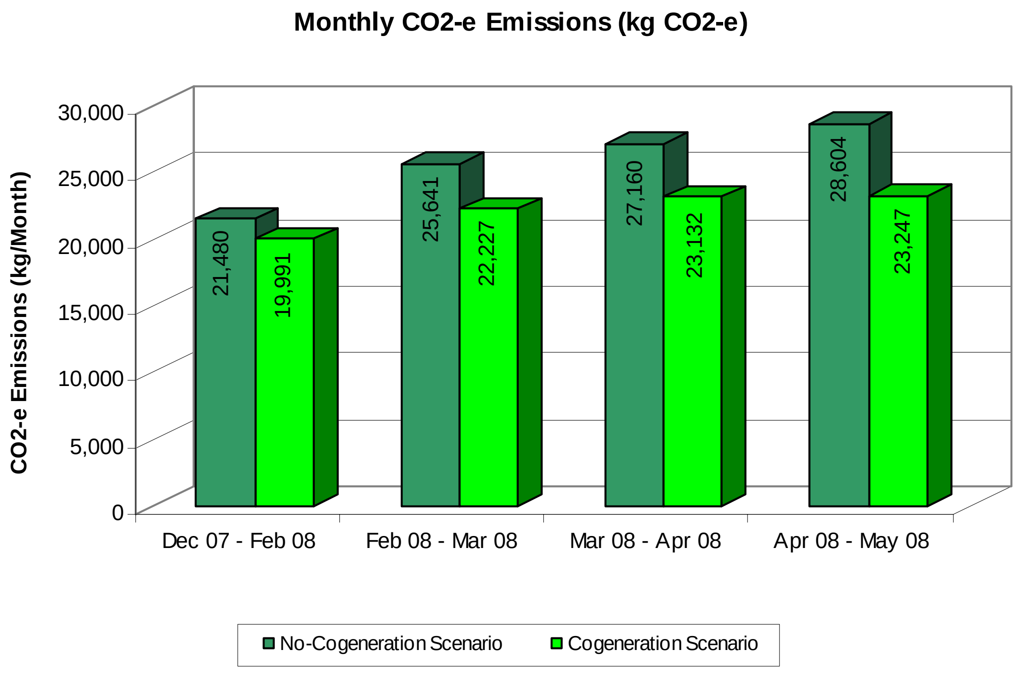


Savings per Month have increased during the past three Reporting Periods. The Cogeneration Unit was originally saving **$68/Month**, increasing to the current saving rate of **$265/Month** compared to the No-Cogeneration Scenario. This figure, whilst a significant increase from original savings, is still rather poor.

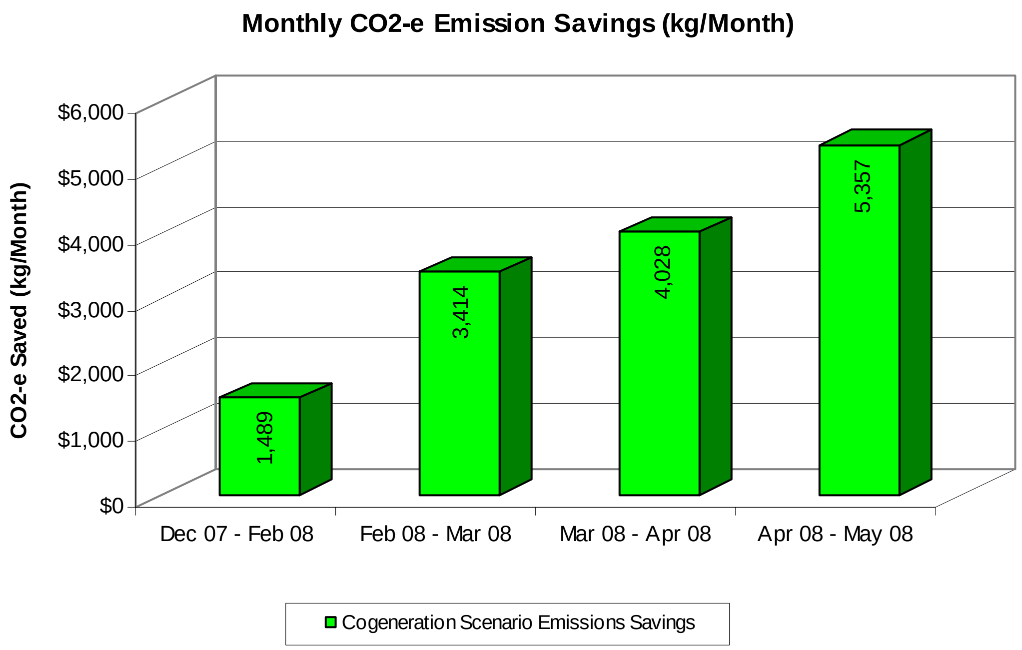


2.2 Emissions

The use of the Cogeneration Unit results in a significant CO2-e Emissions reduction (given the size of the unit). A comparison of the Monthly CO2-e Emissions for each Reporting Period is shown below:



Emission Savings per Month have increased during the past three Reporting Periods. The Cogeneration Unit was originally saving **1,489 kg CO2-e per Month**, increasing to the current saving rate of **5,357 kg CO2-e per Month** compared to the No-Cogeneration Scenario, this is a significant saving given the size of the Unit.



2.3 Payback Period

Since Commissioning, the Cogeneration Unit has **saved a total of $753.24** and **15,612 kg CO2-e**. The current payback period is **58 Years**, well beyond the lifespan of the unit.

This is due to the Cogeneration Unit operating in the proportions of 8.70% Peak/50.72% Shoulder/40.58% Off Peak as well as the current price of Electricity (see **Appendix 4 - Data & Assumptions**).

It should be noted **that if the Cogeneration Unit were to run** in the proportions of **80% Peak/15% Shoulder/5% Off Peak** and if the Electricity Price **were to increase** to 28c/kWh Peak (7c increase), 14.8c/kWh Shoulder (3c increase) and 8.1c/ kWh Off Peak (2c increase) – it would pay back the $185,000 Installation Cost within **13 Years**.

Whilst the Cost Saving and Payback Period is extremely poor, the Emissions Saving is significant.

2.3.1 Standard Installation Cost of Hot Water Boilers

The payback of the project can be reduced if the unused hot water system is reduced. The cogeneration unit was installed with the option to turn it off and run on a standard 100% redundancy hot water system.

Future installations should incorporate the cogeneration into the system and hence reduce the size and cost requirements of the hot water system. Sizing the cogeneration unit for the total building needs will result in economies of scale in some applications.

2.3.2 Solar

Initial solar thermal heating on the site reduces the heat requirements for the cogeneration unit with the result that the cogeneration unit savings are reduced.

2.4 Carbon Credits

There **exists the option** for Carbon Trading through the New South Whales Greenhouse Abatement Scheme using certificates known as New South Whales Greenhouse Abatement Certificates (**NGACS**) – NGACS are credited **per Tonne of CO2-e saved** (tCO2-e) – current credit prices are estimated to be approximately $6 per Tonne CO2-e (tCO2-e).

It should be noted however that trading through this scheme would result in savings of only **$385 per year**.

Currently, with **uncertainty in Carbon Tax and Trading Schemes** imposed by the Australian Government, this result does not reflect highly on the advantages of operating a Cogeneration Unit.

This may change in the future with the introduction of a Carbon Tax or Carbon Trading Scheme – where Carbon Credits would be awarded to those who can reduce or offset their Carbon emissions.

2.5 Conclusion

Since the previous month, the Hot Water setpoint temperature for the Cogeneration Unit has been altered to 65ºC – this has resulted in a slightly longer running time per day. Shortly, the Hot Water setpoint temperature for the Raypack boilers will also be altered – and this should hopefully yield efficiency gains for the Cogeneration Unit.

Since Commissioning, the Cogeneration Unit has **saved a total of $753.24** and **15,612 kg CO2-e**. The current payback period is **58 Years**, well beyond the lifespan of the unit.

Whilst the Cost Saving and Payback Period is extremely poor, the Emissions Saving is significant for the size of the unit.

Taking the savings-to-date and applying the current saving rates for CO2-e and Cost Savings, it is projected that the Cogeneration Unit will have saved **$3,180** and **64,000 kg CO2-e** by the end of December 2008.

It is thus recommended to;

- Set Cogeneration and Gas Boiler Systems to run at **appropriate times**, i.e. Cogeneration Systems should be operated in Peak times wherever possible, in order to **maximise cost savings**.
- **Size** Cogeneration and Gas Boiler Systems **appropriately** according to the building they are installed in in order to ensure the units **run at maximum efficiency** and produce a **higher emission offset** compared to not using Cogeneration.
- Keep the **Emission Savings potential**, both as **Environmental** (kg/CO2-e emitted) and **Financial** (Carbon Credits Traded), in mind when considering the **long-term benefits** of operating a Cogeneration Unit.

3 Appendices

Appendix 1 - No-Cogeneration Scenario

Appendix 2 - Cogeneration Scenario

Appendix 3 - Definitions

Appendix 4 - Data & Assumptions

1 No-Cogeneration Scenario

The No-Cogeneration scenario comprises of two (2) Raypak Gas Boilers providing hot water and Energy Australia providing Electricity to the Cambridge Apartment Building.

For the purpose of this report – the No-Cogeneration Scenario uses Gas Consumption figures from the Raypak Gas Boilers, adjusted by the No-Cogeneration Scenario Gas Multiplier.

Electricity Consumption is equated to the Electricity Generated by the Tedom F25AP Cogeneration Unit.

Gas Rates and Electricity Rates are priced according to the prices specified in **Appendix 4 – Data & Assumptions.**

1.1 Performance

This section details the Performance statistics of the Raypak Gas Boilers, using the No-Cogeneration Scenario Gas Multiplier (see **Appendix 4 – Data & Assumptions**) and the Electricity Consumption equated to that generated by the Tedom F25AP Unit.

As shown below, for the current Reporting Period the No-Cogeneration Scenario would produce a Gas Consumption figure of 162,569 MJ and an Electricity Consumption figure of 6,402 kWhe.

Raypak Gas Boiler Unit Operational Statistics		
Parameter	**Units**	**Value**
Unit Gas Supply Statistics		
Previous Meter Reading	m^3	19,782
Current Meter Reading	m^3	4,239
Cumulative Gas Consumption	m^3	24,020
Period Gas Consumption	MJ	162,569

Energy Australia Electricity Consumption Statistics		
Parameter	**Units**	**Value**
Electricity Consumption Statistics		
Previous Period Electricity Consumed	kWhe	14,051
Current Period Electricity Consumed	kWhe	6,402
Cumulative Electricity Consumed	kWhe	20,453

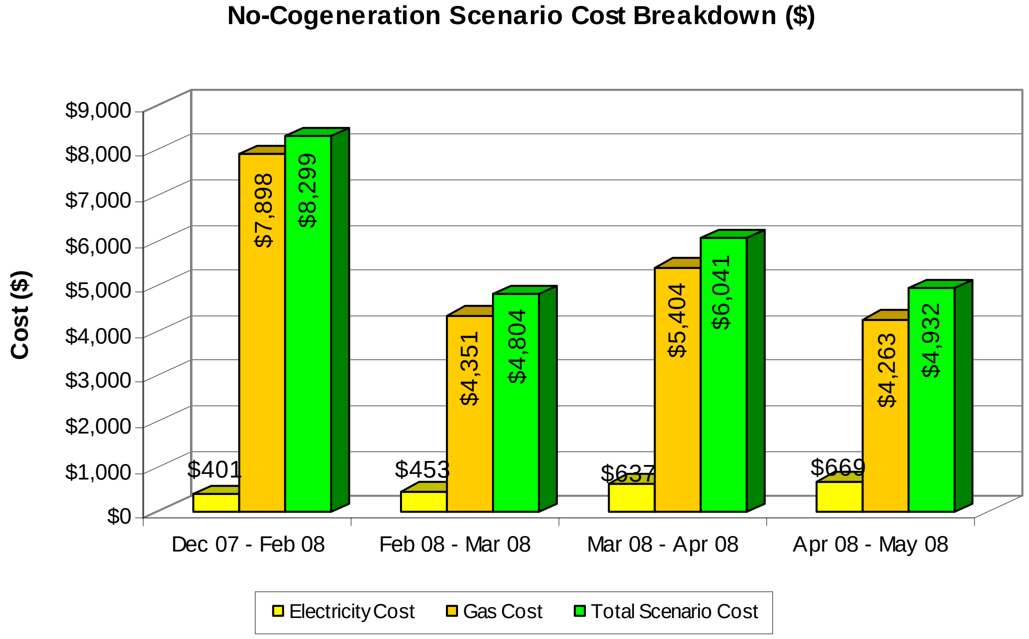
1.2 Costs

Using the data outlined in **Performance**, the No-Cogeneration Scenario Costs were calculated for the Current Reporting Period.

As shown below, for the current Reporting Period the No-Cogeneration Scenario would have produced a Gas Cost of $4,262.81 and an Electricity Cost of $668.81. This gives a Total Scenario Cost of $4,931.62.

No-Cogeneration Scenario			
Parameter	**Units**	**Value**	
Gas Costs			
Gas Supply Fee	$	$	22.50
Gas Rate	$/MJ	$	0.014
Period Gas Cost	$	$	4,262.81
Energy Australia Electricity Costs			
Electricity Supply Fee	$	$	28.61
Electricity Rates			
Peak	$/kWh	$	0.212
Shoulder	$/kWh	$	0.112
Off Peak	$/kWh	$	0.061
Electricity Cost	$	$	668.81
Total Scenario Cost	$	$	4,931.62

No-Cogeneration Scenario Costs for previous and current Reporting Periods are shown below.



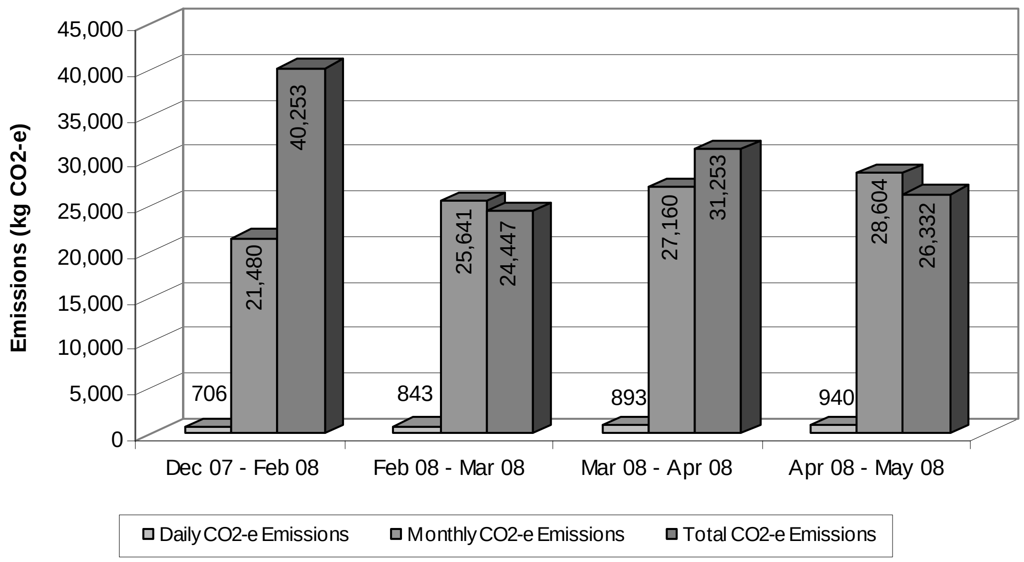
1.3 Emissions

Using the assumed emissions factors for Natural Gas and Electricity, the No-Cogeneration scenario produces an average of 940 kg CO2-e per day during the Reporting Period.

No-Cogeneration Scenario		
Parameter	**Units**	**Value**
Natural Gas Emissions Factor	kg CO2-e/GJ	65.5
Electricity End Use Emissions Factor	kg CO2-e/kWh	1.06
Daily Emissions Produced	kg CO2-e/Day	940
Monthly Emissions Produced	kg CO2-e/Month	28,604
Period Emissions Produced	kg CO2-e	26,332

The Total Emissions produced during the Reporting Period would have been 26,332 kg CO2-e, an average of 28,604 kg CO2-e a month. The No-Cogeneration Scenario Emissions for previous and current Reporting Periods are summarised below:

No-Cogeneration Emissions (kg CO2-e)



1.4 Summary

For the period of Report 3, No-Cogeneration Scenario Gas Consumption and Electricity Consumption would have been 162,569 MJ and 6,402 kWhe respectively. The Gas Cost and Electricity Costs would have been $4,262.81 and $668.81 respectively – giving a Total Scenario Cost of $4,931.62.

On the Emissions front, the No-Cogeneration Scenario would have produced 26,332 kg CO2-e during the Reporting Period, an average of 940 kg CO2-e per day.

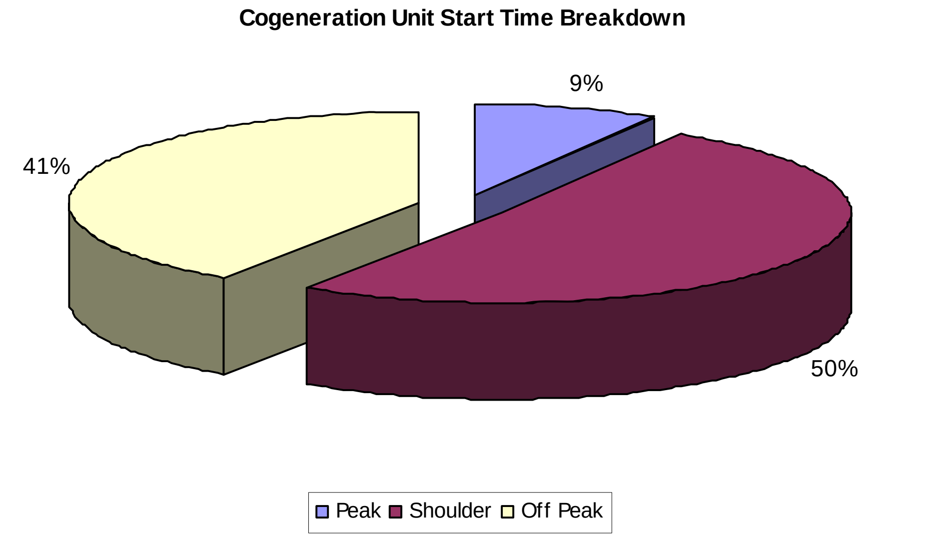
2 Cogeneration Scenario

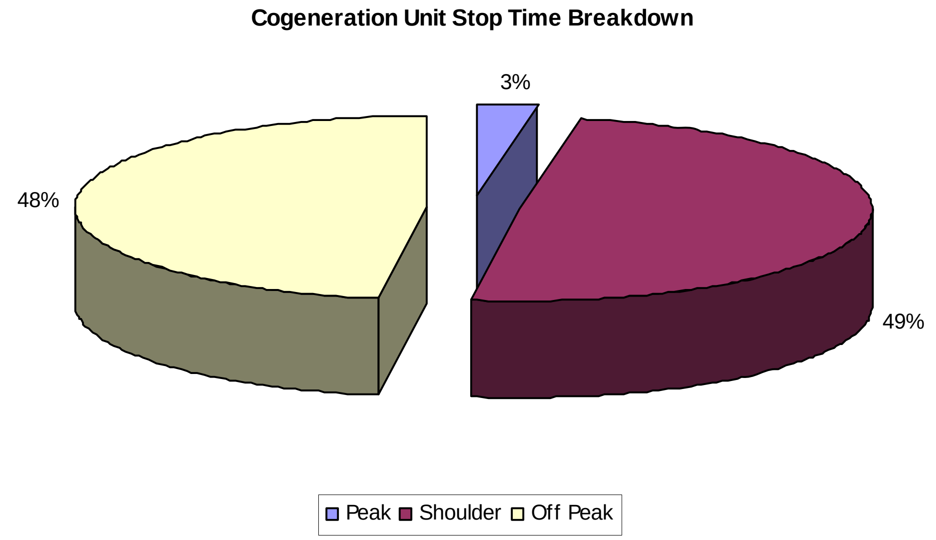
The Cogeneration Scenario comprises of one (1) Tedom F25AP Gas Cogeneration Unit, generating Electricity and a proportion of the hot water for the site, with the remainder of the hot water required being generated by two (2) Raypak Gas Boilers.

Data from the Cogeneration Unit is received directly through the use of a PC/Software Remote Interface, providing full operational statistics for the Unit. Gas Meter Readings are physically taken on site at approximately the same time as the Unit Statistics are downloaded.

The Cogeneration Unit has been noted to be operating primarily during Shoulder and Off Peak times – giving this scenario a distinct disadvantage compared to the No-Cogeneration scenario. It is recommended to alter the operating times and duration so that the Unit primarily operates during Peak times.

The breakdown of current operating times is outlined in **Appendix 4 – Data & Assumptions** and the pie charts below.





2.1 Performance

This section details the Performance Statistics of the Tedom F25AP Gas Cogeneration Unit and the Raypak Gas Boilers.

For the Reporting Period, the Cogeneration Unit consumed a total of 2,427 m^3 of Natural Gas. Similarly, the Unit produced a total of 6,402 kWhe of Electricity and 12,126 kWhr of Heat.

These figures give the Unit a Period Electrical Efficiency of 26.51% and Period Thermal Efficiency of 50.21%. Period Overall Unit Efficiency is thus 76.71%.

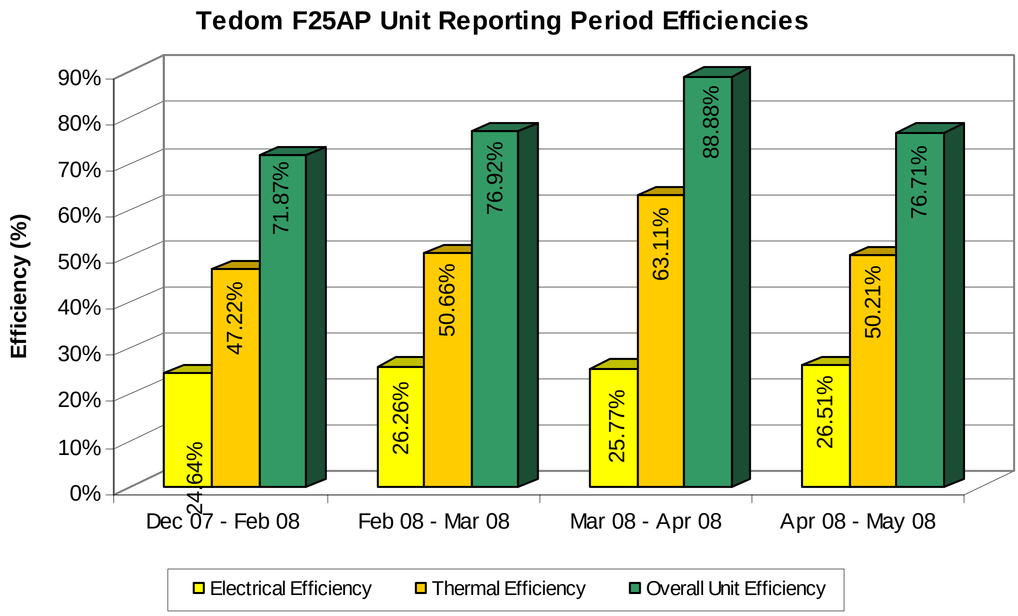
Tedom F25AP Cogeneration Unit Operational Statistics		
Parameter	**Units**	**Value**
Unit Energy Production		
Previous Period Electricity Produced	kWhe	14,051
Current Period Electricity Produced	kWhe	6,402
Cumulative Electricity Produced	kWhe	20,453
Period Electrical Efficiency	%	26.51%
Cumulative Electrical Efficiency	%	25.88%
Previous Period Heat Produced	kWhr	30,221
Current Period Heat Produced	kWhr	12,126
Cumulative Heat Produced	kWhr	42,347
Period Thermal Efficiency	%	50.21%
Cumulative Thermal Efficiency	%	53.58%
Period Overall Unit Efficiency	%	76.71%
Cumulative Overall Unit Efficiency	%	79.46%
Unit Gas Supply Statistics		
Previous Meter Reading	m^3	5,514
Period Gas Consumption	m^3	2,427
Current Meter Reading	m^3	7,941
Period Gas Consumption	MJ	93,073
Gas Supply Pressure	kPa	2.00
Unit Running Statistics		
Total Running Hours	Hrs	901
Total Commissioning Hours	Hrs	70
Number of Starts	No	435
Maintained Secondary Water Temp	ºC	59
Average Exhaust Temp Prior to HE	ºC	620
Average Exhaust Temp After HE	ºC	166

Since beginning Operation, the Unit has consumed 7,941 m³ of Natural Gas and generated 20,453 kWhe of Electricity and 30,221 kWhr of Heat.

These figures give the Unit a Cumulative Electrical Efficiency of 25.88% and Cumulative Thermal Efficiency of 53.58% - with the Cumulative Overall Efficiency being 79.46%.

The Unit has operated for a total of 901 Hours, of which 70 Hours were for commissioning.

The Unit Reporting Period Efficiencies for previous and current Reporting Periods are shown below:



As can be seen, the Efficiency of the Unit has remained fairly consistent since Commissioning was undertaken; however there is a discrepancy in relation to thermal efficiency for the previous month. This is discussed in the main body of the report.

Raypak Gas Boiler Unit Operational Statistics		
Parameter	**Units**	**Value**
Unit Gas Supply Statistics		
Previous Meter Reading	m³	28,430
Current Meter Reading	m³	6,092
Cumulative Gas Consumption	m³	34,522
Period Gas Consumption	MJ	233,643

In addition to the gas used by the Cogeneration Unit, the Raypak Gas Boilers consumed 233,643 MJ of gas, giving a total Gas Consumption of 326,716 MJ.

2.2 Costs

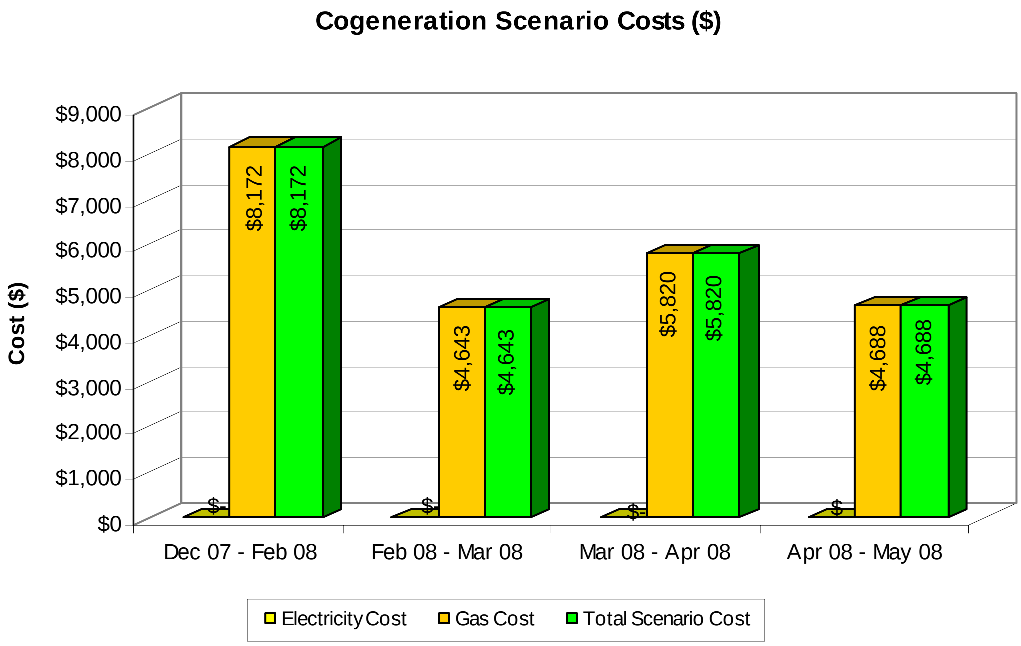
The Cogeneration Unit Installation Cost was $185,000 for the complete project including engineering, installation and commissioning.

The initial 12 months maintenance is covered by the defects liability period and thus there are no extra costs in this regard.

For the Reporting Period, the Cogeneration Scenario Total Cost was $4,687.64 – with this being entirely attributed to Gas Costs.

Cogeneration Scenario		
Parameter	**Units**	**Value**
Gas Costs		
Gas Supply Fee	$	$ 22.50
Gas Rate	$/MJ	$ 0.014
Period Gas Cost	$	$ 4,687.64
Total Scenario Cost	$	$ 4,687.64

Cogeneration Scenario Costs for previous and current Reporting Periods are shown below:



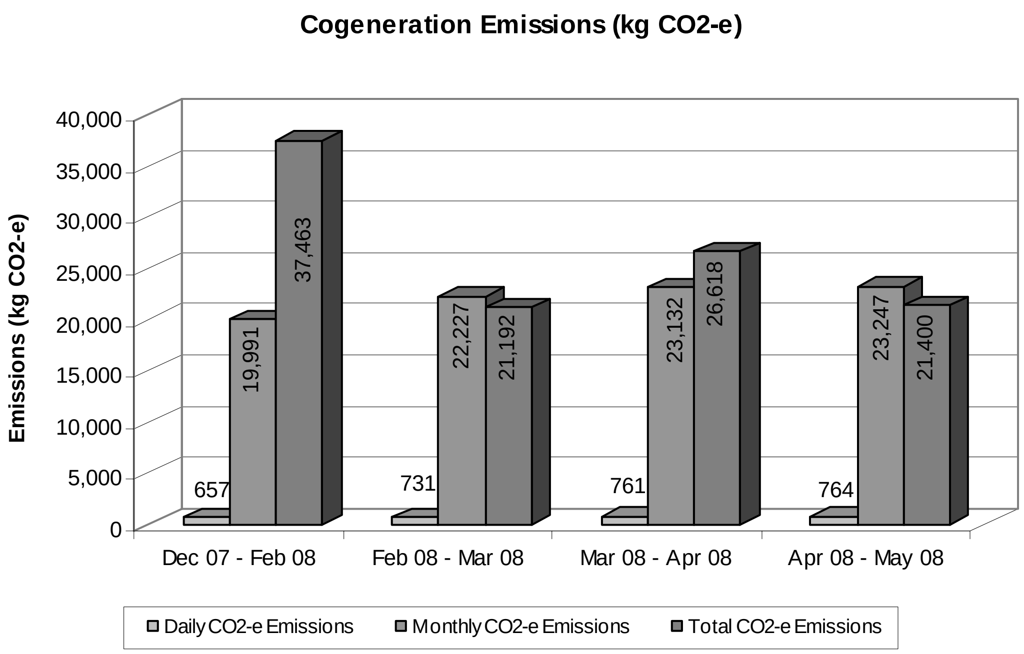
2.3 Emissions

Using the assumed emissions factors for Natural Gas and Electricity, the Cogeneration scenario produced an average of 764 kg CO2-e per day during the Reporting Period.

Cogeneration Scenario		
Natural Gas Emissions Factor	kg CO2-e/GJ	65.5
Daily Emissions Produced	kg CO2-e/Day	764
Monthly Emissions Produced	kg CO2-e/Month	23,247
Period Emissions Produced	kg CO2-e	21,400

The Total Emissions produced during the Reporting Period was 21,400 kg CO2-e, an average of 23,247 kg CO2-e a month.

The Cogeneration Scenario Emissions for previous and current Reporting Periods are summarised below:



2.4 Summary

For the period of Report 4, the Cogeneration Unit had a Period Electrical Efficiency of 26.51% and Period Thermal Efficiency of 50.21%. Period Overall Unit Efficiency was thus 76.71%

Cogeneration Scenario Gas Consumption was 326,716 MJ. The Gas Cost was $4,687.64 – equal to the Total Scenario Cost.

On the Emissions front, the Cogeneration Scenario produced 21,400 kg CO2-e during the Reporting Period, an average of 764 kg CO2-e per day.

3 Definitions

Commissioning – To install and make ready for service or use through operational testing and if necessary, performance or operational parameter adjustment.

HHV – Higher Heating Value, (MJ/m^3) - the amount of heat released by a specified quantity of Gas (initially at 25 °C) once it is combusted and the products have returned to 25 °C. HHV also assumes that the latent heat of vaporization of water in the fuel and reaction products is recovered.

Joule – A unit of energy equal to the work done when a 1 Newton force acts through a distance of 1 meter.

kW – kilo Watt, A unit of power equal to 1,000 Watts.

kPa – kilo Pascal, A unit of pressure equal to 1,000 Pascals.

LHV – Lower Heating Value, (MJ/m^3) - the amount of heat released by a specified quantity of Gas (initially at 25 °C) once it is combusted and the products have returned to 150 °C. LHV also assumes that the latent heat of vaporization of water in the fuel and reaction products is not recovered.

MJ – Mega Joule, A unit of energy equal to 1,000 Joules.

Month – 30.4167 Days**.**

Newton – A unit of force required to accelerate a 1 kilogram (kg) mass by 1 meter per second squared.

Overall Unit Efficiency – A measure of Electrical and Thermal (Heat) Energy output as a percentage of Fuel Energy input.

Pascal – A unit of pressure equal to 1 Newton per Square Meter.

Total Efficiency – See **Overall Unit Efficiency**.

Watt – A unit of power equal to one Joule per second.

4 Data & Assumptions

Electricity:

- Electricity Rates are based on the Energy Australia "Loadsmart" pricing scheme as provided by Mirvac.
- The assumed Electricity Supply Cost is $28.61 with assumed Electricity Rates of 21.2 cents/kWh Peak, 11.2 cents/kWh Shoulder, 6.1 cents/kWh Off Peak.

Gas:

- Gas Rates are based on the AGL "Industrial and Commercial Rate" pricing scheme as provided by Mirvac.
- The assumed Gas Supply Cost is $22.50, with an assumed Gas Rate of $14.21 / GJ.
- The Cogeneration Gas Meter (EC143612) is a Sub-Meter of the 2 Main Gas Meters (06F903376, 06F903376).
- LHV is assumed to be 35.83 MJ/m³.
- HHV is assumed to be 38.35 MJ/m³ as per the AGL bill dated 11.02.08, provided by Mirvac.

Emissions:

- Natural Gas Emissions factor is assumed to be 65.5 as per the Australian Government Department of Climate Change, February 2008 – *National Greenhouse Accounts (NGA) Factors*, Section 1.1.1, Table 2.
- Electricity End Use Emissions factor is assumed to be 1.06 kg CO2-e/kWhe as per the Australian Government Department of Climate Change, February 2008 – *National Greenhouse Accounts (NGA) Factors*, Section 1.4, Table 5.

No-Cogeneration Scenario:

- The No-Cogeneration Scenario assumed Electricity Rate times (Peak, Shoulder, Off Peak) are based on the Energy Australia "Loadsmart" pricing scheme.
- No-Cogeneration Scenario Electricity Costs have been allocated on the basis of Cogeneration Unit Start/Stop times. The breakdown for these allocations is 8.70% Peak, 50.72% Shoulder and 40.58% Off Peak.
- Raypak Boiler Thermal Efficiency is taken as 80.69%.
- No-Cogeneration Scenario Gas Multiplier (difference in efficiencies between Cogeneration & No-Cogeneration Scenarios) is taken as 0.6958.

Cogeneration Scenario:

- Generated Heat (kWhr) is calculated on the basis of the Tedom F25AP Manufacturer Specified 47.0 kWr output, multiplied by Unit Running Time (Hrs).
- Tedom Specified Efficiencies (based on LHV):

Operating Efficiencies & Outputs		
Tedom Specified Efficiencies		
Tedom Specified Electrical Efficiency	%	29.86%
Tedom Specified Thermal Efficiency	%	56.14%
Tedom Specified Overall Unit Efficiency	%	86.01%

- Cogeneration Unit Operating Times:

Cogeneration Unit Operating Time Data		
Parameter	**Units**	**Value**
Start Times		
Peak	%	8.70%
Shoulder	%	50.72%
Off Peak	%	40.58%
Stop Times		
Peak	%	2.90%
Shoulder	%	49.28%
Off Peak	%	47.83%