George Manning Heritage Lifecare

Heat-pump Water Heater
Decarbonisation Report

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Decarbonised
Energy Solutions

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EXECUTIVE SUMMARY

George Manning is a Heritage Lifecare aged care facility in Christchurch.

The site's combined electricity and diesel cost in the 2021/2022 year was $252,270, with an associated carbon emission of 260 tonnes of CO^2 per year.

A decarbonisation project completed by Decarbonised Energy Solutions, has converted the diesel space-heating and resistance (electric) heated domestic water heating to variable-flow heat-pump water heating systems.

As part of the project, Sunshine Solar was commissioned to install a 25 kWp solar PV system. This was commissioned in late June 2022.

During the 10.5 months to date, which covers commissioning of the Solar PV system and the DHW and Space Heating heat-pumps, electricity usage has been reduced by 72,000 kWh at a value of $14,300, with 32,000 kWh produced by the solar panels.

The Space Heating diesel boiler was removed in November 2022, and since then the site has avoided diesel usage of 33,000L compared to the same period a year earlier. At current diesel prices (approx. $1.80/L), this has a value of $62,000.

It is expected that the reduction in energy cost by the project will approximate $135,000 per year.

Site-wide carbon emissions have reduced by 75%. A reduction of 97% has been observed for the heating system.

EXECUTIVE SUMMARY

BACKGROUND

George Manning Resthome is an aged care hospital facility operated by Heritage Lifecare in Christchurch. Decarbonised Energy Solutions was contracted to provide a low carbon solution for the space and water heating systems for the main hospital building. As part of the project, the inconsistency of the hot-water temperature at the outlets was to be resolved.

Decarbonised Energy Solutions specialises in the design and installation of variable flow heat-pump technology and was established to develop demonstration projects based on this technology with the broader aim to main-stream the technology with cost-effective application. Variable flow heat-pumps differ significantly from conventional heat-pumps (and other boiler systems) by removing the primary circulation loop in conventional primary / secondary heating systems. In variable flow designs, the water flow-rate is used to control the heating demand of the building. Conventionally, the primary and secondary flow-rates are fixed flow.

EXISTING SYSTEM

The domestic hot water system was based on an 8,000 L thermal store, with 100 kW of resistance elements configured to use off-peak electricity.

Space heating was provided by radiators throughout the building heated by a 400 kW boiler supplied with a 20% biofuel : 80% diesel blend. The diesel boiler also provided heating for tempered fresh air systems for the kitchen and the corridors in the main building.

In the 12 months prior to removal, the boiler used $154,546 of diesel (80,000L), with an additional maintenance cost. The thermal store operating cost is not metered separately from the rest of the electrical demand from the building. The heating elements were connected via a ripple control receiver to access off-peak tariffs.

The building had a history of erratic hot water temperatures at some of the outlets, and at times, hot water not available at outlets. The boiler also was requiring significant maintenance to maintain operation with several heating outages during winter 2022.

INSTALLED SYSTEM - STAGE ONE

The first stage of the project was carried out in June 2022 and installed a 25 kWp solar PV system by Sunshine Solar.

Following the PV installation, the thermal store domestic hot water system was replaced by a prefabricated hot water module heated by a single-pass heat-pump water heater.

The Decarbonised Energy Solutions Domestic Hot Water Module allowed rapid re-establishment of hot water service with minimal on-site plumbing work required to connect to the existing heated water system.

This allowed the reallocation of the 100 kW electrical supply from the thermal store to supply the space heating heat-pump water heaters.

Decarbonised Energy Solutions' Domestic Hot Water Module for reticulated hot water service

INSTALLED SYSTEM - STAGE TWO

Stage two of the project decommissioned the 400 kW diesel boiler at the conclusion of the 2022 heating season, removed the then redundant diesel storage tank and installed 4 x 90 kW Variable Flow heat-pump water heaters with associated controls. Fan coil upgrades, and an associated project to clean the ducting network was completed in April 2023, with the full system commissioned at this time.

Decarbonised Energy Solutions'
Magnus Variable Flow Water Heaters - Space Heating System,
installed at George Manning Lifecare & Village

Final system optimisation will occur during the last week of June 2023, subject to suitable weather conditions for this process, at the time.

The system is real-time energy performance monitored allow remote tuning and optimisation of the system using the **In-Control Remote Monitoring** platform.

COMMISSIONING

When the new domestic water heating system was first commissioned it was readily apparent that there was limited cold water being drawn through the storage tanks, despite hot water being available at the outlets. The pre-existing erratic hot water delivery, particularly in the morning, was exacerbated by the new system. A systematic approach to understanding what was causing this found the high temperature (sanitary) hot water system was back-feeding into the intermediate temperature heated loop due to an incorrectly set cold water pressure gauge in the roof-space combined with a failed check (non-return) valve. Essentially the 8000L thermal storage tank has been maintained at 80^{o}C since installation, with very limited hot water drawn from it. Resolving the pressure imbalance between the two high and intermediate temperature systems to prevent the back-feeding has also resolved the erratic temperatures (too hot, and too cold) being experienced at the outlets.

The space heating system has commissioned to expectations. The heating demand on the system was relatively low prior to the replacement of the fan coils. With the colder weather and the tempered fresh air fan coils operational the heating demand is as expected.

ENERGY PERFORMANCE

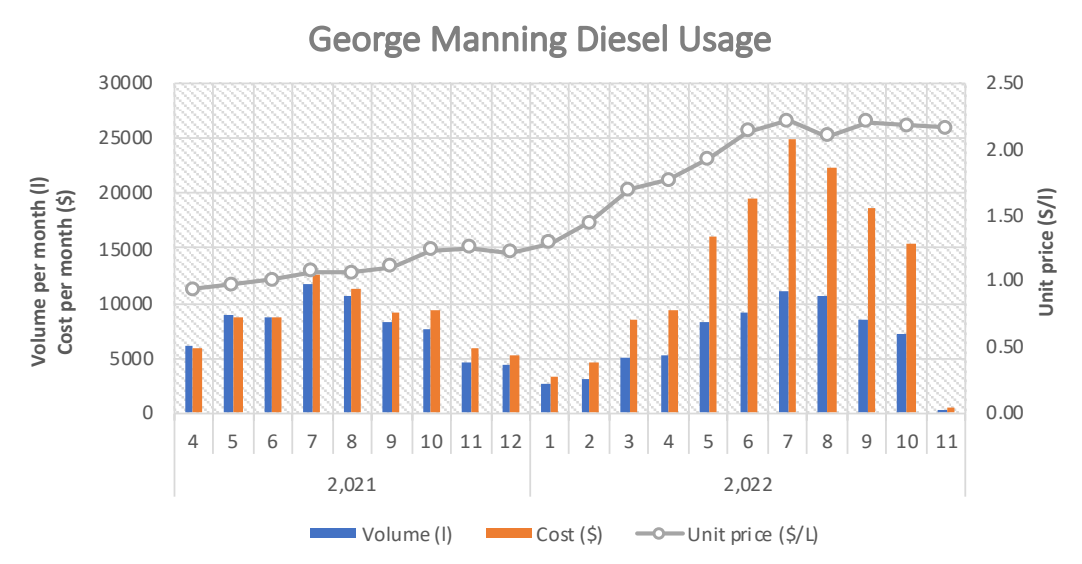
ENERGY PERFORMANCE COMPARISON

Prior to this decarbonisation project, the monthly energy usage was as follows:

Diesel use:

The boiler was fuelled with a 20% biodiesel blend with mineral diesel supplied by Southern Biofuels. During 2022 the price of diesel increased steadily due to both the Ukraine war and the increasing price of NZ Carbon Units on the Emissions Trading Scheme. A downward correction to both the carbon emission and diesel prices has been observed so far in 2023.

In total 79,943L of diesel were used in the 12 months prior to the boiler removal in November 2022, with a carbon emission of 166 tonnes CO2.



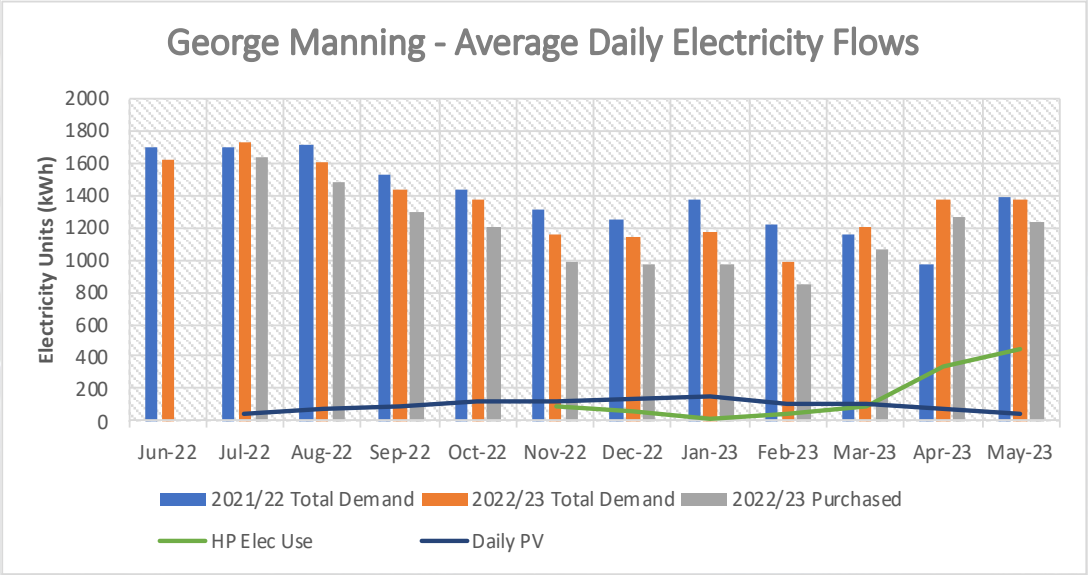
Graph showing Diesel volume consumed, unit cost and monthly cost of consumption at George Manning Lifecare & Village

Electricity Use:

The electricity usage for George Manning is shown below for the 2021 – 2023 period. The data is provided monthly from utility bills. Since the installation of the solar PV system, there have been some periods where electricity use has been aggregated across multiple months. This makes a direct before / after analysis more challenging. The data has therefore been presented based on daily average usage for each month as this allows the different billing periods to be accounted for.

Also plotted, is the electricity usage by the heat-pumps and the electricity generation from the solar PV system. This allows impact of the electrification of the system on the total electricity usage.

At the time of writing, the monthly electricity usage has been lower than the prior equivalent period for all but April 2022. The May 2023 electricity bill covered just 4 days up to the date data analysis was carried out, making the data unlikely to be representative of the month as a whole.



Graph showing Reduced Total Electricity Demand when comparing 2021/2022 and 2022/2023 a result of switch to Heat-Pump Water Heater systems, along with Solar PV Generation and Heat-Pump Consumption.

ENERGY PERFORMANCE

With the 2023 heating season now underway, the increasing electricity usage by the heat-pumps is evident, however to date the site electricity usage remains lower than the equivalent period in 2022. Since the boiler has been replaced, there has been an avoided cost of diesel of $37,000.

The avoided electricity usage is approximately 72,000 kWh since July 2022, at an approximate value of $14,300 (referencing an average of the peak and off-peak tariffs). The increase in the electricity tariff reduces the difference in year-on-year electricity charges to $9,700.

The solar PV panels have generated 32,000 kWh of electricity since installation in late June 2022, and are expected to generate 33,500 kWh over 12 months. This electricity offsets the higher day-time electricity tariff of 23.4 c/kWh.

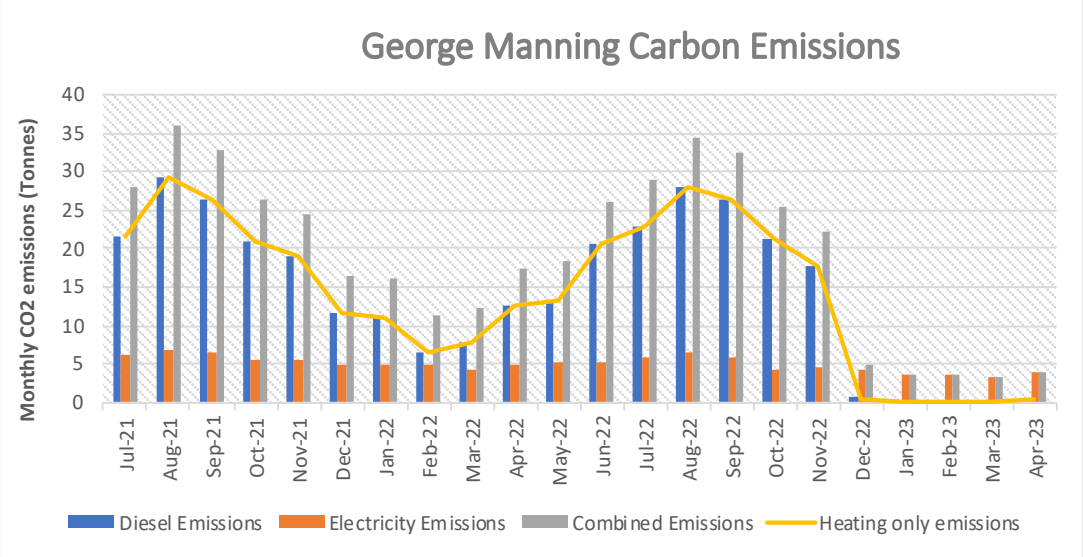
	Total kWh	Cost ($)	Average Tariff	No. of days
29/06/21 – 28/06/2022	519,612	98,274	18.9 c/kWh	365
29/06/2022 – 10/05/2023	386,083	76,445	19.8 c/kWh	315
Normalised Savings for year	72,246	14,304		

Carbon Emissions:

In the year to November 2022, George Manning Resthome emitted 261 tonnes of CO2. The main contributor to emissions at George Manning Resthome was the diesel boiler.

Decommissioning the boiler has reduced the site carbon emissions by 75% and the emissions from the heating system by 98%.

The expected annual emissions for George Manning is 60 tonnes CO2, reducing the site emissions by 4000 tonnes over the 20 year expected life of the heat-pumps.



Graph showing Carbon Emissions at the George Manning Site and the significant reduction mostly as a result of conversion away from diesel heating in favour of the Heat-Pump Water Heater Systems (visible Nov. - Dec. 2022).

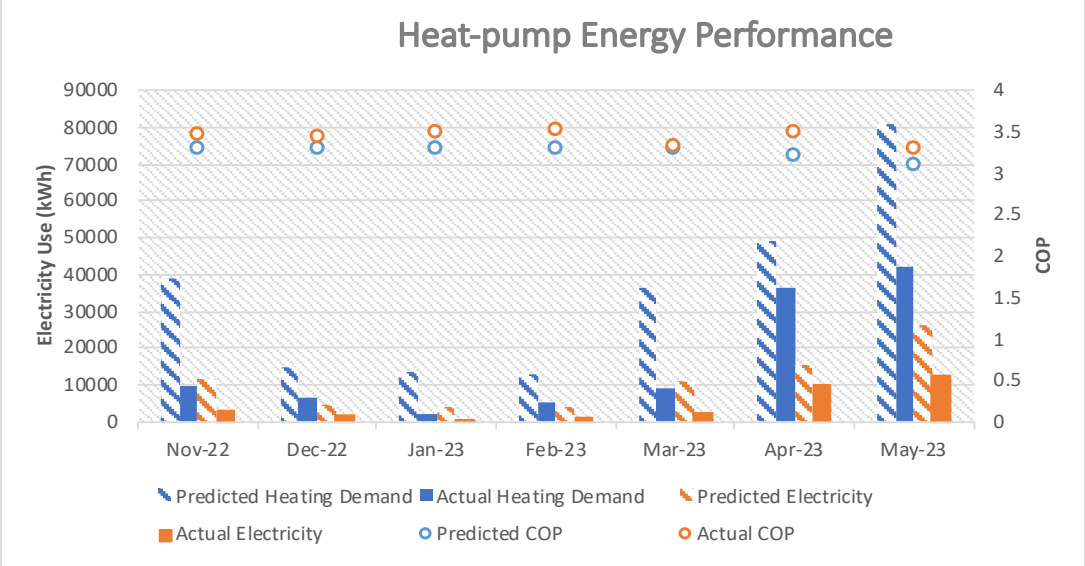
ENERGY PERFORMANCE

FORECASTED SAVINGS

The modelled Energy Performance for the space heating system at George Manning predicted an annual energy saving of $61,000 for the year at a heat-pump co-efficient of performance (COP - Energy delivered / energy used) of 3.0.

Since November 2022 the actual heat demand has been substantially less than predicted by the model. This is particularly the case in March as the fresh air ventilation system was out of service for cleaning.

The monthly COP is tracking slightly higher than what was modelled for the system.



Graph showing system efficiency is better than the Energy Modelling had predicted.

The estimated hot water energy savings from the project was based on a daily usage of 5500L. It is not known what the actual hot water usage is, however it is estimated that in the order of 1500L per day is being drawn through the storage tanks. The remainder of the hot water demand is likely to be met by the ring-main reheat heat-pump also installed as part of this project.

At this stage of the heating season there is insufficient data to make an accurate assessment of what the annual energy savings will be from this project - however a estimated range can be provided.

	Units	Cost/unit	Energy cost ($)	2023 Costs
Diesel Spend	80000	$1.88	$150,400	-$150,000
Electricity Nov to May	32494	$0.198	$6,434	
Electricity Estimated Jun – Oct 2023	108585	$0.198	$21,500	$28,000
Solar 22 Jun – 10 May 20223	31000 kWh	$0.234 (day rate)	$7,254	
Solar Full year	33500 ext	$0.234 (day rate)	$7,839	-$7,839
Electricity usage to date (less solar generation)	- 38,000	$0.198	$7,600	-$7,600
Boiler Maintenance / compliance				?
Project savings (expressed as negative) expected per year.				**-$137,540**
Annual CO2 emissions reduction				**200 tonnes**
Project Cost				**$527,000**
Simple Payback				**4 years.**

Table showing Forecasted Cost Savings ($), CO2 Emissions Reductions (Tonnes) and Return on Capital Investment

The project is forecasted to reduce the site's CO2 Emissions by 200 tonnes per annum, provide $137,500 annual Operational Expense savings and offer a Return On Investment of four years.

At the time the Project Proposal was drafted, annual savings from this project were predicted to be $70,000 plus the boiler maintenance costs. Data received since commissioning and forecasts based on this data, strongly suggest the predicted savings were very conservative.

A follow-up report will be produced late in 2023 to present actual (not estimated) winter heating electricity usage from the system.

Both the solar PV system and the heat-pump systems have shown very similar Return On Investment.

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