Building Services Design Report
Canberra Hospital Strategic Masterplan Framework

Silver Thomas Hanley Pty Ltd

Revision E

Melbourne

Level 2
616 St Kilda Road
Melbourne, VIC 3004
P (03) 9230 5600

Sydney

Level 4
73 Walker Street
North Sydney, NSW 2060
P (02) 9157 0570

Brisbane

Level 9
490 Upper Edward Street
Spring Hill, QLD 4000
P (07) 3831 3300

Perth

72 St Georges Terrace
Perth, WA 6000
P (08) 9242 5857

Canberra

Level 2
1 Farrell Place
Canberra, ACT 2601
P 0475 750 608

Revision Information

Project	Canberra Hospital Strategic Masterplan Framework
Title	Building Services Design Report
Client	Silver Thomas Hanley Pty Ltd
Revision	E
Revision Date	30 November 2021
Prepared By	LCI Consultants Canberra Office Level 2 1 Farrell Place Canberra 2601
Author	LCI

Revision Schedule

Revision	Date	Issue Name	Author	Authorised
A	02.07.2021	Draft Report	LCI	CK
B	13.08.2021	Draft Report	LCI	CK
C	11.10.2021	Draft Report	LCI	CK
D	24.11.2021	Draft Report	LCI	CK
E	30.11.2021	Final Report	LCI	CK

Contents

1 Introduction

1.1 Project Description

The Canberra Hospital is undertaking master planning for their campus in Woden. The first phase of the project will develop a strategic master plan framework. This framework will include a high level plan to achieve net zero emissions and a supporting building services strategy.

1.2 Report Overview

This report addresses the following:

1.2.1 Net Zero Emissions Strategy

- Summary of the ACT climate change strategy and how this applies to the hospital campus.
- Current individual building natural gas and diesel use.
- Current natural gas and diesel used by other ACT government operations.
- Current CO_2 emissions.
- Summary of plant types in each building that will need to be replaced with electric plant.
- Reduction in natural gas and diesel use and associated CO_2 emissions as building are removed or re-purposed.
- Cost estimate for the plant to be replaced.

1.2.2 Building Services Strategy

- Existing engineering infrastructure.
- Recommended upgrade and staging summary to suite the master planning for the site.

2 Net Zero Emissions Strategy

2.1 ACT Climate Change Strategy

The ACT Government has an eight step climate change strategy. The objective is to achieve these steps by the end of 2025. The eight steps are:

1. Reduce staff travel needs by co-locating staff in centralised offices, providing facilities for teleconferencing, exploring co-working hubs and supporting flexible work arrangements and explore incentives to support staff use of public transport and active travel.
2. Ensure all new Government capital works with a budget of more than $10 million either seek or are consistent with an independent sustainability rating such as an Infrastructure Sustainability rating from the Infrastructure Sustainability Council of Australia (ISCA), or a Greenstar rating from the Green Building Council of Australia or equivalent, and review ratings at least every five years.
3. Join the Global Green and Healthy Hospitals network to improve sustainability performance and reduce emissions from ACT Health facilities
4. Establish and implement a pathway to a net zero emissions ACT Government health sector by 2040 informed by an assessment of all current and planned public health facilities.
5. Ensure all newly built or newly leased Government buildings and facilities are all-electric and climate-wise (where fit for purpose).
6. Replace all space and water heating systems in Government facilities with electric systems at the end of their economic lives (where fit for purpose).
7. Ensure all newly leased ACT Government passenger fleet vehicles will be zero emissions vehicles from 2020–21 (where fit for purpose)
8. Implement Canberra's Living Infrastructure Plan to work towards 30% urban canopy cover and 30% surface permeability, account for the value of living infrastructure and assess local needs for managing heat.

To ensure that electricity is carbon neutral the ACT Government has procured all electricity for the ACT through a power purchase agreement. The electricity is sourced from solar, wind and hydro-electric resources. The connection points into the ACT are via the three Transgrid zone sub-stations. To further improve the stability of the electrical supplies, the ACT Government is currently embarking on a battery storage system at the zone substation level. This improves stability and power quality.

2.2 Measured Emissions

The measured emissions measured in the ACT climate change strategy are those from electricity, natural gas and diesel on site; and petrol and diesel in fleet vehicles.

2.3 Actions for the Woden Campus

The direct actions from the ACT climate change strategy are:

1. Natural gas fuelled equipment to be converted to electric systems. This will require modifications to the campus electrical network.

2. Management of the withdrawal from natural gas and diesel and transition to zero emission fuel sources (electric or hydrogen).
3. Increased use of on-site and off-site photovoltaic and energy storage systems to reduce costs.
4. Mitigation of climate change effects through increased tree cover and surface permeability.

2.4 Hospital Natural Gas, Diesel, Petrol Use and CO_2 Emissions

The campus uses natural gas for the following:

- Domestic hot water.
- Air conditioning, heating plant.
- Sterilised steam generation.
- Cooking.

The existing campus has a network of natural gas meters; which are connected to the ACT Government's "Envizi" data reporting system. Base line year energy use / CO_2 emissions is calendar year 2019. Ideally it would be calendar year 2020; however, COVID-19 distorts the figures. The following information was gathered from the Envizi system:

Natural Gas (2019 Calendar Year)		
Building	**Annual GJ Consumed**	**CO_2 Emitted (Tonnes)**
Whole Site	139,381	7,164
Building One Hot Water Generators	74,039	3,806
Building Four Whole Building	379	20
Building Ten Whole Building	0	0
Building Eleven Hot Water Generators	17,505	899
Building Twelve Hot Water Generators	1,626	84
Building Twenty Five Whole Building	7,879	405

Table 2.1 – Typical Annual Natural Gas Use

The campus uses diesel and petrol for the following:

- Emergency generators.
- Fleet vehicles.

The following information was gathered from the Envizi system:

Diesel (2019 Calendar Year)		
	Annual kL Consumed	**CO_2 Emitted (Tonnes)**
Whole Site	75	203

Table 2.2 – Typical Annual Diesel Use

Petrol (2019 Calendar Year)		
	Annual kL Consumed	CO_2 Emitted (Tonnes)
Whole Site	165	393

Table 2.3 – Typical Annual Petrol Use

2.5 ACT Government Natural Gas, Diesel, Petrol Use and CO_2 Emissions

The ACT Government operations as a whole use natural gas and diesel for the following:

- Domestic hot water.
- Air conditioning, heating plant.
- Sterilised steam generation.
- Cooking.
- Emergency generators.
- Fleet vehicles.

The ACT Government operations include:

- Public health facilities.
- Public education facilities (primary, secondary and tertiary).
- Public transport facilities (buses and light rail).
- Public utilities.
- General offices.

The following information was gathered from the Envizi system:

Natural Gas (2019 Calendar Year)		
	Annual GJ Consumed	CO_2 Emitted (Tonnes)
Whole ACT Government	493,241	25,352

Table 2.4 – Typical Annual Natural Gas Use

Diesel (2019 Calendar Year)		
	Annual kL Consumed	CO_2 Emitted (Tonnes)
Whole ACT Government	12,967	35,286

Table 2.5 – Typical Annual Diesel Use

Petrol (2019 Calendar Year)		
	Annual kL Consumed	CO_2 Emitted (Tonnes)
Whole ACT Government	415	989

Table 2.6 – Typical Annual Petrol Use

2.6 Comparison and Reduction Targets

The following tables show the hospitals CO_2 emissions compared to the ACT Governments CO_2 emissions.

Natural Gas (2019 Calendar Year)			
	Annual GJ Consumed	CO_2 Emitted (Tonnes)	Percentage of Total
Whole ACT Government	493,241	25,352	100%
The Canberra Hospital	139,381	7,164	28%

Table 2.7 – Annual Natural Gas Use Comparison

Diesel (2019 Calendar Year)			
	Annual kL Consumed	CO_2 Emitted (Tonnes)	Percentage of Total
Whole ACT Government	12,967	35,286	100%
The Canberra Hospital	75	203	1%

Table 2.8 – Annual Diesel Use Comparison

Petrol (2019 Calendar Year)			
	Annual kL Consumed	CO_2 Emitted (Tonnes)	Percentage of Total
Whole ACT Government	415	989	100%
The Canberra Hospital	165	393	40%

Table 2.9 – Annual Petrol Use Comparison

The ACT Whole Of Government emission reduction targets are:

- 33% CO_2 emissions reduction on 2019 baseline by 2025.
- 100% CO_2 emissions reduction on 2019 baseline by 2040.

2.7 Plant Replacement

The existing natural gas fuelled, and diesel plant will need to be replaced with electric plant to achieve the requirements of the climate change strategy. The supporting electrical infrastructure on the campus will need to be upgraded to provide the additional electrical requirements. This includes upgrades to incoming feeds, transformers, main switch boards and submains cabling.

2.7.1 Space and Domestic Water Heating

Gas fired hot water generators will need to be replaced with air source heat pumps where space permits. For heat pump selection it is important that suitable refrigerants are selected so that the units can continuously operate at low ambient temperatures (-5 ^{O}C). The units will also need to be selected with output water temperatures that match those of the existing air handling units. Where there is insufficient space to install heat pumps, electric resistance hot water units will need to be installed. These units will also need to be selected with output water temperatures that match those of the existing air handling units.

2.7.2 Steam Generators

Gas fired steam generators will need to be replaced with electric resistance steam generators. These units will need to be selected with output steam temperatures and pressures that match those of the existing equipment.

2.7.3 Cooking

Gas fired cooking equipment will need to be replaced with electric cooking equipment.

2.7.4 Emergency Generators

The current back-up generators are diesel fuelled. Typically diesel fuelled generators are selected for hospital environments as they are reliable and do not require large amounts of space for fuel storage. As the technology is developed and commercialised it will be possible to replace the diesel fuelled generators with hydrogen fuelled generators. The generator size would be much the same for both options as would the fuel storage size. In addition to this the hydrogen fuel can be topped up on a 24 hour basis to ensure continuous operation.

2.7.5 Vehicles

The hospital vehicle fleet will need to be transitioned from petrol and diesel vehicles to electric vehicles. This will require electric charging stations to be installed in staff parking areas. Commercial vehicle charging points are typically rated at 22 kW, 415 V, 3 phase. A standard 1 MW Evo Energy transformer would supply approximately 45 charging points. A large hospital campus may contain up to 200 electric charging stations, therefore future planning is required in parking areas to cater for the increased electrical energy use. This means that additional transformers, mains cabling, and main switch boards will be required on the campus.

2.8 Hydrogen Production

Traditionally hydrogen was produced through steam reforming of natural gas or coal gasification; both of which were CO_2 intensive processes. In recent times hydrogen has been produced through the electrolysis of water. This is a water and energy intensive process; however, if all the energy used is from renewable sources the process is considered CO_2 neutral. Good practice industrial electrolysis processes are 75% efficient. When the hydrogen generated from these process is used in vehicles or emergency generators, the round trip efficiency is very good. The downside is that industrial electrolysis processes require a large area of land for the plant and reliable source of renewable energy and water. For this reason many new industrial electrolysis plants are constructed near the ocean and connected to a large photovoltaic system or large wind turbine system. This is not feasible for a hospital campus. It would be more efficient to have hydrogen storage tanks located near the emergency generators on the campus with the hydrogen produced off site and delivered to the campus.

Hot water produced with electric resistant heating is 100% efficient and hot water produced with an air source heat pump is 250% efficient due to the refrigeration process and the use of the ambient air as a heat source. On this basis hydrogen is not an efficient fuel for hot water production.

2.9 Photovoltaics

Hospital buildings typically have limited available roof space for the installation of photovoltaic panels. This is due to the large amount of heat rejection plant, exhaust fans and flues required to provide clinical services. The exception to this are buildings that provide an administrative / commercial function or structured car parks. Based on the high level master plan, the final form of the campus could accommodate approximately 2,000 kW of photovoltaic panels. A 2,000 kW photovoltaic system would generate approximately 3,139,000 kWh/annum. An all-electric 35,000 m^2 acute services hospital building would use approximately 7,175,000 kWh/annum. Therefore a 2,000 kW photovoltaic system would provide approximately 43% of the buildings annual energy requirements.

2.10 Batteries

Large scale lithium batteries can provide significant energy storage and have the potential to supplement emergency generators. An all-electric 35,000 m^2 acute services hospital building would require approximately 4,000 kW of emergency generator capacity. The generators require sufficient fuel storage to operate for a 24 hour period before topping up the fuel storage. This equates to 96,000 kWh of energy supply. A 12m (40ft) shipping container battery system can accommodate 2,000 kWh of batteries and associated inverters, distribution boards and controls. To provide 96,000 kWh of energy supply; 48 shipping container battery systems would be required. These battery systems need to be naturally ventilated and located in an open space for maintenance access and for emergency access (firefighting, etc). 48 shipping container battery systems would require approximately 7,900 m^2 of open space.

This amount of space is not available on the hospital campus. Smaller lithium batteries are suitable for un-interruptible power supply (UPS) systems, which operate for 20 minutes. Continuous emergency power is much better served through hydrogen fuelled generators. In addition the hydrogen fuel can be topped up on a 24 hour basis to ensure continuous operation.

2.11 General Sustainability Initiatives

New buildings replacing the existing buildings on campus, will be constructed to improved sustainability standards. As such new buildings will consume less energy compared to the existing buildings on campus. Potential sustainability initiatives are summarised below.

2.11.1 Electrical Services

Initiative	Proposed ESD Strategy
External lighting	External lighting should be provided around the perimeter of the buildings and external areas in accordance with AS/NZS1158 and Crime Prevention Through Environmental Design (CPTED). External lighting should be controlled via light sensors. LED lighting options should be assessed based

Initiative	Proposed ESD Strategy
	on life cycle analysis to develop the most appropriate external lighting solution.
Efficient internal lighting systems	Generally LED luminaries should be used throughout. Lighting levels should be provided according to AS/NZS 1680.
Switching systems	A centralised lighting control system with graphical user interface to enable remote control should be used. Implementation of area dimming, time clocks, scene lighting and daylight sensing should be discussed with the user groups.
Emergency systems	Emergency and exit lighting should be in accordance with AS/NZS 2293.1 and should be designed to minimise ongoing maintenance and cost. This can be achieved through the following: - Centrally monitored system with automated self-testing; - Long life LED luminaries; - Individual long-life batteries; - Wide area coverage luminaries.
Photovoltaics	Roof mounted or façade integrated photovoltaic systems should be considered.
High quality materials	Minimising the amount of PVC cabling where possible.
Energy monitoring	All sub meters should be linked to the Building Management System (BMS) to monitor energy consumption. There should be a continual monitoring of monthly energy consumption and building turning to optimise energy performance.

2.11.2Mechanical Services

Initiative	Proposed ESD Strategy
Central systems	The buildings air conditioning chilled / heated water requirements should be met by way of a combination of high efficiency variable speed air source and water source heat pumps to match the buildings demand profile in a stable and economical manner. Utilising rejected heat from communications rooms and the like should be adopted.
Secondary systems	Energy efficient AHU's / FCU's with EC/DC motors to provide air-conditioning. Modular variable speed pumps to minimise and reduce energy output for peak and non-peak demands. Preference to be given to energy efficient equipment, with consideration of cost, suitability and maintenance. Air side systems selected to match thermal zones and individual departments, served from zoned secondary heating and cooling circuits to apportion energy use.

Initiative	Proposed ESD Strategy
Heat recovery	Heat should be recovered from ventilation systems either through direct return air or indirect heat exchange where there is a benefit in doing so.
Type of refrigerants	Zero Ozone Depleting Potential (ODP) and Low Greenhouse Warming Potential (GWP) refrigerants should be used.
Passive heating and cooling techniques	Passive conditioning techniques where applicable, to reduce the overall air-conditioning loads. Shading of windows to prevent solar penetration in summer but allow passive heating in winter. Efficient insulation of hot and warm water distribution pipe-work to minimise heat losses. Use of high performance glazing and high levels of insulation to avoid thermal bridging.
BMS	Building Management System (BMS) to schedule and optimise plant efficiency. The air-conditioning system should either shut down or to be set to a wider temperature control band, when a space is unoccupied.

2.11.3 Hydraulic Services

Initiative	Proposed ESD Strategy
Efficient water fixtures and fittings	Low flow taps will be used throughout. Flow rates for water outlets should be controlled by flow restrictors and will deliver water at the flows listed below; - Shower 7.7L/m - Basin 7.7L/m - Sink 7.7L/m - Scrub trough 7.7L/m
Hot water system	The buildings heating water requirements should be met by way of a series high efficient heat pump systems.
Hot water pipework	Additional insulation should be provided for the domestic hot water pipework. The thicker insulation (38mm) will achieve a 26% reduction in energy losses when compared with the industry standard 25m thickness.
Water metering	All water sub meters should be connected to the BMS.

2.11.4 Architectural

Initiative	Proposed ESD Strategy
Daylight	Courtyards and light wells are used to improve daylight on to the floor plates at lower levels. Floor to ceiling glazing where possible to allow daylight deep into floor plate.
Glazing	

Initiative	Proposed ESD Strategy
	High performance building envelope glazing should be selected with a high visual light transmission. Thermochromic glass and split frames should be used.
Landscaping	The new landscape areas should provide new entry points for the campus. They will act as a drop off areas and a place that users/ visitors and staff can access an appealing external environment close to the hospital facilities. It should incorporate shaded seating areas, access to local public transport and access to parking.
Facade	Materials selected for the façade should be part of a modular system based on panel efficiencies thus minimising waste, construction time and costs. Modular systems are largely factory assembled and tested.

2.11.5Structural

Initiative	Proposed ESD Strategy
Description of sustainable concrete and construction techniques-concrete	Timber or PT construction technique will reduce the amount of construction materials – concrete and reinforcement. Recycled material can be used in the form of fly ash or ground-granulated blast furnace slag as a replacement for part of the Portland cement concrete mix.
Description of sustainable concrete and construction techniques-Steel	Use Bondek as permanent slab formwork.
Other initiatives	Design for adaptability – adopting a higher loading allowance to avoid the need to having to strengthen or demolish later; adopting a sacrificial topping zone for provision of future. Set-downs for wet zones; adopt non-loadbearing walls as partitions which allows them to be removed around in future. Source materials responsibly and locally if possible. Minimise off-site transportation of contaminants by the use of on-site borrow pit for storage of excavated materials.

2.11.6Materials General

Materials with low embodied carbon should be given preference over materials with high embodied carbon contents. Common building materials with high embodied carbon content include:

- Aluminium products
- Copper products.
- Polycarbonate products
- Glass products.
- Compressed fibre cement products.
- Steel products.

Common building materials with low embodied carbon content include:

- Plantation timber products
- Natural stone products
- Light weight concrete products.
- Rockwool insulation products.
- Plasterboard products,

The majority of building materials used for large-scale developments in Australia are sourced from overseas, predominantly from Asian supply chains These materials are commonly manufactured using energy-intensive processes and have been transported and shipped significant distances before reaching Australia. As a result, these materials have a relatively low capital cost, but are supplied with a high level of embodied energy at a significant carbon cost. Selecting locally sourced materials can prove to be difficult; however an alternative is to select low carbon or carbon neutral products. Typically these products are sourced from European supply chains. The costs for these products depends highly on exchange rates and international trading policies.

2.12 Campus Staging

Between 2022 and 2040, the Master Plan identifies that the campus will be refurbished in five key stages. The timing of the stages is still to be defined.

2.13 Estimated CO_2 Emission Reduction

Assuming that the existing buildings are replaced or nominated plant within the buildings are replaced, the estimated CO_2 emissions from natural gas usage at the Canberra Hospital at the end of the five stages is summarised below

Stage	Description	Annual CO_2 Emitted (Tonnes)
0	Existing Campus	7,164
1	Buildings 4, 5, 6, 24, GP1, GP2, GP3, GP4 and GP5 Replaced with New Buildings With All Electric Plant	7,016
2	Buildings 7, 8, 9, 10, 23 and Woden Valley Child Care Replaced with New Buildings With All Electric Plant	4,303
3	Building 12 Replaced with New Buildings With All Electric Plant	3,711
4	Buildings 1 and 2 Replaced with New Buildings With All Electric Plant	2,974
5	Buildings 3 and 15 Replaced with New Buildings With All Electric Plant. Buildings 11, 14, 19, 20, 25 and Southern Car Park Retained. Existing Natural Gas Fuelled Plant In These Buildings To Be Replaced With All Electric Plant.	0

Table 2.10 – Estimated Annual CO_2 Emissions

The ACT Whole Of Government emission reduction targets are:

- 33% CO_2 emissions reduction on 2019 baseline by 2025.
- 100% CO_2 emissions reduction on 2019 baseline by 2040.

To meet the ACT Whole Of Government emission reduction targets, all stages, or nominated plant replacements, need to be completed by 2040.