CSU Bathurst
Electrification Roadmap

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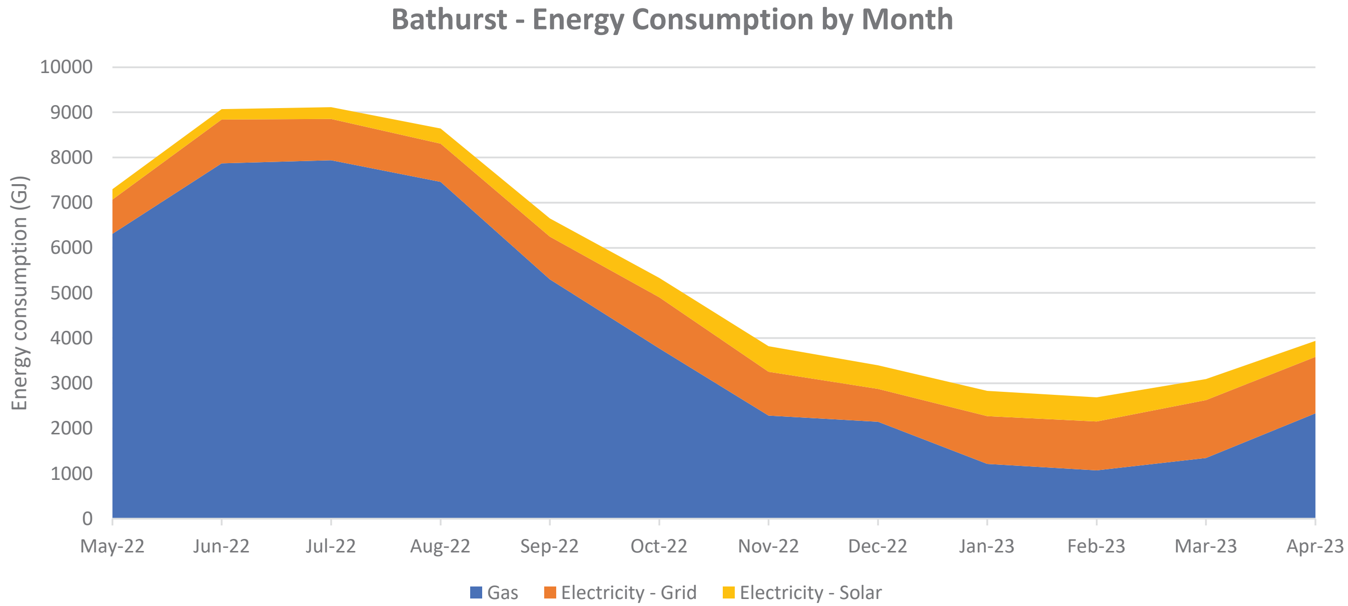
Energy Overview

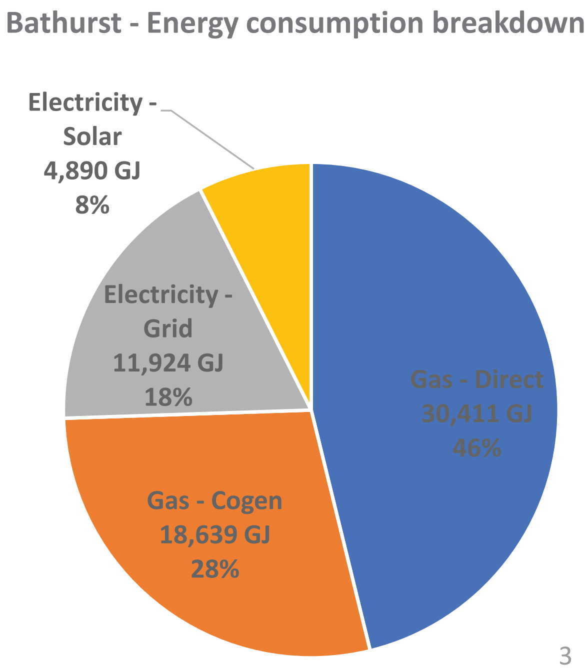
Energy Baseline

Bathurst – Energy Consumption Baseline

Utility	Annual Consumption	Annual Cost
Electricity – Grid	3,312 MWh	$748,634
Electricity – Solar	1,358 MWh	N/A
Natural Gas	49,050 GJ	$ 1,352,229

Bathurst campus currently relies heavily on natural gas due to the following factors:
- Bathurst's cold-climate results in a significant heat load across ~8 months of the year
- The campus's infrastructure was originally designed to be heated using natural gas





Energy infrastructure limitations

Bathurst – Energy Infrastructure limitations

Utility	Supply type	Maximum Supply Available	Maximum Demand (last 3 years)	Demand Available	Comment
Electricity	11kV High-voltage ringmain	2.4MVA (Essential energy connected services agreement)	1.7MVA	~0.7MVA	Site max demand is dynamic due to onsite generation from solar PV and cogeneration systems. A formal review of maximum site demand including the impact of solar PV and cogeneration should be undertaken.
Natural Gas	1 x large supply meter (97%) 1 x small meter (3%)	TBC – at limit		Minimal – site experiences pressure drops at times of peak consumption	The site has experienced pilot lights going out in gas using equipment due to pressure drops in the system associated with limited supply. There is no available gas supply available through the current meter.

Electrification Roadmap

Electrification Roadmap Overview

Stage 1: Planning and enablers

1. Develop and track gas consumption baseline
2. Map out equipment end of life & schedule upgrades
3. Develop equipment replacement standards for minor gas using equipment
4. Improve BMS functionality

Stage 2: Load reduction and efficiency

5. Reduce campus' gas load
6. Increase existing equipment efficiencies
7. Review energy use and baseline

Stage 3: Electrification

8. Electrification pilots
9. Plan and undertake HV upgrade
10. Broader electrification of key assets

Stage 4: Future projects

11. Decommission central energy
12. Solar installations to offset additional electricity consumption
13. Consider future electrification projects

CAL24	CAL25	CAL26	CAL27 onwards

Stage 1: Planning and enablers

#	*Activities*	*How*	*When*	*Who*
1	**Develop and track gas consumption baseline**	• Implement gas consumption baseline to understand site performance year-on-year and compare to other sites. • Track gas consumption by month to assess change in performance between years.	**Jan – Feb (2024)**	
2	**Map out equipment end of life & schedule upgrades**	• Identify equipment scheduled for immediate replacement or nearing end-of-life. • Develop a ranked list of gas equipment needing replacement in the next 12-months.	**Feb – Mar (2024)**	**Maintenance & Facilities**
3	**Develop equipment replacement standards for minor gas using equipment**	• Set up minimum allowable spec for new equipment to ensure it aligns with all future upgrade plans (no gas, etc.). I.e. electric alternatives to existing minor gas users.	**Feb – Mar (2024)**	
4	**Improve BMS functionality**	• Improve BMS functionality to connect to all buildings, capable machinery and the logging of critical parameters, namely HVAC scheduling and status data (to track time of use information and behaviour)	**Apr – Jun (2024)**	**Energy Management**

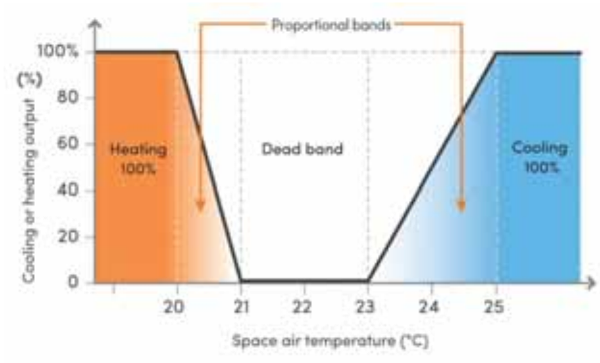
Stage 2: Load reduction opportunities

Improved HVAC scheduling
There is an opportunity to implement automated HVAC on/off scheduling for packaged and central HVAC systems across the campus.

An example opportunity includes McDonoughs. This building is a major gas user and has a BMS system, but no scheduling or control has been implemented.

Est. Saving: 10-20% of space heating gas use

McDonoughs – Uncommissioned BMS



Example of optimised dead band

Improved HVAC & hot water control

Consider reviewing major HVAC systems for control opportunities including:

- Temperature limits for heating and cooling
- Optimised temperature dead bands
- Optimised heating / cooling call lockout
- Chilled and hot water temperature resets
- Boiler sequence control

Est. Saving: 5-10% of space heating & hot water gas use

Staff and student engagement program

During the site visit, 2XE observed many areas being heated or cooled without any staff present, and very high or low temperature setpoints. Improved Staff and student engagement has the potential to produce significant savings via reduced equipment time-of-use.

Universal remote for split systems

Stage 2: Load reduction and efficiency

#	Activities	How	When	Who	Estimated CAPEX	Cost saving	Gas Reduction (%)
5	**Reduce campus' gas and electrical load**	**Improved HVAC Scheduling:** Develop a register of HVAC scheduling by building and whether it is controlled manually or automatically. Systematically implement automatic scheduling where possible.	**Jul – Dec (2024)**		**In-kind**	**$144,000**	**9.4%**
		Improved HVAC & boiler control: Where possible implement the following control improvements: • Temperature limits for heating and cooling • Optimised temperature dead bands • Optimised heating / cooling call lockout • Chilled and hot water temperature resets • Boiler sequence control					
		Staff and student engagement program: Where automatic scheduling of HVAC is not possible, engage with staff in each building to optimize time-of-use, using posters as reminders where necessary.	**Jul – Oct (2024)**				
6	**Increase existing equipment operating efficiency**	**General cleaning of evaporator & condenser fins -** Opportunity to improve the airflow and efficiency of existing units by incorporating filter / fin cleaning into standard maintenance.	**Ongoing**		**In-kind**	**$17,000**	**1.2%**
		Regular servicing of equipment: • Check calibration of thermostats • Check combustion efficiency of major boilers (flue gas analysis) • Check burner, blower fan and air filters • Check for leaks or damages to insulation • Ensure all strainers, filters, oils, etc. are changed regularly to ensure optimal performance.					
7	**Establish new baseline**	• Revise gas consumption baseline to assess the impact of changes	**Jan 2025**		**n/a**		

Stage 3: Electrification

#	Activities	How	When
8	**Electrification pilots**	**JOV Satellite plant electrification:** Implement a central air-sourced CO2 heat pump solution to supply JOV with domestic hot water	**Jan 2025 – Jun 2026**
		Macquarie Village electrification: Test the use of small-scale heat pumps for domestic hot water and air-sourced hydronic heat pumps to supply radiator systems at Macquarie village	
		Windradyne / Diggings electrification: Test the use of small-scale heat pumps for domestic hot water, and the transition from hydronic radiators to refrigerated space heating (using multi-head split systems)	
9	**Plan and undertake major HV upgrade**	**Work with Boschetti to scope out required HV and LV electrical upgrades**	**Jul 2025 – Dec 2026**
		Undertake HV and LV upgrades	
10	**Broader electrification of key assets**	• P**roceed with the electrification of key gas users:** First focusing on central energy connected systems to enable the decommissioning of central energy.	**2027 onwards**

Stage 4: Future projects

#	*Activities*	*How*	*When*
11	**Decommission central energy**	Confirm that all downstream demands have been de-coupled from existing central energy plant and proceed with decommissioning.	**2027**
12	**Solar installations to offset additional electricity consumption**	Using metered data from the electrification pilots, install necessary solar PV to offset the additional consumption and demand associated with electrified systems. Significant opportunity to reduce load by charging hot water buffers during the day.	**2027 onwards**
13	**Consider future electrification projects**	• Consider future electrification projects such as induction cooktops in kitchens, ground sourced heat pumps for hot water, high-temperature energy storage systems, etc.	**2027 onwards**

Electrification Analysis

Priority Areas

Two priority areas were identified to develop indicative business cases for a variety of electrification scenarios for the campus. The age and condition of the sites central energy system has resulted in it being flagged as a high priority. Additionally, student accommodation is critical to campus financial performance and as such ensuring cost-effective delivery of hot water is a high priority.

Central Energy

Decoupling downstream demands by utilising heat pumps with storage. Downstream demands include:

- JOV
- Sheila Swain Building
- Mason Building
- Mansfield
- The Diggings

End goal to decommission central energy

Student Accommodation

Student accommodation direct gas users include:

- Macquarie Village
- Windradyne
- The Diggings (direct gas supplied)
- JOV (already addressed)

Central Energy – Downstream de-coupling Business Cases

Bathurst – Central Energy – Downstream electrification business cases (examples in appendix)

Area / Building	Existing equipment	Proposed Equipment	Confidence level	HHW energy reduction (GJ p.a.)	Electrical gain (MWh p.a.)	Additional max electrical demand (kVA)	CAPEX ($ ex GST)	Cost saving	Payback period
John Oxley Village	Domestic Hot water - Ring Main HX	2 x 76kW CO2 heat pumps (air sourced)	High	808	62	**87**	$525,000	$9,928	N/A
	Space Heating - HX to hydronic radiator loop	Mitsubishi Heavy Industry units modelled	High	2,919	225	**376**	$1,170,000	$28,472	N/A
Mansfield (1411)	Domestic Hot water - Ring Main HX	2 x 76kW CO2 heat pumps (air sourced)	Medium	945	73	**87**	$525,000	$13,416	N/A
	Space Heating - Ducted - Evap. W. HHW Coil	TBC - no heat meter data or specs available for coils	Low	1,060	82	**212**	$675,000	$1,182	N/A
	Space Heating - HX to hydronic radiator loop	Mitsubishi Heavy Industry units modelled	Low	331	26	**118**	$250,000	-$5,987	N/A
Mason (1414)	Domestic Hot water - Ring Main HX	2 x 76kW CO2 heat pumps (air sourced)	High	1,163	90	**87**	$525,000	$18,924	27.7 years
	Space Heating - Ducted - Evap. W. HHW Coil	TBC - no heat meter data or specs available for coils	Low	706	55	**141**	$450,000	$788	N/A
Sheila Swain (1293)	Space Heating - HX to act as evap coil for heating loop	Revere AHGR32AW150	Medium	1,944	150	**78**	$225,000	$39,863	5.6 years
The Diggings	Domestic Hot water - Ring Main HX	2 x 76kW CO2 heat pumps (air sourced)	High	825	64	**87**	$525,000	$10,356	N/A
	Space Heating - HX to hydronic radiator loop	Mitsubishi Heavy Industry units modelled	High	2,065	159	**243**	$544,000	$22,902	23.8 years
			TOTAL	**12,766 GJ**	**986 MWh**	**1,515 kVA**	**$5,414,000**	**$139,844**	**N/A**

Student Accommodation – Electrification Business Cases

Bathurst – Student accommodation – Electrification business cases (details in appendix)

Area / Building	System	Proposed Equipment	Confidence level	Gas reduction (GJ p.a.	Electrical gain (MWh p.a.)	Additional max electrical demand (kVA)	CAPEX ($ ex GST)	Cost saving	Payback period	Like-for-like replacement CAPEX (i.e. gas replacement) ($ ex GST)	Payback period when considering like-for like cost
Macquarie Village	Hot water - Storage - Gas	Bank of 4 residential scale CO_2 heat pumps + optional electric finishing tank	High	1,477	117	**124**	$350,000	$13,672	25.6	$100,000	18.3
	Space heating - Hydronic - Gas	Air-sourced CO_2 heat pump - 1 x AHGR32AW120	Moderate	2,978	236	**600**	$1,500,000	$6,999	N/A	$120,000	N/A
The Diggings	Hot water - Storage - Gas	Bank of 2 residential scale CO_2 heat pumps + storage	High	633	50	**47**	$140,000	$6,605	21.2	$57,600	12.5
	Space heating - Ducted - Gas	Mitsubishi Heavy Industry units modelled	High	549	44	**147**	$366,118	-$7,130	N/A	$40,000	N/A
Windradyne	Hot water - Storage - Gas	Bank of 2 residential scale CO_2 heat pumps + storage	High	319	25	**71**	$205,000	-$2,355	N/A	$37,500	N/A
	Space heating - Ducted - Gas	Mitsubishi Heavy Industry units modelled	High	762	60	**202**	$503,412	-$9,669	N/A	$55,000	N/A
	Kitchen - Gas Cook Top	6.6kW total electric stove	Medium	20	6	**73**	$44,000	-$4,623	N/A	$13,200	N/A
			TOTAL	**6,739 GJ**	**539 MWh**	**1,263 kVA**	**$3,108,530**	**$3,497**	**N/A**	**$423,300**	**N/A**

Note:

- CAPEX is based upon quoted hardware costs + contingency factor for install & LV electrical upgrades (generally 50% - based on costs from JOV project)
- Cost saving is heavily dependent on the increase in maximum demand caused by new equipment. An annual diversity factor of 50% was used p.a. across peak, shoulder and off-peak demand. If a diversity factor of 80% is used, total cost savings drop to only ~$10k p.a.
- Demand and load management of implemented systems will be key to cost effective operation.
- No allowance for HV upgrades included in CAPEX

Remaining campus electrical impact

Estimated additional demands associated with the electrification of other non-priority gas users

Bathurst – Remaining campus – Electrification impact

Category	Replacement type	Est. additional connected demand (kVA)
Boilers	Heat pump	1,811
Equipment	Direct	23
Hot water	Heat pump	548
Kitchen	Direct	558
Space heating	Heat pump	1,811
	Grand Total	**4,751 kVA**

Electrification impact

Bathurst – Electrification impact – Whole campus

Category	Est. additional connected demand (kVA)	Potential diversity factor	Est. impact on total site max demand
Central Energy	1,515 kVA	50%	758 kVA
Student Accommodation	1,263 kVA		632 kVA
Remaining Campus	4,751 kVA		2,376 kVA
Grand Total	**+7,529 kVA**		**+3,765 kVA**

Transformer capacity check (LV)

					No Diversity (assumes 100% of connected load is used)		Load Management (assumes 50% of connected)	
Area / Building	**Supply transformer**	**Transformer Capacity (kVA)**	**Max Read (kW) (last 3 years)**	**Available capacity**	**Additional load**	**Remaining load**	**Additional load**	**Remaining load**
Macquarie Village	S10375	**315**	**64**	**244**	**289**	**-45**	**362**	**-118**
The Diggings	S255	**500**	**82**	**409**	**524**	**-114**	**262**	**147**
Windradyne	S60057	**300**	**N/A**	**TBC**				
John Oxley Village	S218	**315**	**75**	**232**	**463**	**-231**	**231**	**0**
Mansfield	S250 (Lecture complex)	**500**	**TBC**		**416**	**TBC**	**208**	**TBC**
Sheila Swain					**78**		**39**	
Mason	S121 (boiler house)	**750**			**228**		**114**	

Note:

- While electrical demand data was available for some transformers, it wasn't available for all, it is recommended that additional metering is put in place to understand the maximum demand experienced by each transformer.

Electrification Feasibility Summary

The below table summaries key feasibility considerations for electrification of CSU Bathurst Campus

Component	Student Accommodation	Central Energy	Remaining Campus	Total site
Equipment (technical feasibility)	**High:** Suitable heat pump alternatives available for both hot water and space heating requirements. CO_2 heat pumps are recommended for their low ambient operating temperature	**Moderate – High:** High feasibility to replace existing central energy fed heat exchangers with heat pump alternatives. Condition of existing secondary ring-mains is a concern that should be further investigated.	**Moderate:** Electric alternatives are available for essentially all gas equipment utilized by CSU	**Moderate to High**
Electrical infrastructure: Low-Voltage	**Moderate (requires investment):** The shift from central hydronic heating loops to the preferred refrigerated space heating / cooling (split systems) comes with a significant increase in connected electrical demand. In many cases this will require upgrades to cabling to each building to increase capacity, and in other a complete replacement of a buildings distribution board.		**Low – Moderate:** It is clear that significant upgrades to LV electrical infrastructure will be required. Significant problem areas include site kitchens due to the need for a 1-to-1 switch between gas and electric capacities	**Moderate (requires investment)**
Electrical infrastructure: High-Voltage	**Low (requires significant investment):** HV infrastructure is aging and there will be a significant amount of asset refreshing and maintenance. It is anticipated that to accommodate electrification of the campus a significant HV upgrade will be required. Most existing transformers appear to have enough available capacity for electrification if appropriate load management systems are used, however many are reaching end of life and their upgrade may be an opportunity to increase their capacity.			
Electrical Supply: Connected services agreement	**Low:** CSU will need to negotiate a significant increase to the connected services agreement if electrification of priority areas is to be achieved			**Estimated campus-wide additional connected demand:** 7.5MVA **Est impact on total site max demand:** 3.8MVA

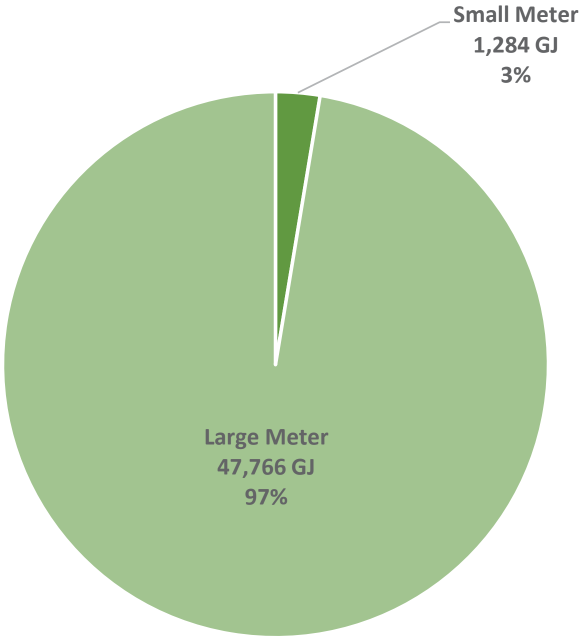
Note:

- The cost associated with equipment hardware, installation and LV electrical infrastructure upgrades have been accounted for in previous business cases.
- Previous business cases do not include costs associated with any upgrades to high-voltage electrical infrastructure across the site.

APPENDIX

APPENDIX:
Natural Gas Overview

Natural Gas Baseline (May 22 – Apr 23)

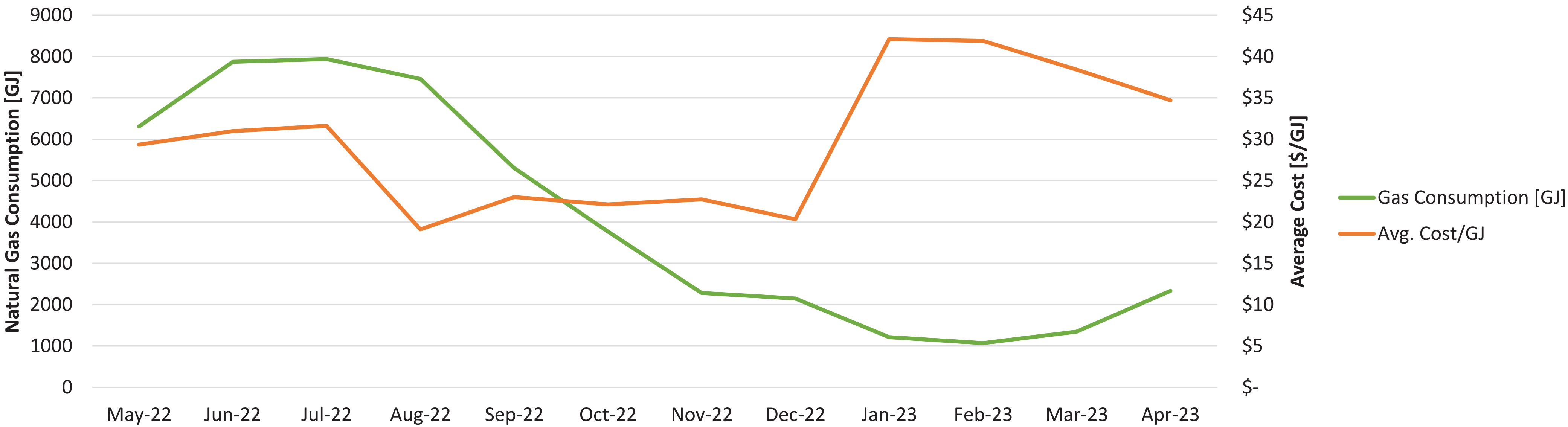


CSU Bathurst – Natural gas use by supply

CSU Bathurst – Natural gas baseline (May-22 – Apr-23)

	Consumption and cost			GHG Emissions (tCO_2-e)		
Source	**Consumption (GJ)**	**Cost ($ p.a.)**	**Average price**	**Scope 1**	**Scope 3**	**Total**
Small Supply	1,284	$17,240	$13.42	66	18	84
Main Supply	47,766	$1,334,989	$27.95	2,461	669	3,130
Total	**49,050 GJ**	**$1,352,229**		**2,528 tCO_2-e**	**687 tCO_2-e**	**3,214 tCO_2-e**

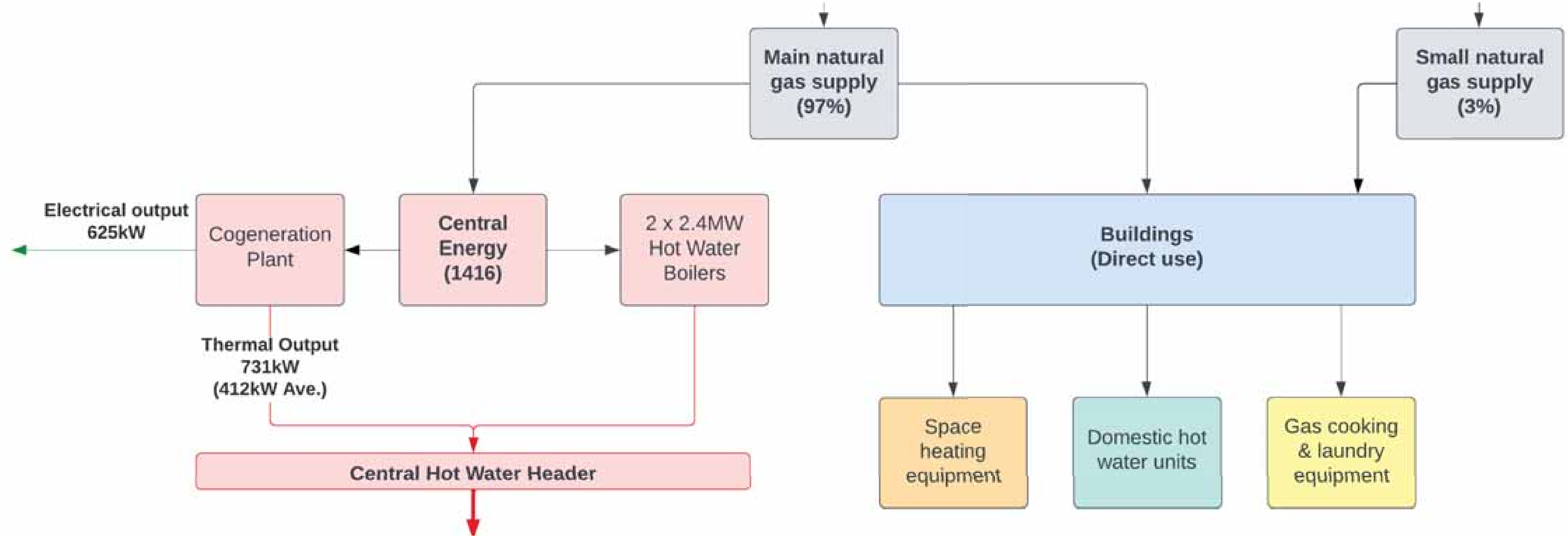
Natural Gas Consumption Profile (May 22 – Apr 23)



Key observations:

- Gas use is highest in winter and lowest in summer, aligning with seasonal temperature fluctuations
- Monthly gas consumption was in highest in Jul-22 at ~8,000GJ
- Natural gas prices increased significantly in Jan-23

Where is natural gas used?

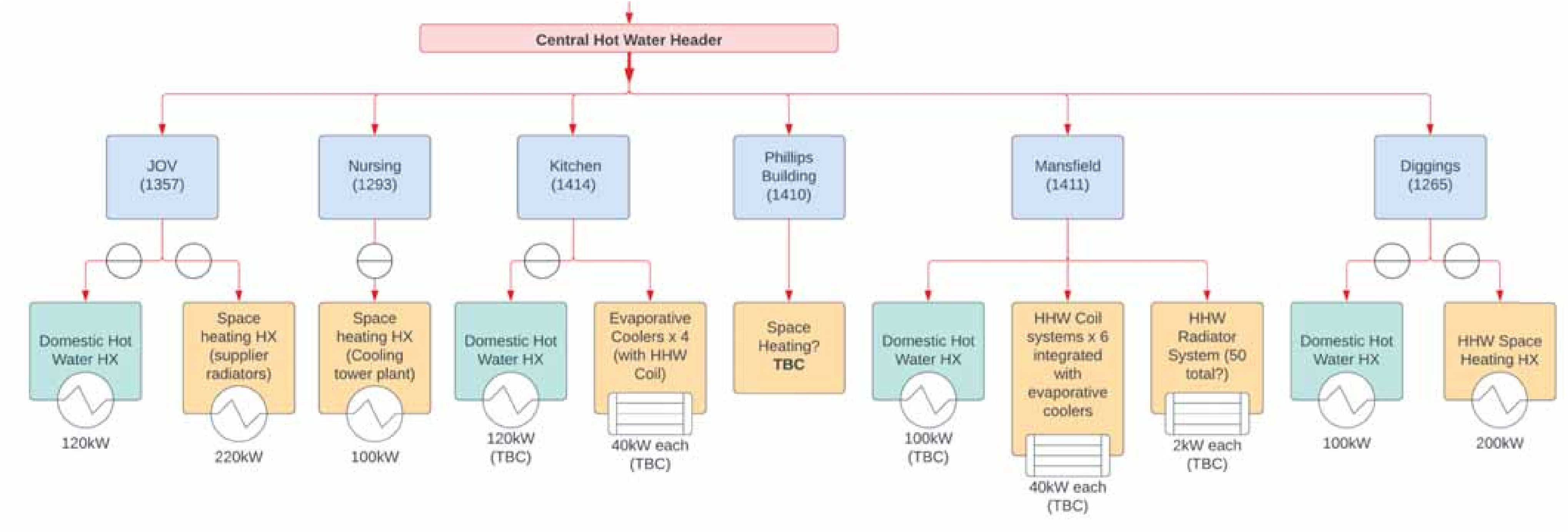


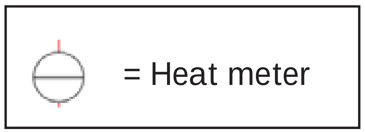
CSU Bathurst – Natural gas use summary

Natural gas distribution map

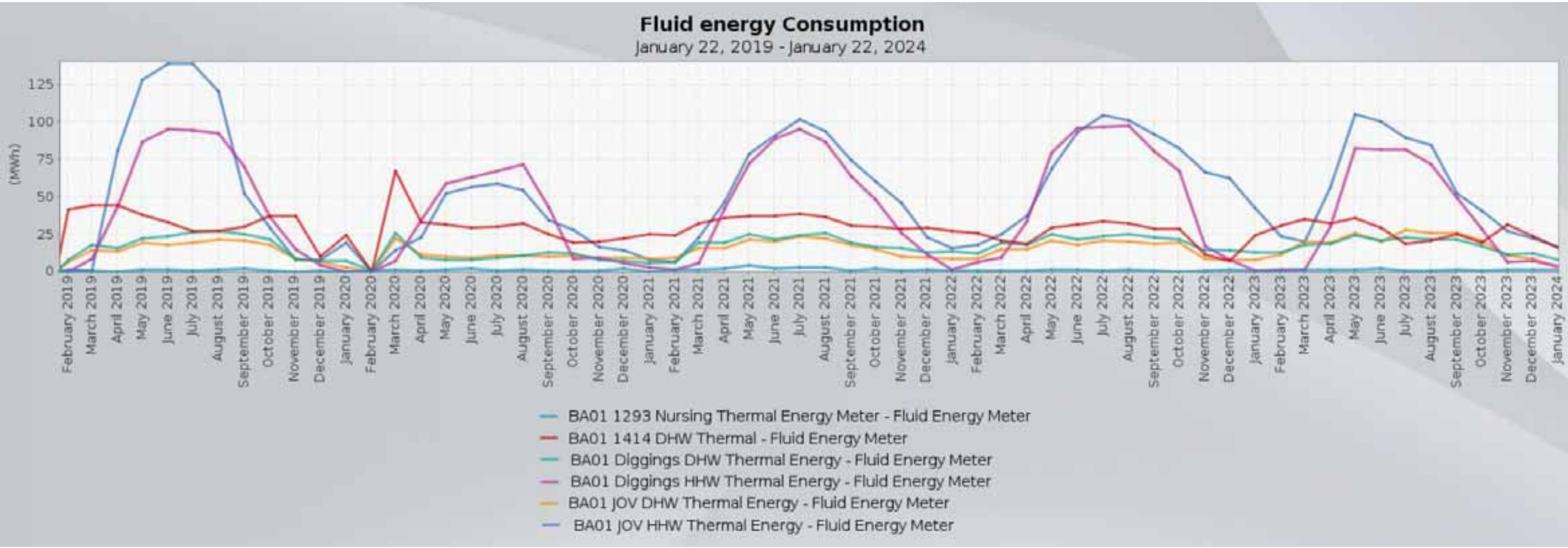
CSU Bathurst – Natural gas infrastructure map

Where is central hot water used?

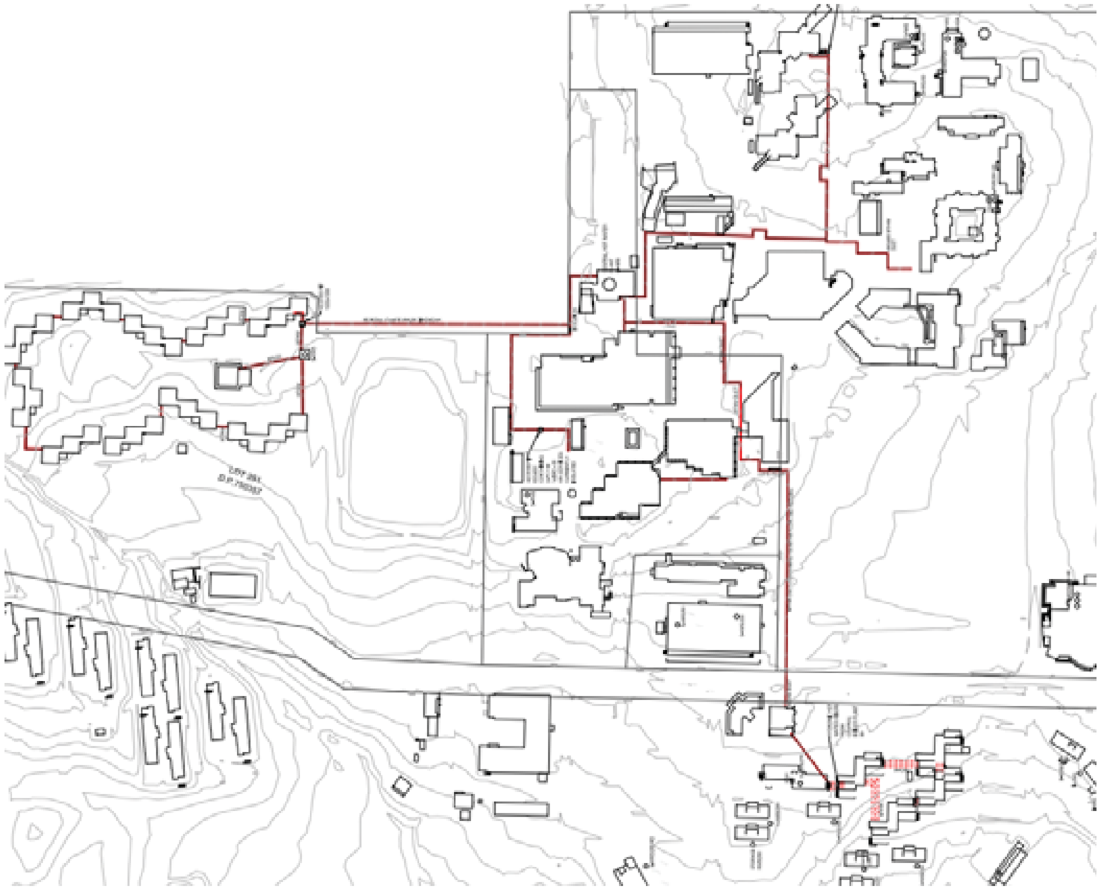




Where is central hot water used?



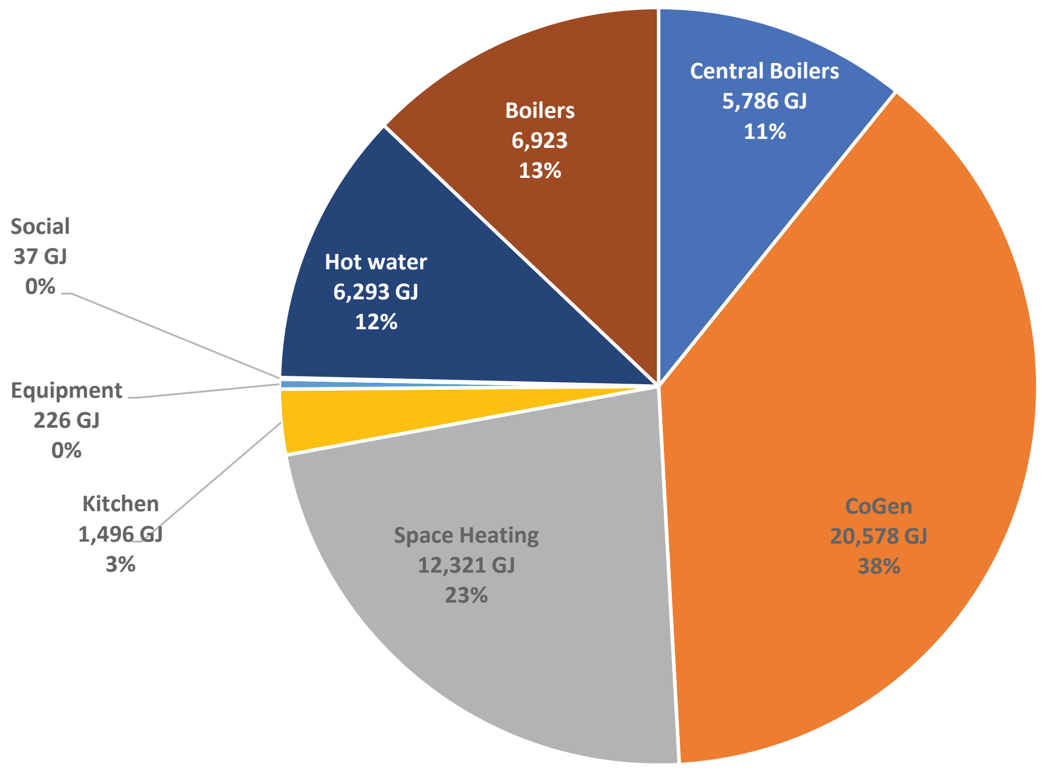
Central energy hot water infrastructure



CSU Bathurst – Central energy hot water infrastructure map

APPENDIX:
Gas & Heat Mapping

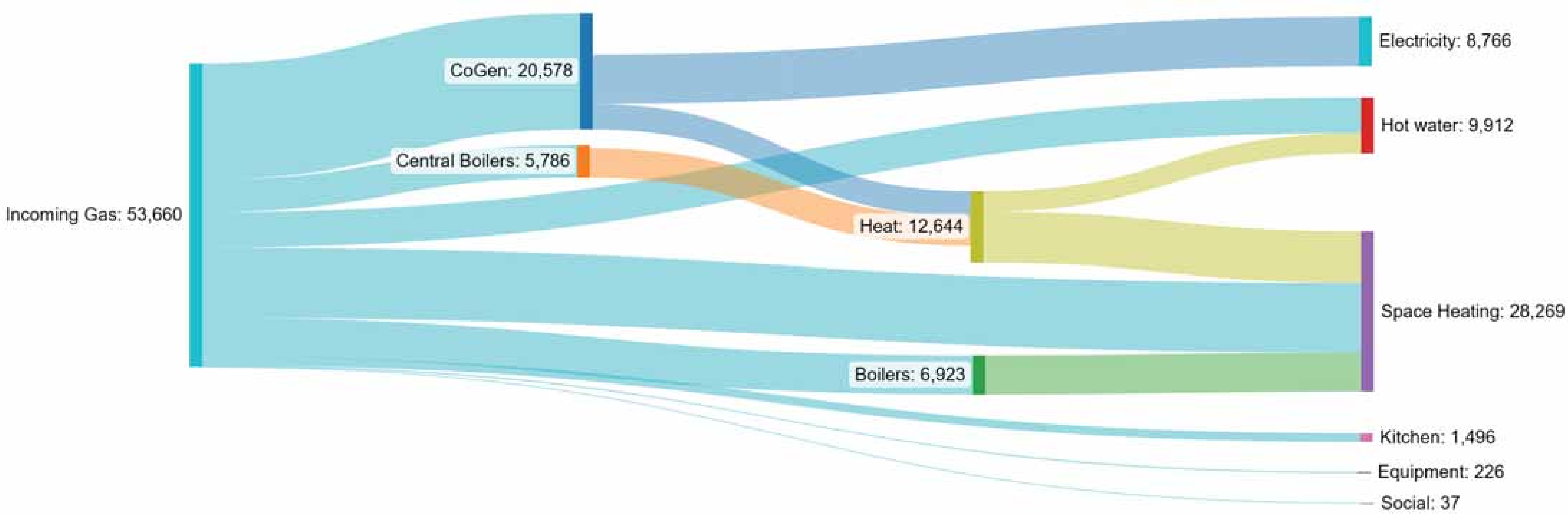
Estimated natural gas use breakdown by equipment



Equipment	Description	Consumption (GJ p.a.)	% of site
Central Boilers	Central energy hot water boilers - 2 x 2.4MW	5,786	11%
CoGen	Central energy gas fired cogeneration plant	20,578	38%
Space Heating	Direct space heating equipment, i.e. ducted gas heaters & flued gas heaters	12,321	23%
Kitchen	Kitchen cooking equipment including gas stoves, grills, ovens & deep fryers	1,496	3%
Equipment	Laundry equipment, bunsen burners, etc.	226	0%
Social	Gas BBQs	37	0%
Hot water	Domestic hot water equipment, i.e. continuous and storage gas hot water units	6,293	12%
Boilers	Individual building Heating Hot Water (HHW) boilers	6,923	13%
	Estimated Total	**53,660 GJ**	**100%**
	Billed total	49,050 GJ	
	Difference to billed total	4,610 GJ	9%

CSU Bathurst – Estimated natural gas breakdown by equipment

Summary - Natural Gas Sankey Diagram



CSU Bathurst – Natural gas use Sankey diagram

Note: main incoming gas listed as 48,600 GJ, rather than billed value of 49,050GJ, as this is a calculated load profile

Central Energy
CoGen & Boiler Observations

GoGen Notes:

- Gas rating: 10.7 GJ/hr
- Gas consumption: 15,433 GJ
- Electrical output: 635kW @ 42.6% efficiency
- Captured electrical energy: 8,766 GJ
- Rated thermal output: 682kW @ 45.7% efficiency
- Captured thermal energy: 4,484GJ
- Total heat loss (Flue + Cooling Tower): 7,328 GJ (35.6% of total)

- Duty: Assumed 7 months of operation at 75% duty, 12hrs per day, based on scheduling for 2024
- Large portion of heat recovery lost, capacity can't be absorbed by existing demand & storage systems
- Excess heat is dissipated through air cooled cooling towers on plant roof

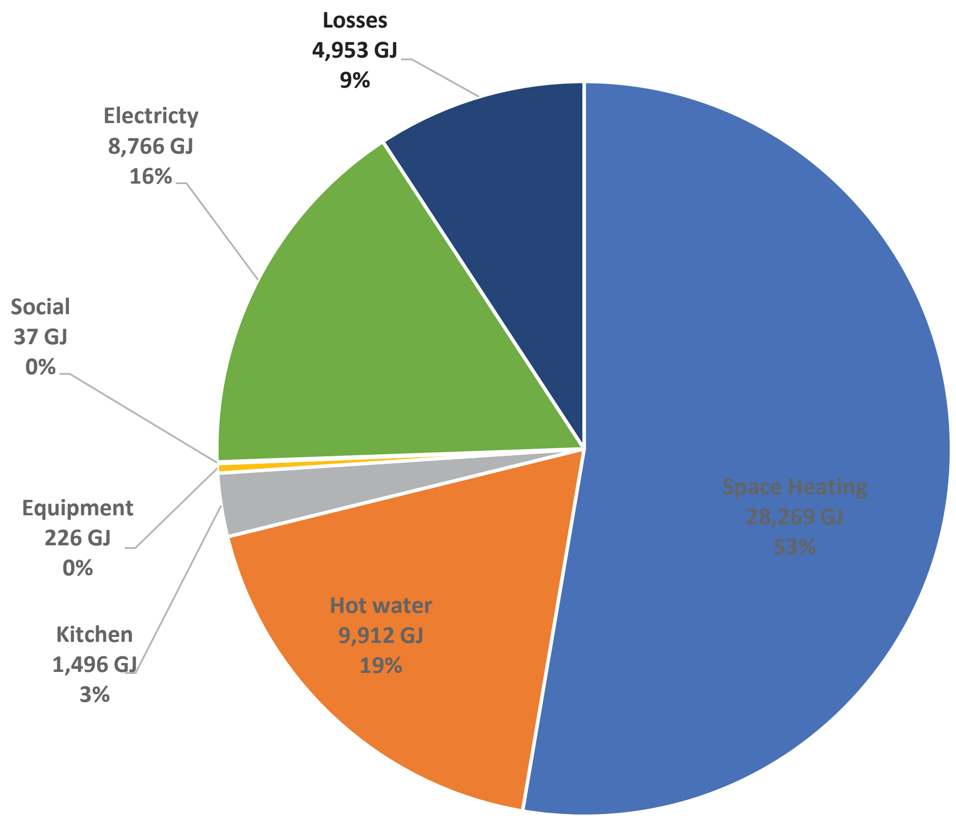
Central Boiler Notes:

- Duty: Assumed 9 months of operation – consistent use schedule
- Very low duty, 5% of available capacity over 9-month period
- Good case for resizing systems and replacement with heat pump technology
- Decentralisation of buildings plausible to eliminate losses in pipe runs


Central energy cogen


Central energy boilers

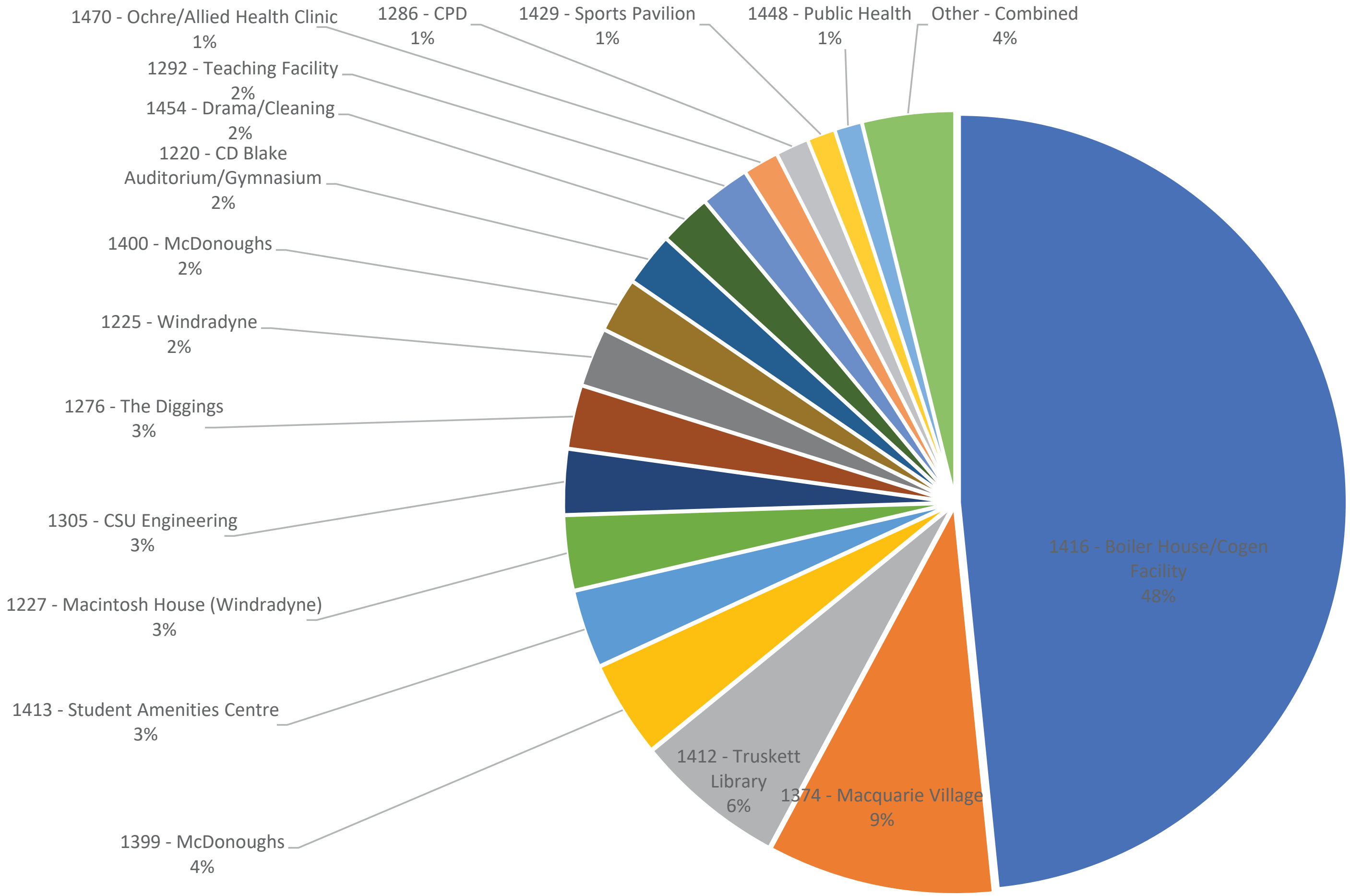
Estimated natural gas breakdown by end-use



CSU Bathurst – Estimated natural gas breakdown by end-use

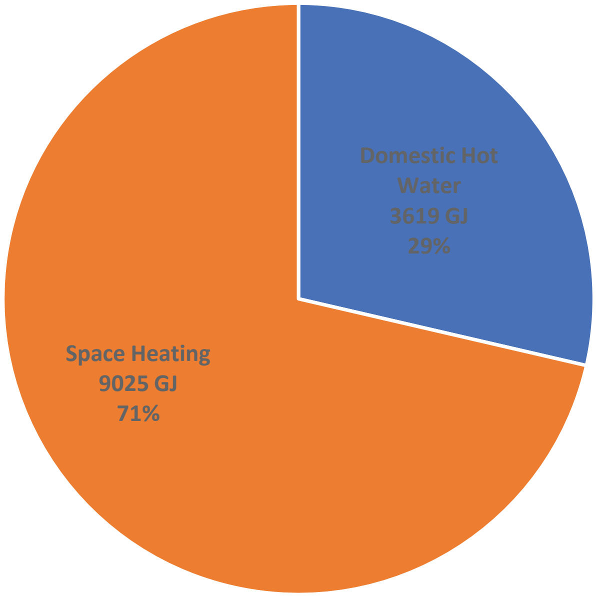
End-use	Description	Consumption (GJ p.a.)	% of site
Space Heating	Energy used to heat spaces either directly or indirectly (via secondary HHW loops)	28,269	53%
Hot water	Domestic hot water used in accommodation, kitchens, bathrooms and other amenities	9,912	18%
Kitchen	Kitchen cooking equipment including gas stoves, grills, ovens & deep fryers	1,496	3%
Equipment	Laundry equipment, bunsen burners, etc.	226	0%
Social	Gas BBQs	37	0%
Electricty	Electricity generated via the cogeneration plant	8,766	16%
Losses	Losses in energy due to equipment inefficiencies, i.e. inability to capture waste heat from the cogen plant & boiler efficiency losses	4,953	9%
	Estimated Total	**53,660 GJ**	**100%**

Natural gas use breakdown by building



CSU Bathurst – Estimated natural gas breakdown by building

Central Energy
Hot water use summary



CSU Bathurst – Estimated hydronic heating by end-use

Building	Annual heat use (GJ p.a.)	% of total
1346 - John Oxley Village	3,606	29%
1293 - Sheila Swain Building	1,944	15%
1414 - Mason Building	1,869	15%
1411 - Mansfield	2,336	18%
1255 - The Diggings	2,889	23%

Data sources and accuracy

Data source	Description	Accuracy
Utility gas billing data: (Main supply & small supply)	Gas billing data was used as the 'single source of truth' for total site natural gas consumption.	Very High
Gas sub-meters	Gas sub-meter data, where available, was used as the 'single source of truth' for the gas using equipment downstream of the meter (on a per building basis). Gas sub-meters captured 32% of total billed gas use during the analysis period.	High
Hydronic heat meters	Several of the downstream domestic hot water and space heating heat exchangers connected to the central hydronic system have heat meters installed. Heat meter historical data for the last 5-years was able to be accessed via the BMS, interval meter / trend data was available for the previous 3-6 months depending on the meter.	High
Equipment ratings and time-of-use	During the site visit, 2XE captured available gas equipment nameplate data. This data was combined with estimated equipment time of use, based on equipment and building type, to estimate annual gas consumption for the equipment.	Medium
BMS	The BMS was used for instantaneous readings of heat meters, and understanding equipment layout and function for each connected building. 2XE assessed the potential of historical gas meter and heat meter readings but there were significant inconsistencies in the observed data and as such it was not used more extensively for the analysis.	-

APPENDIX:
Opportunity Assessment Details

Confidence level legend

Confidence level	*Data available for analysis*
High	• Energy use data available either via the BMS or physical gas meters • Indicative quotes received for equipment / hardware • Estimate costs for electrical and civil / structural upgrades based on previous projects / discussions with contractors
Medium	• Minimal to no energy usage data available for the equipment • Nameplates and specifications available for existing equipment • Indicative quotes for equipment / hardware
Low	• No energy use data available for the equipment • No documentation or nameplates available to determine existing equipment capacity • High-level Capex estimates

Macquarie Village (10%) - Overview

		Value	Unit
	Number of buildings	10	Buildings
	Residents per building	20	Residents
	Showers per building	8	showers
Hot water system (per building)	Type	Gas storage + ringmain	
	Model	Rinnai HD250e	
	Capacity	69	kW
	Storage volume	300	L
Space Heating System (per building)	Type	Gas hydronic underfloor heating	
	Model	Hydroheat	
	Capacity	~40	kW (TBC)
	Storage volume	N/a	
Precinct Total	**Estimated natural gas use**	**5,145**	**p.a.**
	% of natural gas use	**10.6**	**%**

Space heating Notes:

- Underfloor gas heating is significantly undersized for 9/10 buildings.
- Current unit capacity of ~40kW is not fit for purpose and a heating capacity of ~80kW is required.
- A replacement has been designed to meet the heat required of 80kW per building.

Macquarie Village - Gas hot water system

Macquarie Village - Gas hydronic heating system

Macquarie Village – Solution Options

		Hot water solutions			Space heating solution	
Solution overview		Install a bank of 4 x ~3.5kW w/ 400L buffer residential hot water heat pumps or larger skid mounted heat pump system			Install large 120kW air sourced heat pump for hydronic heating water. 1 x AHGR32AW120	
		Value	**Unit**		**Value**	**Unit**
Per building	Heat Capacity (Standard conditions)	14	kW		120 (90 at -7C)	kW
	Buffer storage	1,600	L		200	L
Business Case (Precinct wide)	**Additional elec. Demand**	94	kVA		156	kVA
	Estimated CAPEX	$350k			$1,500k	
	Gas use saving	1,477	GJ p.a.		2,978	GJ p.a.
	Additional Elec. Use	117	MWh p.a.		236	MWh p.a.
	Est. Cost Savings	$13k	p.a.		$31.5	p.a.
	Payback period	27	years		12	years

Combined solution

Potential solution: Option to install a single heat pump that delivers heat for both Domestic hot water and hydronic heating.

CAPEX: ~$2m

1 x Revere CO2 76kW Heat Pump w/ 2 x 500L DHW tanks (1,000L) & 1 x 800L HHW buffer tank ($110k/skid)

Reclaim hot water heat pump manifold

Hydroheat hydronic heat pump

Windradyne - Overview

		Value	Unit
	Number of buildings	11	Buildings
	Residents per building	8	Residents
	Showers per building	2	showers
Hot water system (per building)	Type	Gas storage	
	Model	TBC	
	Capacity	~40	kW (TBC)
	Storage volume	260	L
Space Heating System (per building)	Type	Gas ducted heating	
	Model	Brivis Upflow 92	
	Capacity	25	kW
	Storage volume	n/a	
Precinct Total	**Estimated natural gas use**	**3,025**	**GJ p.a.**
	% of natural gas use	**6.2**	**%**

Windradyne – Gas storage system

Windradyne – Ducted gas heating system

Windradyne – Solution Options

		Hot water solutions			Space heating solution	
Solution overview		Install a bank of 2 x residential hot water heat pumps or larger skid mounted heat pump system			Install reverse cycle split system air conditioners for each room	
		Value	**Unit**		**Value**	**Unit**
Per building	Heat Capacity (Standard conditions)	7	kW		~30	kW
	Buffer storage	800	L		N/A	
Business Case (Precinct wide)	**Additional elec. Demand**	61	kVA		97	kVA
	Estimated CAPEX	$165k			$450k	
	Gas use saving	1,100	GJ p.a.		1,270	GJ p.a.
	Additional Elec. Use	87	MWh p.a.		101	MWh p.a.
	Est. Cost Savings	$11k	p.a.		$8.3k	p.a.
	Payback period	15	years		50+	years

Reclaim hot water heat pump manifold

Reverse Cycle Air Conditioning

The Diggings – Gas Connected Overview

		Value	Unit
	Number of buildings	8	Buildings
	Residents per building	8	Residents
	Showers per building	2	showers
Hot water system (per building)	Type	Gas storage	
	Model	TBC	
	Capacity	~40	kW (TBC)
	Storage volume	260	L
Space Heating System (per building)	Type	Gas ducted heating	
	Model	Brivis Upflow 92	
	Capacity	25	kW
	Storage volume	n/a	
Precinct Total	**Estimated natural gas use**	**1,436**	**GJ p.a.**
	% of natural gas use	**3.0**	**%**

Diggings - Gas hot water system

Diggings – ducted gas heating system

Diggings – Solution Options

		Hot water solutions			Space heating solution	
	Solution overview	Install a bank of 2 x residential hot water heat pumps or larger skid mounted heat pump system			Install reverse cycle split system air conditioners for each room	
		Value	**Unit**		**Value**	**Unit**
Per building	Heat Capacity (Standard conditions)	7	kW		~30	kW
	Buffer storage	800	L		N/A	
Business Case (Precinct wide)	**Conencted elec. Demand**	45	kVA		140	kVA
	Estimated CAPEX	$120k			$450k	
	Gas use saving	632.8	GJ p.a.		549	GJ p.a.
	Additional Elec. Use	50.2	MWh p.a.		43.6	MWh p.a.
	Est. Cost Savings	$4.8k	p.a.		-$8.3k	p.a.
	Payback period	25	years		N/A	years

Reclaim hot water heat pump manifold

Reverse Cycle Air Conditioning

Central: JOV – Solution options

		Decentralised			Centralised
		Option 1: Solar thermal w/ electric boost hot water & refrigerated space heating / cooling	**Option 2:** Heat pump hot water & refrigerated space heating / cooling	**Option 3:** Heat pump hot water & Heat pump radiator space heating	**Option 4:** Central heat pump hot water & Central heat pump radiator
DHW solution		10 x ~4kW solar thermal w/ 14.4kW electric boost + 1,200L buffer **(TBC)**	10 x 15kW heat pump + 1000L buffer	10 x 76kW heat pump + 800L hydronic heating buffer + 1000L hot water buffer	2 x 76kW heat pumps + 3 x 2500L tanks
Space heating/cooling technology		10 x VRV air conditioning solution: 20 x 2kW heads (small rooms) + 6 x 3kW heads (large room)			2 x 150kW heat pumps + 1500L buffer tank
Heating / cooling?		Heating and Cooling		Heating only	Heating only
Additional electrical demand	kVA	**342**	**236**	**214**	**138**
Available electrical capacity after install	%	**-32%**	**1%**	**8%**	**33%**
HV Transformer upgrade required?		**Yes – 500kVA**	**No**		
LV electrical infrastructure upgrades		New MSB for JOV / re-run cables to each cottage + new DB for each cottage			New MSB for JOV – re-run cables to satellite plant
Plumbing upgrades		Re-do hot water plumbing + pull out radiators		Re-do hot water plumbing and hydronic heating / radiator plumbing	Re-do precinct wide hot water and hydronic heating ring mains + cottage level pipework
Staging / timeframe		Upgrade half the cottages initially > undertake transformer upgrade (6-months) > upgrade remaining cottages	Staged upgrade of cottages is possible – equipment ex stock – heat pump skid manufacture time of 3-4 weeks		Renewal of ring mains and cottage pipework will be time intensive. Equipment ex stock – heat pump skid manufacture time of 3-4 weeks
Budget CAPEX		**$2.8m**	**$2.7m**	**$2.6m**	**$2.3m**
Annual OPEX (energy and maintenance)		**$163k p.a.**	**$126k p.a.**	**$106k p.a.**	**$89k p.a.**
Total cost of ownership: 10-year		**$4.7m**	**$4.1m**	**$3.9m**	**$3.4m**
Total cost of ownership: 20-year		**$7.9m**	**$7.0m**	**$6.1**	**$5.5m**

Central: Sheila Swain Building