Australasian Health Infrastructure Alliance (AHIA)

Key Sustainability Guidance

Electrification Guide

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Australasian Health Facility Guidelines

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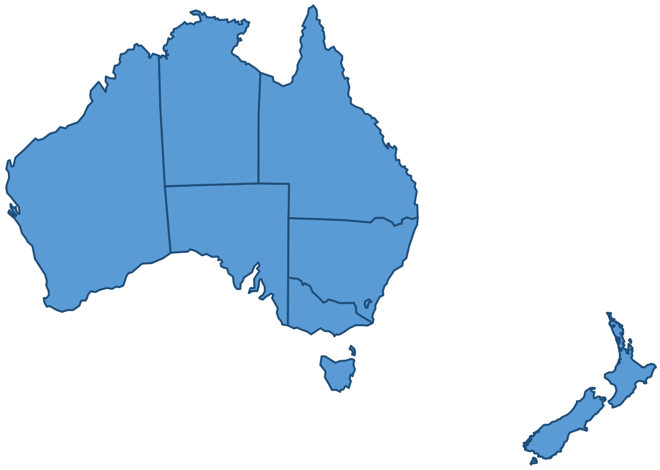
Cultural Acknowledgement

The Australasian Health Facility Guidelines (AusHFG) are developed in collaboration with stakeholders across Australia and Aotearoa, New Zealand.



Acknowledgement of Country

We acknowledge the Aboriginal people as the traditional owners and continuing custodians of the land throughout Australia and the Torres Strait Islander people as the traditional owners and continuing custodians of the land throughout the Torres Strait Islands.

We acknowledge their connection to land, sea and community and pay respects to Elders past, present and emerging.

Acknowledgement of Te Tiriti o Waitangi

We acknowledge Māori as tangata whenua in Aotearoa New Zealand.

Te Tiriti o Waitangi obligations have been considered in developing these resources.

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Definitions of key terms

TERM	DEFINITION
Climate change	A change in the state of the climate that persists for an extended period, typically decades or longer (IPCC, 2022).
Electrification	The process of converting an energy-consuming device, system or sector from non-electric sources of energy to electricity. It is an emerging economy-wide decarbonisation strategy that aims to affect various sectors including transportation, buildings, industry and agriculture. The goal of electrification is not merely to use electricity but to achieve community objectives such as reducing greenhouse gas emissions, lowering energy costs and enhancing grid resiliency.
Emission scope	A mechanism for classifying different sources of greenhouse gas emissions used in carbon accounting. There are 3 ‘scopes’: Scope 1 covers direct emissions from owned or controlled sources. In a building this is typically emissions from burning fossil fuels (for example, diesel, natural gas and LPG) and leakage of fluorinated gases such as refrigerants. Scope 2 covers indirect emissions from the consumption of purchased electricity, steam, heating and cooling. Scope 3 covers activities not owned or controlled by the reporting organisation. This includes production of fuels, electricity transmission losses, embodied carbon in construction and maintenance (including materials and products), waste treatment, water treatment and travel to/from the building.
Global warming potential (GWP)	GWP is a measure of the energy 1 tonne of a greenhouse gas will absorb over 100 years compared with the emissions of 1 tonne of carbon dioxide (CO_2). The GWP of CO2 is 1. GWP of natural gas is 28. The higher the GWP the more the energy contributes to climate change.
Net zero carbon	A net zero carbon building is one where there is a balance between the amount of greenhouse gas produced and the amount removed from the atmosphere on a net annual basis.
Renewable energy	Renewable energy is any source of energy that can be used without depleting its reserves including sunlight or solar energy, wind, wave, biomass and hydro energy. They are generally classified as onsite renewable energy (where the generator is connected behind the meter) or offsite (where the generator supplies to the grid and this electricity is procured).

Abbreviations

ABBREVIATION	DEFINITION
AIRAH	Australian Institute of Refrigeration, Air Conditioning and Heating
COP	coefficient of performance
CO_2	carbon dioxide
CSSD	Central Sterilising Services Department
DHW	domestic hot water
GHG	greenhouse gas
GWP	global warming potential
HFC	hydrofluorocarbon
HHW	heating hot water
HVAC	heating, ventilation and air conditioning
IPCC	Intergovernmental Panel for Climate Change
LCCA	lifecycle cost assessment
LED	light emitting diode
LTHW	low-temperature hot water
MACC	marginal abatement cost curve
NABERS	National Australian Built Environment Rating System
NCC	National Construction Code
PFAS	per- and polyfluoroalkyl substances
TES	thermal energy storage

1. Introduction

1.1 Purpose

Hospitals have large energy demands due to continuous operation, primarily from heating, ventilation and air conditioning (HVAC). The demand is so large that public hospitals consume over half of public-sector energy in most Australian states and territories.[1] With each Australian state/territory and New Zealand committing to net zero carbon emissions, there is an increasingly strong focus on ensuring healthcare facilities are part of the solution to a changing climate. This may include designing new healthcare facilities with electrification in mind from the outset, or by retrofitting existing facilities to achieve electrification by eliminating natural gas as a fuel source.

This electrification guide provides a resource to assist AHIA and its stakeholders to achieve net zero carbon emissions through the electrification of their assets. This will help bring the healthcare infrastructure across Australia and New Zealand up to a climate-ready standard. Electrification is the preferred alternative to traditional gas-based alternatives, such as biogas, biomass and hydrogen, due to its efficiency and versatility, positioning it as the preferred solution for decarbonisation initiatives.

This guide is designed to help implement a consistent approach to addressing electrification challenges in healthcare facilities and ensure a continued alignment with strategies being developed within each state and territory across Australia and in New Zealand. The guidance provides stakeholders with a broad understanding of electrification in the context of health infrastructure and draws on local and global best practice to provide the audience practical steps and initiatives on embedding electrification within the key stages of the asset lifecycle. The guide aims to address electrification challenges in healthcare facilities, offering insights into smart design, technology options, planning, risk management and cost analysis, with case studies and best practices included for reference.

Electrification can be defined as 'the process of converting an energy-consuming device, system, or sector from non-electric sources of energy to electricity' (US Department of Energy, 2022). It is an emerging economy-wide decarbonization strategy that aims to impact various sectors, including transportation, buildings, industry, and agriculture. The goal of electrification is not merely to use electricity but to achieve community objectives such as reducing greenhouse gas (GHG) emissions, lowering energy costs and enhancing grid resiliency.

The key reasons for electrifying healthcare facilities include, but are not limited to, the following:

- **Responding to climate change:** In Australia and New Zealand, the use of fossil fuels such as natural gas typically represents between 10% and 30% of a building's GHG emissions. Electrifying healthcare facilities that are fed by zero emissions grid electricity offers a viable contribution required to the transition towards net zero.
- **Cost-efficiency and risk reduction:** There is a potential risk to system operations because gas may eventually be phased out or curtailed. This could result in a reduction in availability of gas equipment, parts and skilled technicians to install, operate and maintain gas-fired systems. Electrification may offer a cost-effective alternative, especially given the technology for electrifying buildings, such as heat pumps and induction equipment, already exist and is proven.
- **Policy and market trend drivers:** There is an increasing array of government policy instruments and industry drivers being implemented to encourage and advance the sustainability of capital works programs in health care, including the push towards all-electric buildings.

[1] https://www.mja.com.au/journal/2021/renewable-energy-use-australian-public-hospitals

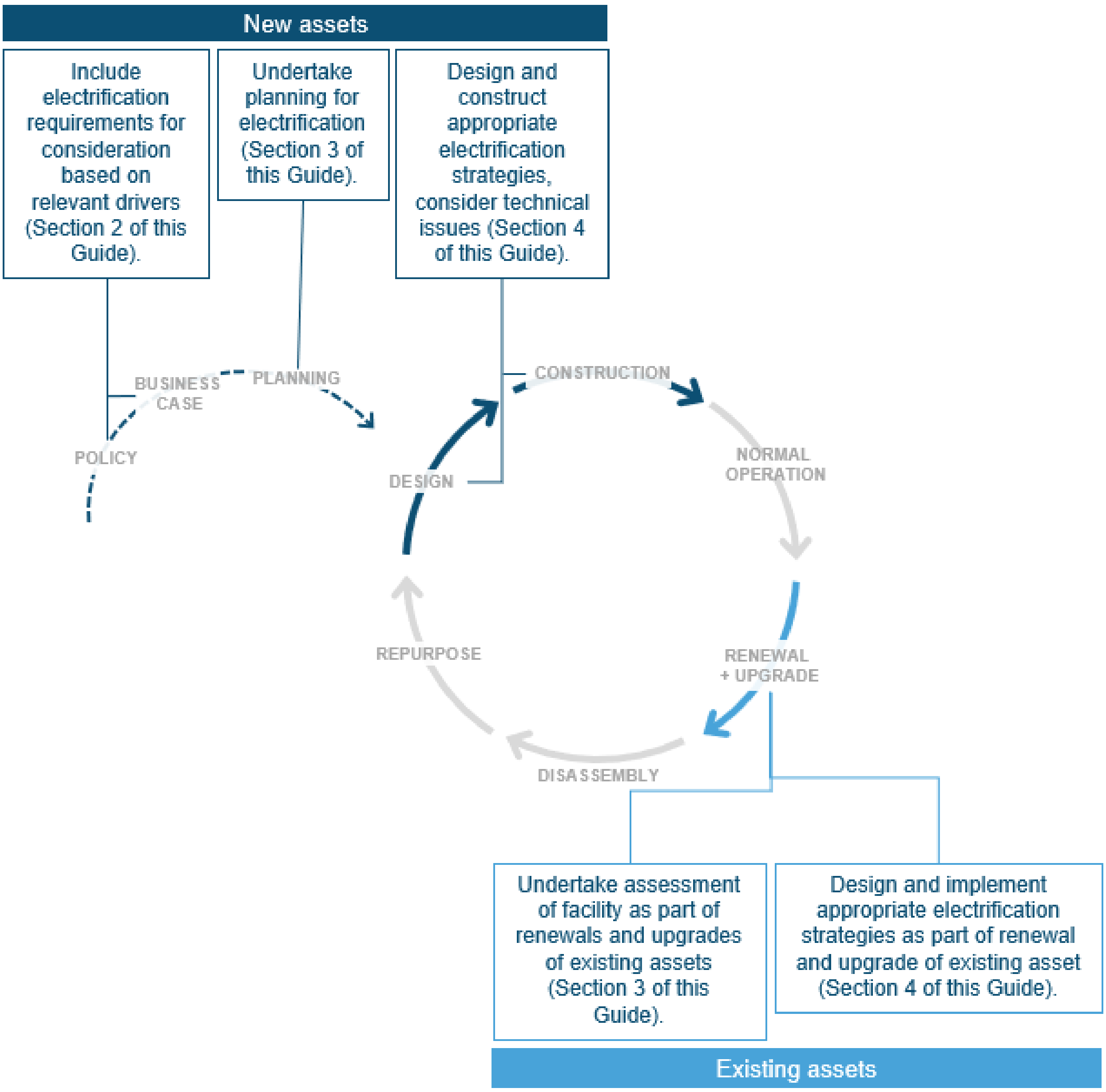
1.2 Audience

This electrification guide is aimed at stakeholder groups involved with the asset lifecycle, from early master planning, through to design, construction and fit-out. For existing health infrastructure, the electrification guide is aimed at facility managers, hospital engineers and asset management teams. For new health infrastructure, the guide is aimed at those tasked with funding, designing and implementing new assets. This document will support planners and designers of healthcare facilities in Australia and New Zealand to apply best practice approaches to electrification using an evidence-based approach to support good decision making.

1.3 When to use this guide

For both new and existing health infrastructure projects, electrification planning should be undertaken as soon as possible in the project lifecycle. Figure 1 shows when to undertake electrification planning in the project lifecycle for new and existing assets.

Figure 1: When to undertake electrification planning in the project lifecycle for new and existing assets



2. Reasons for electrification

2.1 Responding to climate change

Climate change is the single biggest health threat facing humanity. Climate impacts are already harming health, through air pollution, disease, extreme weather events and pressures on mental health.[2] To mitigate the risk of catastrophic climate change, it is crucial to limit the average global temperature rise to below 1.5°C. According to the Intergovernmental Panel for Climate Change (IPCC), we have increasingly limited time before crossing this threshold unless we significantly reduce GHG emissions over the coming years. Failing to do so will result in dangerous, costly and irreversible consequences.

The built environment significantly contributes to Australia and New Zealand's national GHG emissions, accounting for nearly a quarter of the total emissions in Australia[3] and around 20% in New Zealand.[4] Among these emissions, natural gas usage in buildings makes up around 15% of all operational emissions (about 14 million tonnes of CO_2 per year). Healthcare alone represents around 7% of the total national emissions, with about one-third of the GHG emissions being created directly during operation including gas, electricity, water, medical gases and waste (scope 1 & 2).[5] The remaining two-thirds of emissions are indirect operational emissions associated with the supply chain (scope 3). As an example, refer to Figure 2 for a breakdown of emissions from the Northern Sydney Local Health District in NSW total footprint.

The largest source of scope 1 emissions comes from natural gas usage (specifically methane) from combustion in buildings. Among the alternatives to natural gas, electrification is the preferred path endorsed by both the IPCC and the International Energy Agency. The Australian Government has identified electrification as a key technology available now to help get to net zero emissions. Electrification is also the best enabler to deliver buildings fully powered by renewables.

Scope 2 emissions (indirect GHG emissions associated with purchased electricity) are harder to control and are one of the biggest hurdles to reducing emissions associated with buildings. This is because the electricity grid has historically been carbon-intensive, but this is changing, especially in certain states and territories that have greater access to renewable sources of energy.

Energy efficiency and emissions

The energy efficiency of heaters used for space and water heating is represented by the coefficient of performance (COP), which is a measure of the heating output per unit of input power (higher COPs are better). COPs for electric heat pumps can vary significantly depending on the type of heat pump and the conditions they are operating in but typically range between 2 to 5. Compared with conventional gas-fired boilers, which have COPs that typically range between 0.85 to 0.95, electric heat pumps are more energy-efficient. Depending on the local health jurisdiction electricity provider's level of grid decarbonisation, the higher COPs of electric heat pumps will likely result in lower emissions for equivalent heating output than gas-fired boilers.

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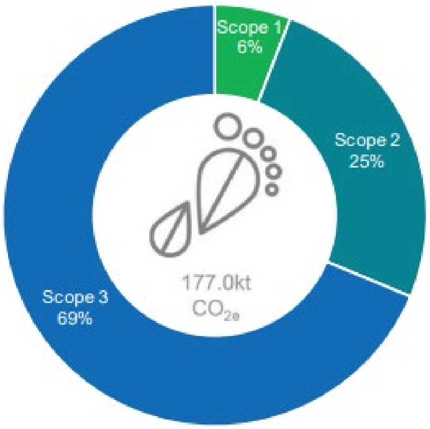
[2] Refer to: https://www.un.org/en/climatechange/science/causes-effects-climate-change#:~:text=Climate%20change%20is%20the%20single,grow%20or%20find%20sufficient%20food

[3] Refer to: https://www.climateworkscentre.org/project/built-environment/#:~:text=In%20Australia%2C%20the%20built%20environment,zero%20emissions%20by%20mid%2Dcentury.

[4] Refer to: https://nzgbc.org.nz/research-and-reports#:~:text=This%20groundbreaking%20report%20outlines%20the,trucks%2C%20clothes%2C%20etc

[5] Refer to: https://www.sydney.edu.au/sydney-environment-institute/our-research/transformative-governance.html

Figure 2: NSLHD baseline carbon footprint (2018/19 FY)



Reference: NSLHD Planetary Health Framework 2024-2027.

2.2 Cost-efficiency and risk reduction

Wholesale and retail gas prices have risen considerably in recent years, which has strained the operating budgets for healthcare facilities that rely on gas. While Australia produces much of its natural gas, it is a globally traded commodity and energy markets are susceptible to shocks, including geopolitical events that may affect major gas producers. These global dynamics can cause costs to fluctuate – and typically increase – over time. As gas prices increase, an all-electric approach for existing and new buildings becomes more cost-efficient and reduces the risk of exposure to volatile gas prices and potential changes in government policies.

There is also a potential risk to system operations as gas is eventually phased out. As availability across Australia and New Zealand diminishes, reduced gas supply together with less equipment and parts availability and a likely shortage of skilled technicians poses challenges for continued operation.

While the upfront capital costs are often higher for electric systems compared with gas-fired options, over a long-term horizon moving to renewable electricity sources may reduce running costs. Also, if gas-fired options are installed now, they will likely need to be replaced to meet net zero targets before the end of their useful life.

In existing facilities, capital costs (including possible electrical infrastructure capacity and plant space increases) need to be estimated early and may affect the cost-effectiveness of projects. As such, it is important that business cases emphasise risk reduction project drivers.

2.3 Policy and market trend drivers

National, state and sector-wide legislation, policies and guidelines

All Australian states and territories and New Zealand have the common goal of reaching net zero carbon emissions for all end-uses by 2050. In June 2022, Australia updated its nationally determined contribution, committing to reduce GHG emissions to 43% below 2005 levels by 2030. The revised 2030 commitment is both a single-year target to reduce emissions to 43% below 2005 levels by 2030 and a multi-year emissions budget from 2021 to 2030. Under the baseline scenario, Australia is expected to reduce its GHG emissions by 32% below 2005 levels by 2030 and be 5% above Australia’s 2021–2030 emissions budget. Australia is expected to achieve a 38% reduction on 2005 levels by 2035. New Zealand has also legislated reaching net zero carbon emissions by 2050 and to achieve as a minimum a 50% reduction (below gross 2005 levels) by 2030.

While there are no mandatory emission reductions requirements in Australia or New Zealand necessitating the immediate electrification of buildings, over the past decade or so, policies have been introduced to greatly improve the sustainability performance of buildings. For example, the Australian Government's *Long-term emissions reduction plan* emphasises electrification as a desirable goal, with policies to achieve this not far behind. Similarly, New Zealand legislated the Climate Change Response (Zero Carbon) Amendment Bill (2019), which stipulated that all buildings will need to measure and reduce the energy use of all healthcare facilities and operate at or near net zero carbon.

States are also taking the initiative to reduce GHG emissions and combat climate change. For example, the Victorian Government has introduced a measure that state government projects that have not yet reached the design stage must be all-electric. The Victorian Health Building Authority is preparing for the transformational shift to all-electric public hospitals. Its *Guidelines for sustainability in healthcare capital projects* already require all-electric infrastructure for facilities under 10,000 square meters and for other facilities to include a plan to transition away from natural gas.[6] Likewise, in New South Wales, under the NSW Government Sustainable Buildings SEPP, state significant developments must be net zero ready and fossil fuel free by 2035.[7]

National Construction Code – Section J

For example, the current National Construction Code (NCC) Section J Energy Efficiency Performance Requirements mandates that all new buildings must have features that facilitate the future installation of onsite renewable energy generation. The NCC includes energy-efficiency provisions in Section J. The primary goal of Section J is to ensure buildings are constructed to a minimum standard to reduce energy consumption and GHG emissions. All commercial buildings must meet the minimum standards detailed in the NCC. This requires buildings to achieve energy use targets, which are proven through either meeting 'deemed to satisfy' requirements or undertaking energy modelling. It primarily focuses on the thermal performance of the building fabric and the energy efficiency of building services. The GHG benefit of heat pumps compared with gas boilers is not considered, nor is the potential for future grid decarbonisation over the life of the building included at the time of certification. The energy modelling protocol uses a reference building compared with the actual building, and due to the calculation methodology at the time of writing, gas boilers can provide a less onerous pathway to compliance in some jurisdictions. This will change as the grid further decarbonises.

Alignment with sustainability rating schemes

Green Star

Launched by the Green Building Council of Australia in 2003, Green Star is an internationally recognised rating system setting the standard for healthy, resilient, positive buildings and places. Green Star's Climate Positive Roadmaps establish the steps required for the built environment to decarbonise new and existing buildings and precincts. The roadmaps have been developed in close consultation with industry and government where they plot a path to ensure climate goals are met in full.

Green Star has been used in the healthcare sector and hospital development in several places. For example, the Canberra Hospital Expansion project's new Critical Services Building is showcasing its environmentally sustainable credentials with the building targeting a 5-star Green Star rating. This is supporting the ACT's *Climate change strategy (2019–2025)* and the ACT Government's target to have a zero-emissions health sector by 2040.

[6] Refer to: https://www.vhba.vic.gov.au/new-public-health-infrastructure-to-be-all-electric

[7] Refer to: https://www.planning.nsw.gov.au/policy-and-legislation/buildings/sustainable-buildings-sepp

NABERS

NABERS (National Australian Built Environment Rating System) provides simple, reliable and comparable sustainability measurement across most types of building sectors. The rating system directs procurement by clearly showing their operational performance and sustainability achievements. A NABERS rating helps to accurately measure, understand and communicate the environmental performance of a building while identifying areas for cost savings and future improvements.

NABERS provides a rating from 1 to 6 stars for a building's efficiency across energy, water waste and indoor environments. This helps building owners to understand their building's actual measured performance compared with other similar buildings, providing a benchmark for progress.

The NABERS Carbon Neutral standard for public hospitals aims to assess and improve the energy efficiency and environmental impact of entire hospital campuses. The NABERS Public Hospitals energy and water rating system evaluates the operational data of hospitals over a 12-month period and provides insights into energy and water efficiency, helping hospitals identify areas for improvement. Public hospitals with a NABERS energy rating of 4 stars or above, and meet the other eligibility criteria, can achieve Carbon Neutral Building Certification through using carbon offsets to cancel emissions or choose renewable energy for stationary energy consumption.

Unlike other NABERS ratings, NABERS Public Hospitals operates through a direct relationship with state health departments, rather than via third-party assessors. Ratings are conducted by trained assessors within health departments, which are then certified and audited by NABERS. NABERS Public Hospitals is part of the NABERS program, which is administered nationally. NABERS Public Hospitals will assist the health jurisdictions to get a better understanding of the environmental performance of their hospital facilities.

3. Planning for electrification

The steps shown in Figure 3 on the next page and in the following section provide a recommended strategy for electrification planning. The steps do not necessarily need to be conducted in the order set out; they can be adjusted to meet the needs of each jurisdiction and for each independent healthcare facility. The planning process for electrification will differ for new buildings versus retrofitting existing buildings. However, there are synergies, and for the purpose of this guide, both are included for discussion and highlighted where the approaches differ.

3.1 Establish the context

Define the project scope and objectives

At the start of the project, the scope and objectives need to be set and clear metrics and indicators to measure progress should be established. For new buildings this should be straightforward – the aim being to design and construct a fully electric building from the outset. For existing buildings, other considerations need to be accounted for, including the time horizon for the facility to be fossil fuel free. For existing facilities a gas transition plan or net zero plan can be developed. This plan should cover how the asset plans to reduce energy consumption, incorporate renewable energy, improve energy efficiency and measure GHG emissions.

Review facilities

For **new buildings**, electrification can be designed from the outset, allowing for the correct sizing of plant rooms and optimising the facility for electric plant and equipment.

For an **existing building**, transitioning to electric-powered systems may require major adjustments and changes to design, particularly of the electrical infrastructure and the gas-powered heating plant. Plant space requirements are often larger for electric systems when compared with gas-fired equipment; pipework requirements are also varied, and adjustments must be made based on whether the electric system can be centralised into a single plant (refer to section 4). Therefore, the first step is to conduct a desktop review and site visit(s) to understand the considerations for the existing building, to examine the options for removing gas as an energy source, and review where and how gas is being consumed. The following steps should be taken:

1. Review fossil fuel consumption at the facility, the uses for natural gas, and the type and age of gas equipment and systems. Note that if data on thermal heating loads (for example, space heating and domestic hot water) is not available, load data should be organised early to enable options to be evaluated and future designs to progress. This could be by installing temporary thermal heating load meter logging equipment or, preferably, permanent meter load recording on building management systems.
2. Identify who has control or the ability to remove gas from a building.
3. Understand the facility's current carbon footprint.
4. Review the available documentation and energy consumption data.
5. Request information to fill gaps and confirm outstanding queries.
6. Undertake site visits.
7. Make suitable technical assumptions where needed.

Figure 3: Recommended steps and activities to achieve electrification for healthcare assets

Stage	***Task***	***Recommended***
Establish the context	**Project definition**	❑ Define project scope and objectives. ❑ Identify time horizon for electrification as part of net zero planning. ❑ Define metrics and indicators to measure success.
	Review facilities *(existing)*	❑ Undertake site visits to review where and how gas is being consumed. ❑ Identify who has control or ability to remove gas from a building. ❑ Understand the current carbon footprint of the facility. ❑ Review available documentation and energy consumption data. ❑ Review facility load, type/age of equipment and system.
	Feasibility assessment	❑ Identify priority opportunities, including budget allowances. ❑ Propose technologies, technical considerations/constraints. ❑ Review asset replacement plans and review gas-substitution pathway. ❑ Consider energy efficiency to reduce demand (reduce need for supply augmentation), backup capacity.
Planning	**Electrical infrastructure review**	❑ Understand total maximum demand, ensure sufficient plant space and capacity for infrastructure. ❑ Consider load demand management systems to manage peak electrical load as part of an overall building electrification strategy. ❑ Ensure appropriate diversity is applied with agreement from the project stakeholders in the maximum demand scenario calculation.
	Stakeholder engagement	❑ Engage stakeholders to gather feedback on electrification. ❑ Obtain peak demand data/meter monitoring information. ❑ Present users benefits and costs of electrification. ❑ Promote stakeholder engagement and ensure efficient building assessments. ❑ Identify the stakeholders who will be impacted by the upgrading infrastructure and communicate plans.
Deliver	**Business case**	❑ Communicate to project stakeholders and sponsors the drivers and benefits for electrification (Reasons for electrification – section 2) This may include cost-benefit analysis, projected usage, environmental benefit and alignment with hospital sustainability goals. ❑ Tools to assist may include the marginal abatement cost curve analysis (MACC) and the lifecycle cost assessment (LCCA).
	Implementation and next steps	❑ Engage a consultant team to design and document the scope of the electrification works. ❑ Technical considerations for each electric system (outlined in section 4) should be included in the design. ❑ Integration with asset management plans and budgets updated accordingly.

Feasibility assessment

The next stage involves preparing a feasibility assessment for each building, including the types of electric technology to employ and any technical or spatial challenges in their deployment. A feasibility assessment should include the following steps:

1. Review the campus master plan (if relevant).
2. Review the facility's heat load as well as the type/age of equipment and systems.
3. Identify priority opportunities for the next 5 to 10 years, including budget allowances, and align where possible with other upgrades or tenant refits planned across the facility/portfolio.
4. Propose technologies, technical considerations/constraints, including:
   - For **new buildings**, allow extra plant space for heat pumps in lieu of gas heating, hot water systems/boilers and thermal storage above the traditional design allowance.
   - For **existing buildings**, review the existing plant room space to identify if there is enough space to accommodate heat pumps for space heating and domestic hot water (DHW) systems. If there is insufficient space, or plant needs to be located outside, new locations should be identified.
   - Depending on space heating, steam plant, DHW and cooking demand, the substation size may need to be increased. The electrical capacity of a building is a potential challenge to transferring to all electric systems, especially for existing facilities.
   - Refer to section 4 for further technical considerations.
5. Agree existing utility costs and prepare calculations of the projected variance in cost.
6. Review asset replacement plans for opportunities to integrate electrification.
7. Identify trigger points – for example, end-of-life equipment replacement, refurbishment/redevelopment projects to align electrification projects.
   - For **existing buildings**, depending on the local building certifiers advice, modifying existing building services may trigger a requirement for installations to meet current Australian Standard code requirements. The cost and spatial impact of these upgrades will need to be considered in the feasibility assessment.
   - Where the need to upgrade existing switchboards is identified (for example, to meet AS/NZ 61439), such upgrades will be required regardless of electrification projects. Therefore, these upgrade costs can be excluded from the electrification project cost-benefit analyses. However, the required capital funding would need to be sought to enable electrification.
8. Integrate electrification with other net zero carbon plans (for example, electric vehicle charging, renewable energy installation).
9. Engage technical specialists to assess options including +/- 20% cost and benefit estimates.
10. Work with stakeholders to agree on preferred option(s).

For larger and more complex sites comprising a portfolio of assets, the same assessment may be undertaken. But it may be helpful to establish an electrification roadmap that will overlay datasets to inform the most impactful projects.

Case study 3: Electrification of Shoalhaven Hospital (NSW) redevelopment

The Shoalhaven Hospital redevelopment undertook a 30-year lifecycle cost analysis on electrification in 2022 that provided important findings for projects. The study found gas options produce less CO_2 per kilowatt of energy but use more energy compared with electricity options.

This case study is detailed in Appendix 1.

3.2 Planning

Electrical infrastructure review

A comprehensive review of electrical infrastructure will need to be undertaken when planning for electrification.

For **new buildings**, this should include the following steps:

1. Assess the maximum electrical demand, considering extra capacity for a full electric building (this should be conducted even if the development may not be fully electric at commissioning).
2. Ensure appropriate diversity is applied with agreement from the project stakeholders in the maximum demand scenario calculation.
3. Allow enough plant space and capacity for larger electrical infrastructure – substation, main switchboard, submains battery storage system (where feasible) – to accommodate fully electric buildings.
4. Consider load demand management systems to manage peak electrical load as part of an overall building electrification strategy. This may include non-critical load shedding, load shifting, electric vehicle charging facilities (including V2G where feasible for fleet vehicles).

For **existing buildings**, this should include assessing the existing electrical infrastructure to identify:

- the electrical capacity of the existing substation and main switchboard
- plant space for an extra electrical switchboard, if needed
- a feasible reticulation path to run extra electrical cabling to new electric equipment
- existing spare circuit breakers and sizes
- historical peak energy demand
- any potential changes/plan to create extra electrical capacity, such as for installing electric vehicle chargers
- any potential changes/plan to reduce electrical capacity – that is, replace existing fluorescent lighting to LED, upgrade to a more energy-efficient HVAC system and so on.

Refer to Section 4 for more technical considerations.

Stakeholder engagement

By engaging with stakeholders and gathering their feedback on electrification, healthcare facilities can ensure the infrastructure meets its needs. This may include:

- obtaining peak demand data / meter monitoring information from similar fully electric facilities and reviewing load diversity assumptions to avoid over-designing electrical capacity
- identifying any changes to central or local plants that may have an impact on users including service disruptions, energy costs and capital cost contributions
- identifying areas and periods of disruption
- presenting the benefits and costs of electrification
- promoting stakeholder engagement and ensuring efficient building assessments
- identifying the stakeholders who will be affected by upgrading the infrastructure
- scheduling meetings with the specific stakeholders to discuss any particular needs or concerns
- conducting stakeholder meetings and gathering feedback
- reviewing and finalising infrastructure requirements based on the stakeholder feedback and any regulatory requirements
- obtaining stakeholder approval for the final infrastructure requirements and ensuring any concerns have been addressed.

The electrification strategy should be reviewed and approved by relevant stakeholders and working groups at each stage of the planning, design and delivery process. The following stakeholders should be consulted as part of this process:

- health asset manager, corporate management, sustainability manager
- sustainability working group
- health capital works authority project director
- Building Code of Australia consultant
- design team
- capital works governance group.

Business case development

The business case for electrification largely rests on the reasons for electrification provided in section 2. If these drivers and benefits are communicated clearly to the project sponsors and stakeholders, then support for the project will be easier to obtain and maintain. The business case should showcase the value-for-money, resilience, policy alignment and sustainability benefits. This should include a cost-benefit analysis, projected usage, environmental impact and alignment with hospital sustainability goals. There are several tools that may help when developing a business case for electrification, including a MACC analysis and an LCCA. Refer to the Appendix 2 for more details.

Case study 2: Infrastructure electrification of existing healthcare portfolio (ACT Government)

Canberra Health Services undertook a feasibility study on the electrification of all DHW and heating hot water (HHW) plants throughout the portfolio, looking at one tertiary and one subacute care and 8 health centres providing a range of services. A MACC of all options under various utility pricing scenarios was conducted.

This case study is detailed in Appendix 1.

3.3 Delivery

Implementation

Depending on the nature and scale of the electrification, the implementation phase will involve engaging a suitably qualified design team consisting of architects, engineers and other specialist consultants to design and document via drawings and specifications the scope of the electrification works. Implementation of the electrification works will be performed by engaging a contractor to finalise design and supply, install, test and commission the electric systems, where necessary. Technical considerations for each electric system outlined in section 4 should be included in the design. Further, the design must be carefully considered to avoid oversized systems, unnecessary upgrades and increased cost.

For **existing buildings**, measure and reduce existing demand to ensure the replacement electric plant is the right size. Oversized systems are prevalent in many facilities. This can be due to design assumptions, a lack of stakeholder engagement, assumptions on final space equipment selections/requirements or poor building envelope performance leading to excessive heat loss from spaces. Undersized cooling and heating systems are also a risk, especially in a sensitive healthcare setting where medical lifesaving devices need constant temperature control and HVAC parameters.

Where building electrification is proposed, it is important that like-for-like replacements are challenged, and robust building assessment is completed to maximise the sustainability benefits of this design initiative. Designing an all-electric building involves careful consideration of how to integrate the systems and find opportunities for efficiencies.

Once electrification of existing buildings is complete, the new electric systems need to be integrated, with other asset management plans and budgets updated accordingly. This will include training facilities management staff and updating operations and maintenance manuals, as necessary.

Next steps

Once the electrification project has been implemented successfully, evaluate the success of the project and share experiences and lessons learned with other jurisdictions and partners. This helps ensure that the AHIA and its members can continue a path towards decarbonisation. Develop a strategy to ensure the building is more resilient and responsive to a changing climate. This may be done as part of the existing sustainability strategy or be a standalone strategy.

4. Technical considerations

4.1 Space heating

Conventional gas system

Space heating is conventionally achieved through centralised gas boilers. These boilers generate hot water, which is then piped to various emitters/terminal units – such as heating coils in air handling units – to warm indoor spaces. Gas boilers also can inject heat into condenser water systems that are piped to water-sourced heat pump air conditioning units. For more localised heating, radiant and direct gas heaters are also used. Generally, radiant gas heating is used more in outdoor space heating applications.

Electric alternatives

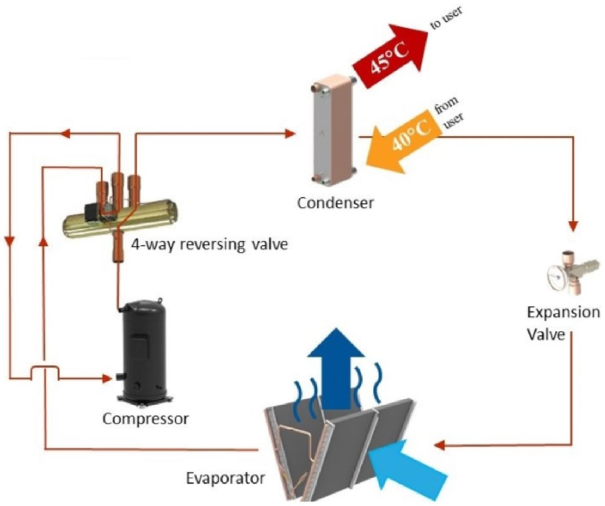
Table 1 lists electric alternatives to gas systems in space heating.

Table 1: Electric alternatives to gas systems in space heating

GAS	ELECTRIC
Gas boiler	Electric heat pump (air and water source) Electric reverse cycle air conditioning (including variable refrigerant flow systems)
Gas radiant / direct heater	Electric radiant / direct heater

Electric heat pumps provide heating by generating low-temperature hot water (LTHW). They use a vapour compression refrigerant cycle in the same way as a traditional cooling system. However, they use a 4-way reversing valve to reverse refrigerant flow from the compressor through the condenser and evaporation coils. In heating mode, the outdoor unit coil is an evaporator, acting as a heat sink within the atmosphere, while the unit heat exchanger connected to the LTHW hydraulic circuit is the condenser, emitting heat (Figure 4).

Figure 4: Electric heat pump cycle schematic in heating mode



Reversible heat pumps

Reversible (also known as '2-pipe') heat pumps can provide both heating and cooling by generating either LTHW or chilled water. This type of heat pump could be used for new building heating/cooling applications, but care needs to be taken so the system design accounts for periods of simultaneous heating and cooling demand. Typically, more than one heat pump unit is needed so both heating and cooling can be provided when required.

Polyvalent heat pumps

Polyvalent (also known as '4-pipe') heat pumps can generate chilled water and LTHW simultaneously through 2 sets of compressors and refrigerant vapour compression cycles in a single unit. This type of heat pump is best suited to buildings with a relatively consistent base load of simultaneous heating and cooling (buildings with enough summer-time heat load – for example, dehumidification re-heat). This ensures heat rejected on the cooling side is used as 'free heating' on the heating side of the system. Design teams should consider the efficiency reduction of this system when providing heating or cooling only.

Variable refrigerant flow systems

Variable refrigerant flow systems are basically a smaller heat pump that use refrigerants as the distribution medium for space heating rather than water systems (LTHW). Using refrigerant as the distribution medium can result in higher embodied carbon compared with water-based systems due to refrigerant leakage. These systems have historically been cheaper to install than water-based systems. Their use is better suited to smaller buildings/facilities.

Other technologies

Other emerging or alternative technologies include electric resistance heating (for example, electric duct heaters), biomass boilers, biogas boilers and hydrogen boilers. However, these technologies will likely not be considered feasible across all sites due to high operating costs, emissions, electrical demand, code compliance, lack of fuel supply and equipment availability and performance.

In summary, a wide variety of electric heating technologies and configurations exist that should be considered by design teams based on the specific requirements of each electrification project.

Impacts and benefits

Using electric heat pumps in lieu of conventional gas boilers will likely have the impacts and benefits listed in Table 2.

Table 2: Impacts and benefits of using electric heat pumps

FEATURE	IMPACTS	BENEFITS
Space and location	✗ Larger plant room space required ✗ More ventilation required – outdoor location preferred for cooling tower or air source heat pump	–
Electrical capacity	✗ Possible increase in peak electrical demand	–
Capital costs	✗ Higher	–
Energy consumption	–	✓ Lower (energy cost is subject to local utility tariff)
Maintenance costs	✗ Higher	–
Health and safety	–	✓ No air pollutants from gas
GHG emissions	–	✓ Lower (with future electricity grid transition to renewable generation)

Technical considerations

Space and location

Electric heat pumps require larger plant room space compared with gas boilers to achieve equivalent heat output. Also, they require adequate natural ventilation to source heat from the air. As a result, heat pumps or reverse cycle air conditioning unit condensers should be located in external courtyards or on rooftops. Where an air-source plant is proposed to be located indoors, follow the manufacturer's installation requirements.

Electrical capacity

For existing buildings, replacing gas space heating systems with electric alternatives will lead to higher electricity demand during heating periods. In many cases, the electricity demand for cooling systems during the summer peak will be greater than that for heating systems in the winter peak and so upgrading the building's electrical infrastructure will not be necessary. An exception may be hospitals with spaces requiring humidity control or in colder climates. Electric heat pumps may be needed for reheat during dehumidification, thus increasing the summer peak electrical demand. Alternatively, waste heat from existing chillers could potentially be used instead for dehumidification reheat.

Heat load

The space heating loads for new and existing buildings will vary by healthcare jurisdiction according to ambient weather conditions defined by NCC Climate Zones in Australia and by the Building Research Association of New Zealand. Heating loads (and associated peak electricity demand) will be greater in colder climates compared with warmer climates. Therefore, the review of loads during feasibility assessment (refer to section 3) should use site specific data.

Water temperatures

The heat delivered through heating hot water depends on both the water temperature and the flow rate. When the water temperature is lower, a higher flow rate is necessary to provide the same amount of heating energy.

In existing buildings, the heating hot water system is often designed to accommodate higher flow temperatures produced by gas boilers (~80°C) and a higher differential between flow and return temperatures (~10 to 20°K); this results in lower design flow rates. To maximise energy efficiency, conventional single-stage air source heat pumps produce hot water at lower flow temperatures (typically ~40°C to 45°C) and a lower differential between flow and return temperatures (~5 to 10°K); this results in higher design flow rates. Therefore, when replacing gas boilers with this type of heat pump, it may be necessary to also install larger replacement pipes, pumps and heating coils (in air handling units or ducts) depending on the system design.

Operating new buildings with lower heating hot water temperatures creates the opportunity to use waste heat from chillers to offer heating during moderate seasons or reheat during dehumidification. This eliminates the need for running heating and cooling systems separately. For existing buildings, significant system upgrades are likely required to recover waste heat.

If replacing existing pipes, pumps and heating coils is not possible and higher heating hot water temperatures need to be maintained, possible solutions include the following:

- Cascade heat pumps (double-stage): This heat pump configuration uses 2 stages of refrigeration (packaged or separate units) to overcome the limitation of single-stage heat pumps and achieve high temperature heating water in the range of 80°C. The first stage air-source heat pump extracts heat from the cold ambient air and then transfers this heat to a second-stage heat pump that generates the high temperature heating water.
- CO_2 refrigerant heat pumps: These heat pumps operate on refrigerant R744 (carbon dioxide or CO_2) and can generate high temperature heating water (approximately 90°C). The refrigeration process relies on the return water temperature entering the heat pumps to be as low as possible (no higher than 60°C), which may not suit existing heating systems and require pipe, pump and coil upgrades. Also, there is currently limited products on the market and unit capacities are generally small. This would require a large quantity of individual units to serve larger buildings such as hospitals.

Refrigerants

Scope 1 GHG emissions includes fugitive leakage of refrigerants. Heat pumps employ a refrigerant cycle, therefore any calculations of emissions carried out during the planning stage such as MACC carbon footprint assessments will need to include refrigerant fugitive emissions. The quantity of such emissions will depend on the refrigerant global warming potential (GWP), refrigerant system charge volumes and assumed percentage of refrigerant loss per annum.

Heat pumps most commonly use a class of refrigerants known as hydrofluorocarbons (HFCs). These refrigerants have a zero-ozone depletion potential, but they can have a high GWP. However, high GWP refrigerants will be phased down in Australia by 2036 in line with the Montreal Protocol[8]. In the long term, this will increase HFC refrigerant, equipment and operational costs.

As mentioned above, heat pumps using natural refrigerants like CO_2 are commercially available. Using CO_2 as a refrigerant minimises environmental impact due to its low GWP in contrast with HFC refrigerants. But for existing and/or large buildings, the associated water temperature and limited capacity constraints would need to be considered. Other natural refrigerants such as propane or ammonia have extra flammability and toxicity considerations that would need to be addressed should they be considered by design teams.

It is also important to note that some low-GWP refrigerants are highly flammable or toxic. This safety issue should be addressed in the design and operation. Safe working methods are required if working with these refrigerants, and their use should be discussed with facilities management before implementation. Refrigerant volumes and locations are best limited to individual heat pumps and locations.

Heat pumps equipped with hydrofluoroolefin refrigerants with very low GWPs are also in the developmental stages. But many of these refrigerants include or can break down into PFAS (per- and polyfluoroalkyl

[8] See https://www.dcceew.gov.au/environment/protection/ozone/montreal-protocol.

substances), which have growing environmental concerns. Restrictions on using these substances is being considered in Europe.

Refrigerant fugitive emissions during operation and maintenance of heat pumps can be minimised by ensuring all personnel adopt industry best practice approaches such as Australian Refrigeration Council refrigerant handling licensing.

Low ambient temperature operation

Air source heat pumps do not operate as efficiently in heating mode as ambient temperatures drop, especially below 5–7°C. An assessment of the site's annual weather data should be carried out, assessing the extent of periods at these low temperatures before deploying the technology.

Below ambient conditions of 5°C, water vapour within the air freezes on evaporator coils, which suppresses airflow across the coil and greatly reduces efficiency. During these periods, air source heat pumps will operate a defrost cycle (rejecting heat via the coils), limiting operation during the cycle. This can be addressed by using a combination of multiple units and thermal energy storage (TES).

Thermal energy storage

This is the process of storing excess thermal energy for later use, typically to shift space heating loads (usually overnight during the lowest ambient temperature) to match the highest efficiency heat pump operation (usually daytime during the highest ambient temperature) or onsite renewable electricity peak generation. TES could provide several key benefits including:

- allowing polyvalent heat pumps to operate in simultaneous heating-cooling mode, even if only heating or only cooling is required by the building at the time
- minimising interruptions due to heat pump defrost modes
- reducing the risk of insufficient heating capacity from air-source heat pumps at extreme low ambient temperatures
- reducing the need to oversize heat pumps, which will help to reduce electrical demand.

Achieving these benefits will likely require large volume, insulated TES tanks; cost and plant room spatial impacts will need to be assessed to confirm their feasibility.

4.2 Steam sterilisation

Conventional gas system

Two most common methods of generating steam for sterilising reusable medical devices in Central Sterilising Services Departments (CSSD) are (1) central steam generation via gas boilers piped to sterilisers or (2) local electric steam generation in sterilisers.

Electric alternatives

Table 3 lists electric alternatives to gas systems in steam sterilisation.

Table 3: Electric alternatives to gas systems in steam sterilisation

GAS	ELECTRIC
Gas steam boiler	Local electric steam sterilisers Electric steam boiler

The preferred electrification of steam sterilisation is to provide new local electric steam sterilisers. Removing reticulated steam pipework also results in energy savings due to heat loss and cost savings through less maintenance. Where this is not possible, central gas steam boilers can be replaced with electric steam boilers. Electric boilers generate steam by heating water using electric resistance heaters.

The above-mentioned space heating electric alternatives are current, proven, commercially available technologies. There are high-temperature steam heat pumps in development around the world for industrial purposes, but there is limited availability in Australia. Other emerging or alternative sterilisation technologies besides using steam include:

- ethylene oxide gas sterilisation
- hydrogen peroxide gas plasma
- peracetic acid sterilisation
- ionising radiation
- dry heat
- liquid chemicals
- vaporized hydrogen peroxide
- ozone.

A CSSD specialist would need to advise on the viability of these alternatives.

Impacts and benefits

Using electric steam boilers in lieu of conventional gas steam boilers will likely have the impacts and benefits listed in Table 4.

Table 4: Impacts and benefits of using electric steam boilers

	IMPACT	BENEFIT
Space and location	–	✓ Smaller plant room space required for central steam boilers ✓ Local and central steam sterilisers are generally the same dimensions – no impact to CSSD room size
Electrical capacity	× Increase in peak electrical demand	–
Capital costs	–	✓ Equal (steam boiler cost only)
Energy consumption	× Higher (energy cost is subject to local utility tariff)	–
Maintenance costs	–	✓ Lower
Health and safety	–	✓ No air pollutants from gas
GHG emissions	–	✓ Lower (with future electricity grid transition to renewable generation)

Technical considerations

Space and location

Electric steam boilers need less plant room space than gas boilers to achieve equivalent steam output. They do not need ventilation for combustion nor flue discharges, which offers more flexibility of location in a building.

Local and central steam sterilisers are generally the same dimensions, so there will be no difference to CSSD room size for these 2 options.

Electrical capacity

For existing buildings, replacing gas steam boilers with electric alternatives will lead to higher peak electricity demand. This will affect the building's electrical infrastructure and may require upgrades if there isn't enough spare capacity.

Other considerations

Electric steam boilers are generally well suited for buildings with consistent and predictable steam demand load profiles. Gas steam boilers are generally better for fluctuating steam loads or high-demand scenarios.

Manufacturers and suppliers of electric steam boilers are currently quite limited in Australia, and initial capital costs are roughly equal with gas equipment. However, as the electrification market and associated supply of electric steam boiler equipment increases, capital costs are expected to be lower that gas steam boilers over time.

4.3 Domestic hot water

Conventional gas system

Domestic hot water is often provided through centralised or local gas boilers. These boilers generate hot water, which is then piped to fixtures requiring DHW – such as sinks, hand basins and showers. Some older hospitals with central steam systems with gas boilers for sterilisation may also use steam calorifiers to generate DHW.

Electric alternatives

Table 5 lists electric alternatives to gas systems in DHW.

Table 5: Electric alternatives to gas systems in domestic hot water

GAS	ELECTRIC
Gas boiler (central)	Heat pumps with thermal storage tanks Heavy duty electric storage
Gas boiler (local)	Instantaneous electric Electric storage

Electric (air to water) heat pumps provide DHW by using refrigerants and vapour compression cycled to extract heat from outside air.

It is also possible to integrate DHW heat pump systems with mechanical heating systems via integrating water-to-water/water-source electric heat pumps. Waste heat from condenser water and chilled water systems can be used as a heat source for water-source DHW heat pumps. For HHW systems a heat exchanger can be installed to enable pre-heating of DHW. For existing systems, detailed investigation of existing capacity and use patterns would be required to determine suitability for integration with DHW systems.

The above-mentioned electric heat pump alternatives are current, proven, commercially available technologies. Solar thermal systems are typically not considered the most efficient option to adopt for DHW heating. The energy savings made from photovoltaic (PV) panels on roofs of buildings generally reduce operating costs more than savings from pre-heating domestic water through solar panels and so is considered the most efficient use of roof space.

Impacts and benefits

Using electric heat pumps in lieu of conventional gas boilers will likely have the impacts and benefits listed in Table 6.

Table 6: Impacts and benefits of using electric heat pumps

	IMPACT	BENEFIT
Space and location	× Larger plant room space required × More ventilation required – outdoor location preferable	–
Electrical capacity	× Increase in electrical demand	–
Capital costs	× Higher	–
Energy consumption	–	✓ Lower (energy cost is subject to local utility tariff)
Maintenance costs	× Higher	–
Health and safety	–	✓ No air pollutants from gas
GHG emissions	–	✓ Lower (with future electricity grid transition to renewable generation)

Technical considerations

Space and location

Electric heat pumps need larger plant room space compared with gas boilers to achieve equivalent heat output. If a plant room has been designed for gas boilers only, there might be challenges in locating heat pumps with the equivalent capacity within the same space. To reduce the extra space required, storage tanks sized to store the daily peak load can be included in the design. Storage tanks can be designed to act as a thermal battery allowing heat pump operation to be optimised to match onsite renewable electricity peak generation, or as part of an electrical demand management system.

Also, heat pumps need natural ventilation to source heat from the air. As a result, heat pumps should ideally be located externally, or in well-ventilated areas. Locating heat pumps near building exhausts can provide an additional heat source and increase their efficiency, subject to providing continued safe access for maintenance at all times.

Electrical capacity

For existing buildings, replacing existing gas boilers with electric alternatives will lead to higher electricity demand, which may affect the building's electrical infrastructure, particularly if electric booster units are recommended to be used within the storage elements.

Water temperatures

In DHW storage systems, water must be heated to a minimum of 60°C to prevent growth of bacteria such as Legionella in line with NCC requirements.

Due to the extra space requirement and the longer heating time required for heat pumps to heat water to the required minimum temperature when compared with gas, storage is usually required to ensure the peak volume of hot water can be delivered, particularly in areas where temperatures may drop below ~10°C and reduce heat pump efficiency.

Refrigerants

Scope 1 GHG emissions includes fugitive leakage of refrigerants. Heat pumps employ a refrigerant cycle, therefore any calculations of emissions carried out during the planning stage such as MACC carbon footprint assessments will need to include refrigerant fugitive emissions. The quantity of such emissions will depend on the refrigerant global warming potential (GWP), refrigerant system charge volumes and assumed percentage of refrigerant loss per annum.

Heat pumps most commonly use a class of refrigerants known as hydrofluorocarbons (HFCs). These refrigerants have a zero-ozone depletion potential, but they can have a high GWP. However, high GWP refrigerants will be phased down in Australia by 2036 in line with the Montreal Protocol[9]. In the long term, this will increase HFC refrigerant, equipment and operational costs.

As mentioned above, heat pumps using natural refrigerants like CO_2 are commercially available. Using CO_2 as a refrigerant minimises environmental impact due to its low GWP in contrast with HFC refrigerants. But for existing and/or large buildings, the associated water temperature and limited capacity constraints would need to be considered. Other natural refrigerants such as propane or ammonia have extra flammability and toxicity considerations that would need to be addressed should they be considered by design teams.

It is also important to note that some low-GWP refrigerants are highly flammable or toxic. This safety issue should be addressed in the design and operation. Safe working methods are required if working with these refrigerants, and their use should be discussed with facilities management before implementation. Refrigerant volumes and locations are best limited to individual heat pumps and locations.

Heat pumps equipped with hydrofluoroolefin refrigerants with very low GWPs are also in the developmental stages. But many of these refrigerants include or can break down into PFAS (per- and polyfluoroalkyl substances), which have growing environmental concerns. Restrictions on using these substances is being considered in Europe.

Refrigerant fugitive emissions during operation and maintenance of heat pumps can be minimised by ensuring all personnel adopt industry best practice approaches such as Australian Refrigeration Council refrigerant handling licensing.

Low ambient temperature operation

Air source heat pumps do not operate as efficiently in heating mode as ambient temperatures drop, especially below 5–7°C. An assessment of the site's annual weather data should be carried out, assessing the extent of periods at these low temperatures before deploying the technology.

Below ambient conditions of 5°C, water vapour within the air freezes on evaporator coils, which suppresses airflow across the coil and greatly reduces efficiency. During these periods, air source heat pumps will operate a defrost cycle (rejecting heat via the coils), limiting operation during the cycle. This can be addressed by using a combination of multiple units and thermal energy storage (TES).

4.4 Cooking

Conventional gas system

Cooking is often provided using gas cooktops and other equipment in commercial kitchens. But electric alternatives, including induction technologies, have significantly improved and have become significantly more

[9] See https://www.dcceew.gov.au/environment/protection/ozone/montreal-protocol

common. The various types of cooking processes mentioned in this section are included for completeness; actual process used will vary by building type (includes retail cafes), jurisdiction and food services model.

Electric alternatives

Table 7 lists electric alternatives to gas systems in cooking.

Table 7: Electric alternatives to gas systems in cooking

GAS	ELECTRIC
Gas cooktop	Induction
Flame and char	Electric charcoal grille Electric grille with steam for moisture
Wok burner	Induction wok burner
Gas oven	Electric oven Electric steam oven

Impacts and benefits

Table 8 lists the impacts and benefits of using gas in cooking.

Table 8: Impacts and benefits of using gas in cooking

FEATURE	IMPACTS	BENEFITS
Space and location	–	✓ Smaller extract ducts ✓ Smaller kitchen possible
Electrical capacity	× Increase in peak electrical demand	–
Capital costs	× Higher × Induction may require new cooking utensils	–
Energy consumption	–	✓ Lower (energy cost is subject to local utility tariff)
Health and safety	–	✓ Better indoor air quality and more comfortable temperatures in the kitchen ✓ Less risk of burns
GHG emissions	–	✓ Lower (with future electricity grid transition to renewable generation)

Technical considerations

When considering alternatives for cooking styles that need flame, localised fuel sources, preferably using renewable biofuel or biogas, can be used. When considering all electric kitchens, the potential to reduce supply and exhaust ventilation flow rates and therefore save fan and cooling energy should be considered because induction cookers emit much less direct heat into a kitchen. Electric kitchens can also create quieter spaces and reduce material use in the fit-out.

Other considerations

Induction cooktops have flat surfaces that can be used to create additional workspace when not used for cooking. They are also significantly easier and quicker to clean than gas burners with less cleaning chemicals required. Induction cookers can also be used for multiple types of cooking due to the ability to control temperatures and therefore reduce the amount of specialist equipment required. Special induction cookware with a ferrous base will be required for use with induction cooktops.

Case study 1: Transitioning the Victorian public health system away from gas

The Victorian Government has committed to achieving net zero carbon emissions by 2045, with interim targets in 2025, 2030 and 2035. This document evaluates a range of technologies and the challenges of transitioning from gas in existing facilities.

This case study is detailed in Appendix 1.

4.5 Other systems

There are other systems in healthcare buildings that use gas or other fossil fuels that will need replacing with electric alternatives or designed for electrification in the future.

Laboratory equipment

Laboratory equipment such as Bunsen burners connected to central piped gas systems could be replaced with portable devices using butane gas cannisters or electric Bunsen burners.

Co- and tri-generation equipment

Gas-fired cogeneration systems, which simultaneously generate heat and electricity for buildings, were once considered a low-carbon transitional technology. They reduced grid electricity consumption while providing a heat source. In tri-generation systems, the excess heat was used to drive an absorption chiller during periods when heating was not needed. The viability of co-generation now depends on natural gas prices relative to grid electricity, efficient year-round heat use, and the pace of grid decarbonisation. In some existing buildings, these conditions are no longer met. Decommissioning co-generation systems may involve turning them off and removing redundant equipment. However, in certain cases, the system may be integrated with emergency power backup, overall heating capacity or cooling capacity. Thoughtful planning to decommission is essential, but freeing up plant space can be a benefit.

Pool heating

Some healthcare facilities have hydrotherapy pools with water that requires heating. Conventional gas-fired boilers could be replaced with electric heat pumps. It is recommended that heat from any mechanical heat rejection systems is recovered and used for pool heating.

Laundry equipment

For healthcare facilities that launder their own linen on site, the most common gas appliances used in commercial laundries are dryers and ironers. Replacement electric laundry appliances generally have higher initial and running costs (based on current 2024 gas tariff prices) and will increase the building's peak electrical demand. However, maintenance costs of electric laundry appliances are generally lower than gas counterparts. Electric dryers typically take longer to dry clothes compared with gas dryers and process smaller loads requiring more individual units; hence the laundry department will need to factor in the extended drying time and staffing ratios when planning laundry schedules. Ironers powered by steam generated via centralised gas boilers can be replaced with ironers with local electric steam generation.

4.6 Electrical capacity

The electrical capacity of a building is a potential challenge to removing gas and switching to all electric systems.

The following outlines several factors that need to be considered:

- the electrical capacity of the existing substation and main switchboard
- the actual annual peak electrical demand in the healthcare facilities based on historical data
- the number of power supplies to site
- the measured available spare capacity during the annual peak demand scenario
- any proposed changes to the building that may change the existing electrical demand (increasing it by electrifying or decreasing it through energy efficiency and demand management)
- spare space availability for extra electrical infrastructure for the electrification.

A site analysis of the electrical master plan should be developed to understand potential load growth into the future. This master plan could be shared with the local network operator to allow them to plan future feeder upgrades.

Electrical infrastructure redundancy requirements will be different depending on jurisdiction, based on state/territory-specific (and NZ-specific) design guideline requirements, facility category/level of importance. For new buildings reference should be made to the local healthcare jurisdiction engineering services guidelines, which nominate minimum redundancy requirements for each state. For existing buildings, as a minimum, electrical supply infrastructure redundancy should replicate the gas supply infrastructure being replaced.

To further inform redundancy requirements, consider undertaking an assessment of power supply reliability. Generally, gas supply to healthcare facilities does not have inbuilt redundancy but is a reliable system. Therefore, careful consideration with the project stakeholders of additional electrical infrastructure redundancy is needed to avoid over-designing while also balancing feasibility and capital cost.

For existing buildings, depending on the local building certifier's advice, modifying existing building electrical services may trigger a requirement for existing switchboard installations to meet current AS/NZS 61439 code requirements. The cost and spatial impact of these upgrades will need to be considered in the feasibility assessment (refer to section 3).

4.7 Backup and emergency power

The electrification of facilities will need to consider the need and extent of standby power. For existing facilities, this may necessitate an increase in existing standby power and associated diesel storage. It requires careful planning and stakeholder consultation to determine if generator backup is required and the appropriate level of generator backup for the electrification system in healthcare facilities.

Consider the following approaches for healthcare facilities:

- Evaluate the criticality of the healthcare facilities and identify systems that are essential for life safety and business-critical operational functionality.
- Evaluate operational implications and protocols for power outages, including identifying suitable backup generators if needed.
- Ensure compliance with all relevant building codes, regulations and guidelines specific to states and territories.
- Assess the reliability and stability of the electricity grid in each region.
- For existing buildings, consider like-for-like replacement when determining generator backup requirements.

Currently, most standby generators are powered by diesel, which contributes to a small percentage of a healthcare building's overall GHG emissions and in the short-medium term are not a priority, or particular focus, for electrification. However, long term, for a building to be completely zero carbon, alternatives such as biofuel or green hydrogen could be considered as and when the technology becomes commercially available.

4.8 Space and location

As mentioned above, electrifying new and existing healthcare buildings will require consideration of electric plant space and location. Electric air-source heat pumps require larger plant room space compared with gas boilers and need natural ventilation to source heat from the air. Hence heat pumps are best located in external courtyards or on rooftops. Locating air-source heat pumps in internal plant rooms will require careful consideration of intakes and discharges to provide adequate ventilation in line with the manufacturer's requirements. All plant locations will require a review of:

- the impact of the building envelope (for example, planning permission, development application, heritage constraints)
- the impact of noise to neighbouring properties
- the impact on structural design (existing buildings may need strengthening upgrades to support heavier, replacement electric plant)
- connection to the existing heating water pipework reticulation
- access for plant maintenance and replacement.

Appendix 1: Case Studies

Case study 1: Transitioning the Victorian public health system away from gas

The Victorian Government has committed to achieving net zero carbon emissions by 2045, with interim targets in 2025, 2030 and 2035. To achieve this commitment, the state must transition away from its current reliance on fossil gas, which led to the release of the *Victorian Government gas substitution roadmap* in 2022, and a subsequent update in 2023. This document evaluates a range of technologies such as electrification, biogas, biomass and hydrogen but identifies electrification as the preferred technology for the building sector.

The Victorian health system is large energy user, accounting for 60% of state government natural gas use. In 2023 a policy was introduced that new facilities will be all-electric, but this leaves the challenge of moving the existing portfolio away from fossil gas.

To support this transition, the Victorian Health Building Authority reviewed gas use across the portfolio, identifying available technologies and assessing implementation barriers and opportunities for transitioning away from fossil gas. The study took a portfolio approach to better understand pathways for gas substitution.

Challenges

- Electrification of large sites have significant challenges on system compatibility and availability of space
- Availability of detailed facility information on gas end users and appliance capacity
- Levers for infrastructure upgrades support like-for-like gas replacement

Successes

- Assessment at the portfolio level provides clear direction on ways to move away from fossil gas
- Electrification of less complex sites provide opportunities
- Electrification of new hospitals is technically and financially viable

Lessons learned

- Electrification is the most viable option, though is still challenging at large hospitals
- Alternative fuels are likely to play a lesser role in gas substitution for buildings
- The capacity of the grid to support electrification of sites is a key enabler

Links:

https://www.climatechange.vic.gov.au/victorias-climate-change-strategy
https://www.energy.vic.gov.au/renewable-energy/victorias-gas-substitution-roadmap

Case study 2: Infrastructure electrification of existing healthcare portfolio

Canberra Health Services undertook a feasibility study on the electrification of all DHW and HHW plants throughout the portfolio. This included 2 hospitals, one tertiary and one subacute care, and 8 health centres providing a range of services. Remaining emissions from the electrified solution was included in the analysis and a natural refrigerant option was to be considered wherever feasible. The project included:

- a desktop review of plant documentation and asset registers
- site visits to all major plants and engagement with key infrastructure personnel
- a technology review of electrification options
- a cost estimate of all feasible options
- a MACC of all actions under various utility pricing scenarios.

While electrification options are specific to the type of asset and its location, several themes emerged across the healthcare services in the study:

- Plant rooms will require expansion, increasing costs and the complexity of project delivery given all facilities will need to remain operable throughout works.
- Resulting annual emissions for electrified HHW plant using HFC refrigerants was 25–50% of the current natural gas plant, driven largely by the required HHW temperature.
- Significant increase in capital cost compared with like-for-like replacement requiring additional funding for the asset renewal program.
- Using low HHW temperatures to optimise heat pump implementation requires upgrading both HHW reticulation and air handling equipment heating coils, requiring deep building refurbishment.

The study provided a range of options for consideration, guided by the MACC to pursue a transition to all-electric healthcare portfolio.

Challenges

- Utility price volatility makes operation cost impacts unpredictable
- Budget to implement recommendations
- Ensuring deep refurbishment of whole buildings

Successes

- Site-specific feasibility
- Identifying common plant types
- Significant emissions reduction for DHW systems
- Natural refrigerant DHW systems are practical

Lessons learned

- Improve thermal metering to inform actual load
- Managing risks outside the hospital boundary is key to managing resilience

Link: https://www.climatechoices.act.gov.au/climate-change/what-the-act-government-is-doing

Case study 3: Electrification of Shoalhaven Hospital redevelopment

The NSW Government has committed to addressing climate change by targeting net zero emissions by 2050. It has also committed to interim targets: a 50% reduction on GHG emissions by 2030 and a 70% reduction by 2035 (compared with 2005). In line with these commitments, Health Infrastructure NSW is designing and delivering infrastructure that is net zero ready. It is prioritising the electrification of new healthcare facilities as the grid shifts to renewable energy sources.

The Shoalhaven Hospital redevelopment undertook a 30-year lifecycle cost analysis on electrification in 2022 that provided important findings for projects. Four different scenarios were analysed and costed:

- scenario 1: gas-fired heating and DHW from day 1
- scenario 2: gas-fired heating and DHW, with space proofing for electrification, and electrification occurring after 25 years
- scenario 3: gas-fired heating and DHW, with space proofing for electrification, and electrification occurring after 15 years
- scenario 4: electrification of heating and DHW from day 1.

The study found gas options produce less CO_2 per kWh energy but use more energy compared with electricity options. They produce higher total CO_2 emissions per annum than electrification, and though the capital cost of electrification outweigh gas, the running costs of electricity were lower. Given both cost and emissions were lower under the full electrification option over the 30-year period, the hospital's new acute building's DHW and HVAC heating are now being fully electrified from day 1, as per scenario 4.

Challenges

- Developing consistent assumptions and obtaining required data
- Sourcing information on electric and gas assets

Successes

- Undertaking a cost-benefit analysis process led to full electrification of the building
- This pilot has prompted development of a cost-benefit analysis and evaluation guide for electrification

Lessons learned

- Electrifying new developments and greenfield sites reduces the carbon footprint and operational costs in the long term
- Other fully electric projects in the design pipeline need to draw on the results of pilots

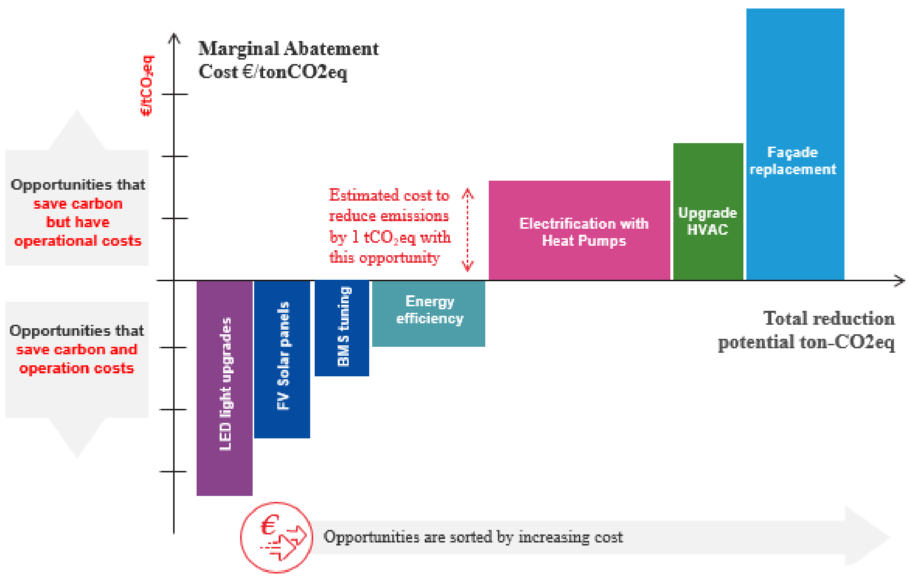
Links:
https://shoalhavenredevelopment.health.nsw.gov.au/about-the-project/acute-services-building
https://www.hinfra.health.nsw.gov.au/projects/project-search/shoalhaven-district-memorial-hospital-redevelopment

Appendix 2: Supplementary information

Marginal abatement cost curve analysis

MACC analyses can be used in business case development and at the project feasibility stage to determine how much will it cost per tonne of emissions saved by undertaking various interventions. The MACC in Figure 5 shows the cost of reducing one tonne of GHG emissions (*x*-axis) for multiple decarbonisation measures of the asset. It also depicts each measure's total reduction potential (*y*-axis) as the width of the bar. Bars below the *x*-axis indicate negative abatement costs, meaning that the measures are effective in both reducing the annualised net costs and the GHG emissions. Net costs are calculated based on the net present value, considering capital as well as operational expenditure.

Figure 5: Marginal abatement cost curve assessment (example)



The MACC assessment should be completed to show costs or savings from different options alongside the potential volume of emissions that could be reduced if implemented, without using offsets. The MACC shows how net costs are calculated based on the net present value, considering capital as well as operational expenditure. Through reviewing MACCs and discussions with AHIA stakeholders, interventions required to achieve net zero can be prioritised. This can be undertaken using the below approach as an example.

- **Abatement potential:** For each technology, the MACC estimates the amount of emissions reduction it can achieve (abatement potential).
- **Cost calculation:** The cost is calculated as the net difference between benefits and the marginal cost of the technology being replaced. It is expressed in present value terms as dollar per tonne of CO_2 equivalent (tCO_2e).
- **Modelling approaches:** Three common modelling approaches are used to construct MACCs:
  - Individual technology approach: Abatement costs are defined at a technology level, often using cost-benefit models and expert opinions.
  - System approaches: These include bottom-up (for example, MARKAL and TREMOVE) and top-down (computable general equilibrium) system models. They account for interactions among technologies and policies.
  - Macro-economic modelling: Computable general equilibrium models are used to estimate emissions based on fuel inputs and emission coefficients.

Lifecycle cost assessment

An LCCA may be undertaken to compare different electrification options to inform decision making. Factors under consideration may include capital, maintenance, carbon impact and energy costs. Electricity and gas price inputs into the LCCA should be agreed with the healthcare jurisdiction, and sensitivity analysis should be included to understand the impact of lower or higher utility prices; these figures can have a dramatic impact on the outcome of an LCCA assessment. For equipment maintenance cost inputs into the LCCA, referencing industry standard maintenance schedule guides, for example, AIRAH DA19 is a useful guide.

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