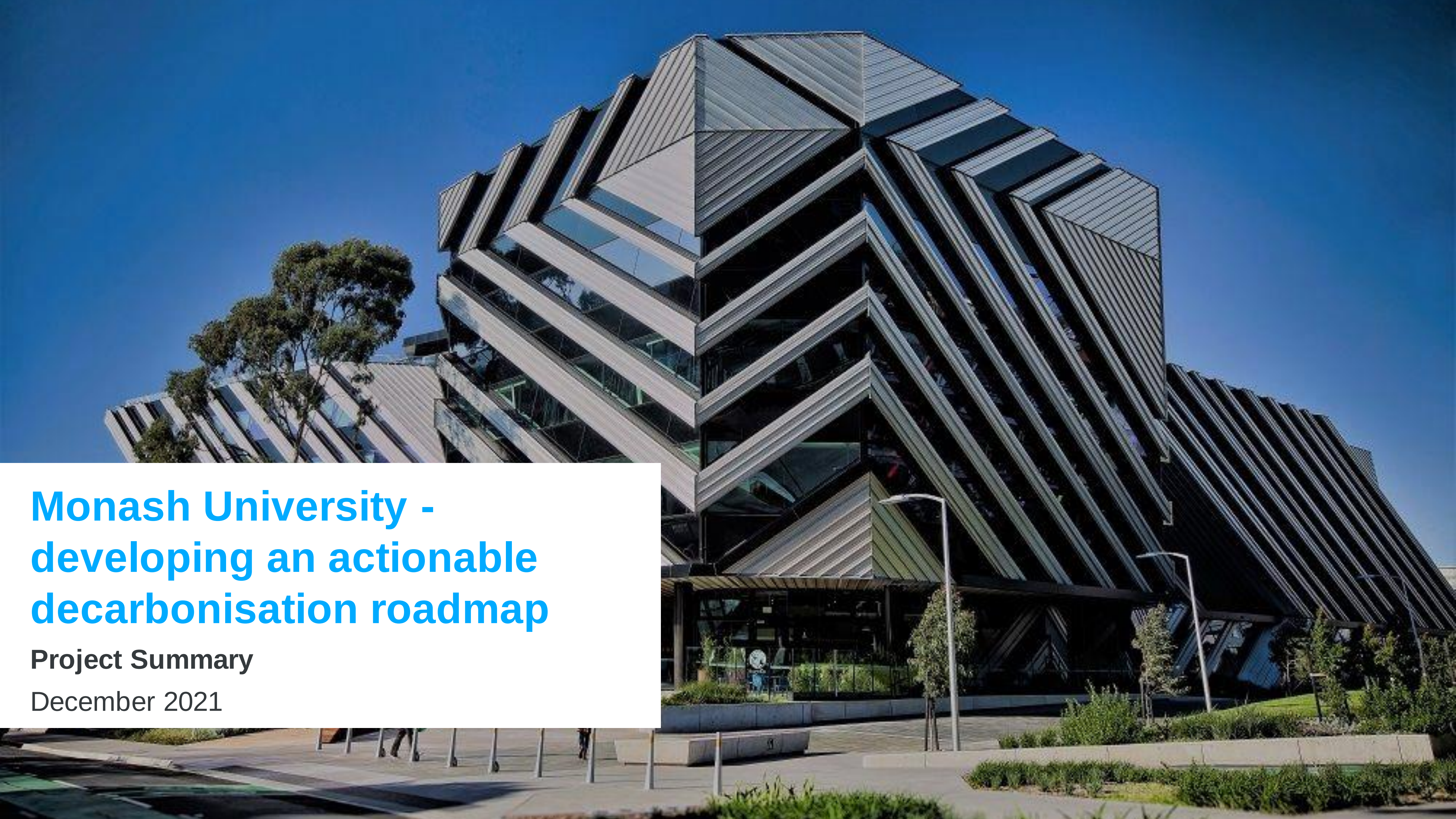


Monash University - developing an actionable decarbonisation roadmap

Project Summary

December 2021

Objective of the study

Accelerated decarbonisation is crucial for Monash University to align itself with its broader sustainability commitments and to remain a competitive leader in the tertiary education sector

The purpose of this report

- Monash has made a strong commitment to innovation and decarbonisation to position itself as a leader among competitor universities in the sustainability transformation.
- The ambitious target of achieving **net-zero emissions by 2030** will set the benchmark for universities and large scale precincts.
- In fulfilment of its commitment to net-zero emissions, Monash engaged ENGIE Impact to identify **cost-effective decarbonisation pathways** for its university campuses.
- This work presents the findings of the Clayton campus base case scenario, which includes its current and projected energy demands and baseline emissions portfolio.

Why is this work needed?

Stakeholder expectations

As one of Australia's largest universities, there are **high expectations from stakeholders** for Monash to take bold and decisive action on climate change and uphold its sustainability commitments.

Rising costs and carbon exposure

Rising operating costs and uncertainty in the cash-flows due to external factors such as **volatility in commodity prices and carbon prices** are creating challenging commercial circumstances which must be managed.

Reliable energy supply and resilience

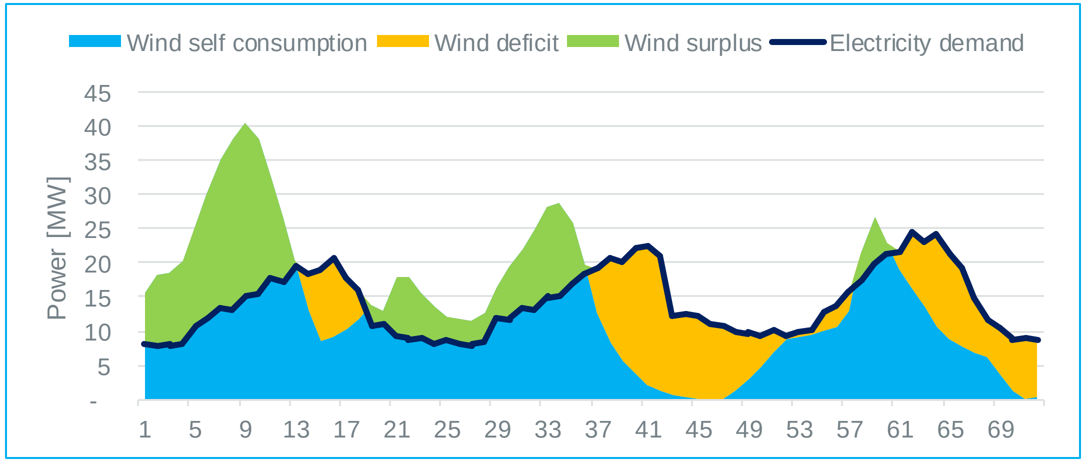
Clean and reliable energy supply is critical for ensuring continuous operations and building a **resilient energy network**. To meet emissions reduction targets without compromising operating continuity, it is essential for Monash to source a cost-competitive, reliable supply of zero-carbon energy across is campuses.

Towards real-time Net Zero

In line with Impact 2030, Monash is updating its Net Zero approach support the decarbonisation of the grid

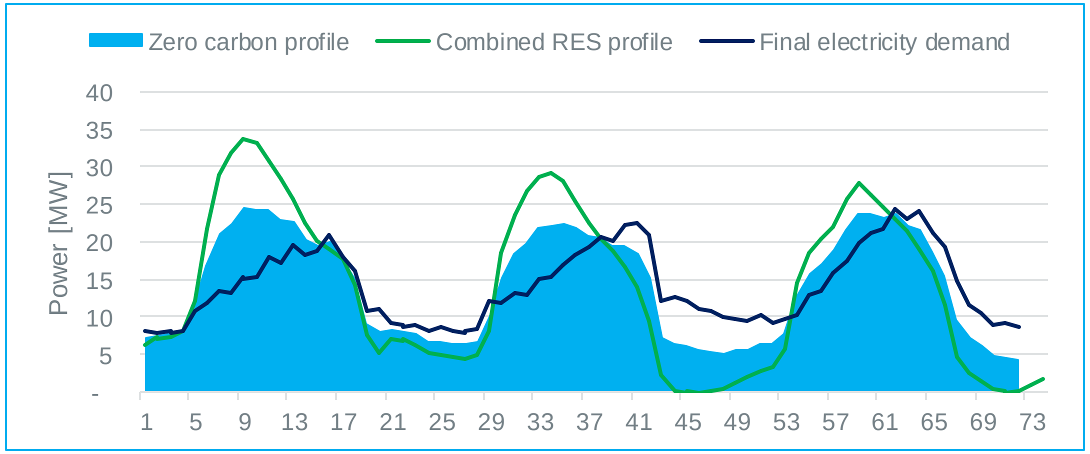
Annual Net Zero / 100% renewables

- Annual green electricity consumption equals annual electricity demand.
- Annual net zero is achieved through the procurement of Large-scale Generation Certificates (LGCs), created by eligible electricity generated by a renewable power station.
- The annual net zero approach relies on interactions with the energy markets for matching supply and demand. Hence, it does not allow a system-wide decarbonisation.
- Furthermore, this approach leaves Monash exposed to energy and carbon pricing.



Real-time Net Zero / 100% renewables

- Monash's electricity demand is matched with green electricity supply on an hourly base.
- The matching is realised by combining solar PV, wind energy, and battery energy storage at the supply side with flexibility on the demand side.
- As there is a direct link between the hourly production and consumption of energy, the real-time net zero approach can scale up to a system-wide level.
- Therefore, it substantially reduces Monash's exposure to energy and carbon pricing.



Scope of work and study objectives

The decarbonisation roadmap provides a pathway for Monash University to reach its net-zero emissions target by 2030

Purpose and scope of the engagement

Objective:

- **Review** the existing decarbonisation strategy, establish ongoing initiatives, and define/validate measurable **KPIs**.
- Engage with the Monash Net Zero team to **co-create** Monash University's decarbonisation pathway.
- Deliver a **phased 'roadmap'** of emissions reduction initiatives that will be prioritised year-on-year to maximise short and long-term value.

Scope:

- Develop an **actionable decarbonisation roadmap** for the Clayton campus that can be replicated and scaled for other precincts.
- **Scenario-based approach** to capture uncertainty on future trends and technology evolutions.
- **Scope 1 and Scope 2** emissions are to be included, as well as a **part of Scope 3** emissions (i.e. captive vehicle fleets).

Our three-stage approach

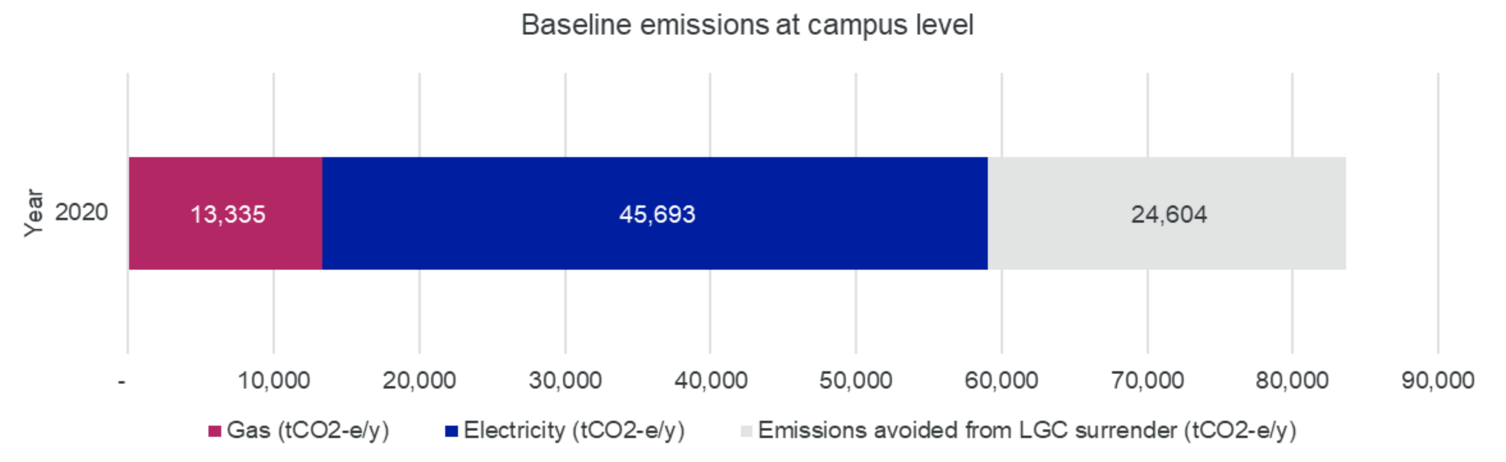
Stage 1
Data Collection & Opportunity Identification

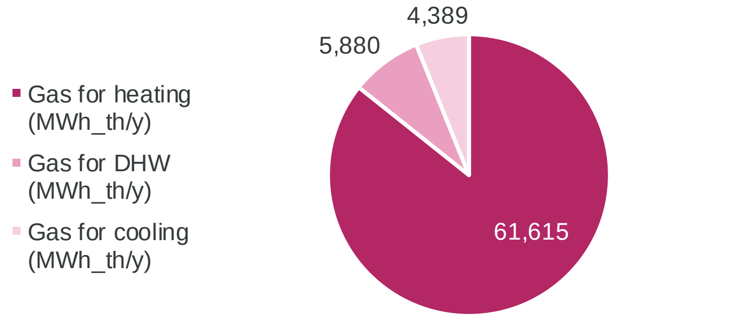
Stage 2
Scenario Development & Modelling

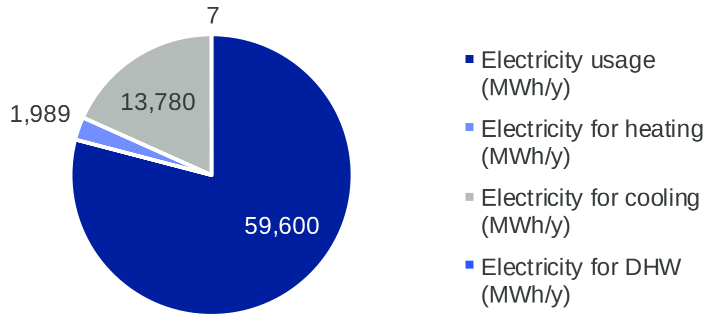
Stage 3
Decarbonisation Roadmap Development

Clayton campus primary energy demand overview

The energy consumption data and its associated CO_2 emissions have been assessed







Observations

- The Monash University Clayton campus has an annual total carbon dioxide emission of **59,018 tCO_2-e**, with **electricity** contributing **77%** and **gas** contributing **23%**.
- **51%** of the **total energy demand** is supplied by **grid and on-campus renewable electricity**, while the remaining **49%** is supplied by **natural gas** for building heating and DHW.
- Monash effectively **reduces its emissions** by **24,604 tCO_2-e/y** in 2020 by voluntary surrendering 35% of surplus **LGCs**[1].
- Primary **annual electricity consumption** is split between electricity usage (**79%**), representing the largest demand, cooling (**18%**), heating (**3%**), and a negligible amount going towards DHW[1]
- Primary **annual gas consumption** is split between heating (**86%**),DHW[1] (**8%**), and cooling (**6%**).

1. DHW: Domestic Hot Water.

Scenario definitions - summary

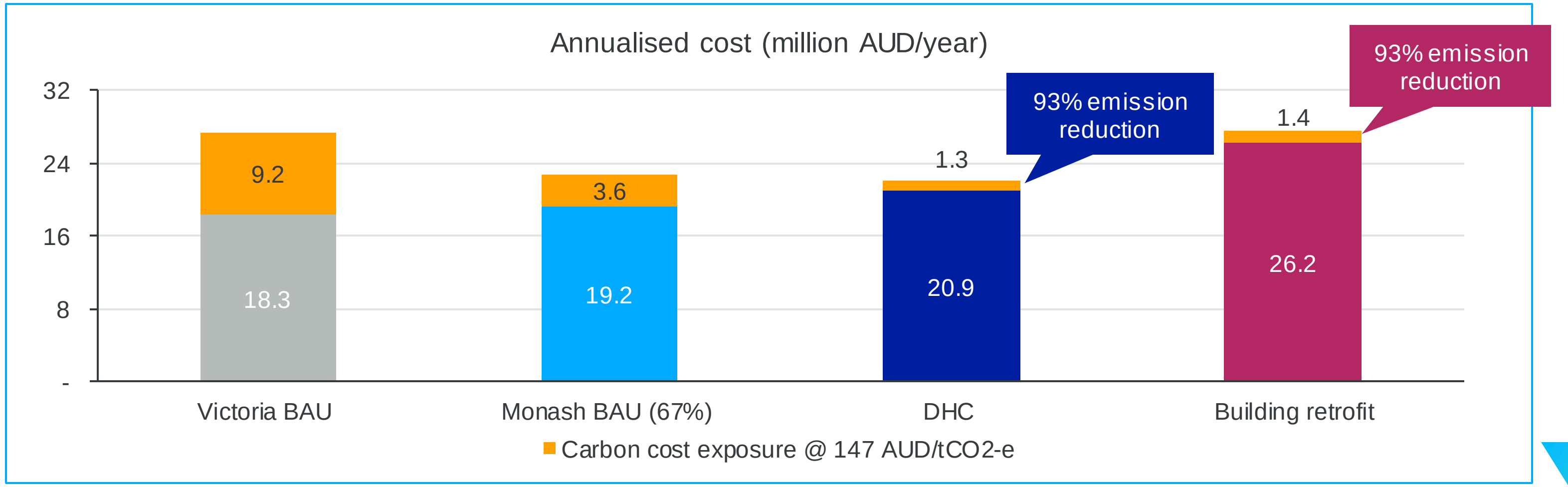
Defining robust decarbonisation scenarios is a crucial first-step towards developing a decarbonisation roadmap and requires a holistic assessment of decarbonisation preferences and ambitions

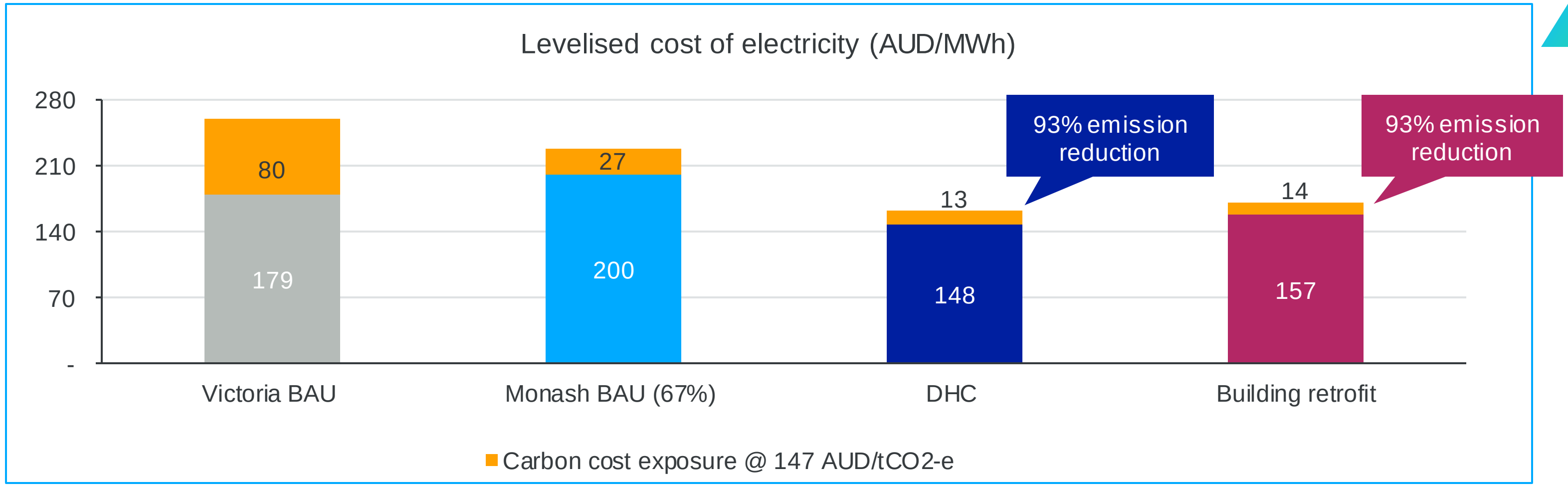
	Scenario 0: Victoria BAU	Scenario 1: Monash BAU	Scenario 2: DHC[1] network	Scenario 3: Building retrofit
Targets & Scope	**Target:** No defined emissions reduction target	**Target:** Net-zero emissions by **2030** **Boundary: Scope 1** and **2**	**Target:** Net-zero emissions by **2030** **Boundary: Scope 1** and **2**	**Target:** Net-zero emissions by **2030** **Boundary: Scope 1** and **2**
Energy supply	Grid energy; Gas; Rooftop solar PV	Rooftop solar PV; Gas; Renewables (standard PPA[2]) with LGC[4] surrender	Rooftop solar PV; Renewables (active PPA[3]) with LGC[4] surrender	Rooftop solar PV; Renewables (active PPA[3]) with LGC[4] surrender
Energy storage		Batteries as a short-term storage option	batteries as a short-term storage option; DHC thermal storage	Batteries as a short-term storage option; Building-level thermal storage
Further emissions reduction measures		Building energy efficiency improvements; Electrification	District heating and cooling; Electrification (non-DHC[1] buildings)	Energy efficiency and deep building retrofits; Deep electrification

1. DHC: District Heating and Cooling; 2. Standard Power Purchase Agreement (PPA): Fixed volume power purchase contract where the retailer bears the risk of renewable production; 3. Active Power Purchase Agreement (PPA) – A pay-as-produced contract (with no-volume obligation) which is enhanced by the on/off-site storage and demand flexibility. 4. LGC: Large-scale generation certificates

Annualised cost and LCOE[1] comparison

The DHC[2] scenario has the lowest annualised cost and LCOE while achieving a higher emission (93%) reduction compared to Monash BAU (67%), compared to the Victoria BAU





Observations

The **DHC[2] scenario** has the **lowest annualised cost** (with carbon cost included) **and LCOE[1]** in all scenarios in this comparison.

Annualised costs

- The **DHC[2] scenario** has a **lower annualised cost** compared to **both BAU** scenarios due to **lower energy costs and lower carbon cost exposure**

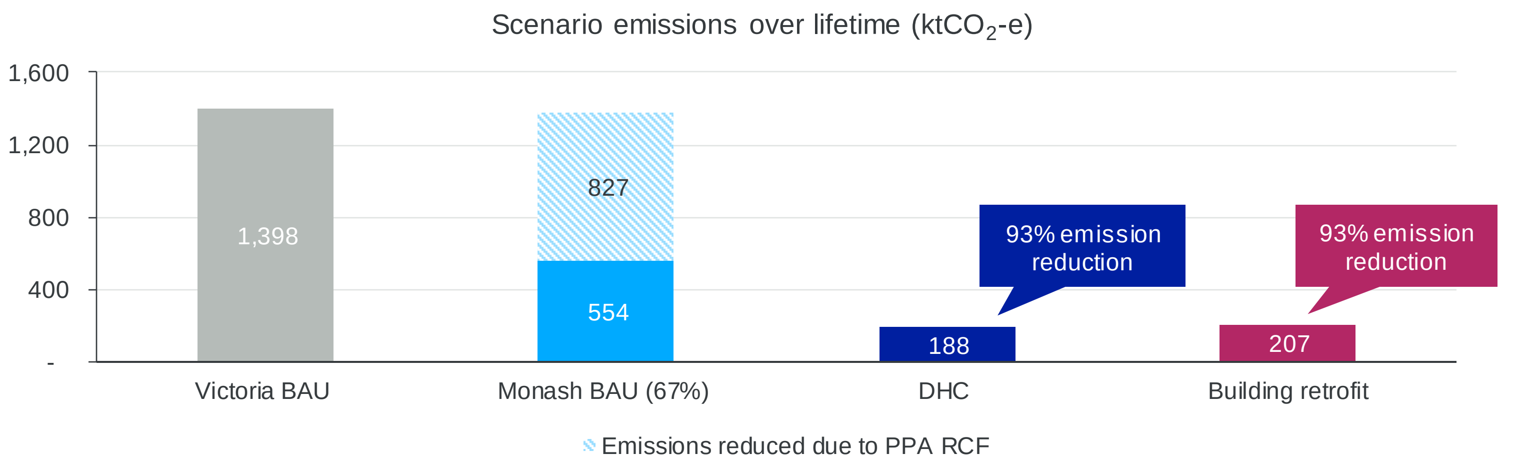
LCOE[1]

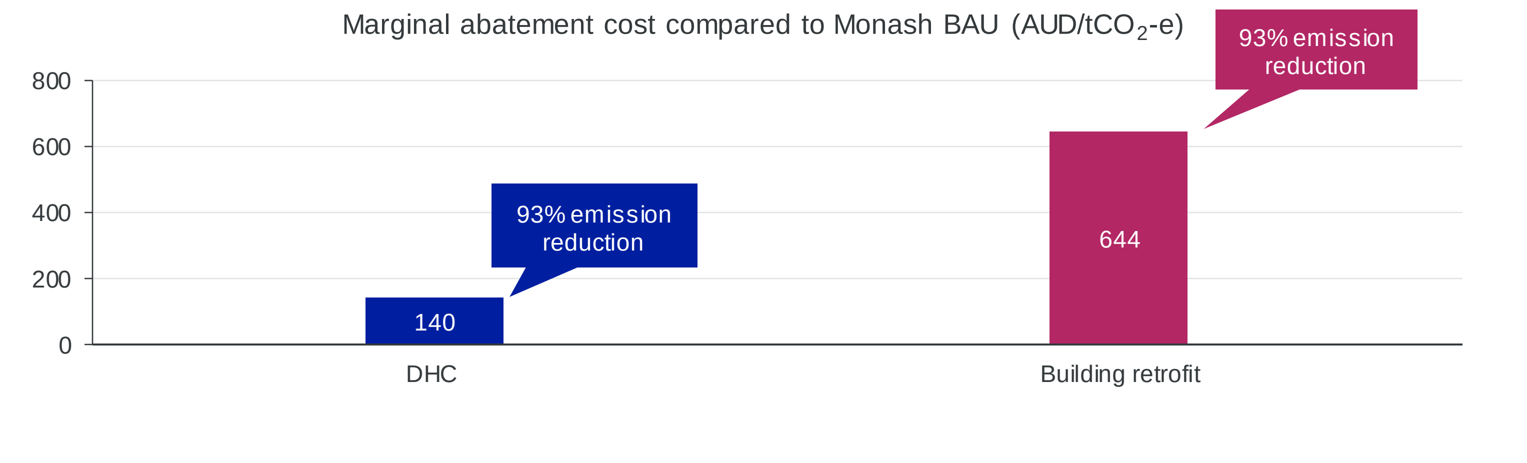
- The **LCOE[1]** in the **Victoria BAU and Monash BAU are significantly higher** than the DHC[2] and the Building Retrofit scenarios due to the higher reliance on grid imported electricity/gas.
- The **DHC[2] scenario has a lower LCOE[1] compared to the Building retrofit** scenario due to the large flexibility in the supply chain being served by the thermal storage capacity of the DHC[2] network.

1) LCOE – Levelised cost of electricity; 2) DHC – District heating and cooling

Abated emissions and MAC[1] comparison

The DHC[2] scenario has a much lower MAC[1] compared to the Building Retrofit scenario while achieving the highest emission reduction over the lifetime





Observations

The DHC[2] has a significantly lower MAC[1] than the Building retrofit scenario

Scenario emissions

- The Victoria and Monash-BAU have significantly higher emissions over the lifetime compared to the DHC[2] and the Building retrofit scenario
- The **Monash BAU** effective emissions are 554$ktCO_2$-e as the rest have been attributed to the **67% electricity supplied from** the existing **PPA is emission free**.
- The DHC[2] and the Building retrofit scenario meet the 93% emission reduction target for 2030 compared to Victoria BAU.

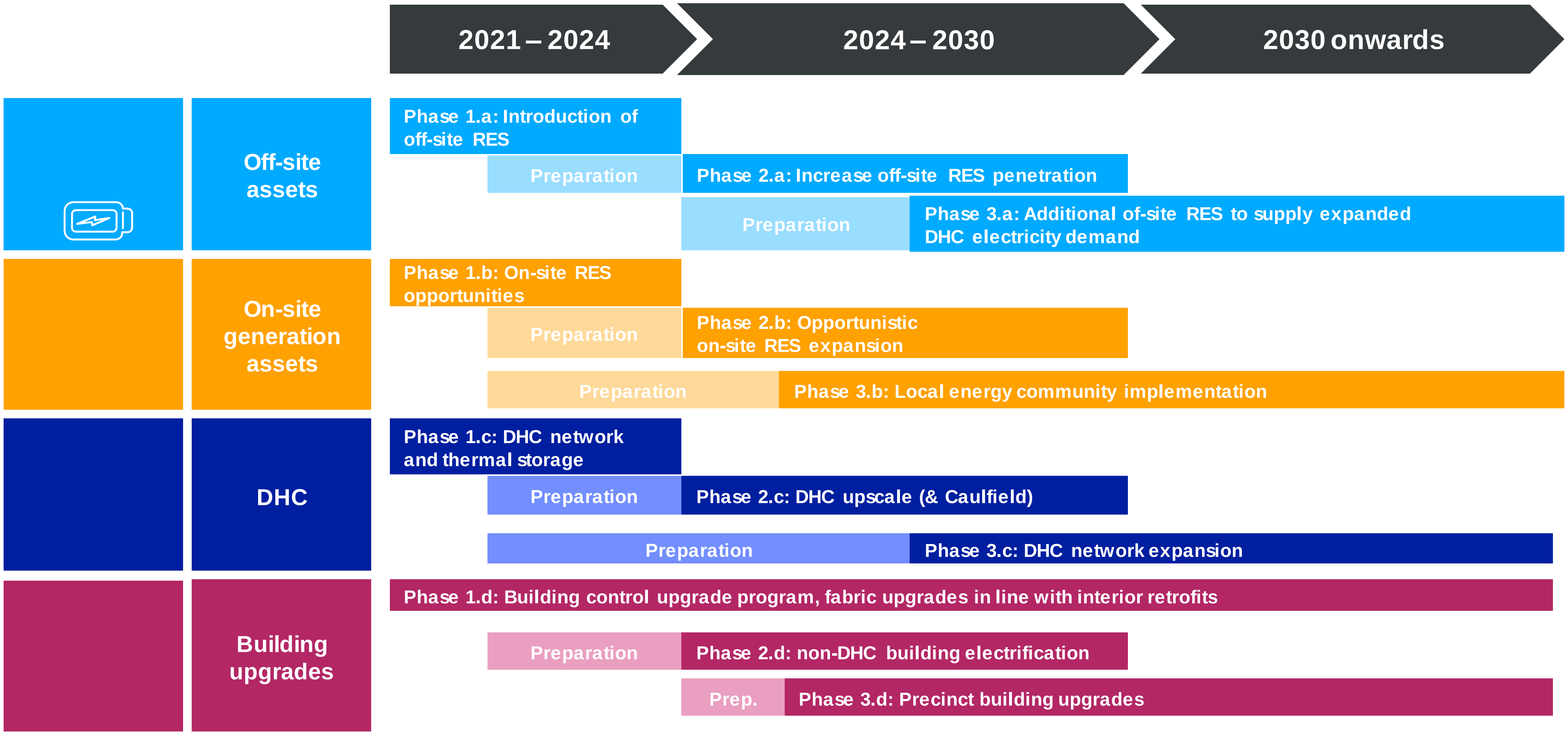
MAC[1]

- The MAC[1] for the **DHC[2] case is significantly lower** than the Building retrofit scenario **due to** the **lower NPC[3] over the lifetime**.
- The MAC[1] for DHC[2] scenario is lower than the cost of carbon required to meet the 1.5°C climate scenario

1) MAC – Marginal abatement cost; 2) DHC – District heating and cooling; 3) NPC – Net present cost

Roadmap timeline

We recommend starting the DHC network implementation as soon as possible, combined with sourcing the required associated renewable energy through an active PPA



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