Healthcare Sector

i-HUB Outcomes and Next Steps

Agenda

- Acknowledgements
- Purpose of healthcare sector activities
- Summary of work < 3 years
    - Technology evaluations
    - Hospital energy use in future climates
    - Pandemic mode ventilation
    - Demand Response
    - CSSD
- Renewable Energy Roadmap
- Future directions - Discussion

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  - Doctors for the Environment Australia (DEA); Climate and Health Alliance (CAHA)

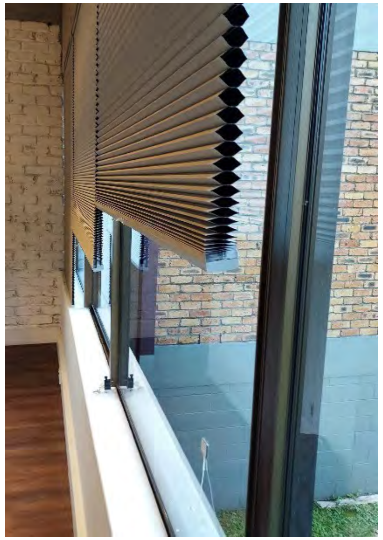
Purpose

- Quantify sector energy consumption
- Reduce energy demand (esp. for HVAC)
- Manage demand
- Enhance value of renewable energy
- Identify new key performance indicators

……. On the pathway to net zero carbon emissions (and enhanced resilience)

Technologies tested in healthcare Living Labs

Technology	Performance outcomes
Synengco Sentient System (HVAC Plant Digital Twin)	Identified 2 of 3 chillers operating 25% below design performance
Norman Australia Honeycomb Blinds (cellular blinds)	Reduced window Uvalue 50-62% 12.5% cooling energy reduction 4.6% total energy reduction
Exergenics Digital Twin	Chiller optimisation: Annual energy saving 432MWh; peak demand reduction 99kVA Chiller staging optimisation: Annual energy saving 188KWh
Graphene Management Group – refrigeration outdoor condenser coating	Annual energy saving 474kWh per unit
Buildings Alive Rapid Efficiency Feedback	Annual energy saving potential 34MWh
Flow Power (energy retailer providing direct exposure to wholesale spot price)	Most months – lower costs High price events – significantly higher costs for short periods HVAC DR opportunities to mitigate this
DNA Energy (HVAC Demand Response wireless technology)	Enables predictive control of HVAC (demand flexibility) – through precool or preheat prior to anticipated spot price fluctuations



Hospital energy use in future climates – Building Simulation

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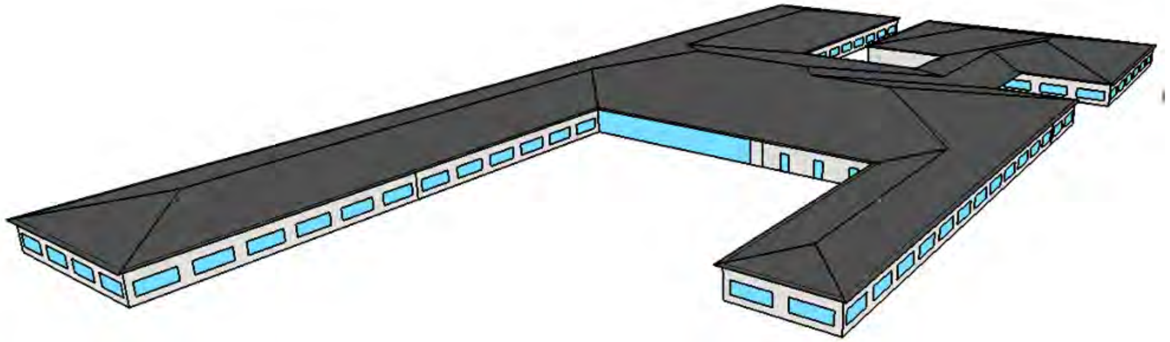
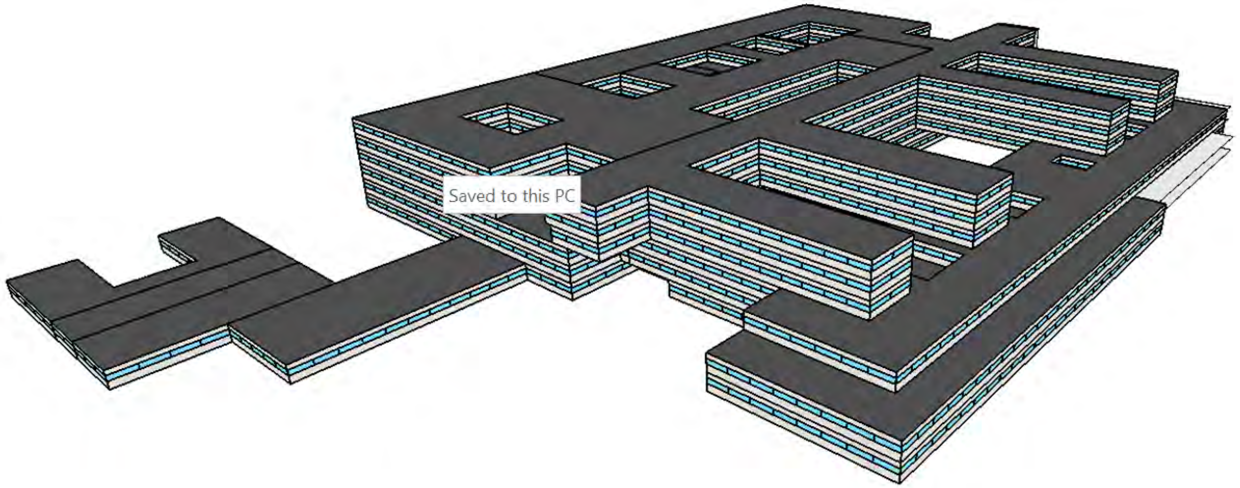
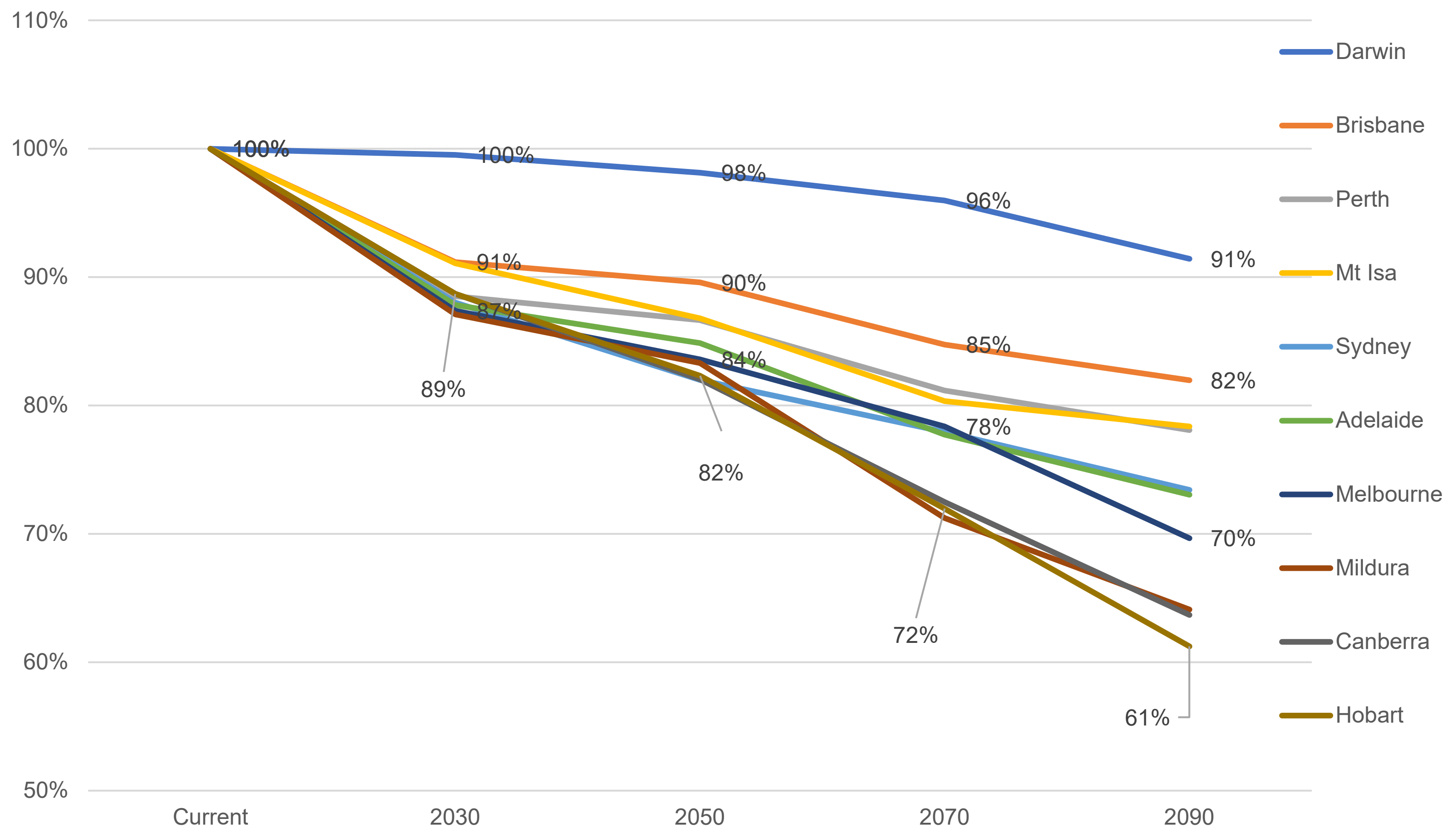




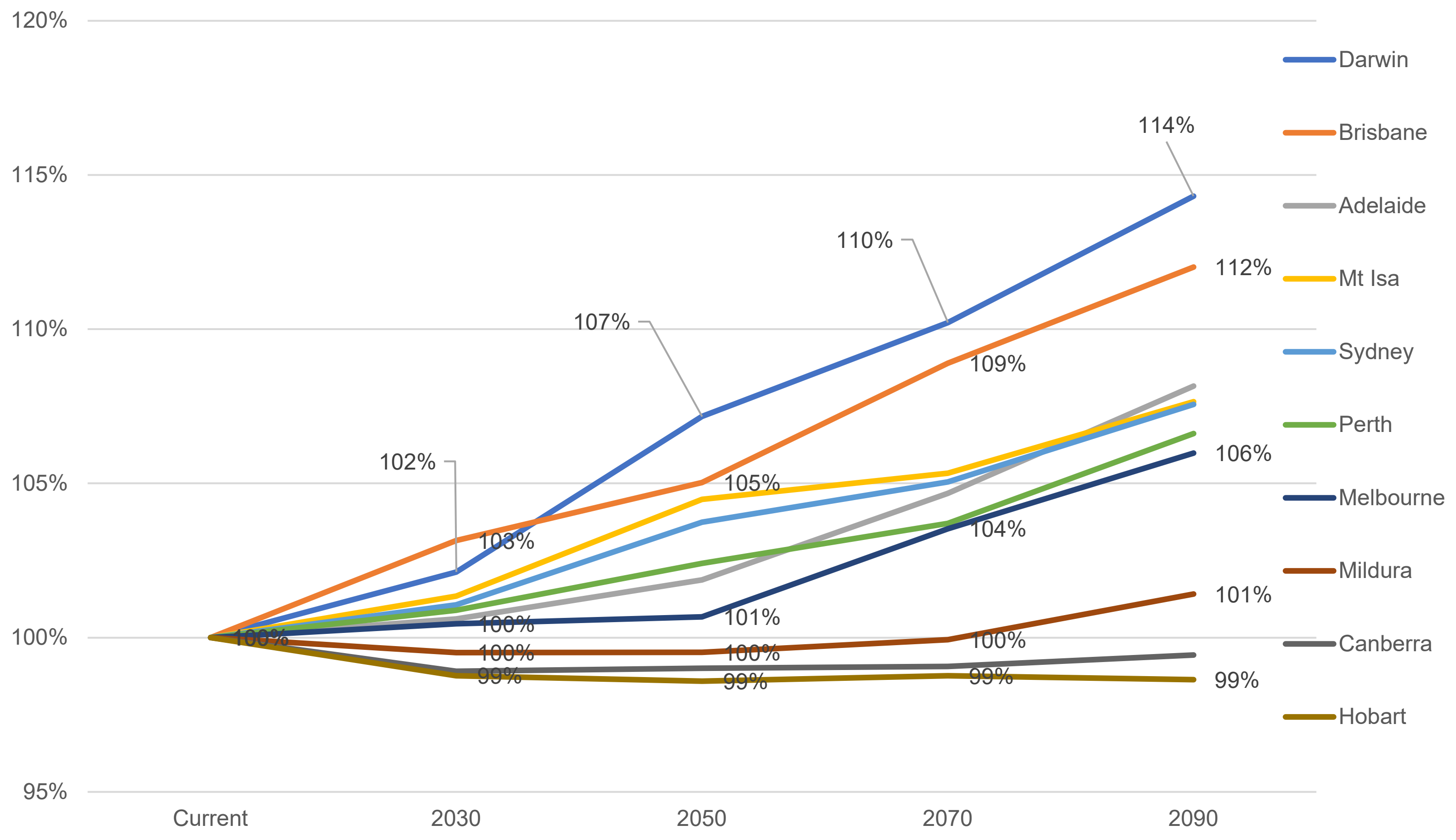
Energy system	Components
HVAC system (without heating)	Energy use for chillers, air handling units (AHU), pumps and fan coil units (FCU) i.e. HVAC excluding heating
Heating only (of the HVAC, not other purposes)	Heating energy for the HVAC system. Heating needs can be met by different technologies, such as electric resistive heating, air source or water source heat pumps, or 4-pipe heat pumps (combining the function of chillers and boilers)
Site total	HVAC systems, heating needs, lighting and all plug-in loads.

Future heating demand for a large hospital



In the 2090 scenario: heating demand is reduced in all locations

Future HVAC load for a large hospital

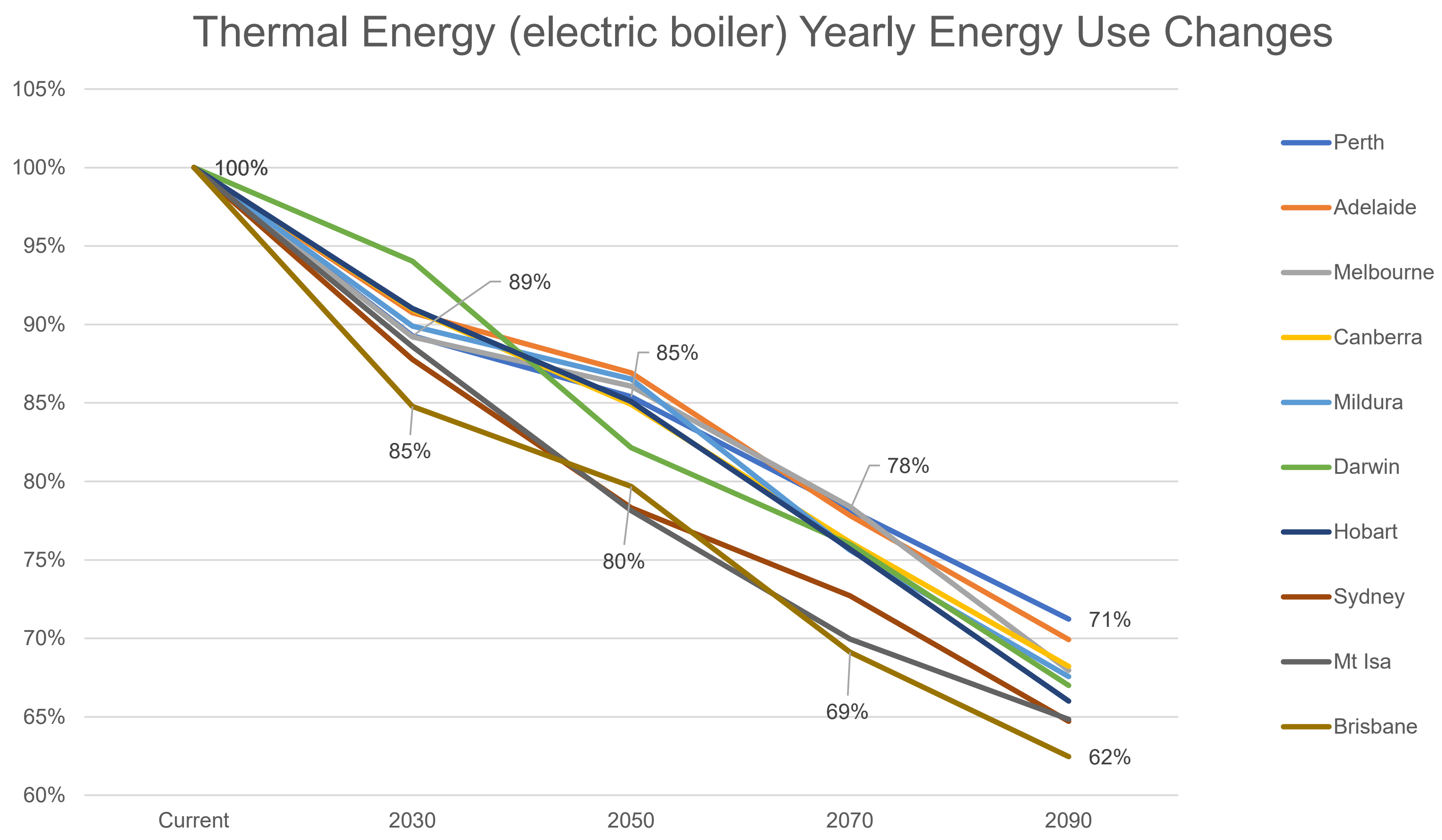


Findings:
Temperate, subtropical and tropical regions all have increased HVAC system load;

Canberra and Hobart may have <1% HVAC load reduction.

The rate of increase is different for different climates

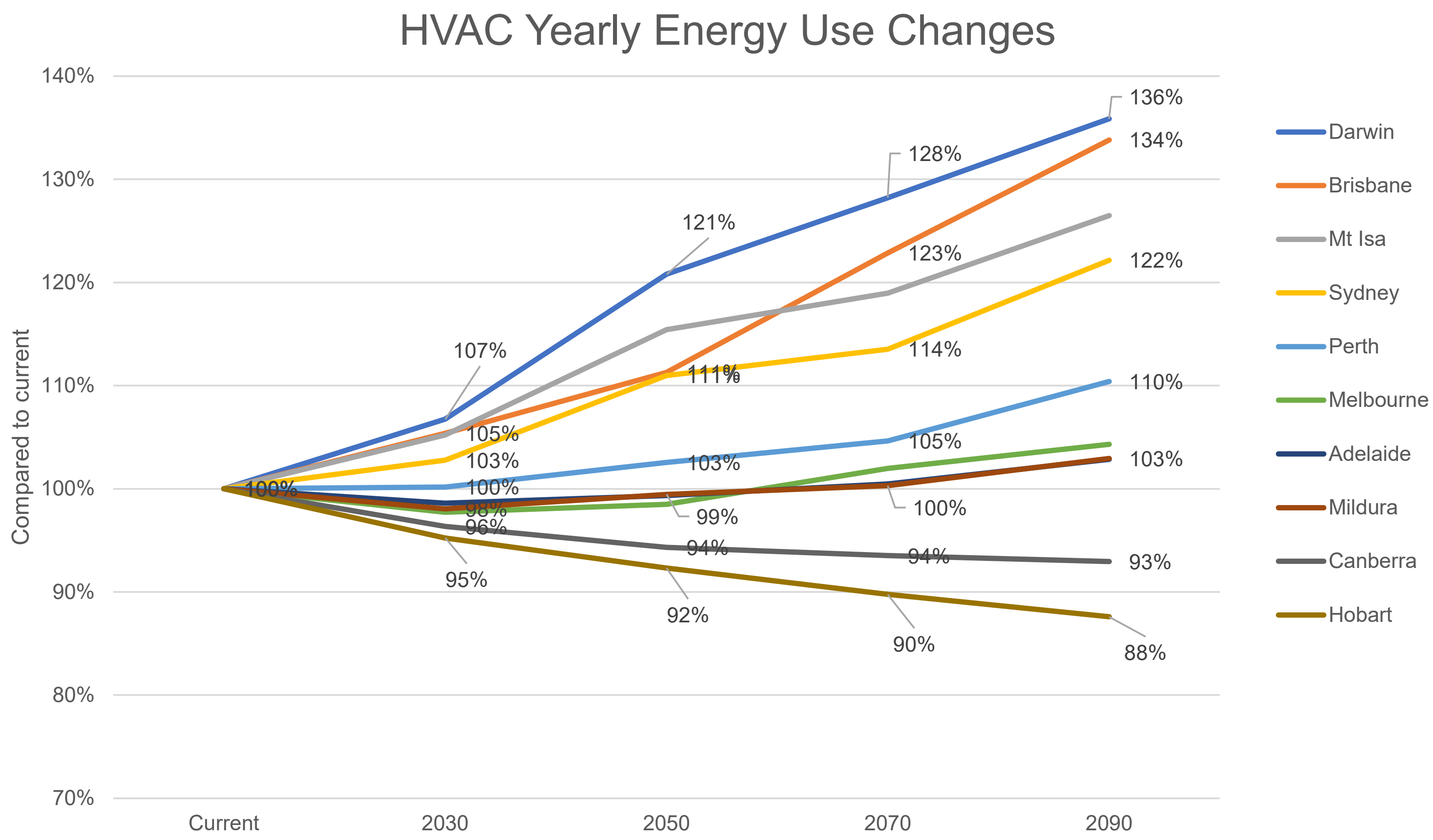
Future heating demand for a small hospital



In the 2090 scenario: heating demand is reduced in all locations

On the average, heating accounts for 18% of a small hospital's energy use in the 2090 scenarios.

Future HVAC load for a small hospital



Findings:
Temperate, subtropical and tropical regions all have increased HVAC system load;

Canberra and Hobart may have 7% ~12% HVAC load reduction.

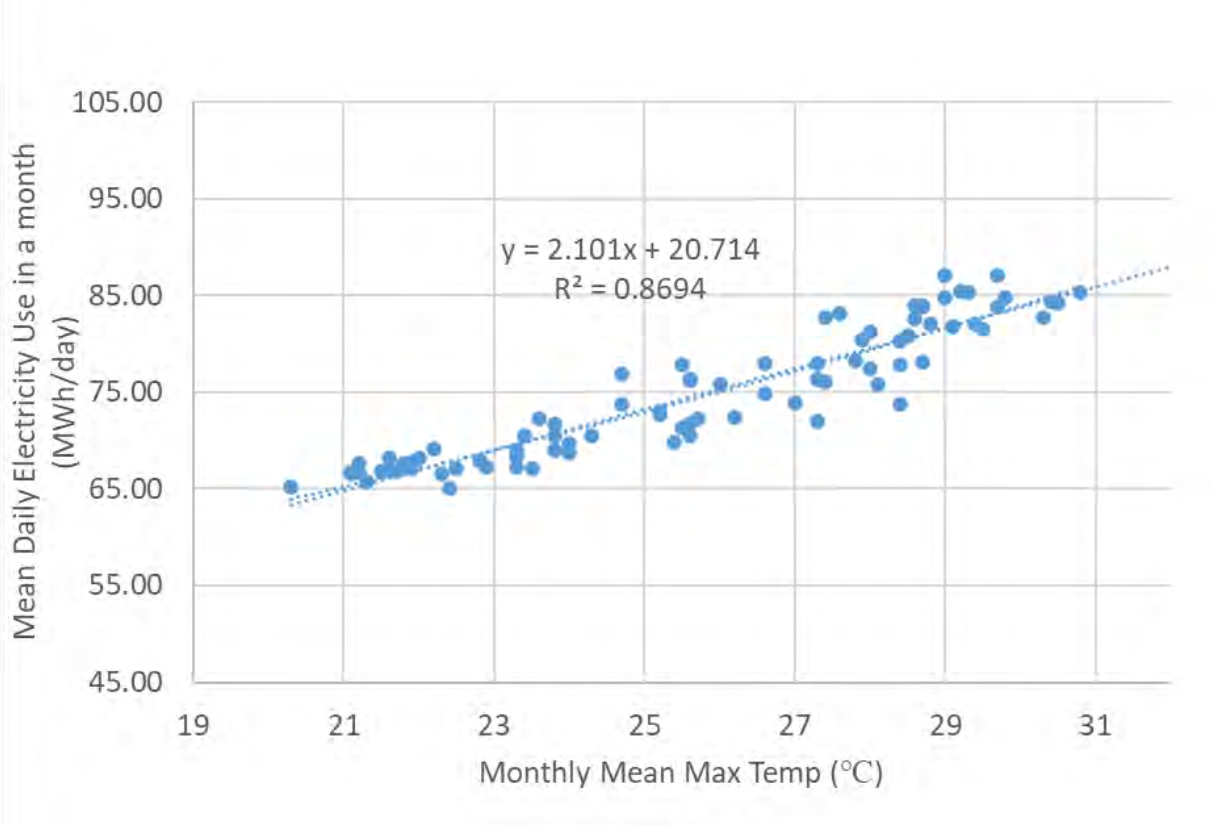
The rate of increase is different for different climates (so some areas need to consider a longer planning horizon than others)

Impact on RE potential – small hospital

Location	2030 GWh increase	2030 kWp PV increase	2050 GWh increase	2050 kWp PV increase	2070 GWh increase	2070 kWp PV increase	2090 GWh increase	2090 kWp PV increase
Darwin	0.17	107	0.36	223	0.19	118	0.20	122
Brisbane	0.08	54	0.09	60	0.18	118	0.17	111
Mt Isa	0.09	49	0.17	95	0.06	33	0.12	70
Sydney	0.04	27	0.11	79	0.04	25	0.12	83
Perth	0.00	1	0.03	21	0.03	18	0.08	50
Melbourne	-0.03	N.A.	0.01	8	0.05	36	0.03	24
Adelaide	-0.02	N.A.	0.01	7	0.02	10	0.03	21
Mildura	-0.03	N.A.	0.02	13	0.01	8	0.04	25

Hospital energy use in future climates – Data modelling

QCH Precinct Monthly Electricity Use vs Temperature



Analysis based on 2015-2021 data

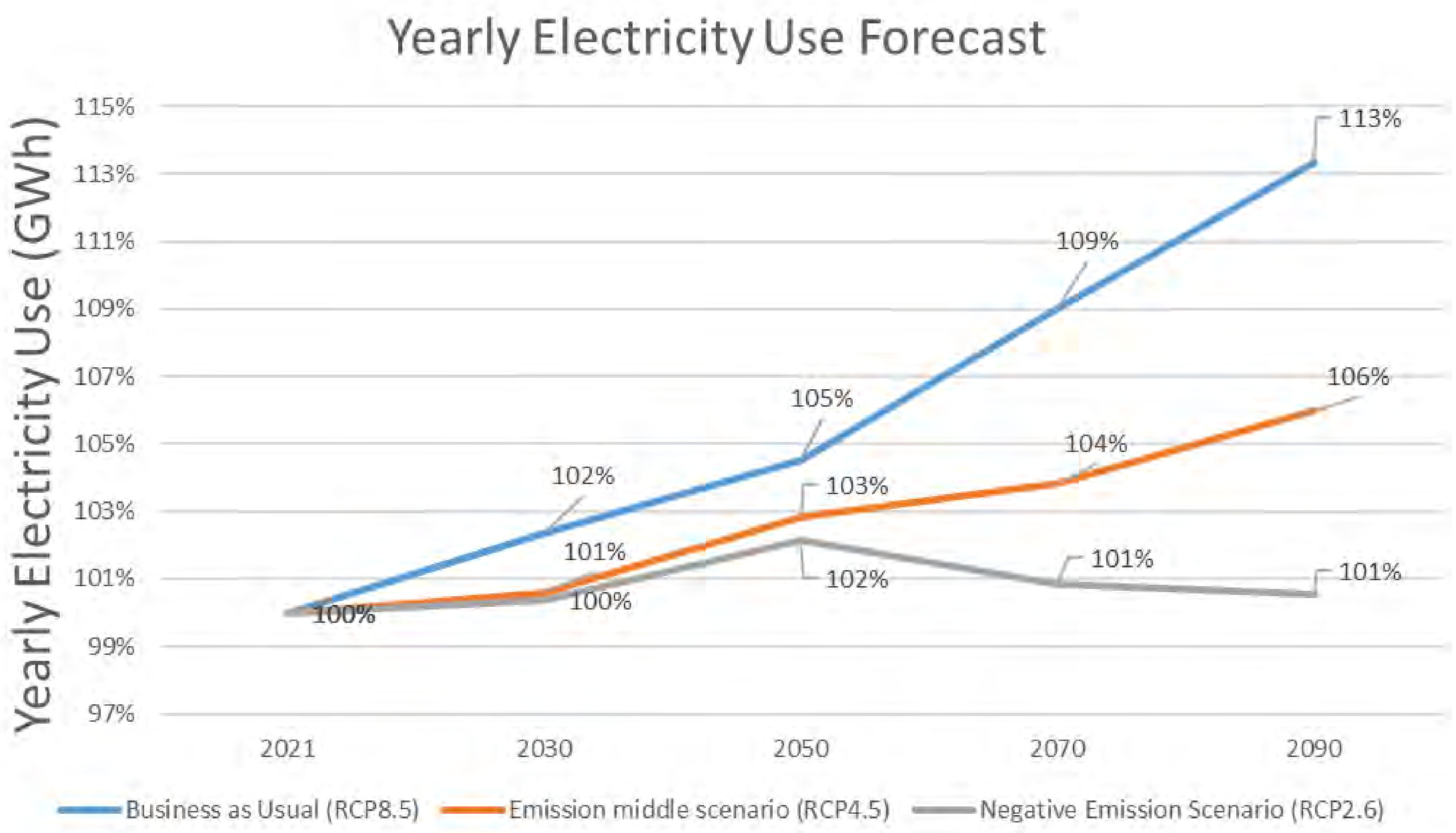
1 sentence version description:

1°C temperature increase leads to 2 MWh/day electricity use increase

2MWh of electricity is about 110 Southeast Qld households' daily electricity use

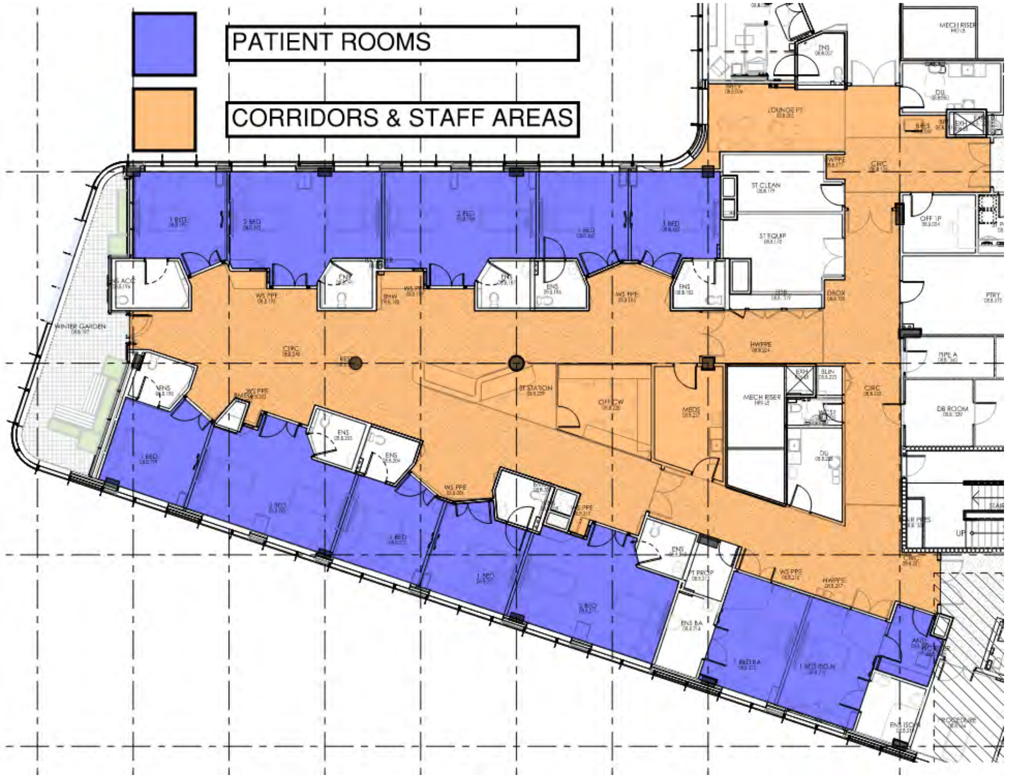
- considering a household uses 18kWh/day on the average

QCH Electricity Forecast 2030 -2090

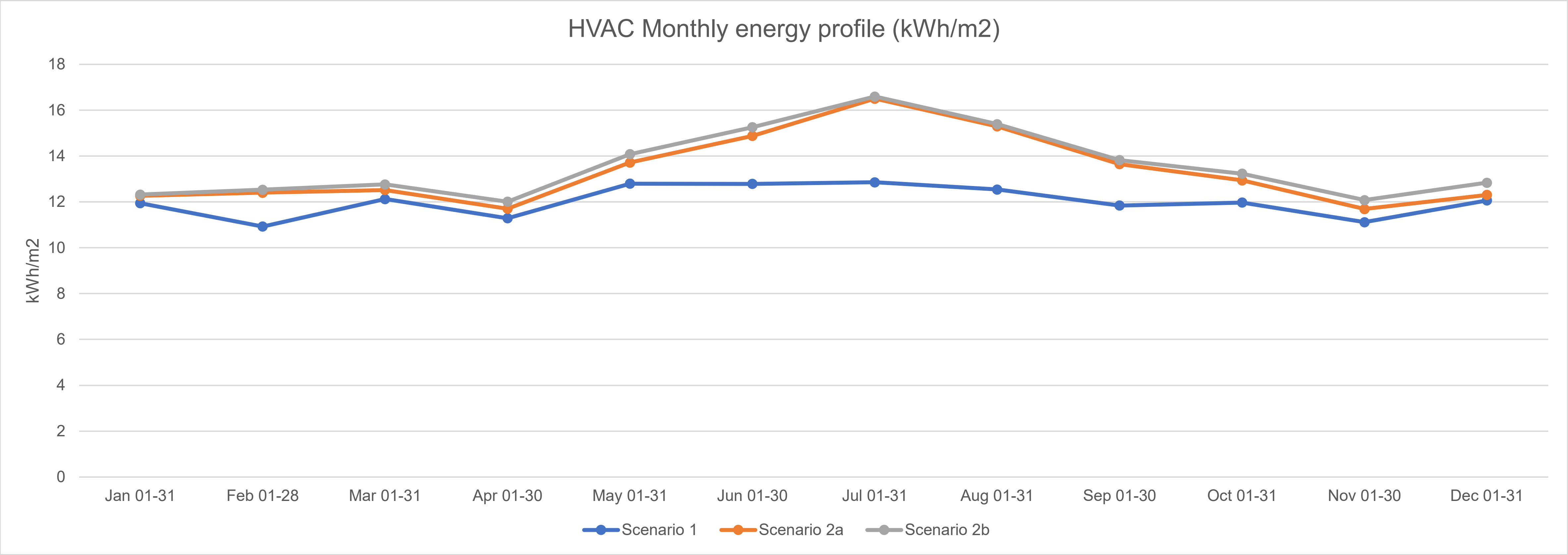


Pandemic mode ventilation – Hospital Ward

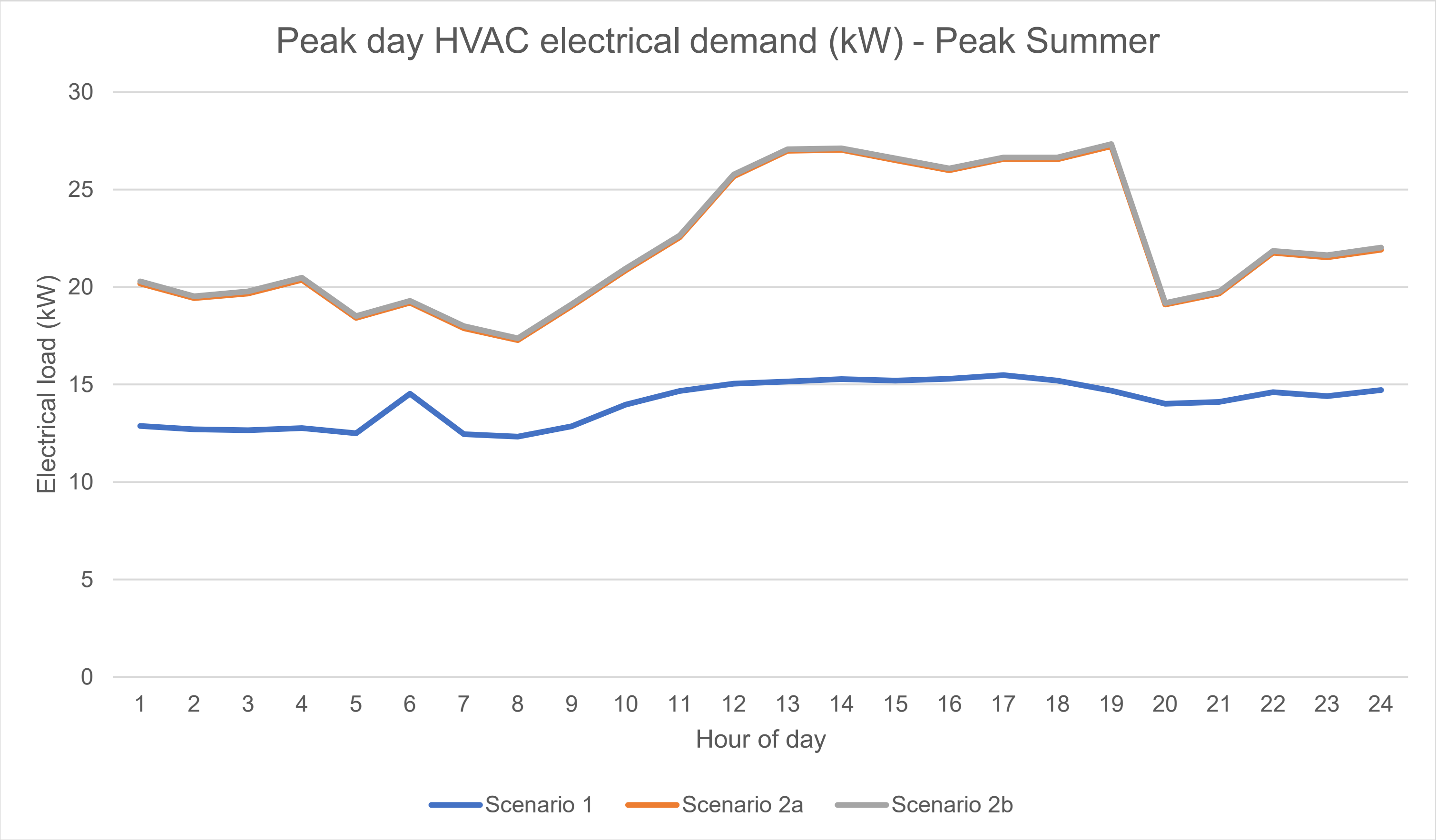
Scenario	Description
Base case – Scenario 1	NCC2019 profiles; Location Melbourne Single zone, constant volume AHU ; no zone reheat; 700Pa
Scenario 2a	Base design changed to 100% outdoor air with G4 pre-filter on outside air & F8 filter in mixing plenum
Scenario 2b	Scenario 2a with F8 filters changed to F9



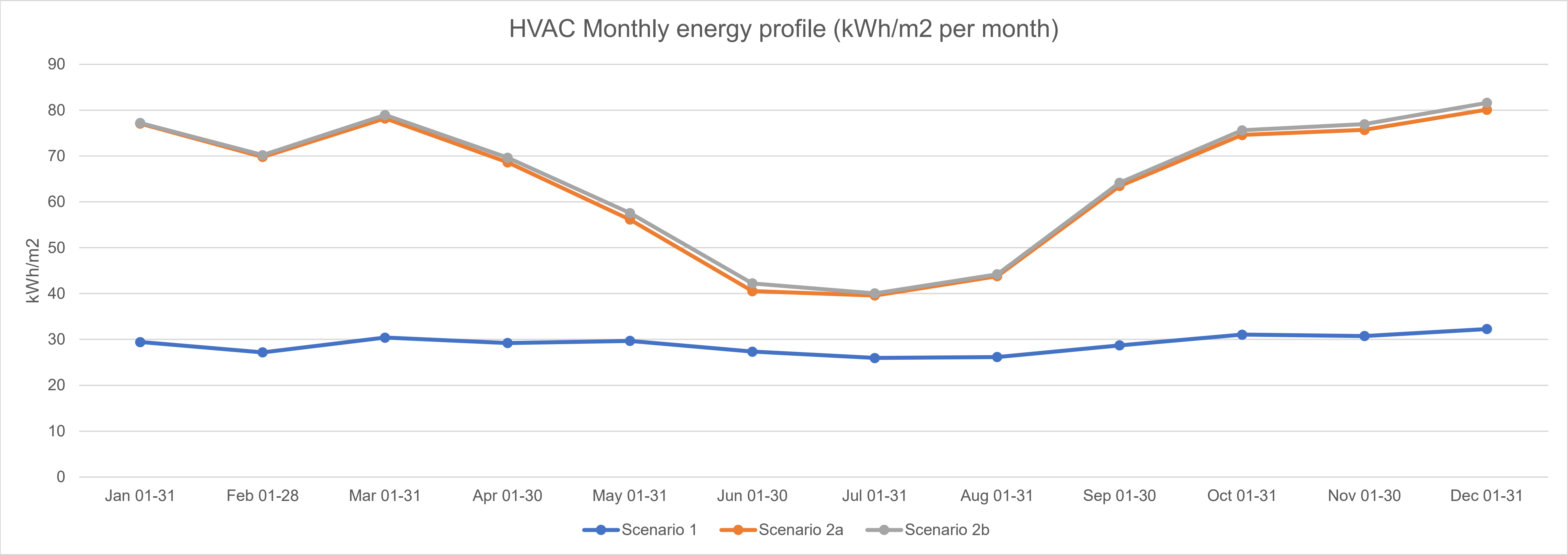
Impact on normalised monthly energy profile



Impact on summer peak demand



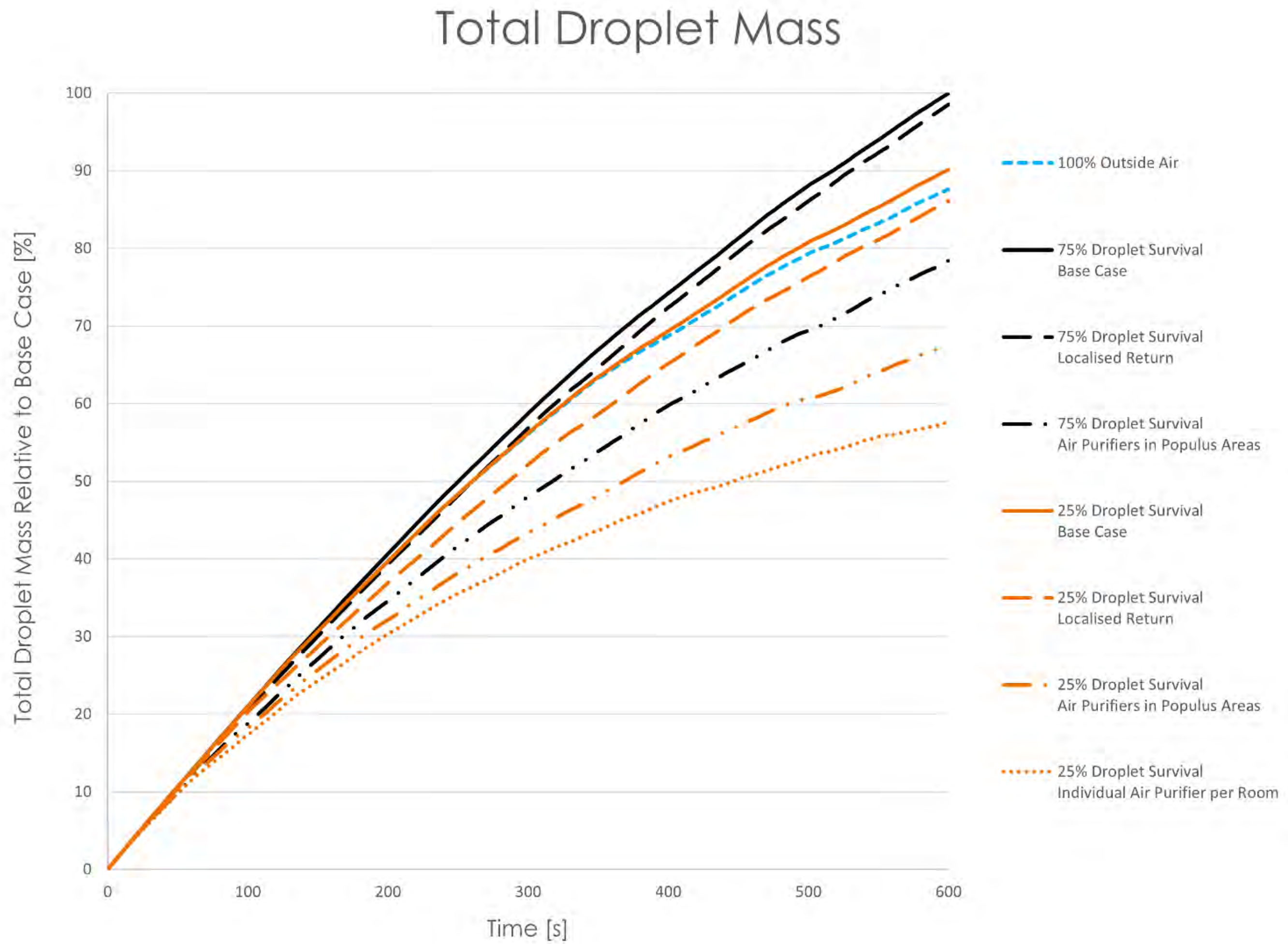
Impact in Darwin



Pandemic – CFD modelling scenarios

Scenario	Notable features	Recirculation % considered
Base Case	Two large return air grilles located in common areas. General doors open.	75% + 25% droplet recirculation
100% Outside Air	Geometry and ventilation rates identical to scenario 1 except with no droplet recirculation with the system. General doors open.	0% droplet recirculation
Localised Return	Localised smaller return air grilles in each room as opposed to that considered in scenario 1. Doors closed.	75% + 25% droplet recirculation
Localised Return + air purifiers in populous areas	Identical to scenario 3 with the inclusion of 4x air purifiers located in populous regions within the common spaces. Doors closed.	75% + 25% droplet recirculation
Localised Return + air purifiers in populous areas + individual purifiers per room	Identical to scenario 4 with the inclusion of 15x smaller air purifiers located adjacent to each bed. Doors closed.	25% droplet recirculation

Ventilation CFD results



Scenario		75% Droplet Recirculation	25% Droplet Recirculation (Brackets denote relative to 25% base case)
1	Base Case	-0%	-9.89% (-0%)
2	100% Outside Air	-12.38%	-12.38% (-2.77%)
3	Localised Return	-1.45%	-13.86% (-4.41%)
4	Localised Return + air purifiers in populous areas	-21.57%	-32.39% (-24.97%)
5	Localised Return + air purifiers in populous areas + individual purifiers per room	N.A.	-42.38% (-36.06%)

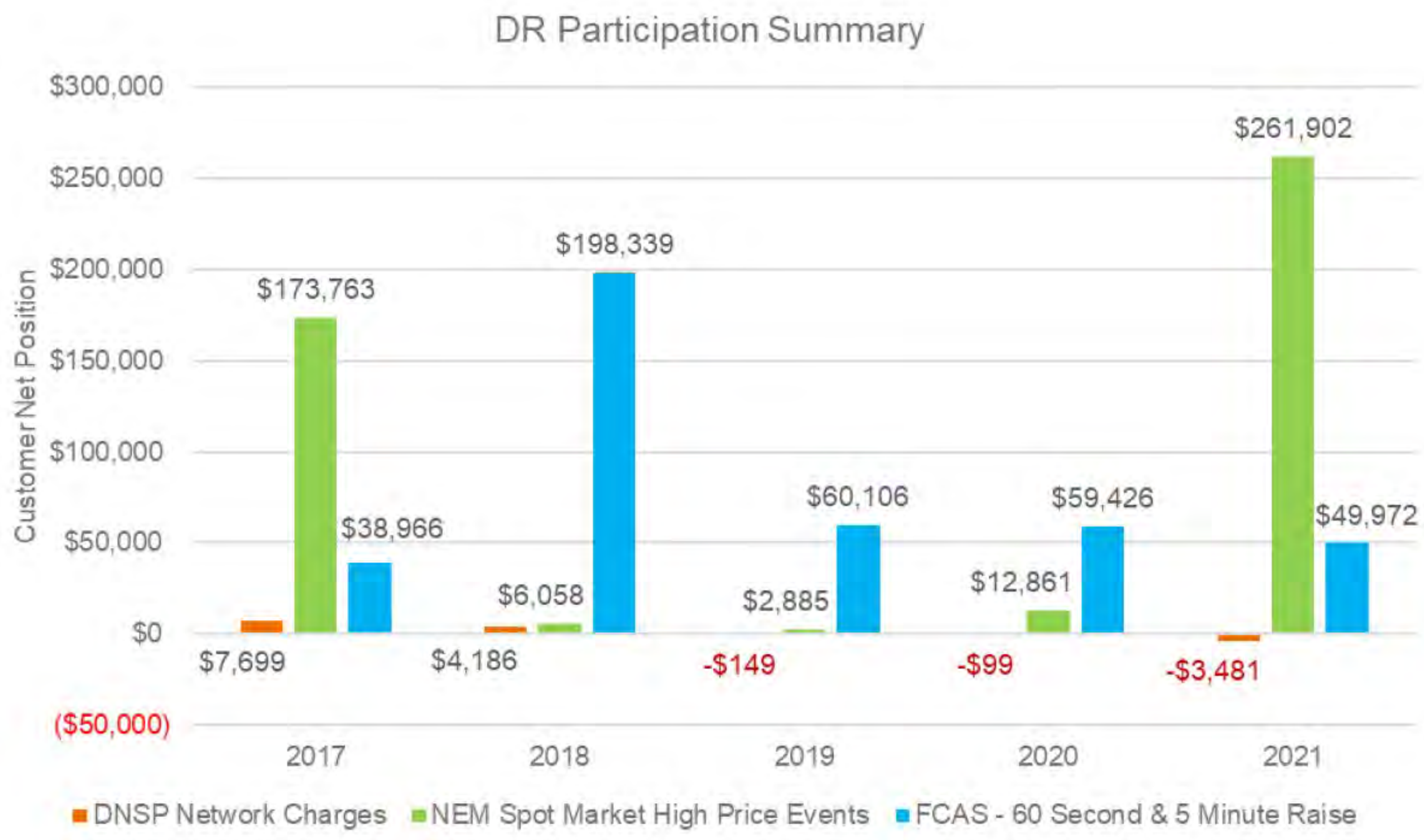
Ventilation implications

- Increasing outside air poses significant challenges
  - Triggers increasing cooling / heating load and energy consumption
  - Ductwork and coil capacities may not be appropriately sized for this change without significant upgrade
  - Capital and operational costs at odds with sustainability objectives
- Effectiveness of outdoor air is sensitive to the droplet recirculation rate, which depends on the type and configuration of the ventilation system
- Portable air purifiers are highly effective in high respiratory activity zones
- Strategically located local exhaust and filtration systems provide more benefit than increasing outside air

Demand Response – market participation

Participation Pathway	Main mechanism	Considerations
No Third Party or AEMO registration required	DNSP Demand charges (price and type vary across networks)	Peak Monthly Demand Peak Annual Demand Seasonal Demand
Participation through a Retailer	NEM wholesale market (Spot Market)	Automatic control or opt-in/out control Trigger price to participate Revenue sharing split Hours of operation control each year
Participation by registering with AEMO or through a Third-Party Aggregator	Wholesale Demand Response Mechanism (WDRM) (from Oct 2021)	Aggregators can bid into 5 minute NEM wholesale market and must respond to dispatch instructions from AEMO Revenue sharing between aggregator and customer
	Frequency Control Ancillary Services (FCAS) - Regulation (minor deviations) market - Contingency (major event) market	Operate on 5 minute intervals. MW available to add/take off the network Payment for availability, even if services not required Require high speed metering and data transfer
	Reliability and Emergency Reserve Trader (RERT)	Emergency research called on by AEMO during extreme events; no payment if not called on.

Major hospital case study



DR – risks / mitigation

Key risks / considerations	Mitigation measures
DR revenue / ROI of infrastructure upgrades	3rd party agreements can negotiate a fixed payment or cost/payment sharing
Loss of control of generators / forced load shedding	3rd party agreements can include optional rather than mandatory control and limit hours of operation
Unattended plant start /stop	Procedures, education, training, signage
Constant start/stop of generators	Minimum run time can be set in the agreement
Underloading generator	Protection system to short down if underloaded
Additional generator wear and tear	DR often requires higher levels of monitoring, leading to better preventative maintenance
Refuelling	Review refuelling schedules and storage More frequent use minimises risk of stale fuel
Greenhouse gas emissions	Diesel emissions currently ~ NEM emissions average DR facilitates larger uptake of renewables on the NEM Longer term alternatives (biofuels, hydrogen, batteries)

CSSD case study: upgrade and electrification

	Existing CSSD	New CSSD
Average Utilisation % During Hours	60%	80%
Operating Hours	18 hrs / day 365 days / year 6,570 Total hours / year	10 hrs / day 365 days / year 3,650 Total hours / year
Electricity Maximum Demand	185 kVA (258A)	618 kVA (860A)
Gas Maximum Demand (MJ/hr)	960 kg/hr Steam (192 per steriliser) 66.2 m3/hr Gas	0
Annual Electricity Consumption	693,000 kWh	1,714,000 kWh
Annual Gas Consumption	261,000 m3 / year 9,720 GJ / year	0

Integrated Design Studios IDS 10, 13, 14

Subtropical and Tropical Mixed Use Buildings incorporating aged care (IDS13/14) – Bolton Clark

- Challenges of mixed-use building typologies
  - No BAU EUI baseline
  - No clear methodology for allocating and reporting KPIs
  - Both a home and workplace (different thermal comfort needs)
- Significant reduction in cooling demand (better buildings) changes options for HVAC technologies, O&M costs and % of load met by PV

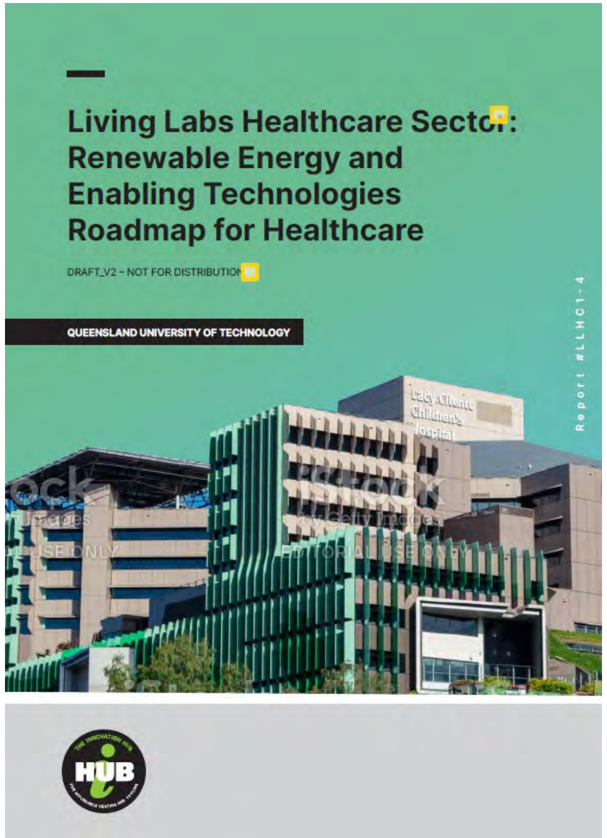
Residential Aged Care Facility Wollongong (IDS10) - Lendlease

- Balancing architectural & engineering priorities
  - Standards considered a limiting factor in deciding what can / can't be achieved
- Five key aspects with commercial viability
  - Design for wellbeing
  - Passive design solutions
  - Operational improvements
  - Additional renewable energy generation
  - Embodied carbon

Data Clearing House Project 9: Health district

- Energy use intensity (EUI) and productivity KPI
  - KPI 1: metered energy data normalised by floor area, beds, bed day
- Environmental and Societal KPIs
  - KPI 2: avoided GHG emissions (tCO2-e and $)
  - KPI 3: avoided air pollution ($ value on PM10 NOx, SO2)
- Energy Network KPIs
  - KPI 4: peak demand by period (KVA per day, date & time matched with BOM)
  - KPI 5: wholesale cost of peak 30 minute electrical demand
  - KPI 6: total self consumption rate (solar export time series per NMI & site)
  - KPI 7: HVAC self consumption rate
  - KPI 8: net facility load factor (avg kWh/peak KVA monthly, seasonally, annually)
  - KPI 9: demand response capacity (KWh/disaggregated HVAC loads)
  - KPI 10: energy cost

Healthcare Roadmap



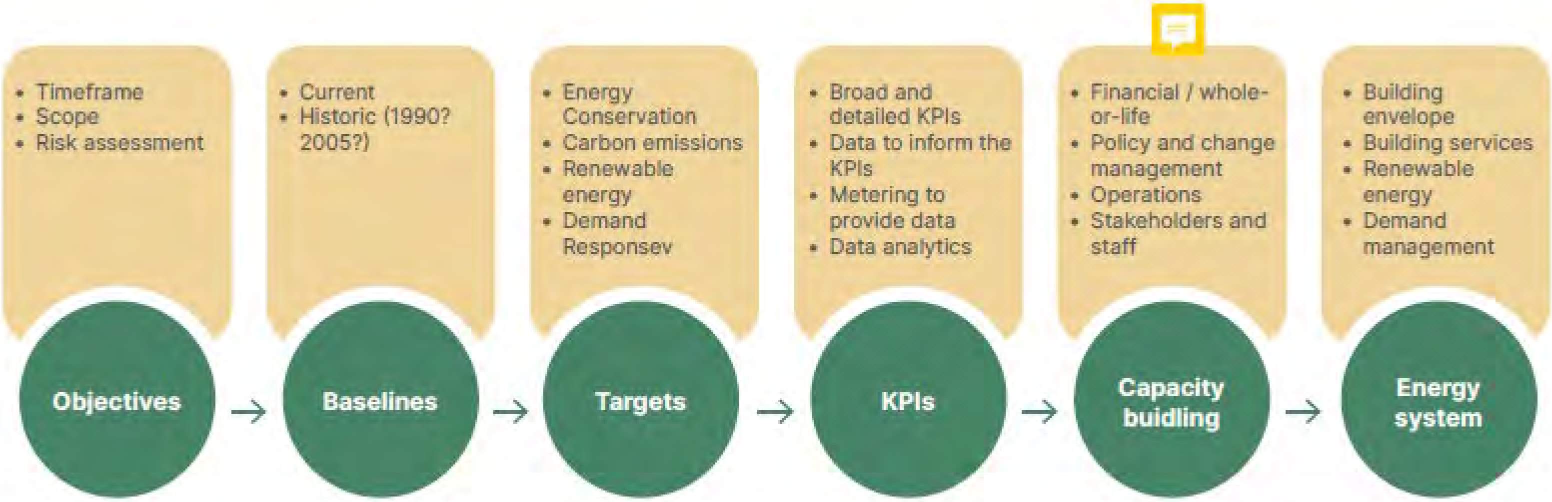


Figure 1.1 **Roadmap structure**

Future work - DISCUSSION

A formal national collaboration vehicle (e.g. Sustainable Healthcare Unit)

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Broad category	Need
Building Models	Development / Approval of hospital and aged care 'model' buildings for use for NCC code development and design development by stakeholders (for optimising building envelope, and for selection and sizing of HVAC systems and renewable energy systems).
Climate files	Comprehensive comparison of different future TMY climate files available, in terms of their respective usefulness for health facility modelling and HVAC and PV system sizing. Development of 'extreme weather' files for Australian contexts, perhaps based on the methodology developed through IEA Annex 80.
Electrification of heat loads	A decision-making framework and guidelines for heat pump technologies, in the move for electrification of heat loads
Demand response	A deeper investigation of energy assets in healthcare facilities that could be utilised for DR (for load shifting, load curtailment). A guideline for DR participation by healthcare facilities.
HVAC&R	A procurement guideline for HVAC in aged care facilities.
Next-gen BMS	A decision-making framework and/or guideline relating to the use of Digital Twins and Artificial Intelligence in predictive maintenance, demand response and predictive control.
Data Platform	Investigation of the value of the Data Clearing House platform and associated apps, to enable better benchmarking and energy optimisation in healthcare facilities.
Ventilation Effectiveness	Further investigation of the decay rate of airborne particles in HVAC systems; and the effectiveness of alternative ventilation strategies. (LLHC 5 and LLHC4 – Technical Report highlight the energy impact of current pandemic mode ventilation strategies and raise questions about the effectiveness of these strategies on containing contamination spread in healthcare facilities.)

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