Fairwater Living Laboratory – Implications for Supply Chain Development

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[i] This research was undertaken by researchers at the University of Technology Sydney as part of the Fairwater Living Laboratory. Publication of these findings must include the attribution: *Thomas, L., Wilkinson, S, Wyndham J, Huete, A., Biloria, N., Woods, A., Kalali, P., Powles, R., Srivastava, A., Liu, Y., Bulut, M., Dritsa, D., Runck, M., Dwyer, S., 2022, Fairwater Living Laboratory Milestone 4 Report Summary: Outcomes for Energy, Network Demand, Residents and Community, Resilience, Urban Heat Effects and Commerciality, prepared for ARENA and Climate KIC.*

INTRODUCTION

Opened in 2016, Fairwater was heralded as one of the country's most progressive, environmentally-friendly community developments: 800 homes set in a landscape including wetlands, and with the largest geothermal heating and cooling system in the southern hemisphere.

The overarching aim of the Fairwater Living Laboratory project was to ascertain whether Fairwater, delivers predicted sustainability, resilience, well-being and commerciality benefits. Commencing in 2019, the study draws on detailed monitoring and occupant feedback of approximately 40 study households from Fairwater, aggregate and precinct level data for network demand, environmental parameters and urban heat, as well as community feedback gained from 97 additional households.

Research undertaken by the University of Technology Sydney as part of the Fairwater Living Laboratory has revealed the reduced peak demand and total consumption for grid energy; and quantified actual energy performance of the geothermal or ground source heat pump (GSHP). Additionally, the study has shown the reduced cost of living for residents (compared to business as usual) as well as the economic benefits to the developer, residents and the distribution network service providers. The study also showed improved urban heat island outcomes compared against a similar nearby site. The study findings highlight the importance of thermally efficient climate responsive building design, well-designed infrastructure to support health, wellbeing and resilience of the resident population. Importantly the study shows that user behaviour and occupant preferences play a key role in the actual performance and savings that can be realised.

The study findings offer a number of insights for supply chain development with respect to GSHP air-conditioning (AC) systems, house construction, and implications for monitoring, user engagement and feedback.

INSIGHTS FOR SUPPLY CHAIN DEVELOPMENT

Implications with respect to the integration of GSHP at the level of the home

- The model of GSHP investigated in this study was completed at precinct scale. Although staging, procurement and installation was not part of the study, it is important to note that the integration of the geothermal AC at Fairwater was only feasible because it was implemented at the scale of a precinct. Installation of GSHP needs to be integrated into the workflow and development of the individual home sites by the developer right from the project inception.
- Economies of scale enabled cost effective installation of geothermal air-conditioning at a precinct level for the developer. The increased outlay for the installation of geothermal air-conditioning over the cost of a home with conventional reverse cycle heat pump air-conditioning represents just $5000 or roughly 1.2% of the average construction cost of a 3-bedroom Fairwater home.
- This difference in cost mainly relates to the drilling of 80m deep bore holes for the refrigerant piping, and the provision of the proprietary infrastructure that is then integrated as part of the air-conditioning system. The cost to implement GSHP technology would have been prohibitive if it had to be done by independent homeowners.
- While the heat exchange characteristic in a GSHP via a refrigerant loop underground distinguishes it from conventional AC systems, the system presents no visible or perceptible difference to occupants. The interior ducting, zoning and air distribution remain similar to other AC systems typically integrated in residential dwellings.
- The system was found to be well received by occupants, who were able to deploy air-conditioning in their homes in much the same way as any ducted air-conditioning system – with standard ductwork, fan coil units, diffusers and control panels.

Considerations and improvements to delivery of AC system relevant to both GSHP and conventional systems.

The seamless integration of ducted air-conditioning to suit market preferences poses the challenge of higher consumption and an over-reliance on air-conditioning all year round. Considerations and improvements include:

- The assumption that bedrooms are only night-time spaces and that living rooms are all occupied simultaneously is not always true.
- Consider smaller AC zones to enable, for example, one bedroom and one living area to be conditioned. This would require strategically configured ducting and dampers, and the capacity of the system to "back off", as well as variable speed drives. The timely opportunity exists for the development of more efficient and cost-effective systems solutions to minimise energy wasted in the supply of cooling or heating to uninhabited zones.

- Include the capacity to have different thermostat settings for different zones and include timer-off options.
- Provide users with feedback beyond thermostat settings – display room temperature in the zones, alongside information about the outside weather that provides cues when it is conducive to shut AC off.
- Revisit the notion of "stand-by". Allow users to easily shut the AC system down for 7-8 months of the year? Our study showed the AC standby was on average 7% of a home's electricity bill.
- The number of households who reported that they have had their geothermal AC system serviced in the last two years was low – if this is a requirement of the systems to maintain optimal operation and efficiency, it should be part of a long-term servicing contract.
- Consider the life of the refrigerant loop, and what happens at the end of life of the system.

Implications with respect to the design and performance of the house

The study emphasizes the benefits of having a proactive recognition of, and attention to the careful design of homes at the outset of a project for thermal comfort, energy efficiency, user satisfaction and occupant needs.

- Fairwater homes, which are more compact than those of the similarly aged suburb of North Kellyville, demonstrated tangible savings in operational energy from a reduction in house size. Importantly, the homes delivered an exceptionally high satisfaction with respect to design and overall comfort for residents. As seen at Fairwater, the success of compact homes hinges on high quality design which is rated highly for satisfaction, comfort, and wellbeing while remaining energy efficient in practice.
- The study homes largely met expectations for occupant thermal comfort even in the absence of air-conditioning. Nevertheless, around 30% expressed dissatisfaction with the thermal conditions in summer and winter. These findings highlight forthcoming challenges with climate change and the requirement for improved thermal performance via design and building fabric.
- Our study results were achieved with code compliant building fabric from 2016. Future housing will benefit from improving thermal performance, air tightness and approaches to whole of house efficiencies in line with increased stringencies.

Our study suggests that there is an opportunity to go further than minimum performance requirements. Energy conservation before "efficiency" is crucial to ensure the passive operation of houses is first choice as far as possible. This aspect is critical if we need to get to Net Zero across the Whole of Economy in a sustainable manner.

- Inclusion of sustainability features at house and precinct level were found to yield very high levels of occupant satisfaction at Fairwater.

- Our analysis reveals that Fairwater properties attracted a premium of $55,487 compared to non-Fairwater properties (with similar attributes, including age) located in Blacktown LGA during 2014 and 2021. Given that most Fairwater properties have not yet been resold, we believe this premium contributes directly to the profitability of the project for the developer. The premium paid for a Fairwater property is 7.1 % of the average price of a non-Fairwater property included in the analysis.

Our study revealed a high level of awareness about sustainability and climate change amongst the households and the wider community. The high take up- where 30% across the community respondents had installed PV solar on their own initiative- indicates consumer willingness to invest and take action.

Designing for Sustainable Practices in Homes

Performance in practice is intrinsically related to the design of the home and its thermal efficiency, the way in which occupants interact with the home's technologies and their preferences, as well as their behaviour and practices.

- The study reveals that the access to "AC on tap" can increase energy demand and squander energy savings achieved through its technological efficiency, and the 'conditioned' expectations of inhabitants, stimulated by a lower tolerance of 'imperfect' conditions and availability of heating and cooling on stand-by, can lead to increased dependence and usage. (See also **Considerations and improvements to delivery of AC system relevant to both GSHP and conventional systems**)
- Building and precinct development should consider ways to motivate sustainable practices through design – these include provision of ceiling fans, fly screens to windows, easy to operate shading devices, indoor-outdoor living opportunities to acclimatise occupants to a wider range of temperatures, integration of trees to reduce the urban heat island effect, and the creation of cool outdoor and social spaces through shaded pathways and parks.

User behaviour and occupant preference play a key role in the actual performance and savings that can be realised. Residents would also benefit from a targeted program of user engagement and education.

Monitoring and Feedback

- Real time feedback on energy use, indoor and outdoor temperatures, weather conditions and forecasts together offer a viable method to support energy reduction. This affords an opportunity for networks to collaborate with suppliers of smart apps as well as experts on consumer behaviours and the designers and developers of homes and precincts to encourage sustainable practices.
- The study identified a clear need for benchmarkable energy data to support analysis and comparisons of residential precincts. Developments of scale should consider integration of occupant engagement, monitoring and metering which can offer better insight for effectiveness of interventions, energy conservation and demand management and

encouragement of sustainable practices.

DIRECTIONS FOR FUTURE RESEARCH AND PARTNERSHIPS

- The study confirmed the value of an integrated precinct-based solution towards decarbonization and sustainability. Many of these outcomes were guided and validated through the adoption of the independent sustainability-driven rating tool Green Star – Communities. Given the lead time of nearly 8-10 years before precincts are fully developed, it will be critical for future developments to aim for similar integrated approaches. Further improvements can be achieved by setting performance targets that are more progressive than contemporary minimum performance standards of the National Construction Code (NCC).
- Strategic actions adopted by industry leaders in the property sector, coupled with economies of scale, can also have the potential to reduce costs for the implementation of increased energy efficiency measures as well as novel technologies and enable them to gain market acceptance and uptake.
- Opportunities for partnerships from a supply chain and building industry perspective include investment in high thermal performance housing, well integrated systems for heating and cooling that are user responsive and enable efficient utilisation of energy resources.
- Follow-on research could explore and test further methods to provide feedback, and user education to drive changes in behaviours for scalable solutions.
- Other investment opportunities include precinct scale EV infrastructure and the installation of shared infrastructure such as micro grids and shared energy storage.
- Living Laboratory style investigations of performance in practice should be a mandatory test bed for all innovative interventions. The success of the Fairwater Living Laboratory reinforces the value of integrating research and innovation within a user-centred approach encompassing multiple stakeholders.

Please contact Leena Thomas, School of Architecture, University of Technology Sydney or Belinda Whelan, Director Climate-KIC Australia to learn more.

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