Fairwater Living Laboratory – Implications for Property Developers

UNIVERSITY OF TECHNOLOGY SYDNEY REPORT

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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 Fairwater Living Laboratory project aimed to assess the performance of renewable thermal energy heat pumps into homes at the Frasers Property Fairwater development in Blacktown, NSW. Research undertaken by the University of Technology Sydney (UTS) has successfully delivered on the project objectives, including demonstrating reduced peak demand and total consumption for grid energy; and quantified actual energy performance of the geothermal or ground source heat pump (GSHP) systems. 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. Improved urban heat island outcomes compared against a similar nearby site has been demonstrated. In doing so it has delivered a technical and commercial evidence base to show the potential for reduction in electricity network augmentation and the commercial merits of industry-wide adoption of GSHP technologies and systems approaches in residential precinct developments.

The property sector is in the best position to work with planning authorities and network utilities to deliver an integrated approach to decarbonising precincts. The study undertaken using the living laboratory framework for investigation reveals the importance of thermally efficient climate responsive building design, a better understanding of occupant behaviour and energy consequences, precinct-based approaches that encompass technology innovation for a decarbonised future as well as well-designed infrastructure to support the health, wellbeing and resilience of the resident population

INSIGHTS FOR THE PROPERTY SECTOR

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

- Our analysis has found that in absolute terms, Fairwater Estate Houses consumed 38% less total electrical energy (average savings of 2,424kWh per annum per household) than the North Kellyville houses (which use conventional air-conditioning) during the 24-month period from 1 Sep 19 to 30 Aug 21.
- As Fairwater Estate houses were smaller than North Kellyville houses, the residual savings more likely to be attributable to take up of heating and cooling were computed by normalising the energy consumption for house size. Our study indicates that Fairwater homes with geothermal air-conditioning return a saving of 21% of electricity energy consumption compared to homes of a similar size with conventional air-conditioning across the study period.
- In terms of greenhouse gas emissions, the savings for a more compact home coupled with geothermal air-conditioning (AC) as seen at Fairwater represents 2.18 tonnes of CO2 e (scope 1, 2 and 3) on average per home per annum and across an 800-home estate could result in 1,746 tonnes of CO2e emissions per annum.
- Fairwater Estate GSHP houses were found to consistently demand less power than North Kellyville houses when ambient (external) temperatures deviate from the comfortable range with substantial benefits to networks via reduction in peak demand and network augmentation. These benefits are increasingly relevant in current scenarios of warming temperatures, increasing housing demand and urbanisation in Western Sydney and other locations around Australia.
- While the staging, procurement and installation were 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 was reported at $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.

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

- 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.
- The seamless integration of ducted air-conditioning to suit market preferences poses the challenge of higher consumption and over-reliance on air-conditioning all year round.
- High performance air-conditioning in and of itself is not a solution in the quest to reducing dependence on air-conditioning, getting to net-zero and maximising sustainability.
- A suite of measures that influence sustainable practices must be considered, with respect to design of the system, feedback to occupants and resident engagement at point of sale and in an ongoing manner.

Implications with respect to the design and performance of the house

The study emphasizes the proactive recognition and attention to careful design of homes at the outset.

- Fairwater homes which were more compact, demonstrate tangible savings in operational energy from reduction in house size. Importantly, the homes delivered an exceptionally high satisfaction with respect to design and overall comfort for its residents.
  As seen at Fairwater, the success of compact homes hinges on high quality design which is rated highly for satisfaction, comfort, and wellbeing and remains energy efficient.
- 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.

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 technologies and their preferences, as well as their behaviour and practices.

- Air-conditioning was a substantive component of energy use in a home (around 40% of annual electricity use) and a key driver of the summer and winter peak electricity demand.
- We found a wide variation between homes in the extent to which AC is relied upon even when climate, construction and occupancy are not different, indicating user preference and behaviour can greatly influence air-conditioning energy.
- 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.
- Building and precinct developers 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.

Residents would also benefit from a targeted program of user engagement and education.

- Precinct level developments have the opportunity to harness roles such as a community liaison to maintain connections and raise awareness amongst residents and empower them in relation to sustainability, climate change and long-term resilience.
- 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 designers and developers of homes and precincts to encourage sustainable practices.

Solar PV

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. However, there are important lessons for the property sector:

- Our study has shown that the Solar PV houses consumed more electricity and air-conditioning (30% more on average) than homes that had never installed Solar PV.
- A high take up in roof top solar was accompanied by increased electricity consumption, low self-sufficiency and low self-consumption, diminishing the full potential for greenhouse gas reductions from renewable energy.
- Almost all Solar PV Study Houses were found to be NET POSITIVE under the simple definition of Net Zero, even when gas consumption is accounted for; however, assuming

the same level of consumption seen in the Solar Homes and current CO2 emission factors for the NSW grid, the present configuration of PV would barely break-even; leaving no surplus for electric vehicles (EV) and the like.

- Towards Net Zero homes and precincts, this calls for redoubled efforts - to mitigate the rebound effect amongst households, and to ensure decarbonisation of the electricity grid.

Implications and benefits in relation to Community Infrastructure, Urban Heat, Open Space and Parklands

- Abundant open space, walking tracks and opportunities for healthy living were some of the important dimensions of the 6 Star Green Star- Communities Fairwater development.
- Fairwater residents were overwhelmingly positive about the extent to which their expectations were fulfilled in relation to environmental sustainability and living in the Fairwater 6 Star Green Star- Communities development.
- Resident feedback indicates that Fairwater encourages and supports access to the precinct's public open spaces, a connection to the natural environment, social interaction with other community members, an active and environmentally friendly lifestyle, as well as the needs of culturally diverse groups and users with diverse abilities.
- Our study revealed heightened activity in the parks over winter and the Covid-19 periods, but also found the activity to be lower than expected over the summer. Our findings reiterate the potential of play areas and other activities and amenities to attract residents outdoors. They reinforce the need to decrease heat stress via shading and trees in these areas.
- Over 80% of residents reported they feel more healthy since moving to Fairwater.
- In addition to the benefits of physical activity or occupation of outdoor spaces, the availability and sense of connection to natural environments were reported to also have a positive impact on residents' perceived well-being, with increased take up and appreciation of amenities over the duration of the Covid-19 pandemic.

Mitigating Urban Heat is crucial in the context of increased urbanisation and climate change. Our study has found that the integration of building and landscape strategies can contribute to the health of residents and the long-term resilience of the precinct.

- The light-coloured roofs of the Fairwater homes were found to have a cooling effect of 3-4 degree C with respect to surface temperature.
- Light-coloured roofs were also found to compensate for the lack of mature trees during the study. Our study comparison with established areas of Blacktown and neighboring suburbs indicates that combined with established trees they will lead to further cooling.

Commerciality

The precinct strategy to transform an old golf course required storm and flood plain management - a quarter of the site was transformed to parklands and outdoor spaces for the community. Although this generosity of land earmarked for parklands may not be available every time, the value of this move has reaped high dividends. Residents overwhelmingly reported that they were healthier, more active physically and experienced improved wellbeing, and nominated it as a main attractor for purchase.

- Our analysis reveals that Fairwater properties attracted a premium of $55,487 (or 7.1 % of the average purchase price) compared to non-Fairwater properties (with similar attributes, including age) located in the Blacktown Local Government Area (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.
- Geothermal air-conditioners were reported to cost around an additional $5,000 compared to conventional air-conditioners or 1.2% of the average construction cost of a 3-bedroom Fairwater home. It can be argued that this additional cost is absorbed by the premium paid for the Fairwater properties, making the geothermal air-conditioners a profitable investment.

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.
- The study findings indicate that the benefits from the reduction in peak demand and network augmentation enjoyed by the networks are greater in comparison to residential customer energy savings from GSHP. This calls for better partnerships between property developers, consumers and the networks to ensure benefits to the network are also passed on to property developers and consumers.
- Additional opportunities for partnerships include: planning for a diversity of uses whereby retail/commercial/public buildings and residential homes take advantage of shared services for heating and cooling to balance power demand between day and night time uses, investment in precinct scale EV infrastructure and installation of other shared infrastructure such as micro grids and shared energy storage.

- The study identified a clear need for benchmarkable energy data to support analysis and comparisons of residential precincts. Property 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.
- We recommend additional larger scale trials be undertaken in future residential developments in which confounding factors may be better eliminated. For example, cross-site and single site comparative studies of conventional and alternate energy/technology options with detailed monitored data for all groups would provide excellent baselines for treatment group comparison.
- 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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