Fairwater Living Laboratory – Implications for Customers

UNIVERSITY OF TECHNOLOGY SYDNEY REPORT

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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.*

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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 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 demonstrated improved urban heat island outcomes at Fairwater compared against a similar nearby site.

From a resident perspective, the study findings highlight the importance of thermally efficient climate responsive building design, and well-designed infrastructure to support the health, wellbeing and resilience of the residential 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 and offer important insights for gaining the best from the home.

INSIGHTS FOR RESIDENTS

Energy, greenhouse gas and dollar savings arising from GSHP

- 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 Sep19 to 30 Aug 21.
- Assuming single rate tariff usage rates ranging from 17.51 to 28.85c, the reduced consumption would result in savings between $425 and $699 per annum (average of $557 per annum at 22.96c). These savings include the twin benefits of geothermal air-conditioning and a more compact house at Fairwater.
- 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 consumptions 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.

- Assuming single rate tariff usage rates as before, the reduction in consumption attributable to the ground source heat pump would result in savings for between $181 and $299 per annum (average of $238 per annum) on average.
- In terms of greenhouse gas emissions, the savings for a more compact home with geothermal air-conditioning as seen at Fairwater represents 2.18 T of CO2e (scope 1, 2 and 3) on average per home. Of this, 0.93 T of CO2e per household or 746 T of CO2e emissions per annum could be attributed to the GSHP system.
- GSHP was found to be viable when installed at a precinct level as part of the construction process such as at Fairwater. This study could not ascertain the costs for installation in a single home.
- The GSHP 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.
- Fairwater Estate GSHP houses were found to consistently demand less power than North Kellyville houses when ambient (external) temperatures deviate from the comfortable range. These outcomes result in substantial benefits to electricity networks as they reduce peak demand and lower the need for network augmentation. These benefits are increasingly important in current scenarios of warming temperatures, increasing housing demand and urbanisation in Western Sydney and other locations around Australia.

House design, comfort and air-conditioning

The study emphasized the importance of well-designed homes that are comfortable and healthy, and can help residents use less energy for heating and cooling.

- Fairwater homes were more compact and demonstrate tangible savings in operational energy from reduction in house size. Importantly, these homes also delivered an exceptionally high level of satisfaction with respect to design, residents' needs and overall comfort for its residents.
- The study homes were found to be thermally comfortable even in the absence of air-conditioning most of the time. Nevertheless, around 30% expressed dissatisfaction with the thermal conditions in summer and winter without air-conditioning which also demonstrates forthcoming challenges with climate change.
- Our study suggests that future housing will benefit from improving thermal performance, air tightness and approaches to whole of house efficiencies in line with increased regulatory standards, and from striving for performance beyond minimum 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.

- Air-conditioning was found to be a substantive component of energy use in a home and key driver of the summer and winter peak electricity demand in the home. However, 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 how often people switch the system at times when AC was not necessarily required, and this could squander energy savings achieved through its technological efficiency.
- We found that 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.
- On the other hand, we found many residents resorted to AC only after adjusting clothing and switching on ceiling fans and taking other measures to adapt to discomfort, and a few went on to set the thermostats to be more in sync with the weather rather than a fixed narrow set of temperatures that would entail more energy.

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 residents and customers:

- Our study has shown that the residents in Solar PV houses consumed more electricity and air-conditioning (30 % more on average) than homes that had never installed Solar PV.
- Our study also found self-sufficiency (or fraction of total electrical energy consumption directly supplied by solar) and self- consumption (or fraction of solar energy generated used directly on site) was low. This diminished the full potential for greenhouse gas reductions from renewable energy and monetary benefits to consumers from poor feed-in tariffs.
- Better on-site utilisation can be achieved by consumption in most homes by aligning usage to sunlight hours, 'right-sizing' systems or through storage of energy via batteries.
- 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.

Designing and Educating for Sustainable Practices in Homes

Our study points to opportunities and the importance of fostering more climate appropriate and user responsive practices through design and education. This is necessary to help residents get the best from their home and to avoid the 'rebound effect' where the benefits of energy efficient technologies are lost to increased energy consumption.

Building and precinct development should consider ways to motivate sustainable practices through design – these include the 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 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 the designers and developers of homes and precincts to encourage sustainable practices.

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, active and environmentally friendly lifestyle, as well as the needs of culturally diverse groups and users with diverse abilities.
- 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 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 compared to non-Fairwater properties (with similar attributes, including age) located in the 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.

DIRECTIONS FOR FUTURE RESEARCH AND PARTNERSHIPS

- 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.
- 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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