Net Zero Energy at Wylie's Baths

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Background

Wylie's Baths is a community tidal pool facility located in Coogee, Sydney. The pool is open throughout the year and is used primarily for recreational swimming but also occasionally hosts weddings and public functions. The primary electricity consumption is associated with the operation of the kiosk which includes: multiple fridges, freezers, a coffee machine, dishwasher, oven and many other appliances. Water heating is required for the hot showers in both the men's and women's bathrooms. This is primarliy supplied by a solar water heating system located on each of the bathroom roofs which is then supplemented by electric boosters. The pool itself consumes no electricity as all water comes naturally from the ocean. The cottage building which houses a single adult is also factored into Wylie's total energy consumption from the grid, but it has been excluded from this net zero assessment[1]. A 12.25kW PV system was installed in March 2021 on the cottage roof to reduce Wylie's demand from the grid. However, their energy bills are still quite substantial and management are interested in implementing further sustainability initiatives. The building layout at Wylie's Baths is displayed in Figure 1.

Figure 1. Building layout at Wylie's Baths.

Barriers Preventing Net Zero Building Uptake

Many nations (including Australia) have adopted 'net zero by 2050' targets in accordance with the Paris Agreement, aiming to limit global warming to 1.5^{o}C [1]. To achieve net zero across the nation, sector specific net zero commitments must also be set. The building sector is responsible for around '30% of global energy consumption and GHG emissions and is the largest contributing sector' [2]. The World Green Building Council (GBC) have recognised the enormous potential to cut emissions by buildings. They have set targets for the building sector whereby [2]:

1. All new buildings must operate at net zero carbon from 2030.
2. 100% of buildings must operate at net zero carbon by 2050.

[1] Excluded due to difficulty in collecting consumption data for cottage building and Wylie's management have less control over cottage resident.

Despite, these targets net zero building uptake is slow. According to a 2017 World GBC Report only 1% of the global building stock are classified as net zero buildings [2]. It's clear society is behind the curve. 4 main barriers were identified that are preventing the uptake of net zero and sustainable buildings [3]:

1. *Financial*: this was the largest barrier as the higher upfront cost of more efficient appliances deter a lot of people.
2. *Perceptual*: there is a market perception that net zero building design is difficult and costly to achieve.
3. *Technical*: people lack the technical know-how and what changes they can do to help them go net zero.

Achieving the World GBC targets is dependent on overcoming these barriers.

Project Aim and Methodology

The project aim was:

"To achieve net zero energy at Wylie's Baths and show it can be achieved in a cost effective way using existing technologies"

Net zero energy is defined where the sites annual energy consumption equals the annual energy generated by renewable sources. Reducing on site demand as much as reasonably possible will be the first priority followed by offsetting the remaining demand using on site renewable generation. If demand cannot be feasibly met via on site sources, off site renewable generation will be considered. Showing net zero can be done in a cost effective way using existing technologies, is vital in overcoming some of the financial, perceptual and technical barriers that are currently preventing net zero uptake. Wylie's Baths can then be used as a case study for educating the community about what can be achieved using existing sustainable technology.

A 3 staged approach was undertaken during the net zero assessment at Wylie's Baths.

1. *Existing energy demand assessment*: overall site consumption data (exc. cottage) has been collected for Wylie's Baths since March 2021, using a solar analytics energy meter. Individual appliance consumption was measured by the installment of energy meters on site. Data for each appliance was collected over a 14 day period between March 2022 to April 2022. This data was used for providing a consumption breakdown per individual appliance.
2. *Exiting energy supply assessment*: energy generation data of the 12.25kW cottage PV system has been collected since March 2021. A helioscope simulation was also run modelling the performance of the cottage PV system and additional PV systems (kiosk and bathrooms).
3. *Sustainability recommendation assessment*: a techno-economic assessment was performed for each sustainability reccomendation, analysing both energy savings and economics where simple payback time, NPV, ROI and LCOE metrics were used for assessing the cost effectiveness.

Energy Demand and Energy Supply Assessment

Wylie's Baths consumes on average 42.396 MWh/yr or 120kWh/day from the gird and generates 15 MWh/yr or 41 kWh/day from the cottage PV system.

A daily consumption breakdown per appliance is shown in Figure 2 and Figure 3.

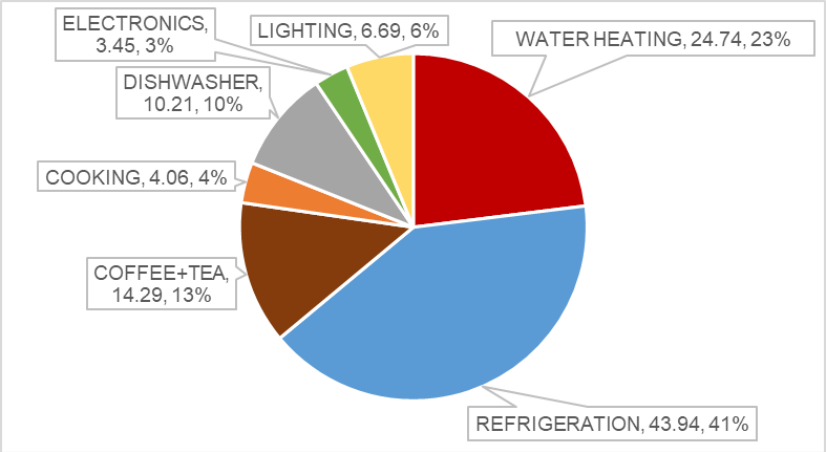

Figure 2. Overall consumption breakdown per appliance in kWh/day at Wylie's Baths.

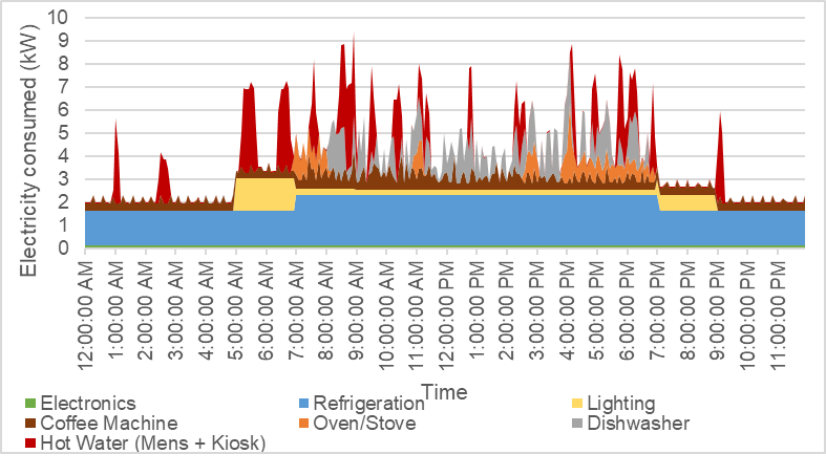

Figure 3. Daily consumption breakdown per appliance at Wylie's Baths (22/3/2022).

The following conclusions were made after the demand and supply assessments:

- Wylie's Baths consume the majority of their energy from refrigerators, water heating (mainly the mens and women's bathroom), cofee machine and dishwasher.
- There is a significant amount of standby power consumed by refrigerators and the coffee machine while Wylie's is closed.
- The electric boosters for the men's and women's bathrooms consume a significant amount of energy. Particularly, in Winter months hot water consumption is high since irradiation levels are much lower and the solar hot water system does not perform as well.
- Renewable generation is currently one-third that of site consumption. A significant amount of additional renewable energy supply is needed to reach net zero.

Recommended Sustainability Measures

The sustainability measures proposed and assessed for Wylie's Baths include:

1. Switching the coffee machine, drinks and display food fridge off overnight
2. Replacing the bathroom electric hot water boosting systems with a heat pump.
3. Installing additional PV on the kiosk and/or bathroom roofs.

The results from the techno-economic assessment are shown in Table 1. Each of the sustainability measures recommended are cost effective since they generate a positive NPV, ROI and have

payback times well below their expected lifetimes. The instalment of a battery[2] with the additional PV installation at Wylie's Baths was also assessed. A battery cost of $1,220/kWh (inc. installation) was assumed during the economic assessment [4]. The simple payback time was approximately 14 years, which exceeds the 10 year expected lifetime of lithium ion batteries [5]. To generate a positive return, battery costs would need to be reduced below $800/kWh. Therefore, only additional PV should be considered at Wylie's Baths at present. As battery costs reduce in the future the battery economics can be reassessed.

Table 1. Techno-economic results for each sustainability measure.

	Switch off overnight	**Heat pumps**	**5.6kW PV (kiosk)**	**5.6kW PV (bathrooms)**	**All sustainability measures**
Annual energy saving (MWh)	3.492	7.122	7.50	6.67	24.792
Energy reduction	13%	26%	27%	24%	90%
Annual cost saving ($)	1,075	2,193	1,467	1,319	7,636
Net upfront cost ($)	60	7,500	7,000	7,000	21,560
Payback time (yrs)	0.1	3.4	4.8	5.3	2.8
NPV[3] ($)	-	19,145	16,541	13,964	-
ROI	-	255%	165%	140%	-
LCOE ($/kWh)	-	0.105	0.057	0.064	-

Conclusion

This study demonstrates the immense energy reduction that can be achieved using just on-site sustainability measures. Wylie's Baths can reach mostly net zero using on-site sources but it would need to meet the remaining 10% using off-site renewable energy. Net zero can be achieved in a cost effective way using existing technologies, without major renovation to the building design and operation of appliances at Wylie's. Examples like this are crucial in educating the community and correct some of the barriers surrounding uptake of net zero building buildings.

References

[1] Australian Government, "The Plan to Deliver Net Zero," Austrlian Government, Canberra, 2021.
[2] J. Burrows and V. Laski, "From Thousands to Billions," World Green Building Council, 2021.
[3] T. Fleiter, J. Schleich and P. Ravivanpong, "Adoption of energy-efficiency measures in SMEs—An empirical analysis based on energy audit data from Germany," *Energy Policy,* vol. 51, pp. 863-875, 2012.
[4] Solar Choice, "Solar Battery Price Index - May 2022," 2022. [Online]. Available: https://www.solarchoice.net.au/blog/battery-storage-price/. [Accessed 2022 July 18].
[5] Australian Energy Foundation, "Your Guide to Choosing the Best Solar Batteries for Your Home," Carlton, 2022.
[6] H. Miles, "How Long Should a Heat Pump Last," Home Inspection Insider, 30 May 2020. [Online]. Available: https://homeinspectioninsider.com/how-long-should-a-heat-pump-last/. [Accessed 14 November 2021].
[7] Australian Energy Foundation, "Your Guide to Choosing the Best Solar Panels for Your Home," Carlton, 2022.

[2] Size of battery: 10kW battery when combined with one additional (kiosk or bathrooms) PV system, 24kW battery when combined with both (kiosk and bathrooms) additional PV systems installed.

[3] Calculated over expected lifetime. Assumed 10 year lifetime for heat pumps [6] and 25 year lifetime for PV system (accounting for inverters to be replaced after 10 years) [7] .