YEAR 1 PERFORMANCE REPORT(2013/14)

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Josh's House is a project supported by the CRC for Low Carbon Living Ltd supported by the Cooperative Research Centres program, an Australian Government initiative.

Curtin University

JOSH BYRNE & Associates

LOW CARBON LIVING CRC

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INTRODUCTION

After 20 years demonstrating sustainable design, environmental scientist & well known ABC Gardening Australia presenter Josh Byrne has undertaken his most ambitious project to date – the building of two accessible 10 star energy efficient family homes.

The houses have been built at a similar square meter cost and time frame as more conventional 6 star homes using readily available materials and technologies.

The design will result in a staggering 90% reduction of a typical home's energy consumption and greenhouse gas emissions. It will only use one third of the scheme water, whilst sustaining a diverse and productive garden.

The rear house is being monitored over a three year period as part of a research project undertaken by Curtin University through the CRC for Low Carbon Living. Data is being made freely available to further our understanding of high performance housing with a focus on water and energy efficiency.

Built in the Fremantle suburb of Hilton, construction of the houses commenced in December 2012 and was completed in June 2013 on time and on budget. This then poses the question, why aren't all new homes built like Josh's House?

'This project is all about providing an inspiring and practical example of how to create beautiful and resource efficient homes that are accessible to the broader community. Key to the project's success will be the partnerships that we will form and foster throughout the process to help share ideas and promote the outcomes.'

JOSH BYRNE

SUMMARY OF RESULTS

The performance monitoring systems at Josh's House are now fully operational and data is available for collection and analysis. Due to the complexity of the installation, different sensors came on line at different times, between November 2013 and June 2014. With this work now complete, the performance of the house can begin to be analysed against the original design.

The solar passive design of the house, with no mechanical heating or cooling present, has been very successful, especially during Perth's hot summer. The average temperature in the living room to date is 22.9°C. On only 5 occasions during the summer of 2013/14 did the internal temperature exceed 28°C – the designed upper limit for thermal comfort. The house had an average internal temperature of approximately 25°C.

During the winter of 2014, the temperature dropped below 18°C (the lower limit designed for thermal comfort) on 15 occasions in the master bedroom, although this occurs early in the morning the temperatures do not drop significantly below 18°C, with the lowest temperature ever reached being 15.8°C.

On average the house uses 11.15kWh of electricity per day, 5.48kWh of which is imported from the grid outside of solar generation periods, with the remainder being produced on site. The average daily PV generation is 15.4kWh/day, making the house a net exporter of electricity (a net export of 4.25kWh per day). This results in an annual saving of $1,543.61 in electricity bills.

The house also uses 89% less gas than the Perth average. Gas is used for cooking throughout the year, and to boost the solar hot water system during autumn and winter. This lower use results in a cost saving of $566.08 compared to the Perth average.

The house uses 92% less scheme water than the Perth average, due to the presence of a rainwater system, grey water reuse and bore water use for irrigation. A site water balance determined that, once the garden beds are established, the site recharges more water to the superficial aquifer than the bore draws each year. The reduction in scheme water use results in an annual saving of $542.15.

The house has annual emissions of 1989 kgCO2e, which is 72% lower than the Perth average. However, the PV generation on-site results in annual offsets of 3324 kgCO2e, making the house 'carbon positive' on an operational basis.

TEMPERATURE

Thermal Performance

Figure 1 shows the thermal performance of the three bedrooms and the living room from the beginning of data collection (28/01/2014) to the end of the 2014 financial year. This covers very hot periods during January and February, and very cold periods during June. Generally, the house has performed very well, with rooms falling within the thermal comfort zone of 18-28°C, which was determined at the design stage.

There were five short periods where the master bedroom and living room exceeded the maximum comfort threshold of 28°C. This was during extended warm periods, with daily maximum temperatures reaching over 35°C, and night minimum temperatures as high as 24.3°C, and not dropping below 20°C. The hottest temperature recorded in either of these rooms was 29.2°C, which does not greatly exceed the upper bound for thermal comfort.

The master bedroom and living room experienced the hottest temperatures as they are on the north side of the house. Bedrooms 2 and 3 remained below the thermal comfort maximum during the whole period for which data was recorded. The north side of the house has seasonal shade plants which are yet to become established. It is expected that the performance of the master bedroom will improve during hot months as these trees have time to mature and provide shading during the hot summer months in years to come.

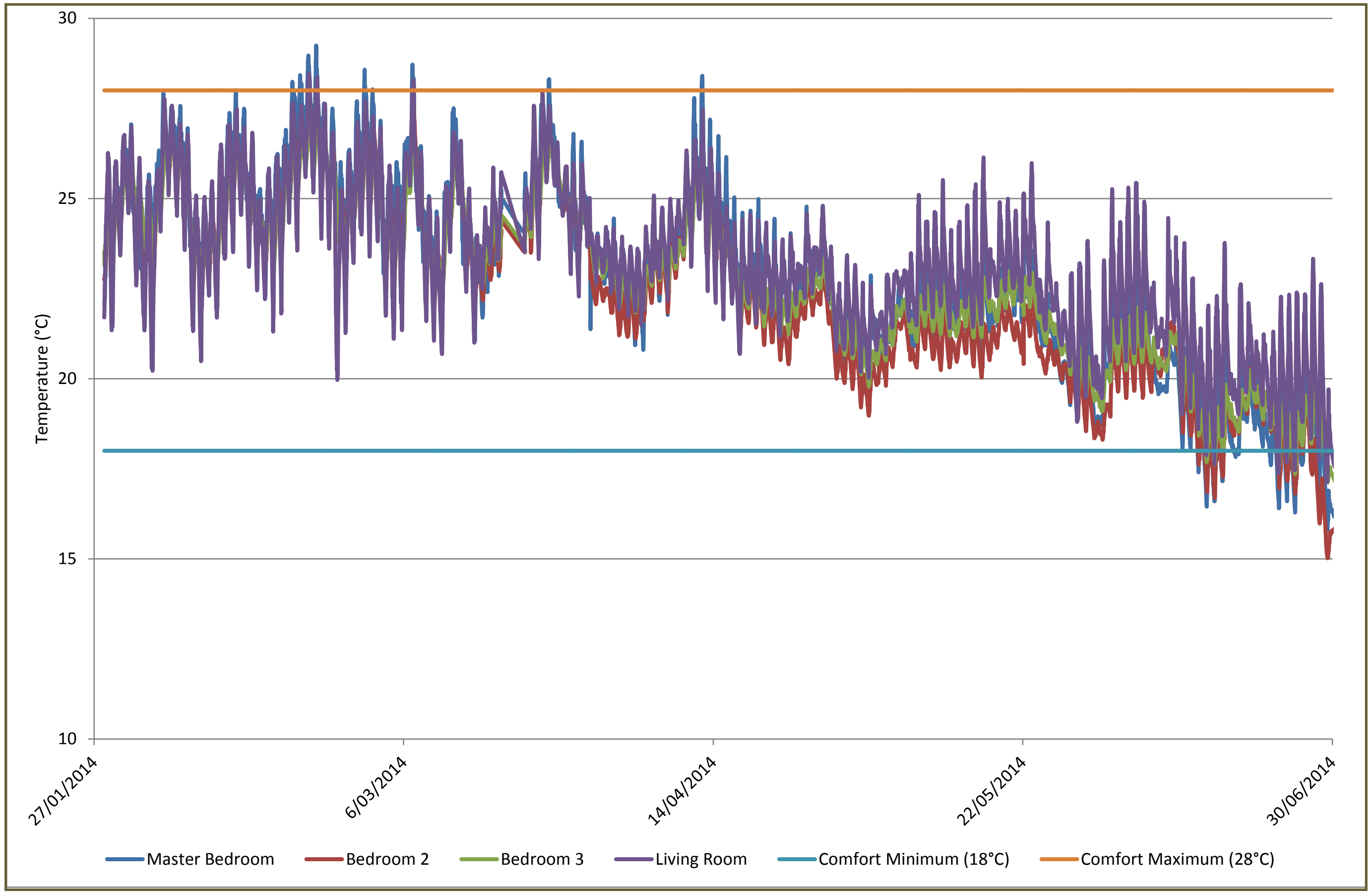


Figure 1: Thermal performance of the three bedrooms and living room since data collection commenced

During two cold periods in Winter, all four rooms dropped below the minimum temperature stipulated for thermal comfort (18°C). This includes an extended period of 7 days at the end of June. It must be noted that only the nighttime minimums dropped below 18°C, and the daily maximum temperatures were still within the thermal comfort range. The lowest minimum temperature reached in the house was 15.02°C in bedroom 2. This room is on the south side of the house. This was during an extended cold period in Perth, where nighttime minimums dropped to 3.1°C and the daytime maximum was only 15°C on one day.

Seasonal Performance

Table 1 shows a breakdown of the average temperature in the three bedrooms and the living room during each season, together with standard deviation, maximum and minimum temperature. The average temperature in each room during all seasons was within the thermal comfort bounds, indicating that the house is performing well. Furthermore, the standard deviations are all reasonably low and consistent across rooms, showing that there are no major departures from the average temperatures. Generally, the maximum and minimum temperatures reached each day in the house were well within the thermal comfort limits. The average temperature in the living room across the entire period was 22.9°C. It must be noted that this data does not cover the entirety of summer or winter, and no data is available for spring yet.

Summer (28/01 - 28/02/2014)						
Room	Average (°C)	Std Dev (°C)	Maximum (°C)	Minimum (°C)	Number of days under 18°C	Number of days over 28°C
Master Bed	25.57	1.34	29.24	21.95	0	5
Bedroom 2	25.05	1.14	27.75	22.03	0	0
Bedroom 3	24.97	1.02	27.26	22.3	0	0
Living Room	24.93	1.65	28.47	19.96	0	0
Autumn (01/03 - 31/05/2014)						
Room	Average (°C)	Std Dev (°C)	Maximum (°C)	Minimum (°C)	Number of days under 18°C	Number of days over 28°C
Master Bed	23.18	1.89	28.72	18.49	0	5
Bedroom 2	22.49	1.9	27.63	18.35	0	0
Bedroom 3	22.85	1.57	27.06	19.39	0	0
Living Room	23.42	1.56	28.27	18.8	0	3
Winter (01/06 - 30/06/2014)						
Room	Average (°C)	Std Dev (°C)	Maximum (°C)	Minimum (°C)	Number of days under 18°C	Number of days over 28°C
Master Bed	19.28	1.54	23.99	15.81	15	0
Bedroom 2	18.99	1.44	21.67	15.02	12	0
Bedroom 3	19.47	1.15	21.98	17.12	8	0
Living Room	20.74	1.65	25.43	17.13	8	0

Table 1: Seasonal thermal performance of three bedrooms and living room

Seasonal Snapshots

Figures 2, 3 and 4 show the temperature profile of the four rooms during a hot week in summer, a typical autumn week and a cold week in winter, respectively, with the outside temperature plotted for reference in each case. The performance of the house becomes evident from these graphs. Even during the weather extremes in summer and winter, the house maintains a steady, comfortable internal temperature. Data for spring is not yet available, but will complete the picture for each season in next year's annual performance report.

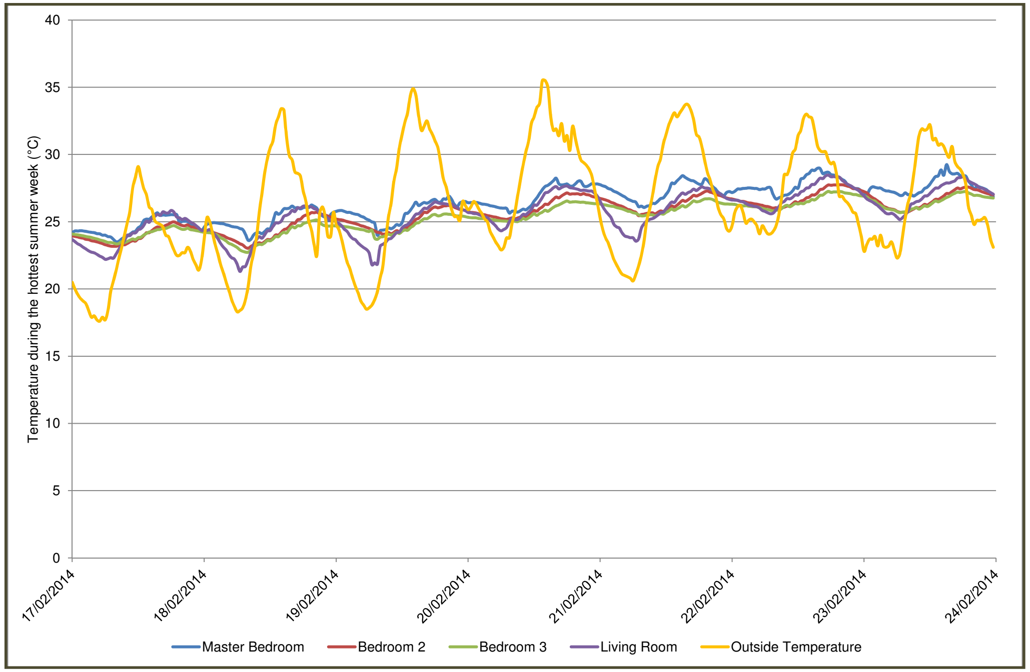


Figure 2: Thermal performance during a hot week in summer

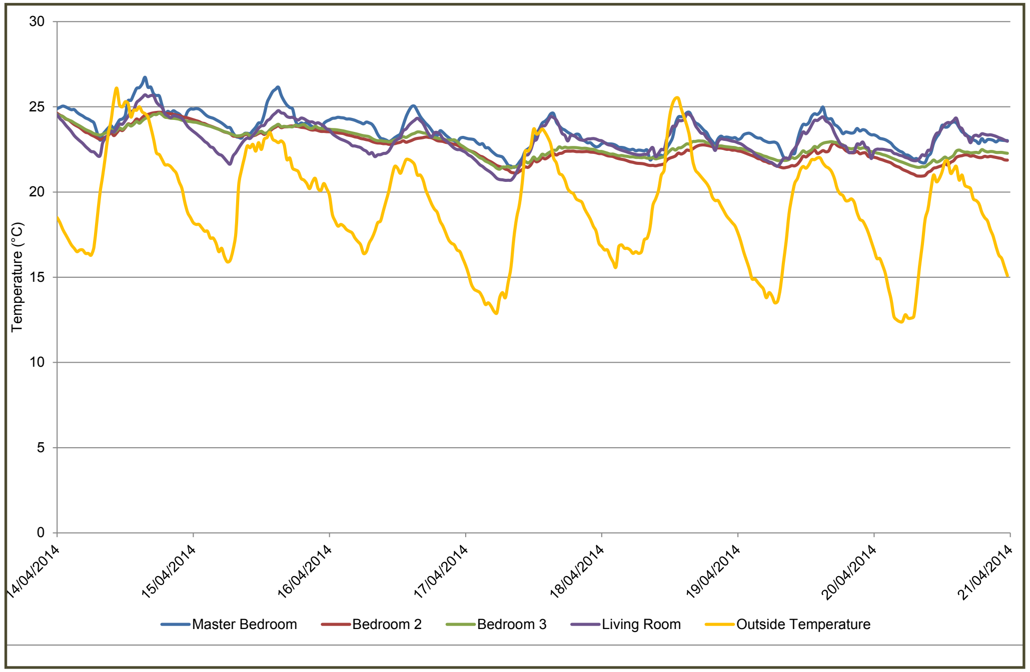


Figure 3: Thermal performance during a typical autumn week

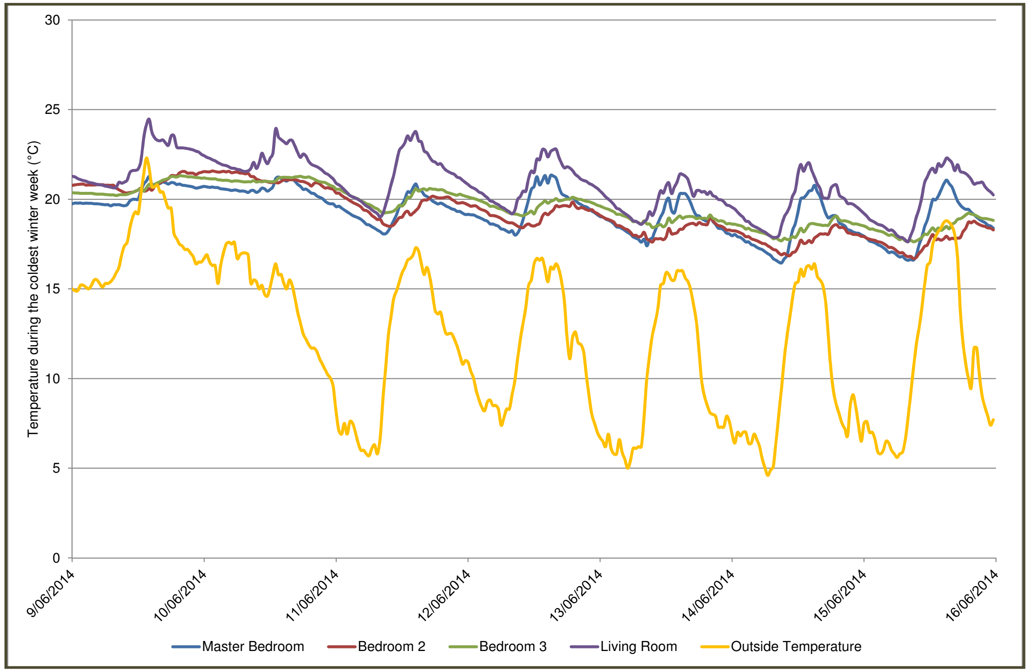


Figure 4: Thermal performance during a cold week in wineter

Living Room Vertical Temperature Profile

Finally, Figure 5 shows the vertical temperature profile for the living room over a two week period in May. Temperatures are taken from (in ascending order of height): slab; wall; ceiling; roof cavity; roof surface; with outside temperature shown for reference.

The temperature of the slab, wall and ceiling do not fluctuate a great deal – less than 5°C over the course of each day. The temperature in the roof cavity varies more, almost reaching the same maximum temperature as the ceiling during the day, but dropping greatly overnight. This is a good sign, as it means that heat is not leaking from the ceiling to the roof cavity. The ceiling is providing good thermal insulation for the house so that minimal heat is lost overnight during cold months. The temperature at the roof surface shows the greatest fluctuation. On one particular day, it rose from a minimum of 15°C to a maximum of 42°C.

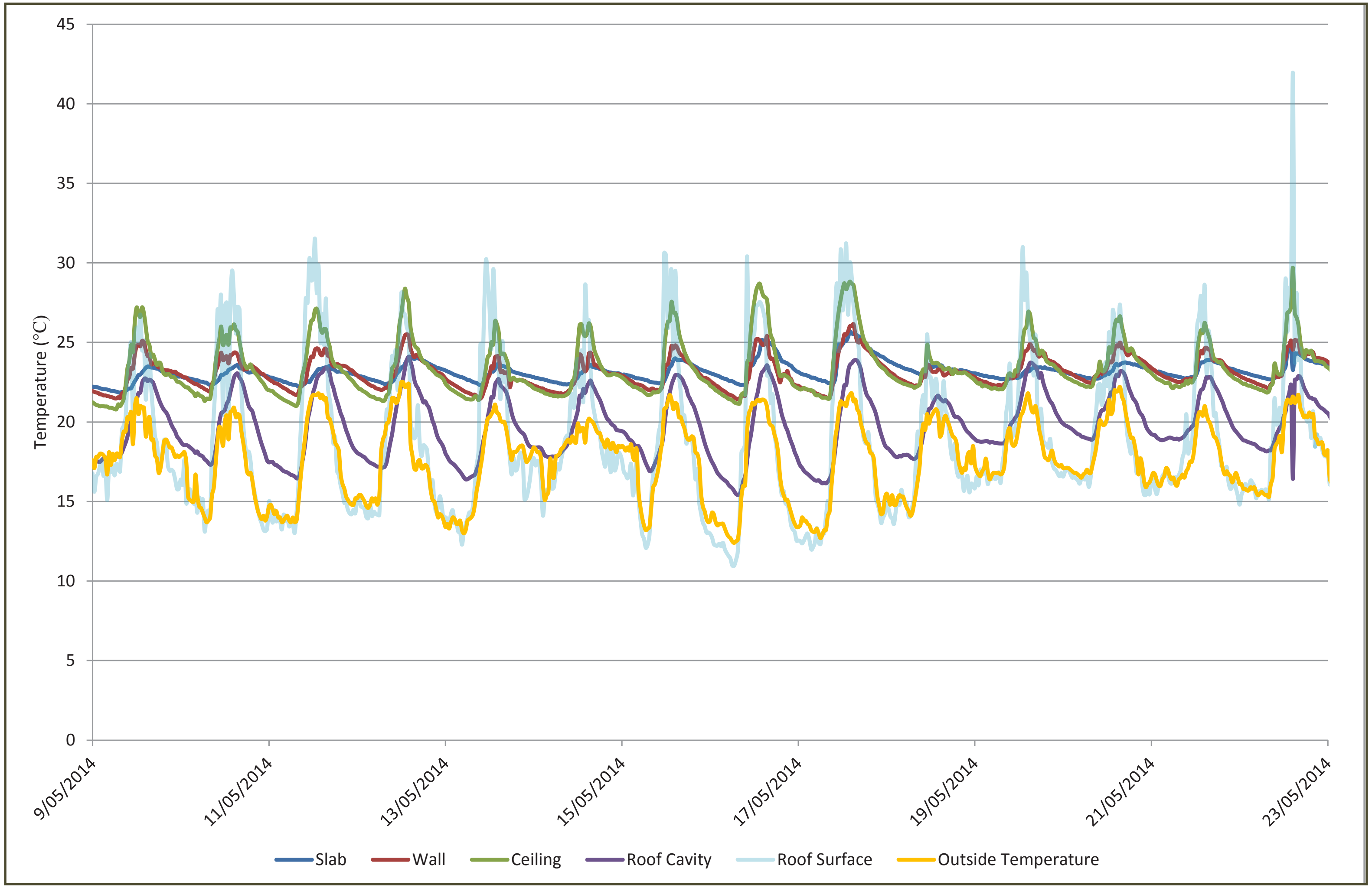


Figure 5: Vertical temperature profile of living room over a two week period in May 2014

ELECTRICITY

Electricity Use

The house uses an average of 11.15kWh per day, compared to the Perth average of 18kWh per day. This is a reduction of 38% compared to the business as usual scenario. However, the PV system is generating 15.4kWh of electricity per day. Because this energy is generated during sunlight hours, some grid electricity is still required. Utility bills show that the house is using 5.48 units (or kWh) of grid electricity per day, which is a 70% reduction over the business as usual case. The other 5.67kWh used at the house each day is produced on-site, with the remaining 9.73kWh exported to the grid each day. As such, the house is a net electricity exporter.

This lower energy use results in a significant cost saving of almost $1,200 per year on electricity bills. This is shown graphically in Figure 6.

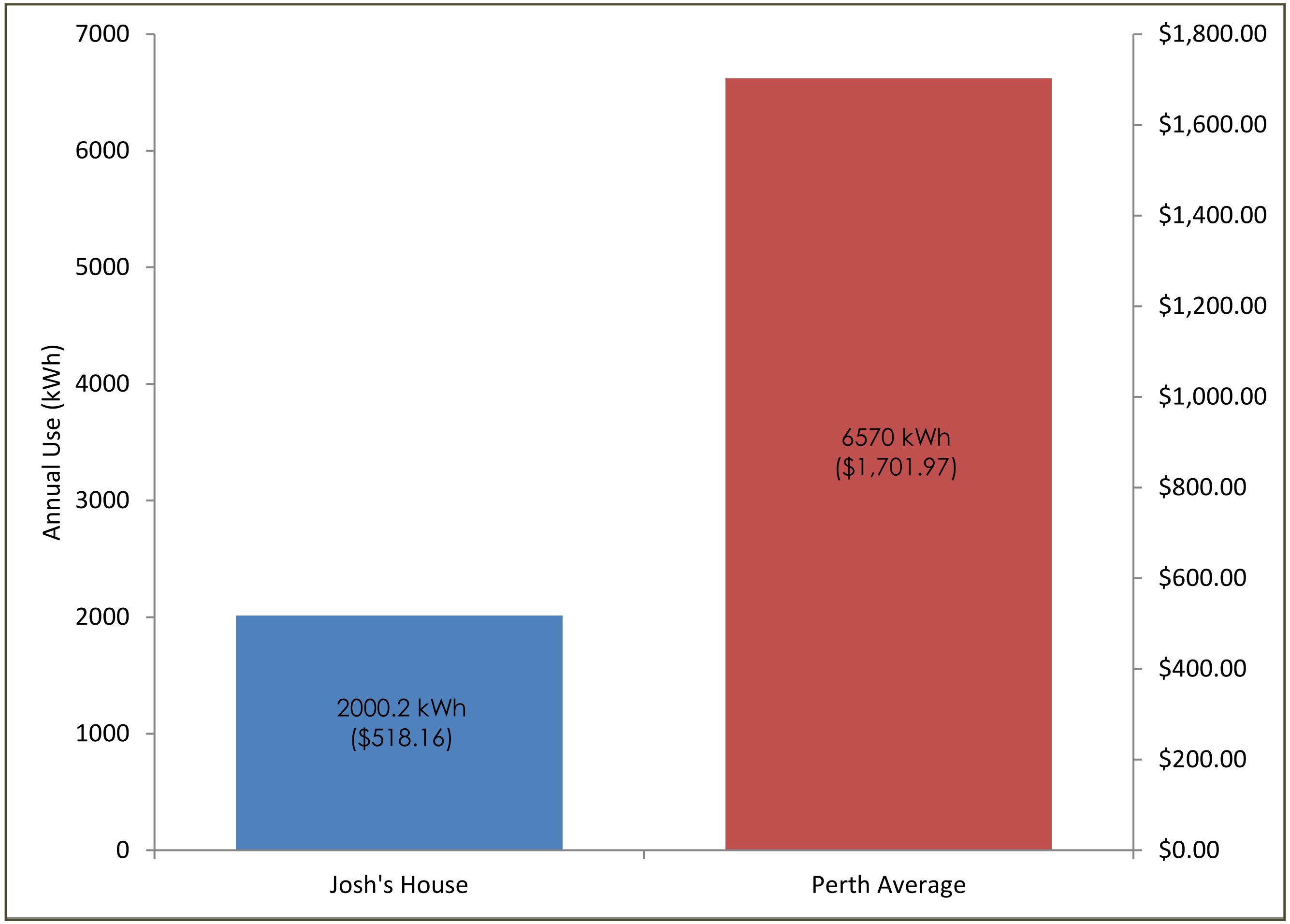


Figure 6: Annual grid electricity consumption cost at Josh's House and at an average Perth residence

PV Generation

This cost saving is even greater when electricity exported to the grid (and therefore credited by the utility provider) is taken into account. The average PV generation at the house is 15.4kWh per day. The PV production over time at the house, along with a moving average, is shown in Figure 7.

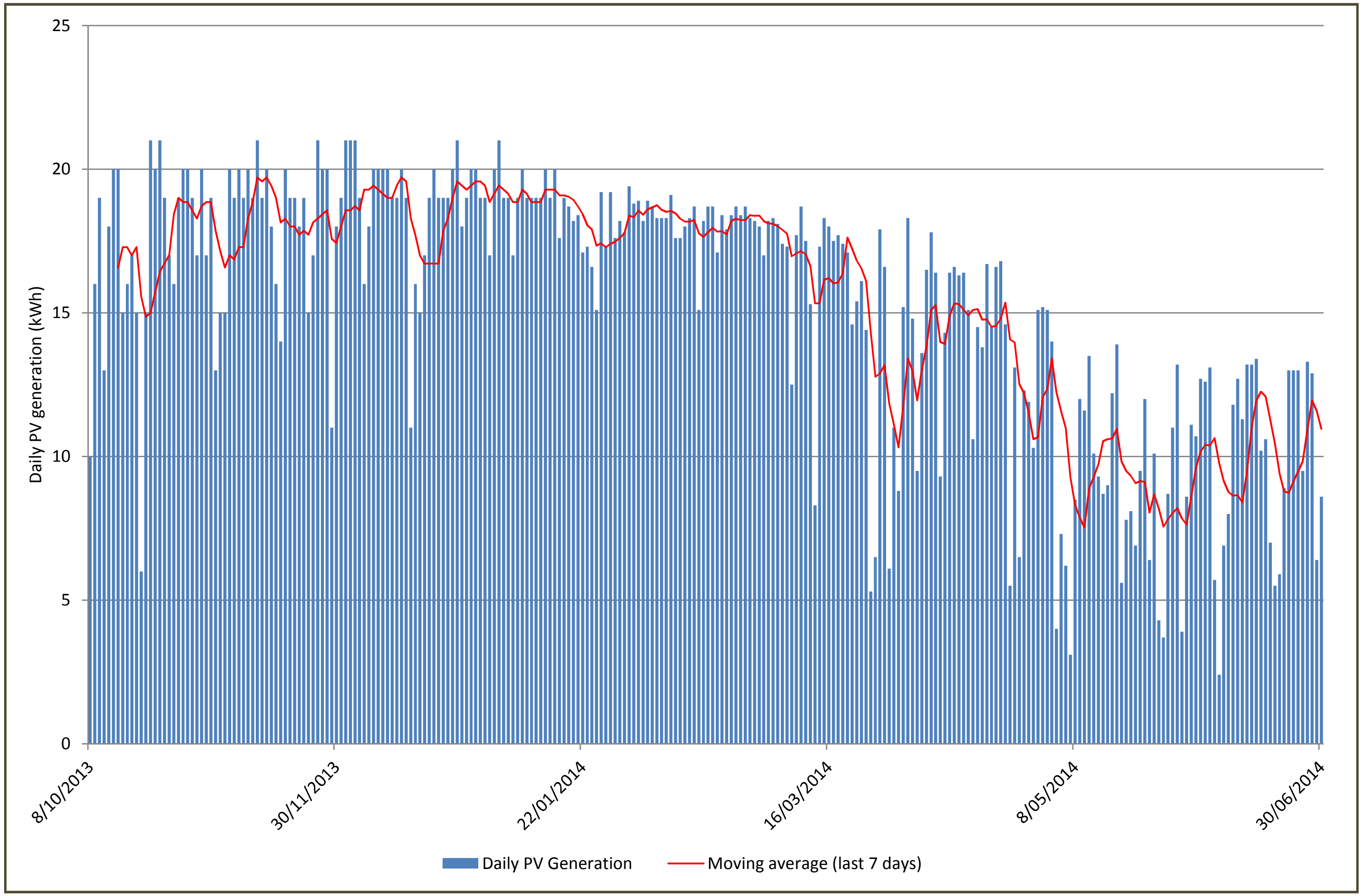


Figure 7: Daily PV production at the house shown with a 7-day moving average

Monthly PV Performance

PV production varies greatly over time, with the highest daily average production occurring in December (18.8kWh) and the lowest daily average production occurring in May (9.2kWh). The summary statistics are shown in Table 2, which shows that not only does the average daily production fluctuate, but the highest and lowest daily production does also. In January and February, the minimum daily production was 15.1kWh. In June, on the other hand, the minimum daily production was 2.4kWh and the highest daily production for the whole month was only 13.4kWh – this is lower than the lowest day in January or February. This is due to the large variation in solar radiation intensity at different times of the year, as shown in Table 2.

The monthly average PV production is displayed graphically in Figure 8. It is clear that production is much higher during the hot, clear summer months and drops off during the autumn/winter months. This is due to a combination of shorter days and increased cloud cover.

Month	Sum (kWh)	Daily Average (kWh)	Std Dev (kWh)	Lowest daily production (kWh)	Highest daily production (kWh)	Average solar radiation (MJ/m2/day) (data from BoM)
Oct-13	409	17	3.6	6	21	22.5
Nov-13	541	18	2.5	11	21	27
Dec-13	584	18.8	2.1	11	21	28.5
Jan-14	573.3	18.5	1.2	15.1	21	28.5
Feb-14	511.9	18.3	0.8	15.1	19.4	25
Mar-14	470.3	15.2	4.1	5.3	18.7	21
Apr-14	419.3	14	3.2	5.5	18.3	15
May-14	284.9	9.2	3.5	3.1	15.2	11
Jun-14	305.2	10.2	3	2.4	13.4	9

Table 2: Summary statistics of PV production

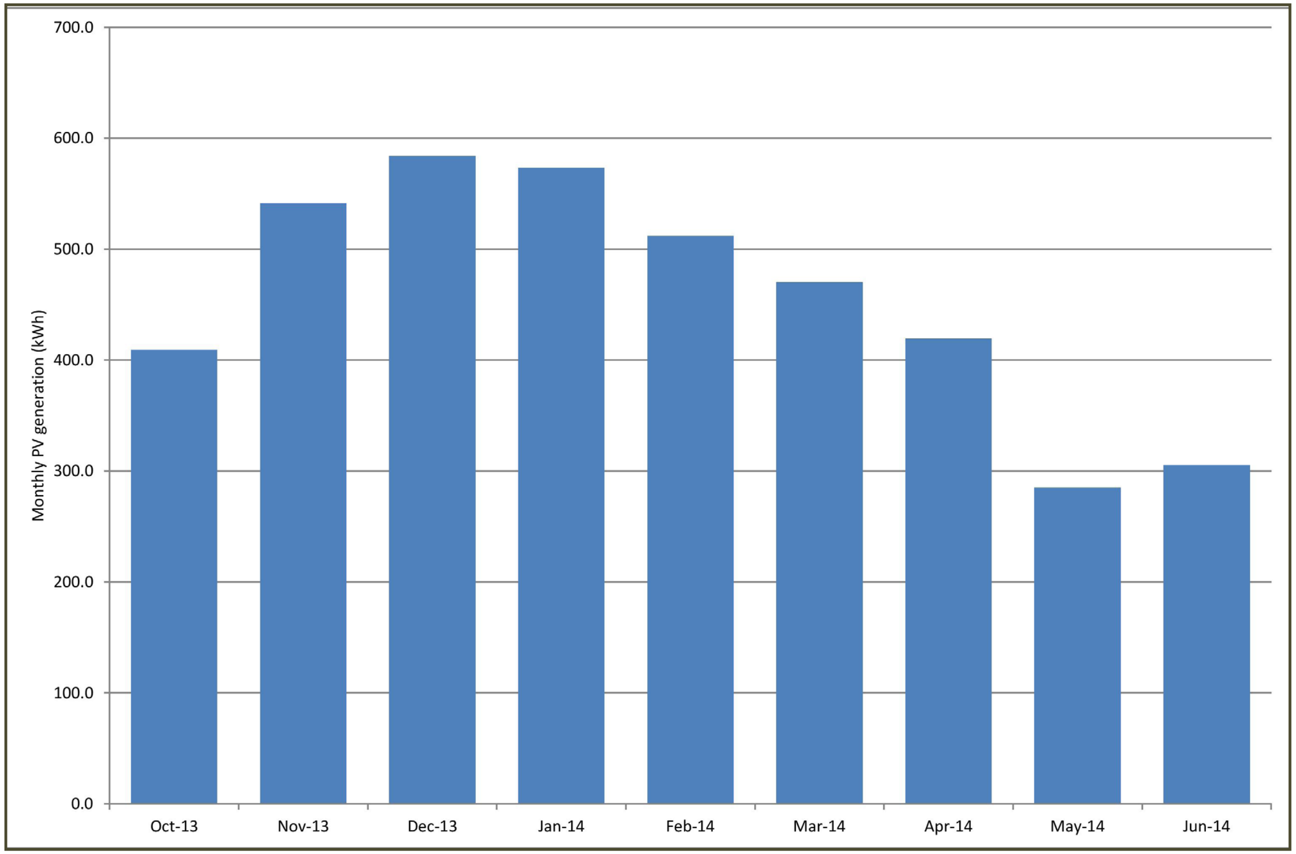


Figure 7: Daily PV production at the house shown with a 7-day moving average

Cost Saving

On average the house consumes 11.15kWh per day. 5.48kWh of this is provided from grid electricity, with the rest (5.67kWh per day) being generated on-site. With an average daily PV generation of 15.4kWh per day, this means that 9.73kWh are exported to the grid each day, on average. The rebate for exported electricity to the Perth grid (Synergy) is $0.088529/kWh. This results in a daily rebate of $0.86, or an annual rebate of $314.41, which reduces the annual cost of electricity further, to $203.75, which is 88% lower than the average Perth household pays each year. This is shown in Figure 9.

The feed-in tariff for electricity exported to the grid is 8.8529c/kWh, whilst electricity imported from the grid is charged at 25.9052c/kWh. It is due to this unequal pricing that the house still pays for some electricity consumption, even though it is a net exporter of electricity.

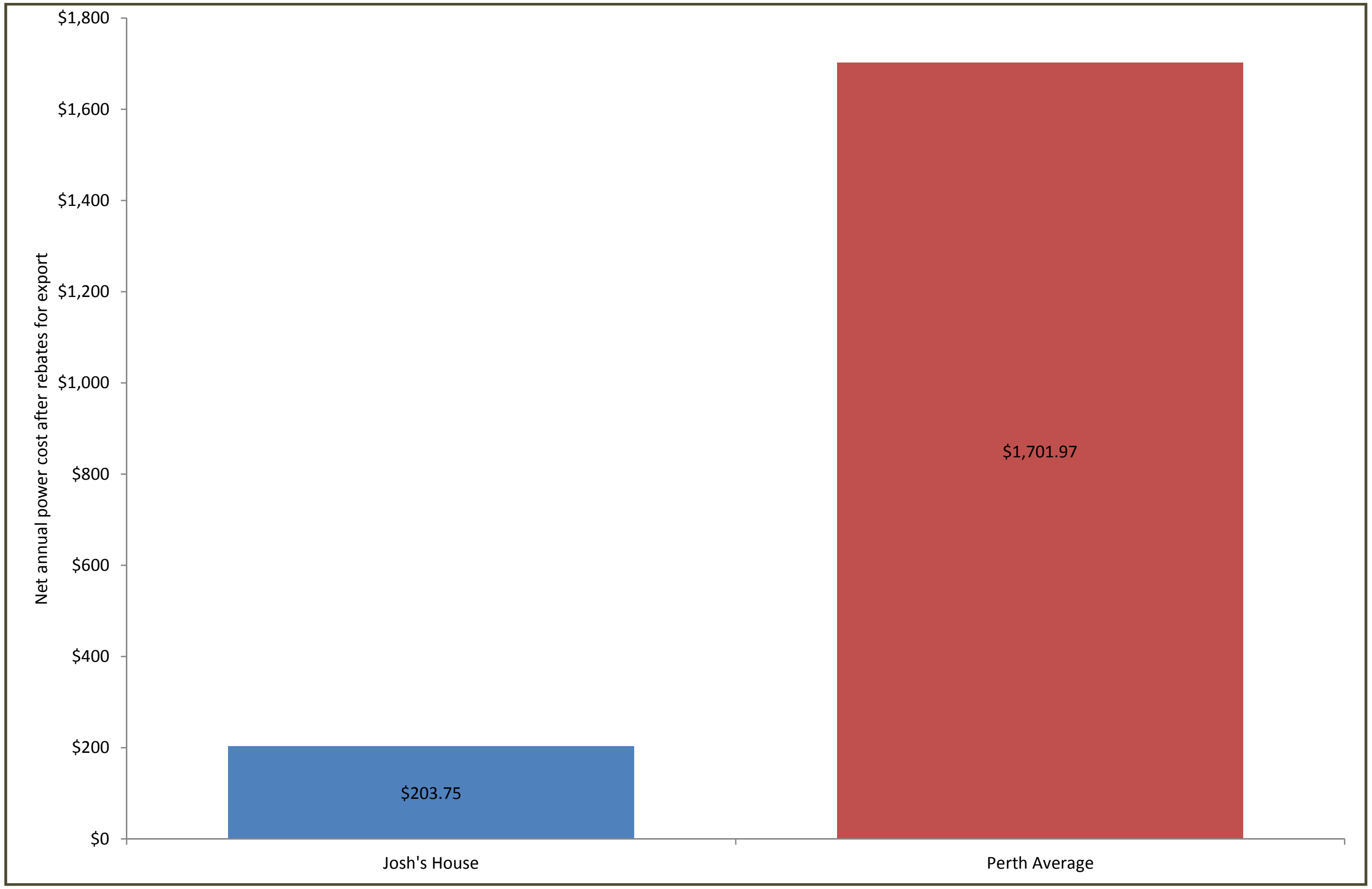


Figure 9: Annual cost of electricity (usage charges only), after rebates from exporting to grid

Energy Use Breakdown

The breakdown of energy uses in the house compared to energy uses in a standard Perth residence[1] is presented in Table 3, and shown graphically in Figure 10. The proportionate breakdowns are very different, due to the presence of the various pumped water systems at Josh's House (rainwater, greywater and bore water), and the absence of mechanical heating and cooling.

Recently, the monitoring system was modified to allow the appliances to be divided into four separate circuits, which will allow for more detailed analysis of future data. This is important, because the appliances account for 50% of the energy consumption in the house. It will be beneficial to break this down further to obtain a more detailed energy use.

	Josh's House (kWh/day)	Perth Average (kWh/day)
Appliances	5.62	9.18
Lights	1.62	1.98
Cooking	0.85	0.54
Bore Pump	2.04	N/A
Rainwater System	0.67	N/A
Greywater System	0.35	N/A
Heating & Cooling	N/A	3.24
Water Heating	N/A	3.06

Table 3: Electricity end uses at Josh's House compared to Perth average

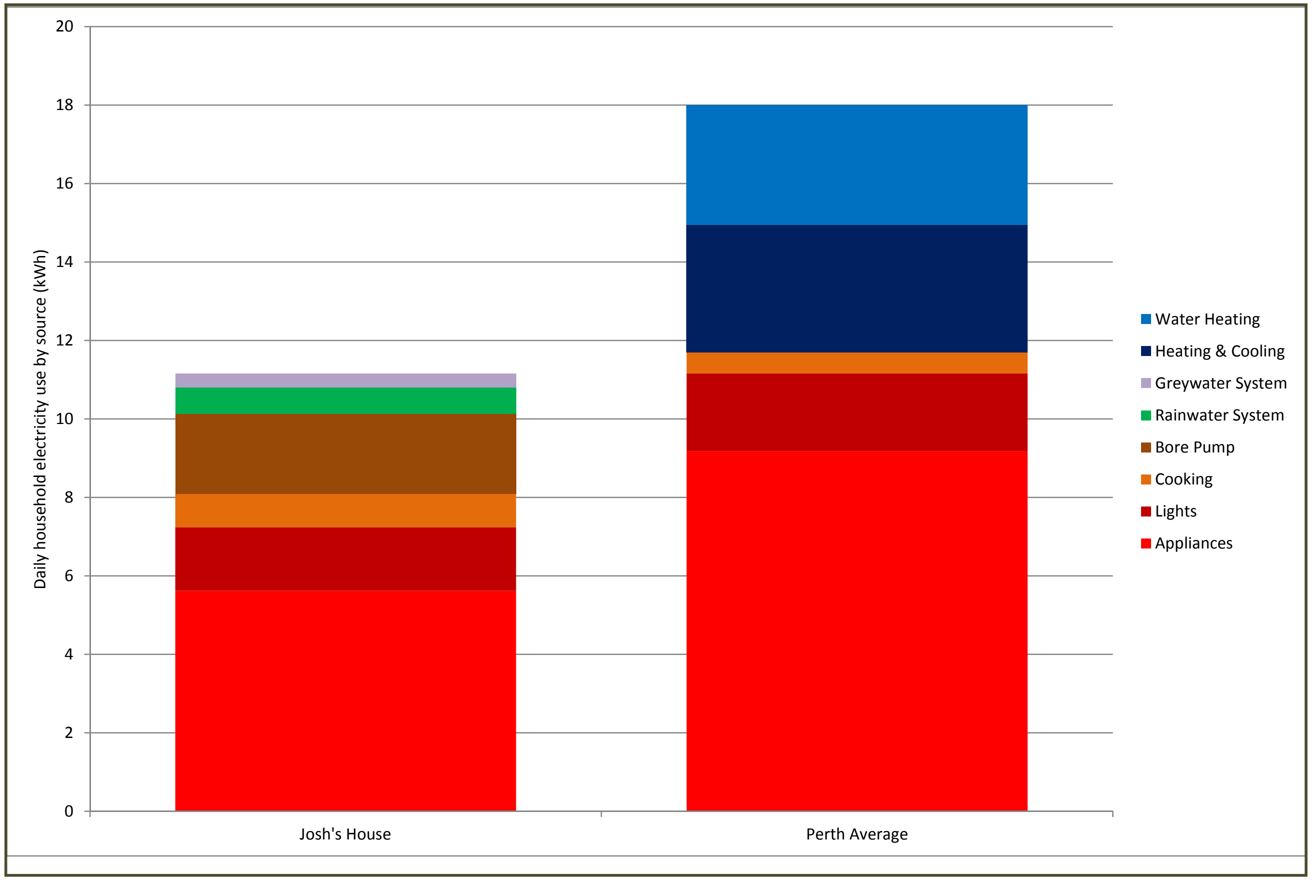
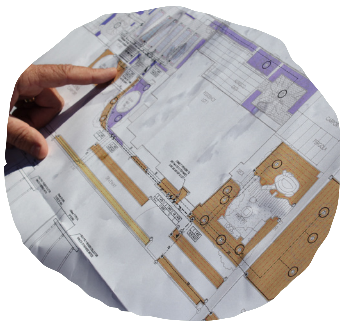


Figure 10: Proportionate energy use at Josh's House compared to the Perth Average

[1] Source: Synergy: https://www.synergy.net.au/atôhome/deliveryôinôyourôhome.xhtml.



GAS

Gas Use

Gas use at the house is also significantly lower than the Perth average. Josh's House uses an average of 1.46 units per day, compared to 12.95 for an average Perth household (note that 1 gas unit is equivalent to 1kWh). This is a reduction of 89%. This reduction in consumption results in an annual cost saving of $566.08, shown in Figure 11.

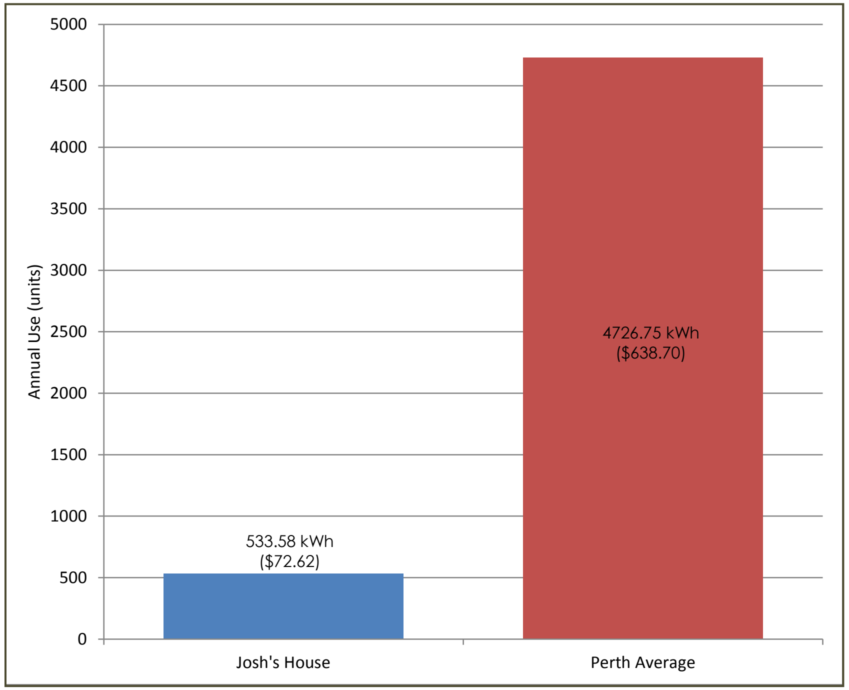


Figure 11: Annual gas consumption cost at Josh's House compared to Perth average

Breakdown of Gas Use

Gas is used for two purposes at the house – cooking and heating water. Cooking occurs year-round, and the quantity used does not vary significantly over the course of the year. However, due to the presence of a solar hot water system, gas is only used to boost this system during cooler months. It was necessary to switch on the gas booster on May 8 2014. It is anticipated that this will be switched off in October. Once switched on, the quantity of gas required for water heating is much greater than the quantity required for cooking. This is shown in Figure 12.

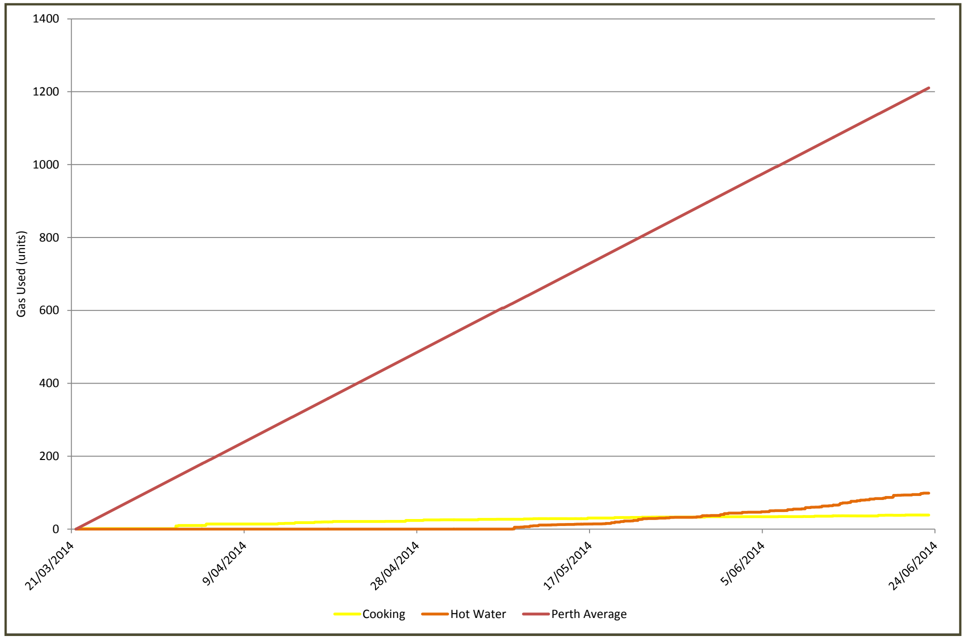


Figure 12: Gas use at Josh's House compared to Perth average

Seasonal Gas Use

The quantity and purpose of gas used at the house will vary greatly over the course of a year. A breakdown for each season, based on a combination of collected data and modelled projections is presented in Figure 13. It can be seen that the quantity of gas used for cooking remains steady throughout the year. It is the quantity used for water heating which varies greatly, from none being required during the summer months, to a moderate requirement in spring and autumn, up to a significant requirement during the cold winter months. In all seasons, gas use is significantly lower than the Perth average. Future data collection will enable a more clear analysis to be completed in this area.

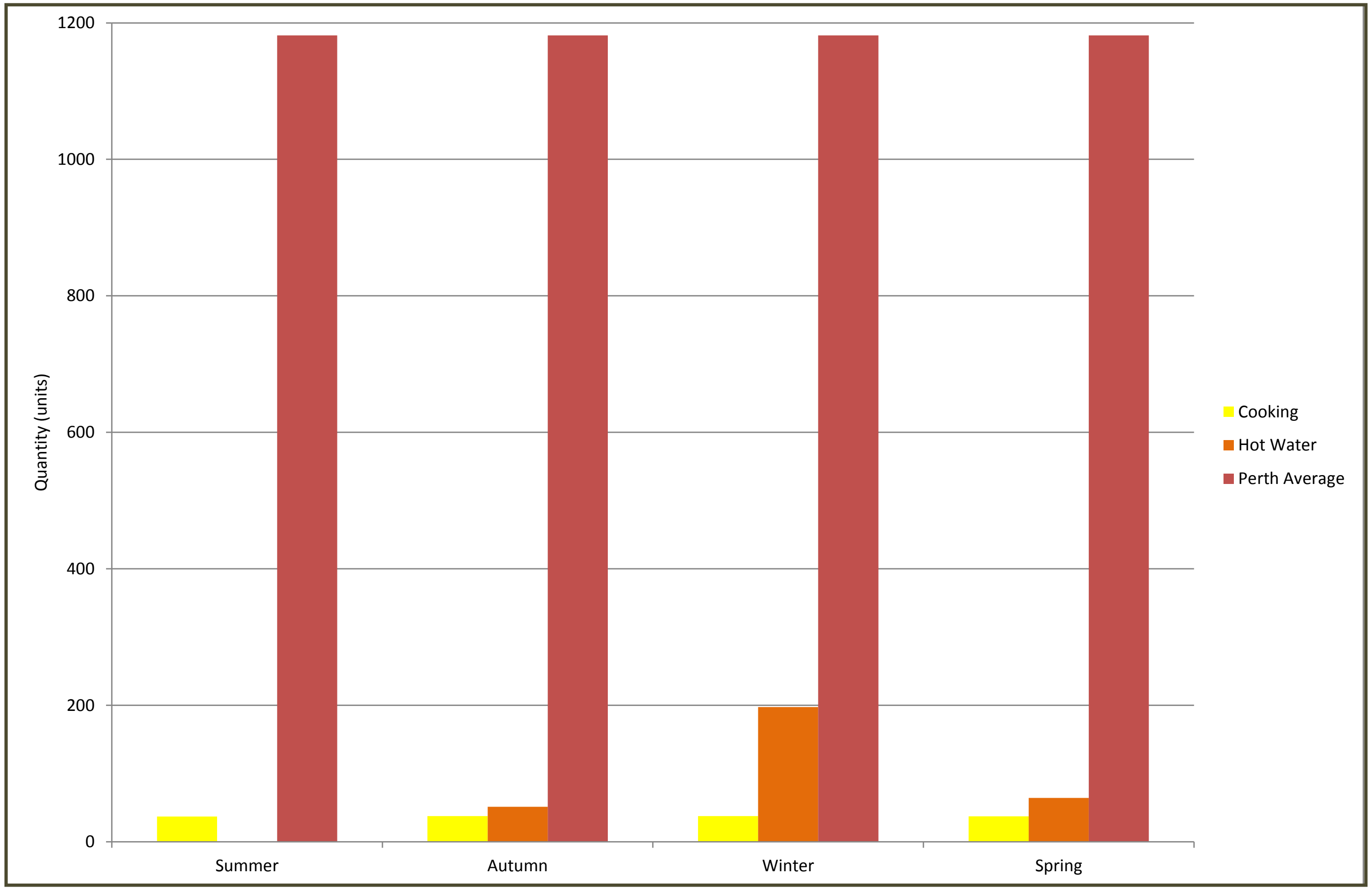
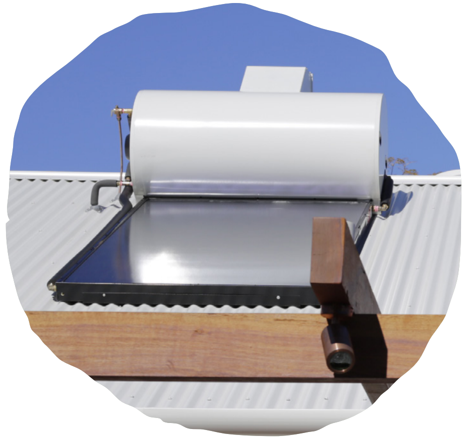


Figure 13: Seasonal gas breakdown at Josh's House compared to Perth average



WATER

Water Performance

The alternate water systems that have been installed at Josh's House significantly reduce the demand for scheme water. The alternative water sources include a 20kL rainwater tank collecting from 205m2 of roof surface, and a bore pump. The house also reuses greywater for irrigation. This results in Josh's House consuming 92% less scheme water than the Perth average household.

There are a number of ways in which the Perth average water consumption per household could be calculated. We believe that the most accurate estimate is obtained by starting with the average consumption per person, fixing the quantity used for irrigation (as this quantity remains constant regardless of the number of occupants at a property), then scaling up according to the number of residents. The Perth Residential Water Use Study (2008/9) ("PRWUS") was used as a source for information.

The PRWUS states an annual water use per person of 106kL, and an annual household water use of 277kL. This implies an average of 2.61 residents per household. The proportion of water used for irrigation and hand watering (i.e. outdoor use) is 42%. Based on these figures, the internal water use per person is calculated to be 61.48kL per annum. The total internal water use for a 4-person residence would therefore be 245.92kL per annum, or 674L per day. Internal water use at Josh's House is approximately 200L per day. This comparison is shown in Figure 14.

The reduced water consumption results in a cost saving of $560.15, or 94%, from the Perth average consumption. This is shown in Figure 15.

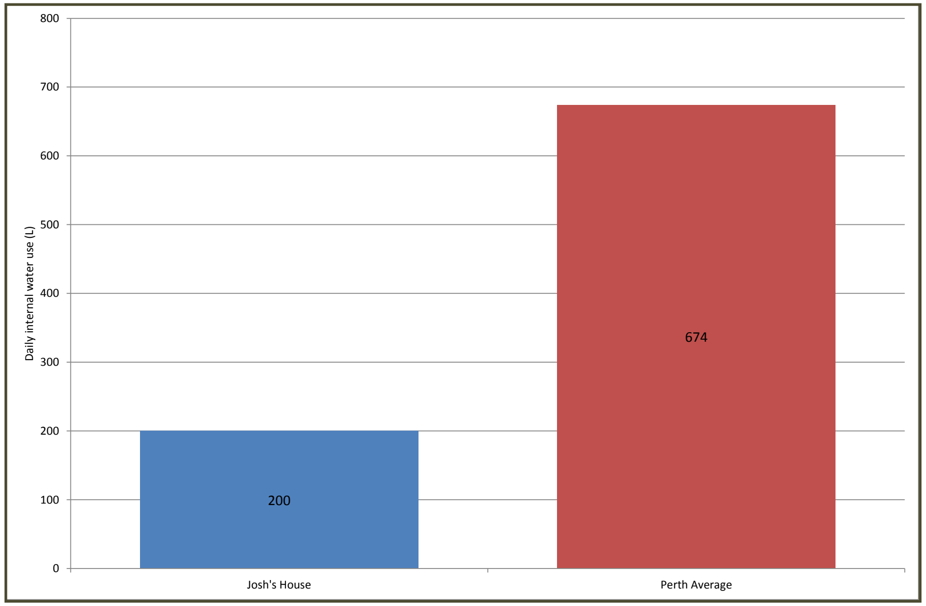


Figure 14: Daily internal water use at Josh's House compared to Perth average

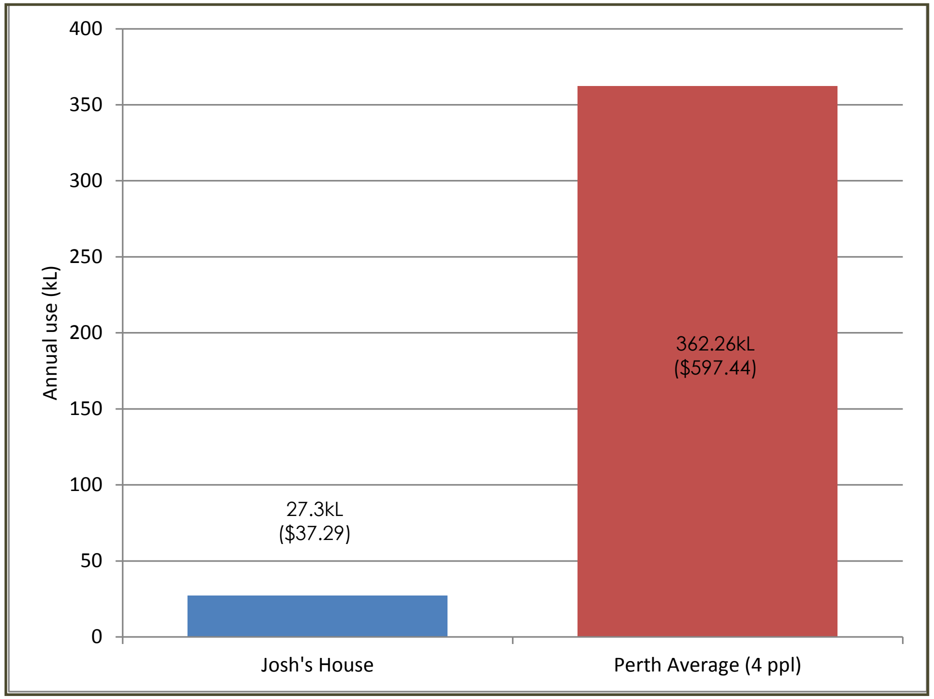


Figure 15: Annual water use charges at Josh's House compared to Perth average

Proportionate Breakdown of Water Use

The proportionate breakdown of water use by source at Josh's House is shown in Figure 16. This shows that bore water dominates consumption for irrigation purposes. Scheme water only accounts for 12% of all water use at the house.

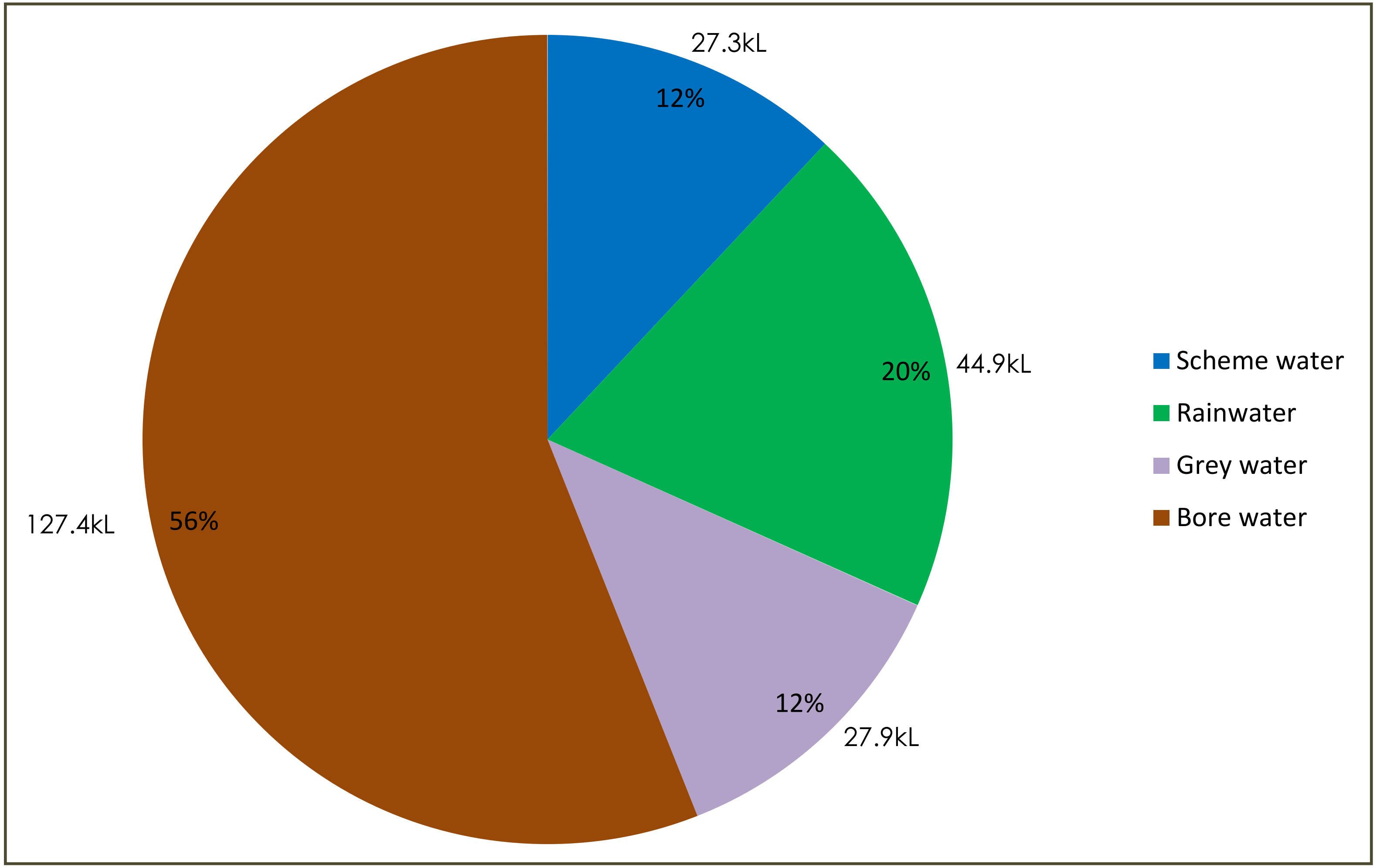


Figure 16: Proportionate breakdown of water use by source at Josh's House

Site Water Balance

A site water balance was carried out at Josh's House to determine the interaction between the bore and the superficial aquifer. The landscape surrounding surfaces at the house were designed to be 100% permeable. This is to minimise the effect on local groundwater of using bore water for irrigation, by ensuring that as much rainfall as possible is infiltrated to the superficial aquifer. The driveway consists of pebbles overlaying drainage cells, with the rest of the landscape being comprised of a combination of turf, mulch, plants, deck and gravel. Additionally, the rainwater tank overflows to an underground soak, increasing the quantity of water recharged to the aquifer.

Accounting for evaporation and plant uptake, a small net uptake (18.6kL) was calculated for the first year, when more water is required for establishment of the gardens. After establishment (year 3+), a net annual recharge of 47kL to the superficial aquifer is expected. This is shown in Figure 17. These figures were calculated by applying a recharge factor of 0.5 to rainfall data at the site, which is the estimated recharge factor applicable to residential sites in Perth.[2]

This is an important finding because it means that not only is scheme water being saved by using bore water for garden irrigation (as discussed earlier), but that the bore water being drawn up from the superficial aquifer is being more than replenished by having 100% permeable surfaces at the property, resulting in a net recharge to the aquifer each year.

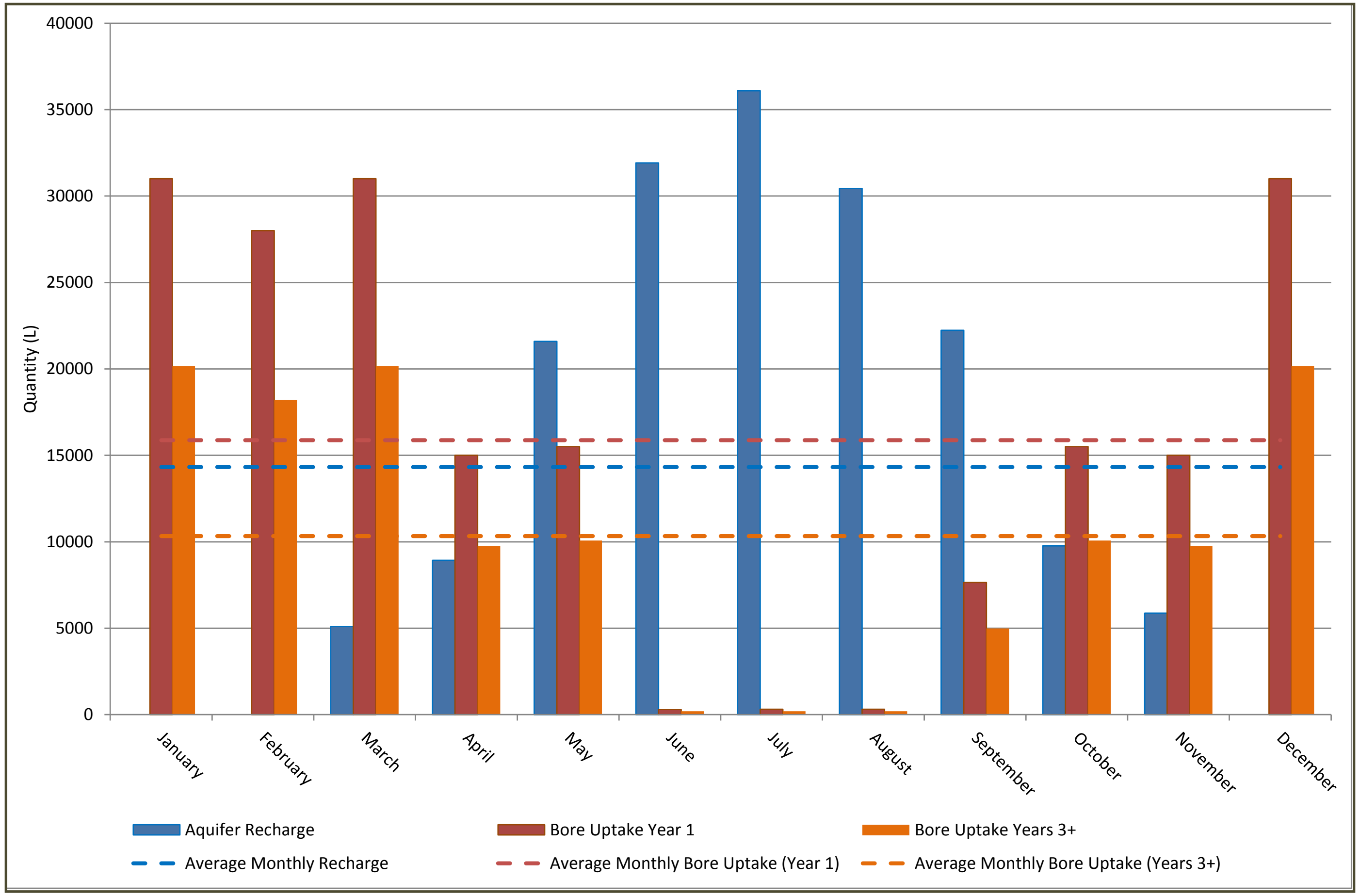


Figure 17: Monthly bore uptake versus recharge

2 Department of Water, 2009. Perth Regional Aquifer Modelling System (PRAMS) model development: Application of the Vertical Flux Model. Government of Western Australia, Department of Water, Hydrogeological record series. Report No. HG27, February 2009

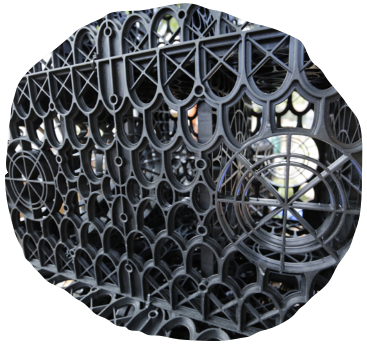
Water-Energy Nexus

Finally, the water-related energy use was calculated for each of the pumped water sources at the house. Figure 18 shows how each water system compares to the reported annual energy use per unit volume by the Water Corporation for the last 4 years, taken from annual reports.

The water-energy nexus is even more important because the average energy consumed per kL of potable water delivered by the Water Corporation has slowly risen from 1.2kWh/kL in 2010 to 1.7kWh/kL in 2013. This upwards trend is likely to continue as Perth relies more and more on energy-intensive desalination plants to supply the growing population. As a comparison, the Kwinana desalination plant uses 4.1kWh/kL.

From Figure 18 it can be seen that the grey water system at Josh's House is using less energy per kL than the centralised utility. Furthermore, it is not using any energy as standby power. This is a significant finding, because it is important not to focus exclusively on the water-saving benefits of these systems, but to also consider the energy implications. In the case of the grey water system, it is a positive result from both a water and an energy perspective.

The rainwater and bore systems also have an operational energy demand which is comparable to larger scale centralised supply, however these two units have a large standby power draw. In the case of the bore supply, the energy demand is comparable to the Water Corporation figures, in spite of the large standby energy draw. The standby power of the rainwater system however is particularly high as a result of the power used to run the UV disinfection lamp which remains on constantly to ensure sterilisation of the water. The low water consumption recorded at the house in comparison to the Perth average amplifies the issue because the standby draw for both these devices is constant – that is, if daily water usage was greater, then the kilowatt hours recorded per kilolitre consumed would be reduced.



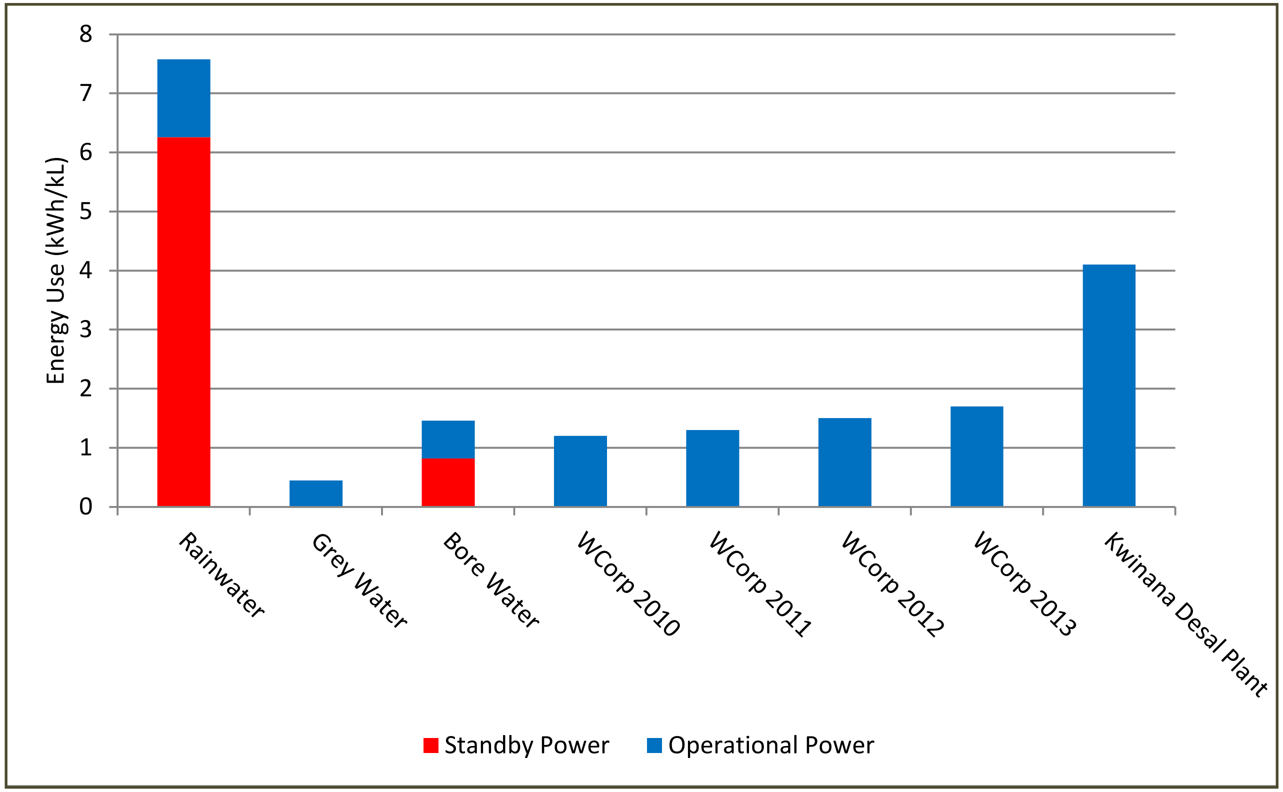


Figure 18: Water-related energy use of pumped systems at Josh's House compared to Water Corporation's reported values

GREEN HOUSE GAS EMMISIONS

Operational Emissions Generated

Due to the grid electricity and gas use being significantly lower at the house than the Perth average, the CO_2e emissions are also significantly lower. The emissions from Josh's House are 72% lower than the business as usual case, and these emissions are more than offset by the generation of PV electricity on-site which is exported to the grid. This is shown in Figure 19.

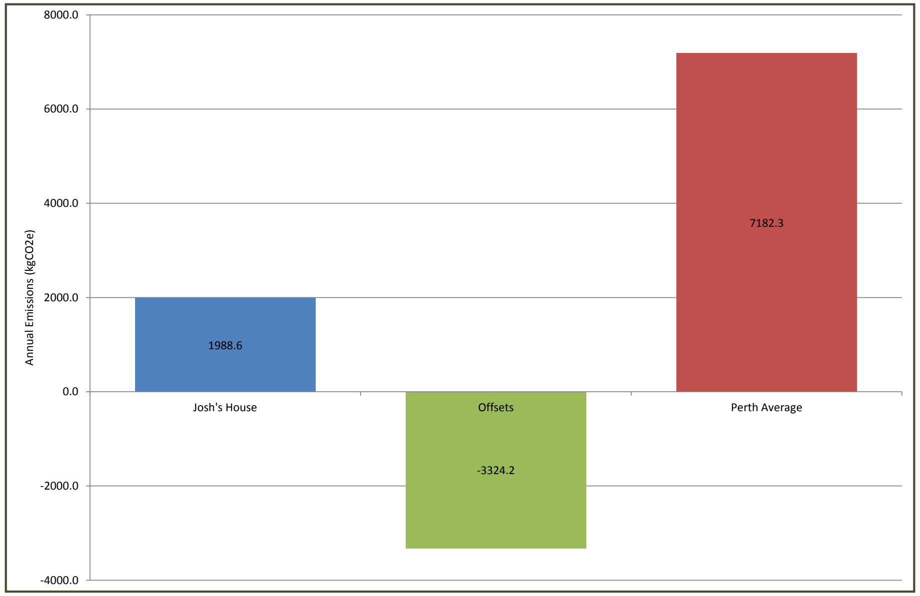


Figure 19: Breakdown of emissions from each source at Josh's House

Operational Emissions Breakdown

The breakdown of greenhouse gas emissions at Josh's House is presented in Figure 20. It shows that electricity-using systems are much more significant to the total emissions than gas-consuming sources. This is due to the increased GHG emissions associated with producing electricity (from coal-fired plants) compared to combusting natural gas .

It also shows that more than half of the emissions from the house are attributable to various appliances within the house. This increases the importance of the recent division of these appliances into four separate circuits. The appliances on each circuit will be recorded, so that a more detailed analysis can be presented based on future data.

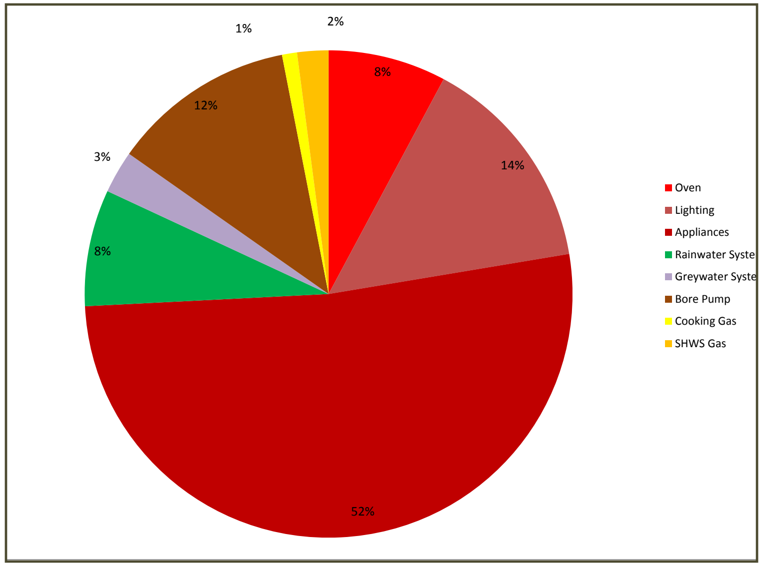


Figure 20: Annual greenhouse gas emissions at Josh's House compared to Perth average

ASSUMPTIONS AND QUALIFICATIONS

Graphs

2013-14 JH Energy use by source v Perth average

- JH Energy use by source is based on data available for each electricity use within the house, expressed as a percentage of total use.
- Perth average electricity usage percentages are from Synergy website: http://www.synergy.net.au/at_home/delivery_in_your_home.xhtm

2013-14 JH Energy cost v Perth average (after rebates)

- Perth cost is based on 18kWh daily usage at a cost of $0.259052/kWh.
- JH cost is based on 5.48 units of grid energy used per day (from Synergy bills) at $0.259052/kWh. An annual rebate of $314.41 from exporting 9.73 units per day at a feed-in tariff of 8.8529c/kWh is then subtracted to get the total.
- Service charges are not included in this calculation.

2013-14 JH Energy use v Perth average (no PV)

- JH energy use is based on collected data showing 11.15kWh average daily electricity consumption, compared to Perth average of 18kWh per day.
- Service charges are not included in this calculation.

2013-14 JH Energy use v Perth average (with PV)

- JH energy use is now based on 5.48kWh of consumption per day, calculated from Synergy bills. This takes into account that some of the electricity consumed at the house is generated on-site.
- Service charges are not included in this calculation.

2013-14 JH Gas use v Perth average

- Based on gas data from the house, JH uses 1.46 units of gas per day at $0.1361/unit (Alinta Energy).
- Perth average is 12.95 units per day. First 12 units each day cost $0.1361/unit; over 12 units costs $0.1228/unit (Alinta Energy).
- Service charges are not included in this calculation.

2013-14 JH water use by source v Perth average

- JH water use was calculated using actual data.
- Perth average was calculated as above, and divided into internal use (58%) and external use (42%) according to the Perth Residential Water Use Study (Water Corporation, 2010).

2013-14 JH Water use and cost v Perth average

- JH uses approximately 198L of water internally, daily. Rainwater is used for 227 days per year, meaning scheme is used for 138 days per year. So JH uses 27.3kL at $1.381/kL.
- Perth average was calculated using data from Perth Residential Water Use Study Perth Residential Water Use Study (Water Corporation, 2010). External water use was isolated, then internal water use per person was scaled up to 4 people (because JH has 4 residents). This resulted in an estimated Perth average use of 992.5L per day for a 4 person household, or 362.3kL per year. The first 150kL is charged at $1.381/kL; 150-500kL is charged at $1.841/kL.
- Service charges are not included in this calculation.

2013-14 JH Water site balance

- Bore uptake was calculated from manual bore data sheet.
- The amount recharged to the aquifer was calculated by calculating the size of the site (m2) and the annual rainfall (mm) from the Bureau of meteorology website. By subtracting the area of the roof, the size of the site exposed to rainfall is determined, which is 100% permeable. A recharge factor of 0.50 is applied, which is the estimated recharge factor applicable to residential sites in Perth[1]. Finally, this was topped up with the annual overflow from the rainwater tank, estimated by JBA modelling.

[1]Department of Water, 2009. Perth Regional Aquifer Modelling System (PRAMS) model development: Application of the Vertical Flux Model. Government of Western Australia, Department of Water, Hydrogeological record series. Report No. HG27, February 2009.

2013-14 JH Emissions & Offsets

JH emissions calculated by using:

- Net daily grid electricity usage (5.48 units) calculated from Synergy bills received to date, scaled up to annual usage.
- Average daily gas usage calculated from meters in the house (SHWS & cooking) and scaled up to annual data, taking into account the period for which SHWS booster will be turned off. Booster was switched on 8 May 2014. Estimated date to switch off is 1 October 2014. This date was estimated by looking at BoM annual temperature averages and seeing when the outside temperature rises to above the temperature at which the booster needed to be switched on (8 May 2014).
- The data was recorded in L of gas, which was converted to units.

JH offsets calculated based on 9.73kWh exported to the grid per day (on average).

Calculations of emissions for each energy source were based on conversion factors in: Department of Transport (2011). Green House Gas Emissions from Households in Western Australia. Prepared by SMEC for the Department of Transport.

2013-14 JH Emissions by source

- Data available so far for each electricity and gas use were scaled up to an annual figure. The annual figures were then converted to emissions using the method above.
- Oven, lighting and appliances are presumed to remain constant over the whole year.
- Rainwater system in use from 4 May (actual date switched on, 2014) to 18 December (actual date switched off, 2013) – 227 days per year. It uses 1.35kWh per day when switched on (actual data).
- Grey water turned off on May 11 (actual date), and presumed to be turned back on approximately September 1 (estimate – after sprinkler ban ends).
- Bore power is based on actual power usage data per kL, scaled up to an annual value using JB's manual bore data sheet.

Assumptions:

Thermal comfort zone is 18-28°C

Seasonal gas use

- Cooking gas was presumed to be constant throughout the year, as it should not fluctuate significantly.
- SHWS gas booster needed to be switched on from 8/5/14 because of the low temperature. Looking at annual temperature data for Perth, this same temperature will be reached again around October. As such, it was presumed that the SHWS booster will be turned off on 1/10/14, resulting in 146 days of use per year. The quantity used per day whilst switched on is presumed to remain constant throughout this period, and is based upon data already collected.

Site water balance

- Water drawn from aquifer was based on the "manual bore data" spread sheet, for years 3+. The amount recharged to the aquifer was calculated by calculating the size of the site (m2) and the annual rainfall (mm) from the Bureau of meteorology website. By subtracting the area of the roof, the size of the site exposed to rainfall is determined, which is 100% permeable. A recharge factor of 0.50 is applied, which is the estimated recharge factor applicable to residential sites in Perth[1]. Finally, this was topped up with the annual overflow from the rainwater tank, estimated by JBA modelling.

  [1]Department of Water, 2009. Perth Regional Aquifer Modelling System (PRAMS) model development: Application of the Vertical Flux Model. Government of Western Australia, Department of Water, Hydrogeological record series. Report No. HG27, February 2009.

Emissions

Calculations of emissions for each energy source were based on data in Department of Transport (2011). Green House Gas Emissions from Households in Western Australia. Prepared by SMEC for the Department of Transport.

JOSH'S HOUSE PARTNERSHIPS

Curtin University

JOSH BYRNE & Associates

LOW CARBON LIVING CRC

SOLAR DWELLINGS
SMARTER SUSTAINABLE HOMES

HIGHBURY HOMES
Perth's most flexible builder

WATER CORPORATION

City of Fremantle

PHASE3
Phase3 Landscape Construction Pty Ltd.

VAMMEDIA

JOSH'S HOUSE PARTNERSHIPS

PROJECT CONTRIBUTORS

Amazon Soils, Boral, Britone, Chromagen, Command Plumbing, Complete Connection, Davey Products, DSATCO, Eco-Growth, Ellenby Tree Farm, essastone, Gainsborough, GWA Bathrooms and Kitchens, Green Acres Turf Group, Gyprock CSR, G&V Earthmoving, Hanson, Intelligent Home Technology Centre, Instant Waste Management, James Hardie, Perth Patterned Concrete, Termi Mesh, The RH Group, Valspar, Wesbeam and Wespine.

INDUSTRY NETWORK PARTNERS

AWA, GWIG. Irrigation Australia, Landscape Industries Association,
Nursery & Garden Industry of Australia, Smart Approved WaterMark, UDIA