Our Household Energy Transition

Becoming a Fossil Fuel Free Family

2018 ANNUAL REPORT

UPDATED

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Dave Southgate

Foreword

This is my third annual report tracking the progress we are making toward my family's goal to become a Fossil Fuel Free Family. As far as possible I have kept this document in the same format as the 2016 and 2017 Annual Reports to allow easy comparison across the years.

We are continuing to move towards our goal, but progress has slowed. We have now more or less maxed out our opportunities for reducing the carbon footprint of energy use within the house. The big potential gains now lie with modifying our car use. Unfortunately, we seem to be in a holding pattern waiting for new EVs to come onto the Australian market.

For me this annual report acts as my end of year stocktake. After examining the progress we have made each year I work out my broad plan of action for the coming year. I spell this out in the final chapter.

Dave Southgate

Canberra

January 2019

Background

Over the past six years my family has been working toward becoming fossil fuel free (FFF) by transitioning our household energy use. We are aiming to be in a position where we make no direct use of fossil fuels, which effectively means no grid electricity, gas or petrol, within our household by 2020. I wrote about the beginning of this journey in my book *Our Household Energy Transition: Becoming a Fossil Fuel Free Family* which I released in February 2015[1]. I refer to this as the 'Transition Book' throughout this short report.

In that project initiation book I provided information relating to our household energy use and carbon footprint for the three years 2013, 2014 & 2015. Early in 2017 I produced my first annual report on the project's progress.[2] That report essentially updated the earlier information to include data on 2016 and also included some commentary on the actions that we took in that year to help us toward our FFF goal. I subsequently produced a similar project annual report for 2017.[3]

As indicated in the Foreword, in this 2018 annual report I have deliberately kept the format as close as possible to the one I used in my previous annual reports – I have done this not only to make my writing task easier but also to facilitate easy comparison between successive annual reports. However, I have included one new chapter in this report – 'Energy Monitoring' (**Chapter 7**) – in order to capture the strides we made in 2018 on a topic that is very close to my heart.

In early 2019 I had a stark reminder of why we are working toward being fossil fuel free. We took a short family holiday in the S Island of New Zealand and were totally amazed by the rapid rate of recession of the glaciers. I hadn't imagined they were disappearing so quickly. The photo to the right was taken on the path up to the Franz Josef glacier. It's a long way between where the glacier ended ten years ago and where it is today!

Franz Josef glacier: New Zealand. Photo taken 3 Jan 2019

[1] *Our Household Energy Transition: Becoming a Fossil Fuel Free Family*. Dave Southgate. Feb 2016: https://docs.com/dave-southgate/9347/becoming-a-fossil-fuel-free-family

[2] *Household Energy Transition: 2016 Annual report.* Dave Southgate. Feb 2017: https://southgateaviation.files.wordpress.com/2017/02/annual-report-2016final.pdf

[3] *Household Energy Transition: 2017 Annual report.* Dave Southgate. Feb 2018: https://southgateaviation.files.wordpress.com/2018/02/2017-annual-report.pdf

Key Events for 2018

Some important energy/power milestones for 2018:

90%	Fossil Fuel Free for our house (excluding cars)
98%	Fossil Fuel Free for hot water
90%	Fossil Fuel Free for our electric vehicle (Nissan Leaf)
300 kWh	Total energy used for winter heating (down from 6,000 kWh when we were heating with gas)
10W	Heated jacket gave beautiful warmth in winter
10W	Evaporative cooler provided surprising level of personal cooling in summer

In many ways 2018 was a frustrating year for our project – it was a year where it seemed to take forever to get anything done. The whole of the solar industry in the ACT seemed overloaded with work and long waits for action were the norm. I'm still waiting for new EV models to appear on the Australian market! Having said that, I did have some real wins which have set us up for the future.

The wins

Heated Hoodie

Over the past few years I've become very interested in finding more effective ways for people to keep warm inside their homes. In particular, I've become a strong believer in the philosophy of 'Heat yourself: not your house'.[4] This concept essentially involves individuals keeping themselves warm using some form of direct personal heating. It probably works best by utilising a heat source which is attached to the body via heated clothing. After much searching, and some trial and error, in July I found just what I had been looking for – a wonderful heated hoodie. Brilliant! I discuss this in detail in **Chapter 4**, but in short this enabled me to keep wonderfully warm and cosy on our cold Canberra evenings using less than 10W of power!

Energy Monitoring system

I guess it goes without saying that I couldn't carry out our 'fossil fuel free' project without robust energy monitoring. Monitoring our generation and consumption of electricity is fundamental to tracking our progress. Up to this year I have been acutely aware that my energy monitoring has been one of the key weaknesses of the project: while I've had access to rock solid data from our electricity meter; and reasonably robust electricity generation from my PV inverters; the quality of

[4] *Heat yourself: not your house. The low-cost way to keep warm at home.* Dave Southgate. Oct 2017: https://fossilfuelfreedom.com/2017/10/05/our-warm-low-energy-winter/

my data for several of my disaggregated energy uses has often been poor. It has had questionable accuracy and/or intermittent and missing data. In May 2018 I had a professional 'always on' data monitoring system installed which is constantly monitoring 9 circuits within our house. While this is not perfect it has improved my ability to track our energy consumption no end. I discuss this in detail in **Chapter 7**.

The disappointments

No new EV

This has been an issue of profound disappointment. At the end of 2017 I fully expected that I would buy a new second generation EV during 2018. In particular, I had my eye on the latest version of the Nissan Leaf (40kWh battery). Very sadly the expectations generated by the EV manufactures were not met.

In late 2017 I was advised by my local Nissan dealer that the new Nissan Leaf would be available in Australia by May 2018 and I envisaged that we would buy one of these. However, the Leaf 2 did not materialise and this delay has changed my plans. Over 2018 the promise of two new 'non-luxury' EVs with a 64kWh battery coming on to the Australian market emerged – the Hyundai Kona and the Kia Niro. The appearance of these two cars suddenly made the 40kWh new Leaf much less attractive and I came to the conclusion that we will now hold on to our current Leaf and look to replace it with an EV with a >60kWh battery. I am hoping that this will occur in 2019 but I'm now very cautious – it's now simply a case of 'hope for everything; expect nothing'. I discuss this further in **Chapters 2 & 8.**

The consolidation of the solar industry – innovation threatened

I should stress at the start of this section that I am not in any way trying to criticise the solar industry with my comments – I fully accept that what has happened has been as the result of commercial pressures. If companies in any field fail to respond to commercial pressures, they disappear.

When I started out on our energy project about 6 years ago I can remember one of the principals of Canberra's largest solar company saying to me something like 'we really like customers like you who want us to install unusual equipment, it lets us try out new products'. In those days, when the rooftop solar industry was relatively immature, it seemed that solar companies would be happy to install almost any product as long as it met the appropriate Australian Standards and they could source it from a reputable distributor.

Come forward to 2018 and the game seems to have changed dramatically. It seems that most companies now only support, and want to install, a very narrow range of products – typically one or two brands of both PV panels and inverters. Maybe one brand of battery. The attraction of this arrangement to the installing companies is self-evident (bulk buy, limited training of staff, optimising stock levels, excellent knowledge of the product, faster installation, etc). This leads to lower costs which is, of course, great for the 'normal' customer who is simply wanting to install a new solar PV system. However, this is very disappointing for someone like me who is trying to squeeze the last few kWh out of a mature solar PV system and is looking to install more esoteric equipment. Life is now much harder.

This year, on more than one occasion, when I wanted to install an 'interesting' product I struggled to find a licenced electrician to install it. I discuss some examples later in the report. While I generally persevered, I imagine many people with less time than me would simply give up and not install the innovative devices that can be used to extend the capacity of a solar PV system. Opportunities for introducing new products are being lost.

A similar situation is now very evident more widely across Australian solar experts. I have been following energy discussion groups on the internet for some time and the narrowing of ideas is now becoming quite worrying. Some years ago all sorts of ideas were freely discussed and a range of energy solutions were being installed; now it seems that if anyone dares to venture far off the conventional pathway (eg for home heating – fill gaps; insulate; heat pumps) they are given very short shrift. In my view this is very sad – I think we should be encouraging diversity not closing ideas down.

More limits to growth

In my last annual report I spelt out my plans for going three-phase and adding an additional 4kW of solar PV in 2018. However, very early in the year these plans came to a shuddering halt when I was told by my local solar PV installer that if I added even 1kW of additional PV capacity we would lose all of our ActewAGL FIT – an income of approximately $650 in 2018. This sent me on a different path for much of 2018 as I attempted to find a local company willing to install a hybrid off-grid/grid-tied solar PV hot water system which I had identified would let us squeeze a few more kWh out of our roof (see discussion in **Chapter 3**). Despite much effort, this did not work out either but by the end of the year I think I found a better solution which will enable us to install additional solar PV in 2019. So I guess we are now back to square one – I discuss this in **Chapter 8**.

Changing the mindset: ultra-low energy devices

Australians, and I guess most Western societies, have become totally immersed in a high energy lifestyle. Energy has been so cheap that we have adopted wasteful practices. However, it is not proving easy to change our ways: we recognise that we need to make big energy savings (and hence CO_2 reductions) but our response is often not particularly smart. For example, when we want to reduce our petrol use the conventional response has been to put great effort into producing more efficient petrol cars (well we can't even get that far in Australia!) rather than asking ourselves the fundamental questions: why not an electric car; maybe we could take public transport or cycle?

Clearly we now need to change our thinking. We need to focus on what we are trying to achieve rather than simply focusing on making our current practices more efficient. For example, I seem to find myself constantly harangued by promoters of heat pumps for domestic energy use – 'heat pumps are so efficient!' Indeed they are – they are certainly much more efficient at heating the air in a space than their rival products. However, we need to stand back and ask ourselves what are we trying to do when we heat the air inside a room or a building? Are we trying to keep people warm or are we trying to keep buildings warm? There's a big difference!! Do we really need to heat all the air in a room or a house to keep people warm? If all we are trying to do is keep people warm then there are many ways to do this which are generally going to use much less energy (and probably be more comfortable) than using heat pumps. I discuss this in **Chapter 4**.

I tend to look on using heat pumps for domestic heating as something akin to driving 1km to the shops to buy a loaf of bread. Certainly it'll be much more efficient to use a small economical car than a gas-guzzling SUV, but what about walking, cycling or using an e-bike? You achieve the same end but use much less energy (and probably feel much better for it) if you leave the car in the garage.

Over 2018 I became increasingly interested in what I term ultra-low energy devices. As I mentioned earlier, for some time now I've been interested in the concept of 'heat yourself: not your house' but I guess the real potential of low energy devices only hit me when I acquired my heated hoodie in July. Attaining beautiful warmth using only 10W!! Amazing!! The alternatives typically use >1,000W and most likely don't achieve the same level of thermal comfort. This has now inspired me to look even further into the low energy world by thinking more deeply about the drivers for our energy consuming actions: I am now training myself to ask the 'what am I trying to achieve?' question before I race off and find a way to respond to the standard question of 'how can I make this action more efficient?'. I delve into this issue further in **Chapter 4.**

New Meter Box

When we started our energy transition project we already had quite a full electricity meter box. As we progressively moved off gas we added all sorts of electrical equipment: solar PV systems; car chargers; FIR heaters; the energy diverter + electric hot water; induction cooker; and some energy monitoring equipment. Our meter box was overflowing!! Electricians were clearly struggling when they did any work at our house. As I mentioned earlier, in the early part of 2018 I was contemplating going three-phase and clearly I needed a much larger meter box if I wanted to go down that route. While going three-phase did not happen, I did find a new energy monitoring system that I wanted to install (see **Chapter 7)** and this would have only worked out with a new meter box. The photo on the right is an inside shot of my wonderfully neat new meter box. The energy monitoring devices are sitting on the right (marked – see also **Figure 36**).

You can see the overall size of the new meter box in the photo on the left**.** The smaller box to the right of the meter box is the gateway which controls our Tesla Powerwall 2 battery.

Summary of Energy Outcomes

Overview

Figure 1 shows the energy type split for our energy use during 2018. In very broad terms, about 55% of our household energy use was from petrol; 40% from our solar PV system; and 5% from grid electricity.

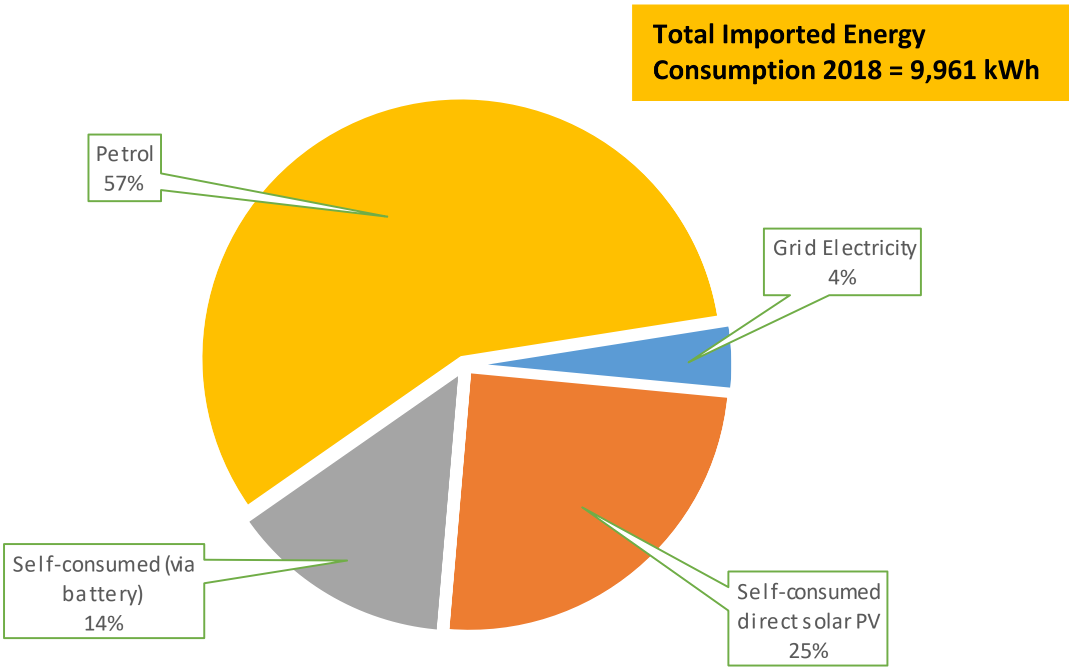

Figure 1: Breakdown of our household energy use 2018

Energy Source	Energy Use (kWh)
Grid Electricity	653
Self-consumed direct solar PV	4,040
Self-consumed (via battery)	2,270
Petrol	9,308
Total Energy Use	16,271

Our energy consumption patterns changed quite markedly in 2018 compared to 2017. The figures for 'grid electricity' and 'self-consumed' (via battery) more or less swapped over. This is primarily because 2018 was the first year that our Tesla Powerwall 2 was operating for a complete year – in 2017 it was only in place for about the last three months of the year. The figure and table show a dramatic increase for petrol use but this is essentially because this year I have changed the way I am reporting our petrol consumption (see **Chapter 2**). This increase in reported petrol use leads to an approximate 30% increase in the reported total energy use for our household over 2018.

As I have commented many times before, it is important to note the very significant amount of energy we use in the form of petrol even though our main family car is an EV. For some reason most people seem to forget about their family cars when computing their family energy use.

Figure 1 shows that in 2018 we were about **40% fossil fuel free** (the % which derives from our own solar PV) which was more or less the same as in 2017. This static position largely reflects our reported increase in petrol use. If considering electricity in isolation, we were over 90% fossil fuel free in 2018 compared to approximately 70% fossil fuel free in 2017.

Figure 2 shows a breakdown of our total household energy consumption by use category for 2018.

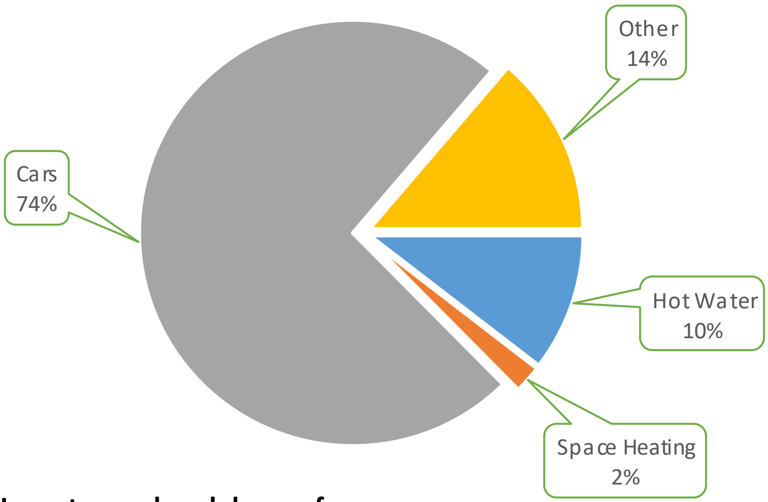

Figure 2: Use category breakdown of our household energy consumption 2018

This figure emphasises the growing dominance of motor vehicles in our household energy use. The ACT Government's actsmart 'Heating your home' internet page states that '*For most Canberra households, space heating in winter accounts for more than half an entire year's energy*'.[5] I think we must be doing something right when it comes to heating!

Average daily electricity consumption 2018 = 19kWh/day

Figure 3 shows the breakdown of our household electricity use by source. This indicates the important role of the battery in enabling us to achieve a figure of over 90% FFF for our electricity use in 2018 (only 9% of our electricity came from the grid). Our total daily electricity consumption (19kWh/day) is similar to the Australian daily average.

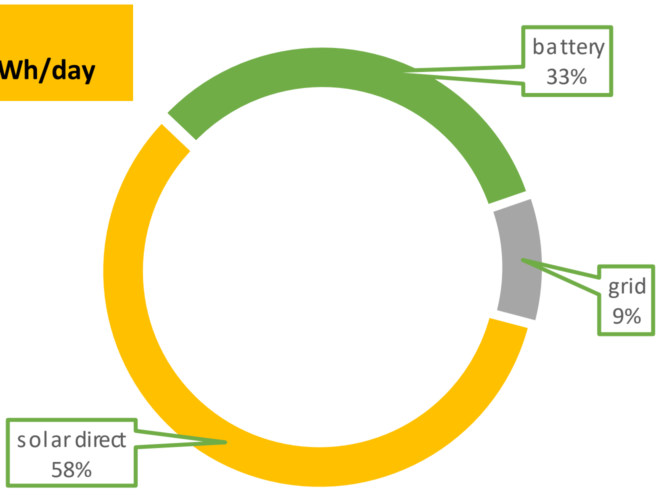

Figure 3: Breakdown of our household electricity use in 2018

[5] *Heating your home*. ACT Government. actsmart: https://www.actsmart.act.gov.au/heating-your-home

Disaggregating the data

In order to place the 2018 data in context, and to allow tracking of changes, the next six Figures are extensions of, and extractions from, Figures that I included in the Transition Book and in the Annual Reports for 2017 and 2018.

While I have very solid data for total electricity use, I have had to make some assumptions in allocating energy use data to disaggregated categories. I discuss the key assumptions in **Chapters 2 to 5**. All CO_2 data for energy use for 2018 is based on the 2018 conversion factor for NSW/ACT electricity published in the 2018 Australian Greenhouse Accounts (the Government updates this publication each year).[6]

It is important to note that many of the energy and carbon reductions that we made between 2015 and 2016 were made in the context of the quite dramatic changes we made to our household energy set-up in 2015. However, we are continuing to make incremental changes in our household energy set up which I believe will result in important changes over time. I discuss my proposed energy reduction actions for 2019 in **Chapter 8.**

Imported Energy (grid electricity, gas, petrol)

It can be seen from **Figure 4** that in 2018 we had an approximate 75% reduction in the use of grid electricity compared to 2017. This is directly contributable to our Powerwall 2 being in operation for a full year for the first time. This reduction led to an about 30% reduction in our overall use of imported energy and in our household carbon footprint.

Year	Grid Electricity		Gas		Petrol		Total	
	kWh	CO_2 (kg)	kWh	CO_2 (kg)	kWh	CO_2 (kg)	kWh	CO_2 (kg)
2013	1,790	1,539	8,466	1,559	16,206	3,888	26,462	6,986
2014	4,128	3,550	8,426	1,552	4,964	1,191	17,518	6,293
2015	4,945	4,249	1,460	269	4,964	1,191	11,369	5,709
2016	3,735	3,137	-	-	4,964	1,191	8,699	4,328
2017	2,757	2,604	-	-	4,964	1,191	7,721	3,795
2018	653	535	-	-	9,308	2,258	9,961	2,793
% Change 2018/2017	-76%	-79%	-	-	88%	90%	30%	-26%

Figure 4: Household imported energy use for 2018 compared to earlier years

[6] Australian Government Greenhouse Accounts Factors 2018: http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2018

Notes: (1) The grid electricity data in **Figure 4** is extracted from our quarterly electricity bills. The meter readings in the quarterly bills do not precisely coincide with the beginning and end of the calendar year. Therefore there are slight discrepancies between this data and the numbers in some of the other Figures (eg **Figure 7**) which are based on my daily electricity meter readings throughout the year.

(2) This Figure shows only imported energy data – it does not include the consumption of our own solar PV electricity.

Energy End Use

Figure 5 shows the end use breakdown for our household total energy use in 2018 compared to previous years. The most notable change from 2017 is the approximate 40% reduction in the amount of energy we used for heating – this continued our strong downward trend in heating energy consumption resulting from our adoption of the 'heat yourself: not your house' philosophy. As noted earlier, the increase in the car energy use results from my adoption of a different methodology for monitoring petrol use. This is discussed in **Chapter 4.**

Year	Hot Water (kWh)	Space Heating (kWh)	Cars (kWh)	Other (kWh)	Total (kWh)
2013	2,920	6,194	16,206	1,142	**26,462**
2014	2,555	6,463	7,581	1,338	**17,937**
2015	2,213	1,995	7,396	2,109	**13,713**
2016	1,733	983	7,482	2,516	**12,714**
2017	1,782	569	7,655	2,718	**12,724**
2018	1,692	342	11,914	2,223	**16,271**
% Change 2018/2017	-5%	-40%	56%	-20%	

Figure 5: End use household total energy consumption for 2018 compared to earlier years

Energy use in each of the end use areas shown in the Figure is discussed in **Chapters 2 to 5**.

When discussing our energy use, I usually like to think in terms of daily consumption for the separate end uses. I show these in **Figure 6.**

End Use	Daily Energy Consumption (kWh)
Hot water	**4.6**
Space heating	**2.3** (for the five-month heating season in Canberra)
EV	**7.1**
Petrol car	**25.5**

Figure 6: End use energy consumption for 2018 broken down to daily figures

Energy Generation (solar PV)

Year	Solar PV Total Production (kWh)	Imported Energy Consumed		Exported Electricity		Net CO_2 Footprint (kg)
		kWh	CO_2 (kg)	kWh	CO_2 (kg)*	
2013	2,772	26,462	6,986	2,772	2,384	**-4,602**
2014	4,906	17,518	6,293	4,476	3,849	**-2,444**
2015	10,980	11,369	5,709	8,863	7,622	**1,913**
2016	12,251	8,699	4,328	8,265	6,942	**2,614**
2017	14,119	7,402	3,215	6,413	5,323	**2,108**
2018	15,225	9,961	2,793	8,613	7,063	**4,270**
% Change 2018/2017	**8%**	**35%**	**13%**	**34%**	**33%**	**103%**

Figure 7: Summary of our solar PV production in 2018 compared to earlier years

***Note** *It is assumed that each kWh of solar PV (ie carbon zero) electricity which we export displaces one kWh of grid electricity (ie predominantly coal based electricity) somewhere in the network*

Figure 7 provides data for our solar PV generation and export over the period 2013-2018. Despite my hopes, we did not add any additional PV capacity in 2018. 2018 was the first full year with our current 10kW capacity solar PV system.

Our consumption of imported energy increased by around 35% in 2018 compared to 2017 – this is again a result of the new monitoring approach for our petrol consumption. On the other hand, our quantity of exported solar PV electricity increased and overall our net carbon footprint improved.

Costs

The data in **Figure 8** is derived from our household electricity bills and includes the electricity and gas supply charges. As indicated earlier, the big jump in our petrol costs is related to the new way I have estimated our petrol usage in 2018 (I explain this in **Chapter 2**). We disconnected our house from the reticulated gas supply system in December 2015. We paid approximately $360 for electricity supply charges in 2018 – about 70% of our total electricity bill.

The Figure shows that for the third year running our energy costs were more or less balanced out by our energy income from our FITs.

Year	Electricity ($)	Gas ($)	Petrol ($)	Total Fuel Bill ($)	Credit from Solar ($)	Net Fuel Bill ($)
2013	475	991	2,558	4,024	1,241	**2,783**
2014	766	1,112	780	2,658	902	**1,756**
2015	1,085	488	676	2,249	1,495	**754**
2016	886	-	676	1,562	1,559	**3**
2017	818	-	676	1,494	1,742	**-248**
2018	499	-	1,365	1,864	1,811	**53**
% Change 2018/2017	**-39%**	**-**	**102%**	**25%**	**4%**	

Figure 8: Cost breakdown for our household energy use for 2018 and earlier years

Note: The petrol costs for 2018 have been estimated using an average price of $1.40/litre

Carbon Footprint of our Energy Use

Figure 9 that shows that our total carbon footprint is continuing to slowly reduce. It is important to read this table in the context of the detailed discussions on our patterns of energy consumption in **Chapters 2 to 5.** While there are large relative reductions in the size of our carbon footprint in the 'hot water', and 'space heating' categories the absolute reductions are comparatively small. As noted earlier, the increase in the carbon footprint of our cars is primarily due to the changes I have made in reporting petrol use. The 'other' column has been computed by difference and I don't believe the relative changes are meaningful. I consider these large swings are simply highlighting the difficulties of accurately computing the disaggregation between the categories rather than identifying major shifts in the composition of our carbon footprint. Clearly as we approach a fossil fuel free status the relative errors in our carbon footprinting are likely to increase.

Year	Hot Water (kg CO_2)	Space Heating (kg CO_2)	Cars (kg CO_2)	Other (kg CO_2)	Total (kg CO_2)
2013	538	1,326	3,888	982	**6,734**
2014	470	1,376	3,442	1,151	**6,439**
2015	435	1,594	3,283	397	**5,709**
2016	80	826	3,283	139	**4,328**
2017	48	472	1,784	1,491	**3,795**
2018	26	280	2,445	42	**2,793**
% Change 2018/2017	**-46%**	**-41%**	**37%**	**?**	**-26%**

Figure 9: End use carbon footprint breakdown for 2018 compared to earlier years

Chapter 1

2018 Generation: Solar PV

Our solar PV production and export for the past six years was summarised in **Figure 7.**

As noted earlier, I was thwarted in my attempts to add more solar PV capacity and therefore 2018 was what has turned out to be a rare year for us – we started and ended the year with the same solar PV system(s)!

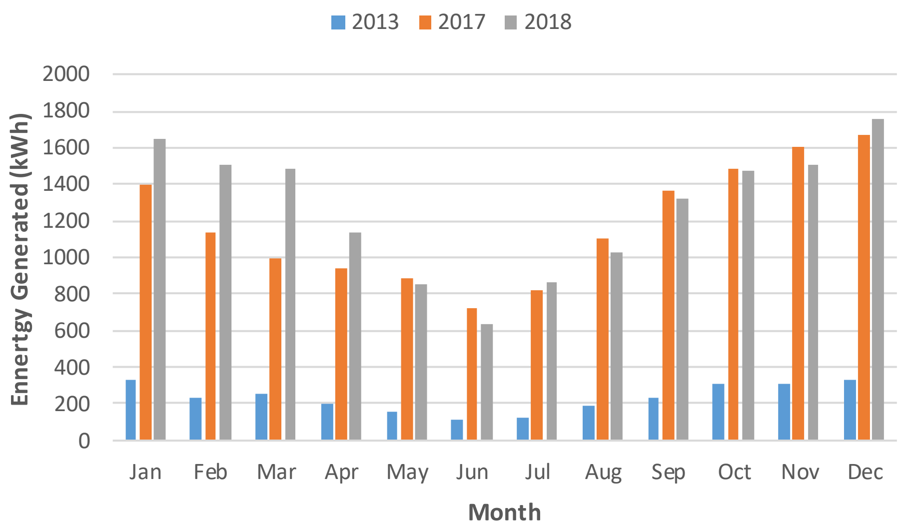

Figure 10: Comparison of our household 2013, 2017 & 2018 solar PV production

Figure 10 compares our solar production across 2013, 2017 and 2018 broken down by month. I have included the three years of data to show how our solar PV capacity has increased/varied since we started our FFF project. We installed our last 2kW solar PV system in April 2017.

Self-consumption of solar PV electricity

In my previous reports I discussed my preference not to focus on 'self-consumption' but to think more in terms of achieving '% grid independence'. Ultimately, I am looking at us achieving effective total independence from the grid (say 95% independence) before I will claim we have reached our goal of 'Fossil Fuel Freedom' with respect to our house energy consumption (ie not counting our petrol car).

Figure 11 shows how our level of grid independence varied over 2018. For comparative purposes I have included the corresponding Figure for 2017 as **Figure 12**. This shows that between the two years we have gone from being around 70% grid independent to just over 90% grid independent. Going further back we were about 50% grid independent in 2016. While some of this improvement has been as a result of adding additional solar PV, I think it is self-evident that the major breakthrough came with the installation of our Powerwall 2 in mid-September 2017. The step change can be seen very clearly in **Figure 12**.

2018 overall rate of house grid independence = 91%

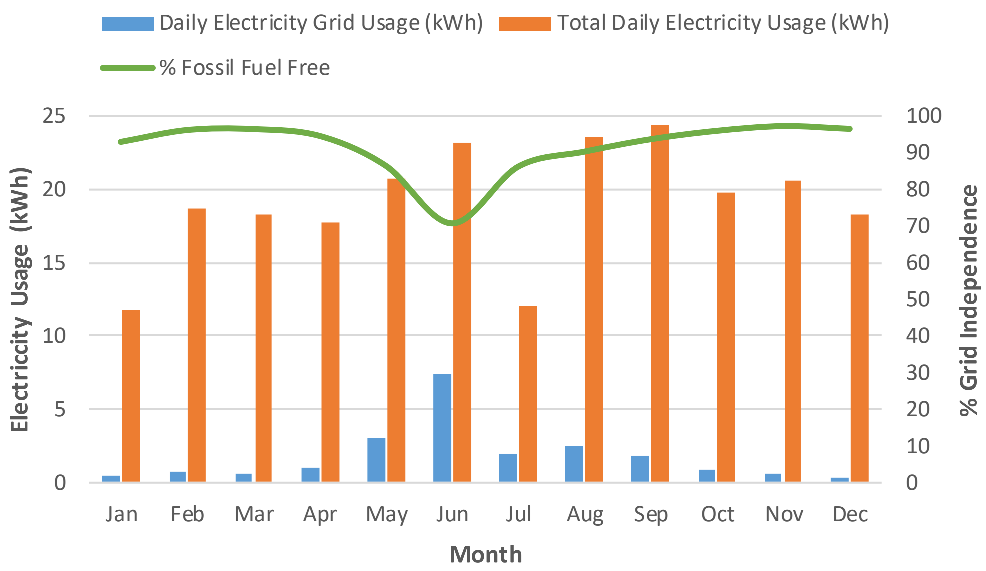

Figure 11: Variation in grid independence over 2018

Note: *We were away on holiday for much of July.*

2017 overall rate of house grid independence = 70%

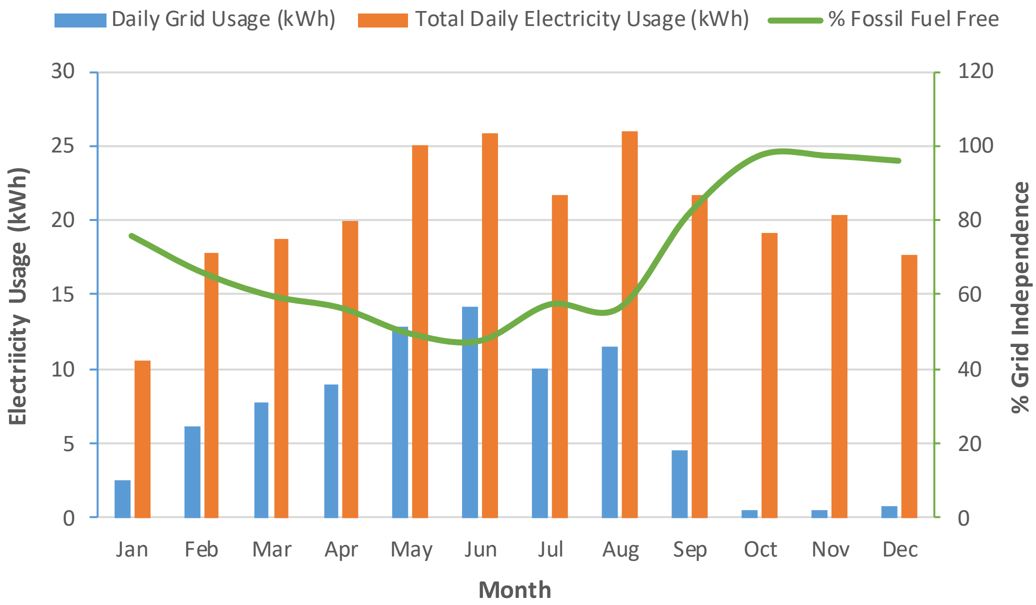

Figure 12: Variation in grid independence over 2017

I also like to compare how well we are progressing in terms of grid electricity consumption v solar PV production – this is shown in **Figure 13.** This picture clearly illustrates that, while overall we are in good position, we were struggling in winter to avoid using grid electricity (this picture is distorted somewhat by the fact that we were away on holiday for much of July). In simple terms, the problem is that we are not able to generate enough solar PV in the winter months to keep our Tesla Powerwall 2 charged (see **Figure 35**).

Average grid electricity consumption 2018 = 1.8 kWh/day

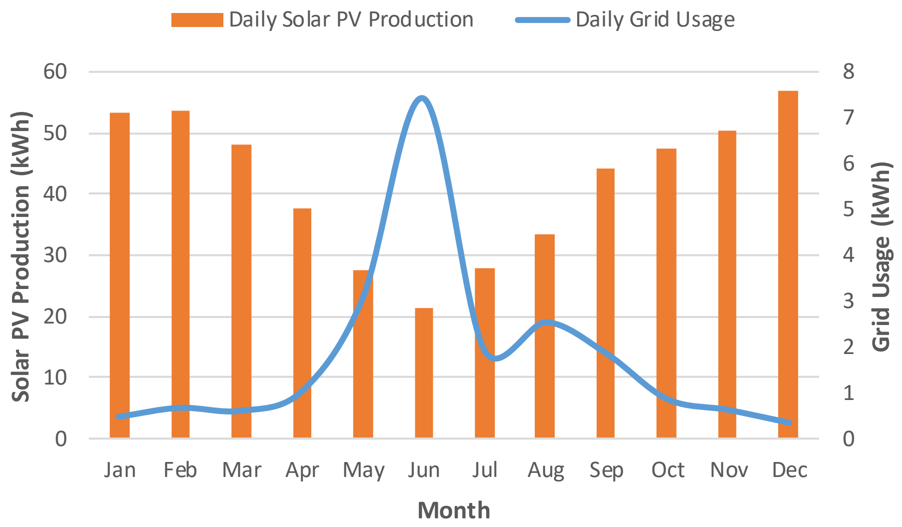

Figure 13: Grid electricity consumption compared with solar PV generation for 2018

Next Solar PV Steps

I had been aware all along that our prime winter constraint was going to be a lack of solar PV capacity rather than a lack of battery capacity. Therefore, at the beginning of 2018 I made attempts to add additional solar PV capacity to our house to assist us get through winter in a position as close as possible to fossil fuel free. However, I was not able to progress this primarily due to constraints imposed by our retailer (ActewAGL) (see my comments in the **Key Events** section at the start of the book).

After much frustration and chasing of options, I think I now have a way ahead and I hope to be able to add more solar PV in 2019. I discuss this in **Chapter 8**.

Chapter 2

2018 Consumption: The Cars

Despite my dream of being able to buy a new generation EV in 2018, we did not manage to change our cars. As everyone interested in EVs knows, none of the new 'affordable' EV models made it to the Australian market; I think we're all hoping that 2019 will see some serious EV action.

We have now had our EV (a Nissan Leaf) for five years and our petrol car (a Hyundai i30) for about seven years. We have used the cars in more or less the same way for the past five years. Our energy use for the cars in our household over the past six years is summarised in **Figure 14.**

Year	Electricity		Petrol	Total
	Grid (kWh)	Solar (kWh)	kWh	kWh
2013	0	0	16,206	**16,206**
2014	2,617	0	4,964	**7,581**
2015	2,432	N/A	4,964	**7,396**
2016	1,007	1,511	4,964	**7,482**
2017	714	1,977	4,964	**7,655**
2018	228	2,378	9,308*	**11,914**
% Change 2018/2017	**-68%**	**20%**	**88%**	**86%**

Figure 14: Energy consumption of our cars 2013-2018

***Note:** I have changed the basis for my petrol use calculations for 2018 – hence the sudden jump in energy use for our petrol car. I discuss this below.

To date I have not kept detailed records of our petrol usage and the numbers in the Figure for petrol energy use are simply estimates (see Appendix A.4 in the Transition Book). For the years prior to 2018, the petrol energy usage estimates relate only to our normal 'week to week' use of the car – not holiday use. I did this in order to allow a realistic comparison of energy use between years of our 'regular household' energy use. For some of our holidays we fly; for others we drive in our petrol car. However, this approach involved a lot of arbitrary petrol allocations and I came to the conclusion it will be best in the future to simply report the total petrol usage of the i30, whatever the reason for the car travel. This is a compromise which will inevitably lead to some comparisons being made between apples and oranges.

The data shown in **Figure 14** indicates that about 90% of the energy we used in our EV over 2018 came from our solar PV system. This figure was about 75% in 2017 and about 60% in 2016 – I attribute the improvement almost totally to the installation of the Powerwall 2. Naturally, the level of grid independence for our EV charging varied throughout 2018 – this can be seen in **Figure 15.** This figure once again illustrates our lack of solar PV energy in the winter months.

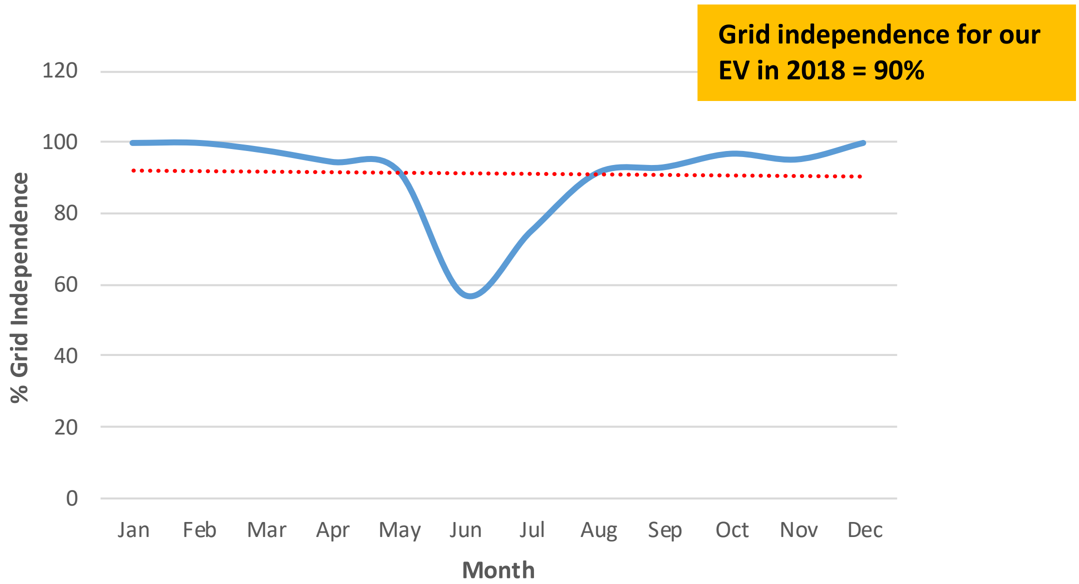

Figure 15: Variation of EV charging grid independence across 2018

The total energy used by our electric car in 2018 was more or less the same as in 2017. Similarly, we travelled about the same distance in the two years and achieved the same rate of efficiency. This is summarised in **Figure 16.**

Year	Energy Used (kWh)	Distance Travelled (km)	EV Efficiency (kWh/100km)
2016	2,518	14,292	17.6
2017	2,691	15,141	17.8
2018	2,606	14,631	17.8

Figure 16: Comparison of EV energy use 2016-2018

Note: I only had reliable monitoring data for my EV charging for part of 2018. Therefore, the energy use has been computed using data on the car energy efficiency, and distance travelled, displayed on the EV dashboard; the reported energy use has been multiplied by 1.2 to take account of energy losses in the battery charging process (about 20% of the energy input is lost in the charging process).

The data shown in **Figures 16** is comforting in that it indicates that there has been no major degradation in our EV's performance over the last year.

Once I had our Solar Analytics data monitoring system in place (see **Chapter 7)** I was able carry out detailed 5 sec datalogging of our EV charging. **Figure 17** shows the hourly profile of our EV charging from May to Dec 2018. I commonly do not use the car in the morning and therefore this is my prime time for direct solar charging. I generally go out in the EV around midday/early afternoon and return about 4pm. The late afternoon charging peak is very evident in the figure – this charging usually comprises a mix of direct solar charge and energy from the Powerwall 2 (the proportions vary throughout the year). The overnight charging energy in 2018 was almost solely sourced from the Powerwall.

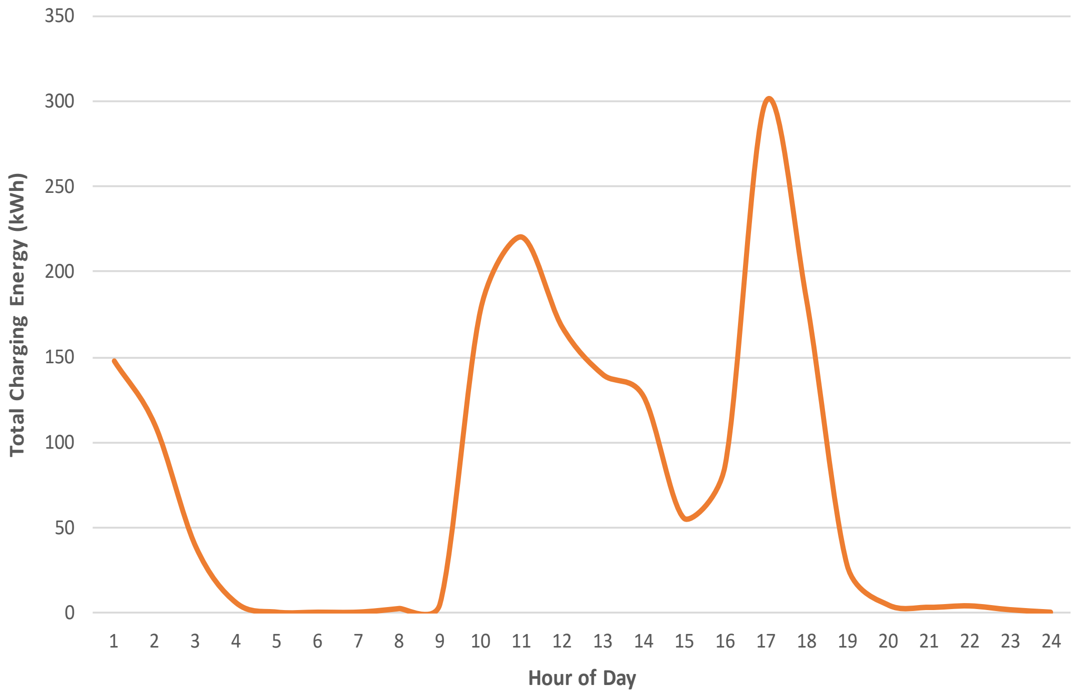

Figure 17: Hourly profile of our EV charging May-Dec 2018

Figure 18 gives shows the days in 2018 when I injected at least some grid electricity into our EV. I have set this information against the daily solar PV output of our net FIT system (the output of our gross solar PV system is not available for charging the EV). It is very evident that we struggled to produce enough electricity in winter to meet our electricity demand for the EV (and the rest of the house - you can see a related picture in **Figure 35**). Over 2018 we used at least some grid electricity in our EV on 43 days.

Throughout 2018 I primarily charged the EV at home using my solar PV direct charging system based around our Immersun energy diverter.[7] I used a public rapid charger on three or four occasions over the year.

[7] *Using an Immersun to Automatically Solar Charge an EV*. Dave Southgate. Jun 2016: https://sway.office.com/CpaWPJYHRNUDMRAG?ref=Link&loc=play

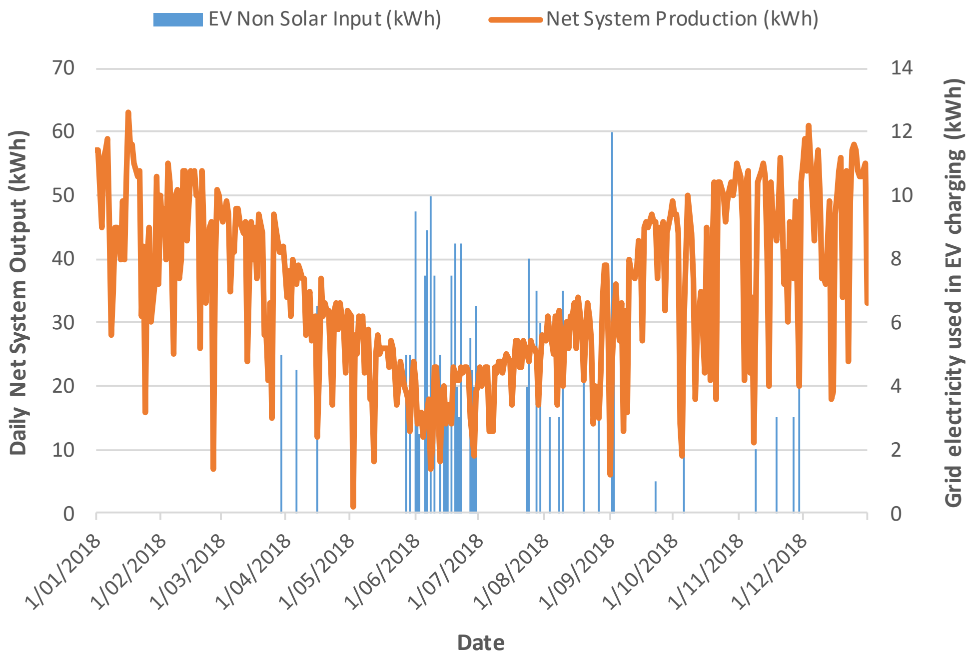

Figure 18: Days in 2018 when we used at least some grid electricity in our EV

EV Battery Status

When you buy a Nissan Leaf it shows the new battery as having 'twelve bars'. Over time, as the battery slowly degrades, the bars start to disappear. As I understand it, if the battery loses more than three bars before five years, or 100,000km, is reached Nissan will replace the battery under warranty. I reported in my 2017 Annual Report that I lost my third bar in August 2017. I did not lose a bar in 2018 and I have now passed the five years of ownership mark so I will not be eligible for a new battery under warranty if/when I lose my next battery bar.

Having said that, I did feel that the range of the car deteriorated over the year. A year ago I estimated that the range was about 90km; I would now put this at about 85km (it is worse in winter than in summer for our Canberra based car). I don't see this as an immediate problem but if I'm not able to upgrade to a new generation EV within the next two or three years than it may get me thinking – I envisage that if the range degrades to around 65km then it will force me to change the way I use the car (eg more charging at public charging points).

At the moment replacing the battery in the Leaf is an expensive proposition if you get Nissan to do it – the cost I generally see quoted is around $35,000!! At this price, it is not hard to imagine third party EV battery refurbishment businesses cropping up when the transition to EVs gathers pace.

My Next EV

At the beginning of this report I mentioned my disappointment at not being able to get a new generation EV during 2018. I am very keen to get a new EV with a battery around the 60kWh size in 2019, but a lot of the current indicators don't give me a feeling of confidence that they will be readily available in Canberra anytime soon. It appears that all the EV manufacturers are continually putting back the release dates of their offerings by 'just a few months'. Unfortunately, 'months' seem to be turning into 'years'. I discuss this issue in **Chapter 8**.

Chapter 3

2018 Consumption: Hot Water

I discussed our household water heating in Chapters 5 & 8 of my energy Transition Book.

In essence, we have a resistive hot water system which is controlled by an Immersun proportional energy diverter. The Immersun was operational for the whole of 2018.

The Immersun had another brilliant year and, with the help of our Powerwall 2, gave us problem free hot water throughout the year using electricity which was almost all (98%) sourced from our home solar PV system. By way of comparison, a typical domestic roof-top solar thermal system gets about 80% of its annual energy from the sun (about 20% of the annual energy consumption is winter boosting). In addition to water heating, as noted in the previous Chapter, the Immersun was a key tool in our direct solar PV charging of our EV. Having said that, for a number of reasons I am planning to replace the Immersun with an Eddi[8] (to all intents and purposes a newer version of the Immersun) early in 2019.

Figure 19 shows the overall picture of our hot water energy use and carbon footprint of our household hot water for the past six years. It can be seen that our annual hot water energy use has been quite stable over the past three years.

Year	Electricity Consumed (kWh)		Gas (kWh)	Total Energy Consumed (kWh)	Carbon Footprint (CO_2 (kg))
	Grid Sourced (kWh)	Solar PV			
2013	0	0	2,920	2,920	538
2014	0	0	2,555	2,555	470
2015	207	544	1,394	2,145	435
2016	95	1,638	-	1,733	80
2017	58	1,724	-	1,782	48
2018	32	1,660	-	1,692	26
% Change 2018/2017	**-45%**	**-4%**	**-**	**-5%**	**-46%**

Figure 19: Comparison of our hot water energy use 2013 - 2018

[8] *Eddi*. Myenergi: https://myenergi.uk/product/eddi/

On average we used 4.6 kWh/day to heat our water throughout 2018.

Figure 20 breaks down the 2016 hot water energy use into monthly data. It also shows how the level of grid independence of our hot water electricity varied throughout the year. [We were away on holiday in July.] We used no grid electricity for water heating during six of the months in 2018.

2018 rate of grid independence for hot water = 98%

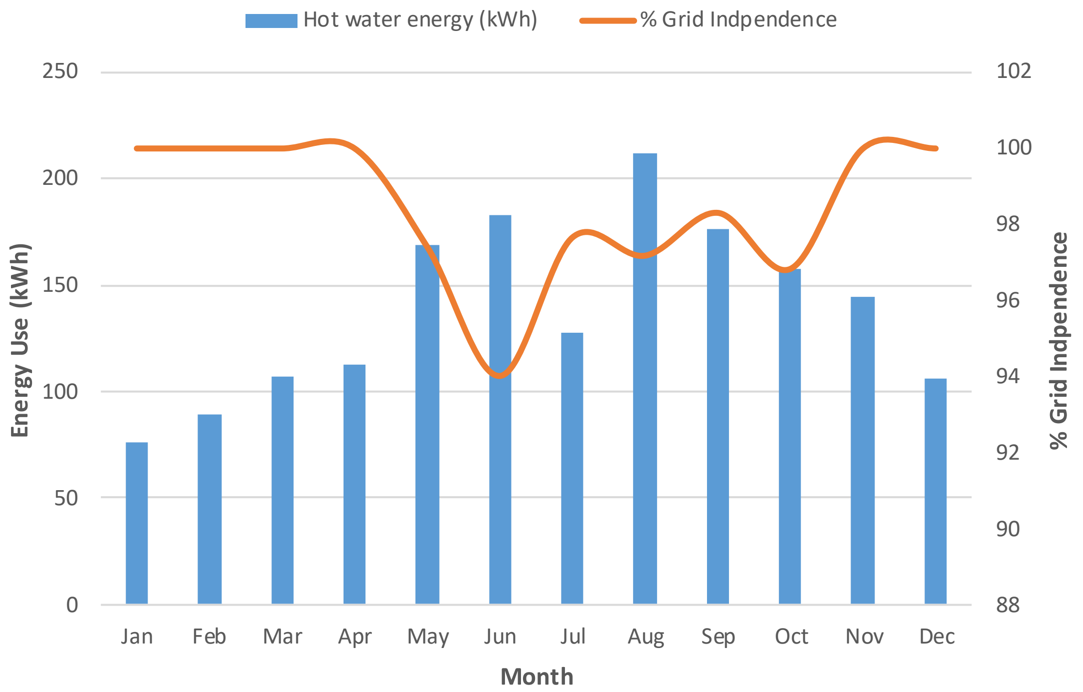

Figure 20: Hot water % grid independence and daily energy use 2018

Hot Water – Next Phase

Early in the year, when I discovered I would not be able to add any more solar PV capacity to our roof due to capacity constraints imposed by our electricity retailer (discussed at the start of the book), I decided that I would try to squeeze more capacity out of our total energy system by updating our hot water arrangements. I opted to do this not through any dissatisfaction with our current Immersun set-up (quite the contrary I think it is wonderful) but it was the obvious candidate for taking some of our energy consumption off grid. Initially, I looked at installing an evacuated tube solar thermal roof top solar hot water system but for many reasons this wasn't going to work for us and I began looking at off-grid solar PV solutions for hot water. The *HotPV* system[9] appeared to be the ideal solution for our situation but sadly this didn't fall into place. However, as things worked out this was all probably for the better because right at the end of the year I found an electricity

[9] *HotPV™Solar Hot Water made Easy!* Easywarm: http://www.easywarm.co.nz/

retailer, *Energy Locals*[10], that provides services in the ACT that does not impose the type of solar constraints which are applied by ActewAGL. This means that, barring unforeseen problems, we can now go three-phase and increase the solar PV capacity of our house.

I mentioned in passing a few paragraphs ago that I am planning on installing an Eddi energy diverter to replace our Immersun. The Eddi (**Figure 21**) is made and marketed by the same team that developed the Immersun (but it's a new company) and it appears to have more or less the same form and features of the Immersun with some important enhancements. Most importantly for me it can operate in a three-phase environment; it also has a very important 'by-pass' feature which allows the energy diverter to be by-passed in the case of system failure. This is very attractive to me as I have always wondered what I would do if the Immersun decided not to work one day – I don't want my family to be without hot water; equally I don't want to be rushed into hasty decisions on new systems simply to avoid having no hot water. I understand that households commonly run their hot water systems until they breakdown and then simply do a 'same day' replacement with exactly the same system because they don't want to be without hot water – I've done that myself over the years! I'm trying to be more organised now.

Figure 21: The Eddi energy diverter

[10] Energy Locals Community Power: https://energylocals.com.au/

Chapter 4

2018 Consumption: Heating

In 2017 we stopped heating our house and transitioned into a 'Heat Yourself: Not Your House' mode. We discovered that this approach to winter heating really works – wonderful comfort; very little energy use. I wrote a report on this towards the end of winter 2017, recognising that I had not yet perfected what we were doing.[11]

Working on ways to improve on our 2017 personal heating gains was one the most exciting parts of our energy project for 2018. It was the area where I think we had our greatest energy win for the year – the discovery of a piece of heated clothing that really works indoors. I discuss this later in the chapter.

At the start of winter, I was not expecting that we would have any great reductions in our heating energy use over what I term our five-month Canberra 'heating season' (May – September) compared to 2017. I thought that we had almost reached the limit on energy saving in this area, but it can be seen from **Figure 22** that we were able to make some further progress.

Year	Electricity Consumed (kWh)		Gas (kWh)	Carbon Footprint (CO_2 (kg))
	Grid Sourced (kWh)	Solar PV		
2013	274	0	5,920	1,326
2014	274	0	6,189	1,376
2015	1,853	142	0	1,594
2016	983	0	0	826
2017	569	0	0	472
2018	342	0*	0	280
% Change 2018/2017	**-40%**	**-**	**-**	**-40%**

Figure 22: Comparison of total winter heating energy use 2013 - 2018

***Note** I was unable to accurately allocate heating energy use between grid and solar PV electricity.

[11] *Heat Yourself: Not Your House.* Dave Southgate. October 2017: https://www.slideshare.net/davesouthgate/heat-yourself-not-your-house

While there was a marked drop in our heating energy use in 2018 compared to 2017, this gain should be treated with some caution since we introduced a more accurate and complete energy data monitoring system for 2018 - the data for 2017 and earlier years may have contained estimates that were overly conservative.

Over the 2018 winter we had our house battery available for the first time. As I have indicated in **Chapter 6**, we emptied the battery on many days. Typically, we would start the evening with some energy in the battery, but this would be depleted over the late evening and night (say for example by some cooking and heating demand and some charging of our EV battery). On these occasions some of the heating energy used would have been solar PV energy stored during the day, but I have no way of accurately allocating this to any particular end use. Given this, the amount of solar PV energy allocated to heating in **Figure 22** is shown as '0' recognising that this is a conservative approach (although the magnitude of the carbon involved is relatively small).

You can see that in 2018 we used about 95% less energy to keep warm over winter than we did in the first two years of the project when we were using ducted gas heating. Subjectively I was also much warmer in 2018 compared to when we were heating with gas.

Figure 23 shows the breakdown of our heating energy use by month, and by heating device, over the 2018 heating season. I have reduced this to a per day basis as we were away on holiday for three weeks in July.

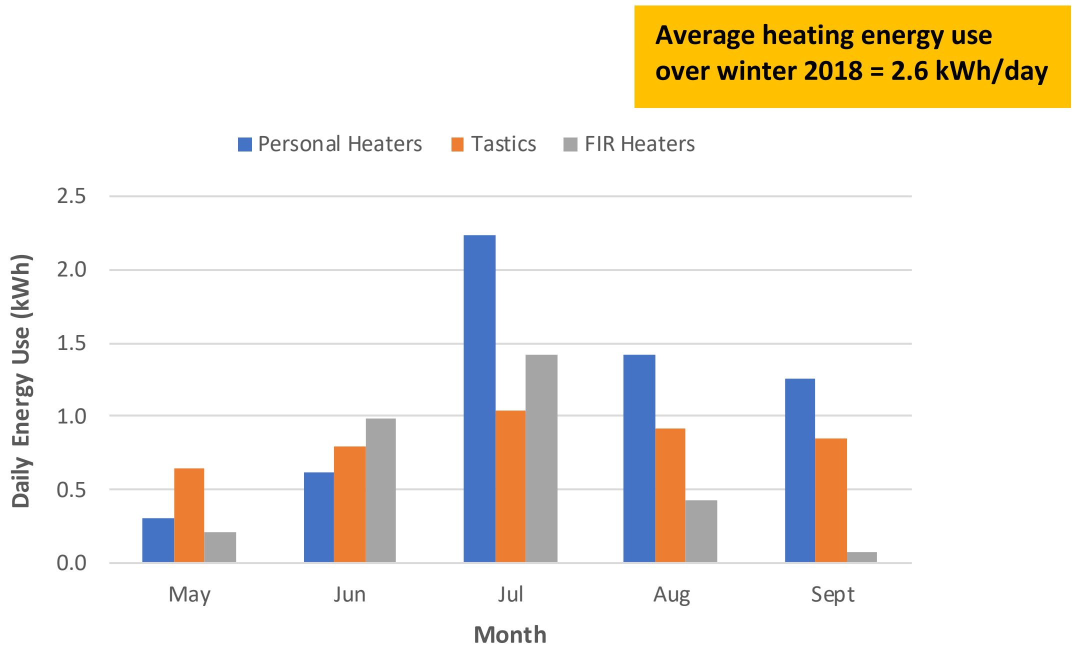

Figure 23: Breakdown of heating device contributions by month

It can be seen that the level of energy use for the Tastics was relatively invariant across the winter – my family seems to use the Tastics as much for light as for heat (very energy intensive lighting!). It is also interesting to note that our use of the FIR panels dropped off quite markedly as the winter progressed – I can only surmise from casual observation that my family became acclimatised to the cooler temperatures as the months passed. For example, in early winter my wife or one of my children would turn on the FIR heater(s) over breakfast time; in Aug/Sep they seemed to do this much less even though the house internal temperatures at this time were very similar across the winter.

The 'personal heaters' category captures the heating energy used by my wife and children in running personal heaters when they are in the bedrooms (my wife has a 400W FIR panel + other devices such as her heated seat pad; my children have blow heaters which can operate at up to 2,000W).

Monitoring Heating Energy Use

In mid-May we installed a new house energy monitory system (I discuss the details of this new system in **Chapter 7**). This new system gave us discrete 5 min datalogging on two of our heating circuits – the circuits for the ceiling mounted FIR panels and the Tastics in the bathrooms. We also installed 5 min datalogging on the power circuit which covers our bedrooms and the office – this is the circuit which provides power for our personal heaters. The results of this monitoring are shown in **Figure 24**.

Energy Use (kWh)	Personal Heating	Tastics	FIR Heaters	Total
Total	168	108	66	342
Daily Av	1.3	0.8	0.5	2.6

Figure 24: Breakdown of heating energy use by heating device over winter

Notes

1 All the data for the three circuits was adjusted to take account of the fact that the new monitoring system was installed in mid-May. Dummy readings were inserted into the dataset for the first half of May based on the assumption that the energy use for each circuit was constant across the month. [A conservative assumption]

2 All data for the first three weeks of July were removed from the dataset since we were on holiday over that period and we used no heating while we were away.

3 The circuit I monitor for our 'personal heating' energy use also provides power for a number of other devices in our house – for example, our fridge and all our computers. I have therefore adjusted the power readings for that circuit over winter to in an attempt to exclude energy use for non-heating activities. I did this by examination of the energy use on that circuit after the end of the heating season (during October 2018) – after this analysis I deducted 2kWh/day from the energy use data on the power circuit over the winter to arrive at the heating data values. I believe this is a conservative approach – ie if anything I am overstating our heating energy use.

4 As noted earlier, my family tends to use the Tastics to provide light as well as heat (I do not like using the Tastics as the heat is much too fierce for my hairless head!); nevertheless, I have allocated all the energy used on the Tastics circuits over winter to heating.

5 You can find a detailed description of our FIR heating panel set-up in some of my earlier reports.[12]

Having dataloggers on our heating circuits now allows me to look at our heating energy use in some detail. **Figure 25** shows the heating energy use breakdown by hour of day across the whole of the heating season.

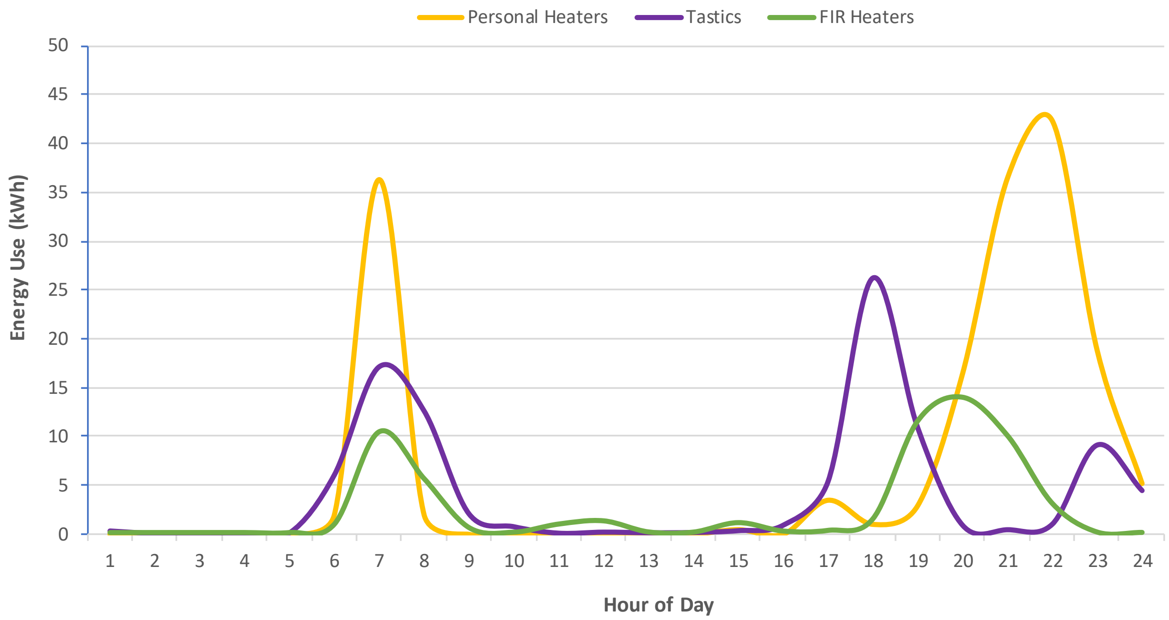

Figure 25: Heating energy use over winter 2018 for individual heater types

The energy use patterns paint an expected picture. There is a more or less coincident morning peak for all three circuits as the family gets up and readies for work/school. The evening pattern is somewhat different showing peaks first for the shower time (Tastics) and then for our family time (eating/TV, etc) (FIR) before the energy use moves to heating in the bedrooms/office.

It can be seen that we used virtually no heating during the day throughout winter. I am often at home during the day but I keep (very nicely) warm simply by using warm/heated clothing – I discuss this in the next section.

Further Work on Personal Heating Devices (PHDs)

In the opening part of the report I have already mentioned my fascination with applying the 'heat yourself: not your house' principle to keep warm inside a house. Keeping warm in this way demonstrably uses much less energy: subjectively I feel much warmer when heating myself directly with either radiant or conducted heat rather than indirectly via warm air.

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[12] *An Assessment of Far Infrared (FIR) Heating Panels*. Dave Southgate. Oct 2016: https://sway.office.com/CjnI8NPUyibAyBHY?ref=Link&loc=play

Against this background, in all my reports on this this topic I have always attempted to emphasise that my efforts relating to personal heating are very much a work in progress. My search for a suite of effective PHDs continues.

My Heated Hoodie

At the beginning of 2018 my thoughts were very much focussed on identifying heated clothing that would effectively keep a person warm in a cold house.

I had initially moved into the heated clothing field in 2017 when I bought a heated vest designed for bush walking/skiing, etc. This did not work out as an indoor garment and I reported on this in one of my earlier papers.[13]

Searches for 'heated clothing' in Google brought up myriad of options – generally heated clothes for outside workers; motorcyclists; and participants in outdoor recreation. As far as I can tell these all work extremely well for the purpose for which they are designed but, as my 2017 experience demonstrated, they are unlikely to really work indoors: too heavy; too bulky; harsh abrasion resistant material; short battery life, etc.

Despite the rather unpromising options I had managed to find, I was on the point of going to shops to try out some workmen's heated clothing when I came across a garment that appeared to be just what I was looking for – a soft heated hoodie with heating panels for both the front and back.[14] This seemed to tick all my boxes: nice soft material that I could easily wear like a jumper at home; long sleeves and all-round heating of the body (relates to the shortcomings of my first heated jacket). I bought one and it is brilliant!! One of the most exciting steps in our energy transition! Beautiful heat using less than 10W! I show a photo of the inside of the garment in **Figure 26**.

Figure 26: My wonderful heated hoodie

Some thoughts/observations. The hoodie is beautiful to wear indoors – it is lovely and soft and being fully zipped it is very easy to get on and off. It has three heat settings and for most of the time over winter it was warm enough on the lowest setting. I did not really use the highest setting. To get the best heating effect I think the heating pads need to be as close as possible to the skin – however, I've seen quite a few comments that the pads should not be in direct contact with the

[13] *Heat Yourself: Not Your House*. Dave Southgate. October 2017: https://fossilfuelfreedom.com/2017/10/05/our-warm-low-energy-winter/

[14] *Evolve Heated Hoodie*: https://www.zarkie.com.au/product/evolve-heated-hoodie-grey/

skin. I wore a thin thermal vest next to my skin and then put the hoodie over this as the next layer. I generally followed this up with a thick warm fluffy layer – my onesie or dressing gown – which seemed to keep the heat in. This thermal sandwich gave a beautiful heating effect which kept my whole body warm (particularly when wearing thermal leggings) in rooms where the air temperature was around 10-12°C.

Another thing I really like about the garment is the battery set-up. It uses a generic USB power bank which is exactly the same as those commonly used for powering mobile phones and similar devices. This means charging is really simple and very flexible (my other heated jacket has its own unique charger and battery which can make life much more difficult). Once fully charged the battery would generally last for two full evenings (say around 8 hours).

While the subjective assessment is all thumbs up, the game changer is the energy use. Conventionally a person may use 1,000W or 2,000W to keep themselves warm using a blow heater. My hoodie has a maximum power draw of 10W when on the highest setting. The mid setting uses about 7.5W, while the low setting uses about 5W. The power bank I've been using (this easily fits into a special pocket in the garment) has a capacity of around 40Wh. This all sounds too good to be true but I've yet to find the catch – why do people insist on using so much energy to keep warm?

While the heated hoodie is perfect for me, and I don't intend to look for anything further (though I would possibly be interested in trying out companion heated leggings), I could not persuade the rest of my family to wear something similar. I am therefore continuing to look for other low energy personal heating options.

Low energy blow heaters

Throughout 2018 I kept searching in vain for low energy FIR panels. I wanted to buy a small size panel that would run at about 200W. Maybe I will come across one in the future, but at the end of the year I cast my net wider.

I stumbled across some low power fan heaters for personal use which may work out. As an experiment I bought a small 50W blow heater – see **Figure 27.**[15] I am not a great fan of using blow heaters for room heating but maybe they work OK for personal heating? After all, we've been using personal fans for cooling over the summer with a fair bit of success. My plan is to try and replace the 400W FIR panel in front of my wife's desk with the 50W blow heater – her initial reaction to a very cursory test was quite positive! I'll report back next year!

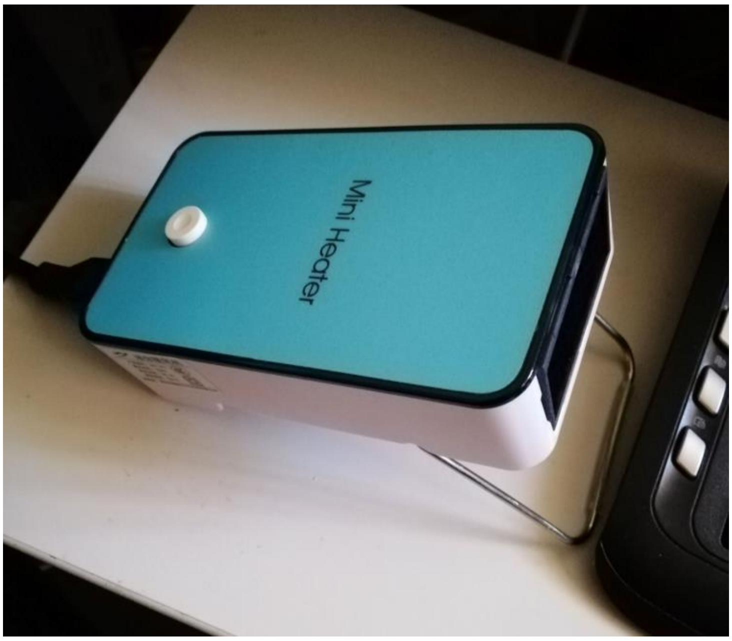

Figure 27: My experimental 50W personal blow heater

[15] *Portable Mini Handheld Electric Winter Heater Desktop Air Fan Warmer – Blue*: https://www.banggood.com/Portable-Mini-Handheld-Electric-Winter-Heater-Desktop-Air-Fan-Warmer-p-1121096.html?rmmds=search&ID=225&cur_warehouse=CN

You can gauge the size of the mini blow heater by looking at **Figure 28** (the heater is circled).

I have located other personal blow heaters with a power draw around the 200W mark. I may also try to get one of these to test over winter.

Figure 28: Photo giving an indication of the size of the 50W heater

Personal Cooling

While this is primarily a chapter about heating, I have decided to add this section on cooling since it is consistent with my interest in personal, rather than space, heating/cooling.

As I have written *ad nauseam*, in my view using the air that we breath to heat/cool people in a building via space heating is bound with problems: it is very wasteful since large volumes of air have to be treated; to be effective gaps need to be sealed and the fabric of the building insulated; sealing gaps can lead to poor indoor air quality; the diffuse nature of convection heating is not satisfying for many people; and moving air around can carry irritants, allergens, etc.

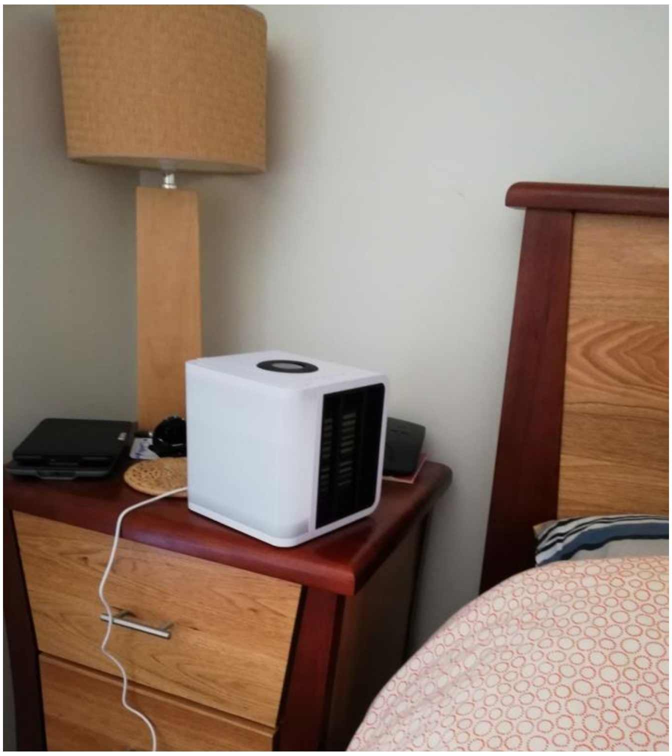

Figure 29: Our USB evaporative cooler

While I have now convinced myself that personal heating via radiation (FIR panels) and conduction (heated clothing) is both extremely comfortable and energy efficient, I am not so advanced with my thinking on personal cooling. Having said that, I am happy to concede that personal heating is much easier to achieve than personal cooling.

Over the years I have purchased quite a number of items designed to keep an individual cool – these have primarily been designed to keep someone cool when outside in Australia's searing summers. I have found *Personal Cooling Products* a good source of such devices.[16] On very hot days, when the temperature inside our house is over 30°C, I will often wear a wet neck tie to help me keep cool.

Our normal active devices for keeping us cool are fans. We have quite a number of these around our house and we simply move them around as/when required. The large ones typically draw around 40W; by way of contrast both my wife and son use small USB fans (10W) to good effect when they are sitting at their computers. At the end of 2018, I decided to test out a USB evaporative cooler (10W) that I fell across one day on the internet.[17] This is shown in **Figure 29**.

I must admit that this device has surprised me – I guess I had very low expectations of such a low powered device. If you recognise its constraints, it is very effective. Being a USB device means that we can plug it into a normal 240V outlet or can use it anywhere in the house by plugging into a standard USB power bank. It has a somewhat subtle output as far as air volume/speed is concerned unless it is within a few cm of you (which is fine), but it is very cooling: when the relative humidity in a room is less than about 50% the cooler produces an output which is normally about 6°C cooler than the air in the rest of the room; if the humidity is around 75% the cooling effect drops to around 3°C. The relative humidity in our house in Canberra is generally less than 50%.

We moved the device around our house as required, over the 2018/19 summer, but it got most use sitting on the top of our bedside cabinet (this is shown in **Figure 29**) blowing a gentle stream of cool air across our heads as we slept (it has a variable speed fan which is very nice).

Overall, I can now see that personal cooling will work. However, at this stage it cannot match personal heating where you can take the heat with you wherever you go (via heated clothing).

I feel that I now have the 'bit between my teeth' as far as personal cooling is concerned and am seriously looking at testing a *Close Comfort* device over next summer – see **Figure 30** (I copied this image from the Close Comfort website).[18] The *Close Comfort* personal air conditioner is relatively high cost but it appears to offer serious (refrigerative) personal cooling at a power draw of less than 300W. While this device clearly has shortcomings, I see it as a great development – conventional air conditioners are simply way too energy intensive. The multiplicity of space cooling (as opposed to personal cooling) units now being installed in Australian homes is putting our electricity networks under enormous strain during summer.

Figure 30: The Close Comfort personal air conditioner

[16] *Personal Cooling Products*: http://www.personalcoolingproducts.com.au/

[17] *evaLIGHT USB personal air cooler*: https://www.kogan.com/au/buy/evapolar-usb-personal-air-cooler/

[18] *Close Comfort: Air conditioning reinvented*: https://www.closecomfort.com.au/

Chapter 5

2018 Consumption: Other

I my first Annual Report (2016) I included the table below in an attempt to capture the main electricity consuming devices in our house that haven't been monitored/reported on elsewhere in the book. I term these devices as being in the 'Other' category. Over the past two years we have made several purchases of electrical goods of some kind or other but none of these have significant power and/or energy draws and I don't think it is necessary to change the table at this time.

Figure 31 shows my estimates of the annual energy use of the key individual electricity consuming devices in our house which I have placed under the 'Other' category.

Device	Rated Power (kW)	Variable Power	Typical Use/Week (hours)	Notional Annual Energy Consumption (kWh)	Comments
Induction Top	7.4	Y	5	200	Usually use one/two 'elements'
Electric Oven	3.6	Y	4	200	
Electric Kettle	2.2	N	1	115	
Washing Machine	2.1	Y	6	25	
Iron	1.8	Y	1	15	
Tastics	1.1	N	1	60	
Microwave	0.8	Y	2	85	
Vacuum Cleaner	0.7	N	0.5	20	
TV – Plasma	0.4	N	30	600	
TV – LCD	0.1	N	5	25	
Desk Top Computer	0.1	N	40	200	
Fridge	0.1	Y	168	350	
Lights	0.006	N	40	150	Single globe = 6W

Figure 31: Notional annual energy use by the main 'Other' electrical devices in our house

The Figure only includes what I can identify as the major electricity users in our house. In addition to the items shown in the table we also have numerous low powered, or very occasional use, electrical devices in addition to our more recently purchased PHDs: mobile phones, router, toothbrushes, shavers, radios, laptops/tablets, clocks, cooling fans, etc.

The values shown in column 5 for the annual energy consumption can only be treated as very indicative ‘guesstimates’. Having said that, the total annual energy use in the ‘Other’ category for 2018 shown in **Figure 5** (which I computed by difference based on the energy use of the other end uses) = 2,223kWh. The total of the annual energy use for the individual items shown in column 5 in **Figure 31** = 2,045kWh. Therefore, overall I believe my energy guesstimates appear to be quite reasonable.

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Chapter 6

The Battery

We had our Tesla Powerwall 2 installed in the second week of September 2017, therefore 2018 was our first full calendar year with the battery. It was sitting on the wall of our garage simply minding its own business all year (see **Figure 32** – same photo as in last year's report). It did not fail, or need attention, in any way. It is one of those devices which you can install and forget if you like, though I of course continually monitored its progress and recorded its state of charge at the beginning of every day throughout the year.

Figure 32: The Tesla Powerwall 2 sitting on the wall in our garage

In broad terms the battery performed very much as I expected. It was very happy, and essentially never ran out of charge, for about nine months of the year but it struggled for the other three. We simply do not have enough installed PV capacity to keep the battery charged on winter days. From my monitoring of our energy use and solar PV production over winter, I was aware the battery would run out of charge on most days over winter but my efforts to install more PV capacity before the arrival of the shorter/colder days did not work out (see my comments in the **Key Events** section at the start of the book).

On average, over the whole of 2018, we imported approximately 2 kWh/day from the grid. Approximately 33% of our electricity consumption for the year was provided by the battery. Over the seven 'good' battery months (summer, parts of spring & autumn) we drew 140kWh from the grid; over the most difficult winter period (May to Sept) we imported 510kWh from the grid (noting that we were away on holiday for the first three weeks in July).

Over 2018 we injected 2,620kWh into the battery (all solar PV electricity) and drew 2,270kWh from the battery. **This gives an overall charging efficiency of 87%.**

Figure 33 shows how the amount of energy drawn from the battery varied across the year. It is readily apparent that the battery works harder in the colder months (when our solar PV production is at its lowest).

Average energy drawn from battery in 2018 = 6.2 kWh/day

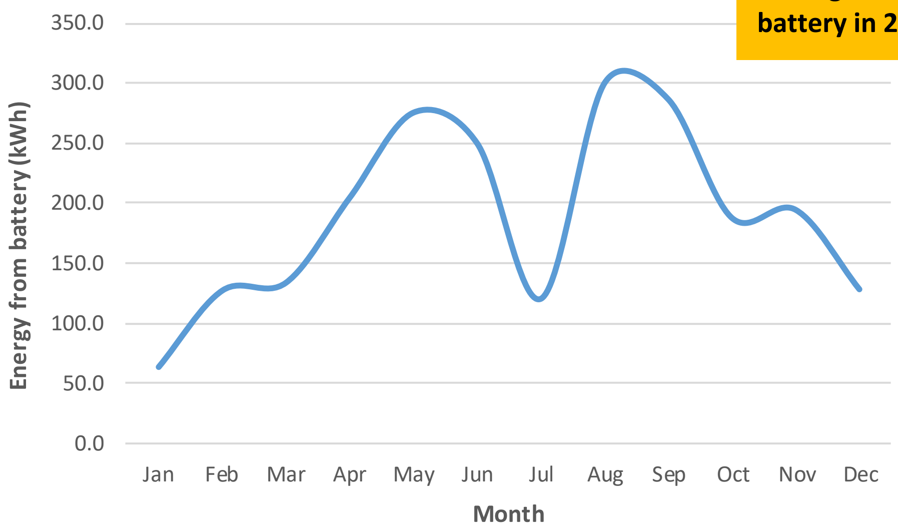

Figure 33: 2018 monthly variation in energy drawn from the battery

Figure 34 provides further insight by showing how the contributions to our total electricity consumption from the battery, direct solar PV and the grid varied across the year. This figure again highlights our lack of solar PV capacity over the winter months.

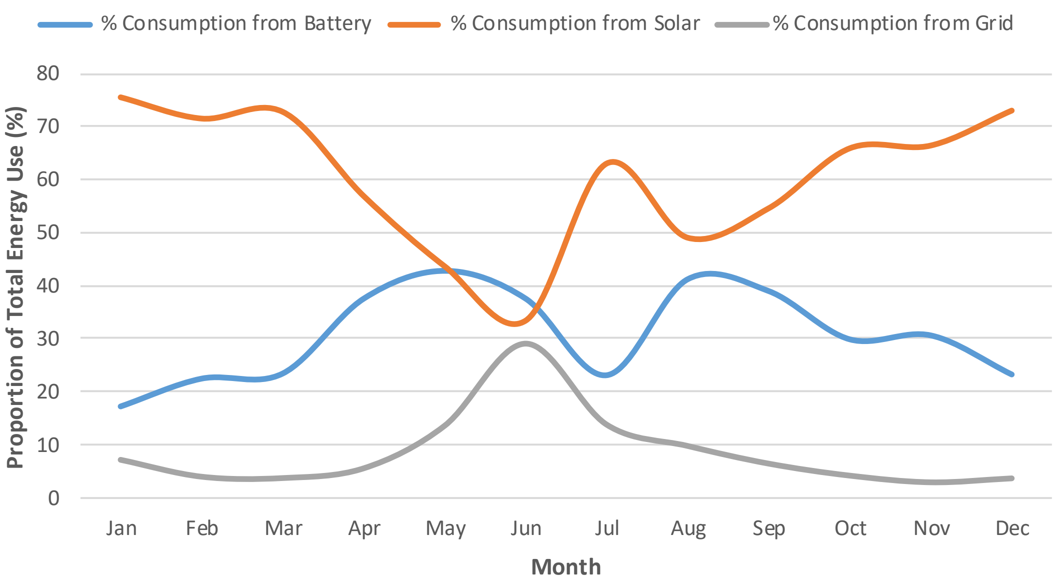

Figure 34: 2018 monthly variation in the components of total electricity consumption

Figure 35 provides another view of the lack of solar PV capacity in winter time. The orange line shows the amount of solar PV generated by our net FIT systems on a daily basis throughout the year (the output from our gross FIT system is not available to charge the battery). The blue vertical lines show those days when our battery was empty at the end of the day. In total our battery was flat on 65 occasions throughout the year; 57 of these days were in the May-Sep period. [As noted before we were away on holiday for most of July].

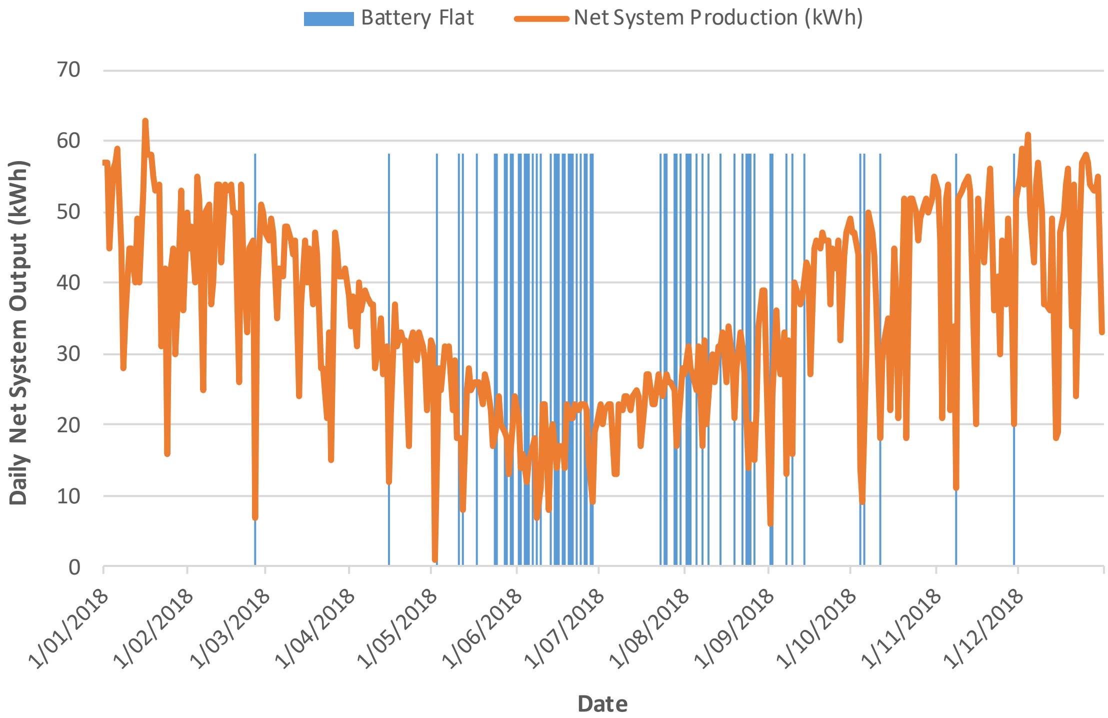

Figure 35: Graphic showing the relationship between daily solar PV generation and the Powerwall 2 being flat

Chapter 7

Energy Monitoring

As long as I can remember I've been fascinated by data. All my working life I was involved in gathering, interpreting and making decisions based on data. Not surprisingly, one of the great attractions of our energy transition has been the beautiful streams of data that are generated.

In the early part of the transition, my data gathering simply revolved around recording daily high level (and good quality) data such as that provided by our electricity meters and solar PV inverters. However, it wasn't long until I was looking for much more disaggregated data. In order to include even relatively basic analysis in my reports I needed to know how the energy consumption of individual devices/circuits in our house varied throughout the day/month/year. This 'data chase' became a core part of the project.

Over a period of about five years I purchased, and used, quite a number of monitoring devices. These ranged from the basic single socket type energy/power meters, through the more powerful Efergy monitoring system up to a commercial grade data logger.

Figure 36: My two Solar Analytics monitoring units

While all of these worked at some level, they were less than perfect: often they suffered from dubious accuracy; some relied on batteries; often I had to write down readings; with other systems I needed a qualified electrician to change CT clips from one circuit to another; more advanced systems used wifi but these were frequently temperamental; I was commonly measuring current and assuming constant voltage to derive power/energy; etc. This meant that much of the disaggregated information I was reporting was not particularly robust and I had to make a number of assumptions.

At the beginning of 2018 I concluded that I needed to take my monitoring to another level and I began to search out more robust hard wired energy monitoring systems. This led me to install a Solar Analytics (SA) energy monitoring system.[19] Overall, this system has been brilliant!! A wonderful step up from all my previous monitoring efforts.

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[19] Connect with your solar: https://www.solaranalytics.com/au/

You can find details on the system on the company's website but in essence it is a remote data monitoring and archiving service for which you have to pay a fee. At the moment I am paying $60/year for this service. This gives me acess to both real time and archived data – at any time I can download a detailed 5 min sample time datalog across all the nine circuits I am monitoring.

The system uses data logging units built by a Sydney based company Wattwatchers[20] – each unit allows monitoring on 6 circuits. These are shown in **Figure 36** The monitoring data is continuously being transferred to the SA servers in Sydney via a 3G datalink (no wifi required).

For a long time I had been resistant to this type of system because the data is being gathered and stored by a third party. What happens if the company goes bust? What happens if the third part computer system goes down at a critical time? In the end I relented and took the position that on balance the advantages of this type of system outweigh the disadvantages.

My thoughts on the Solar Analytics System

As I said a few paragraphs ago, overall this system has been brilliant for me. However, it is not perfect and the software in particular has quite a number of 'quirks'.

Hardware

The monitoring units shown in **Figure 36** have been rock solid. Over the nine months the system has been in place I have not been aware of any outages or lost data. The accuracy cross checks I have been able to make have given me great confidence in the robustness of the readings – such a wonderful feeling after years of pussyfooting around with marginal data.

Being able to permanently datalog twelve circuits means that I no longer need to keep moving monitors and/or CT clamps between different circuits. I now no longer need to do sample monitoring. Everything just looks after itself – I have no need to interfere in any way in the data gathering process. Such a contrast to the days when I had to keep an ever watchful eye on batteries, memory banks; and failing wifi networks.

Software

At one level the user interface for accessing the data is very nice. A sample screenshot of the key real-time consumption page is shown in **Figure 37**.

The user can track, in more or less real-time, power draw in the top part of the chart. The bottom part shows a picture of aggregated energy use for time windows selected by the user. This is all very nice but, without going into great detail, there are limitations to this set up. For example, there are labelling constraints so that in the diagram: 'office' primarily relates to our standalone heaters; 'tenant' is measuring the energy used by our Tastics; while 'other' gives energy readings for our FIR panels. There are no graphics showing hourly energy use, which I find a bit strange as this is standard fare on all other data monitoring systems I've used.

That aside, I would describe the software shortcomings as idiosyncrasies rather than problems. It is very simple to download a detailed monitoring file at any time and it takes me very little effort to dump this into an MS Excel Pivot Table to get a real appreciation of our energy use patterns (this is a very quick process). It's just a bit more clunky than being able to do quick database queries and graphics via the internet user interface.

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[20] Wattwatchers: https://wattwatchers.com.au/

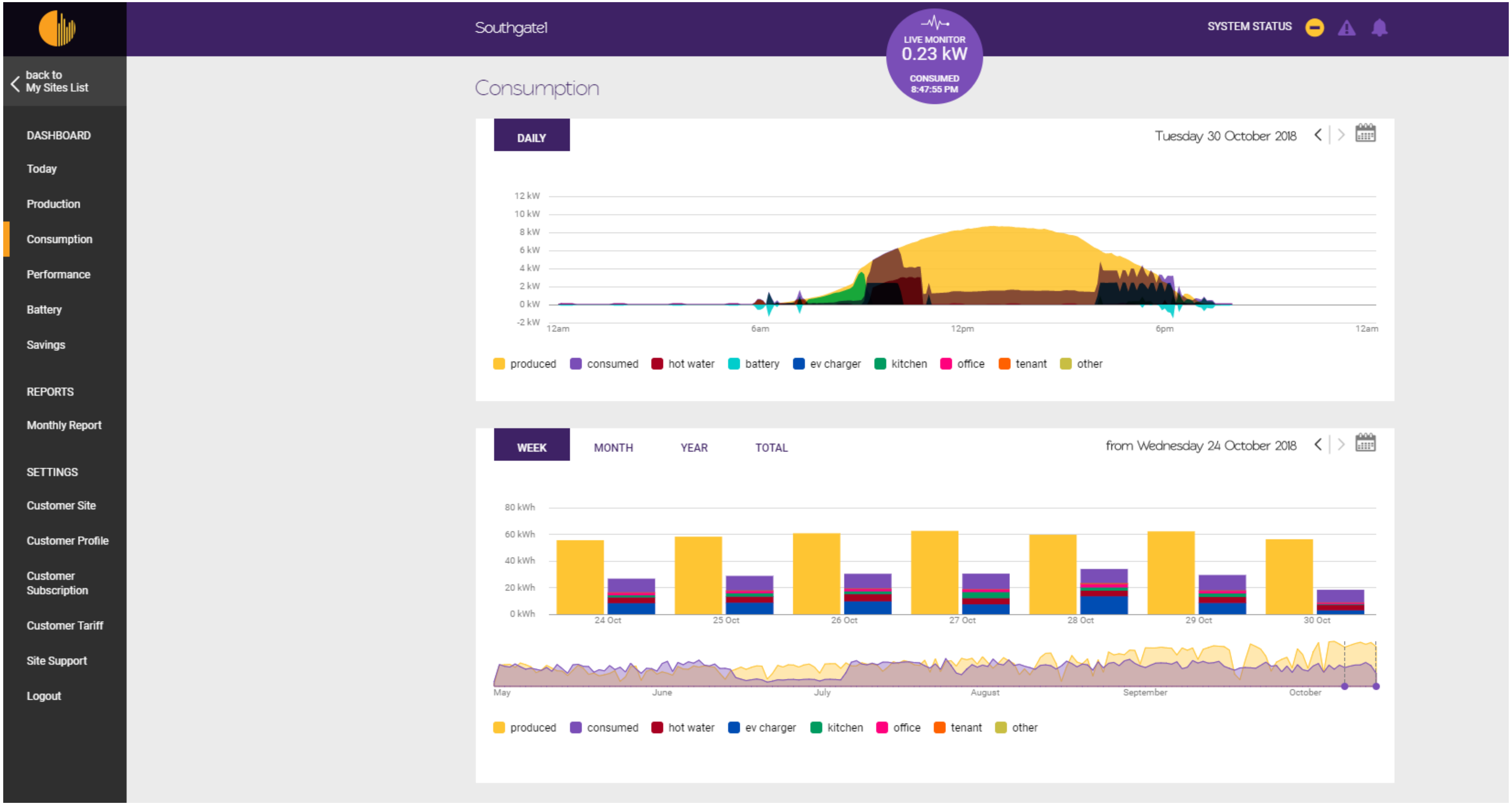

Figure 37: Screenshot of the Solar Analytics consumption reporting internet page

Chapter 8

Looking Ahead to 2019

Overall, I am not unhappy with how the project proceeded in 2018 – while there were real disappointments, we clearly had some big wins. As I have indicated in the earlier chapters, having the battery has been a game changer; and being able to get on top of our winter heating has also been a very exciting development. Having the new data monitoring system has been wonderful. Perversely, hitting the road blocks on adding additional solar PV capacity was not a total negative since this made me re-think some of my ideas and re-group on future action to increase our solar PV generation. I think I now have a way ahead for 2019.

While I am optimistic about our solar PV position, I'm nowhere near as confident about the transport component of our family carbon footprint. 2018 was a shocking year for EVs in Australia – the anticipated arrival of new generation 'affordable' EVs did not eventuate. Clearly, petrol is our family's carbon Achilles heel. The proportion of our carbon footprint attributable to petrol continues to grow; maybe 2019 will be the year when we can start making serious reductions in our family petrol use. Having said that, our children are now approaching the age where they may either own, or regularly borrow, cars – this could totally blow our petrol carbon footprint out of the water within the next few years.

Expanding our Solar PV Capacity

It has now been apparent at for at least the past two years that, even with the Powerwall, we have inadequate solar PV capacity to cope with winter in anything like a FFF state. In this report, and my Annual Report for 2017, I have discussed my efforts, and failures, to add additional solar PV capacity. However, in the last two months of 2018 an opening appeared which seems to offer a solution. As a result of this I have developed a three-stage strategy to expand our solar PV capacity.

Stage 1: *Changing our electricity retailer*

As I have described elsewhere, we have not been able to expand our solar PV system because our retailer (ActewAGL) will pay no FIT for any of our exported electricity if our generating capacity exceeds 10kW. Even if we went to 11kW we would lose about $650/year!! However, things have now changed. Right at the end of the year I discovered that *Energy Locals* now has an electricity retail licence for the ACT and, unlike ActewAGL, they appear to have no solar PV capacity limit. I have yet to resolve a few issues, but subject to everything working out, I plan to change over to *Energy Locals* so that we can expand our solar PV capacity.

Stage 2: *Going three-phase*

At present we have 10kW of solar PV capacity in our house which is operating single phase. Under the current rules of our electricity distributor (Evoenergy) we are allowed to have 30kW of solar PV capacity if we go three-phase. Consistent with this, I have been advised that in order to expand our solar PV system we will need to go three-phase. While this creates a few issues, I don't see these as problems. As I noted in **Chapter 3**, I am changing our energy diverter over to the Eddi so that I will have three-phase capability for our hot water heating if I need it (this may not be necessary as I think I may be able to get away with the Eddi sensing only one phase). Apart from my energy diverter I don't foresee having to change any other equipment. At this stage I'm not sure whether I will need to install a three-phase inverter to manage any new additional solar PV capacity.

Stage 3: *Maxing out the solar PV on our roof*

Whenever I look at the sun streaming down on the unoccupied areas of our roof, I see a missed opportunity – in effect we are simply pouring solar energy down the drain when we could so easily capture and use it. Ideally, I would like to see our roof achieving its solar potential. At the moment we have approximately forty solar PV panels on our roof. I would guess that we have space for at least another 4kW of panels – some of these may need to be installed on a south facing roof. Anyway, the plan is to get quotes for maxing out the roof and see where this takes us.

Attacking our transport carbon footprint

Even casual observation of the data in this report shows that transport is primarily the area where we are failing to become fossil fuel free. In many ways I feel like our family is a microcosm of the ACT (Australian Capital Territory) – we mainly have our electricity consumption under control from a carbon perspective, but we are simply thrashing around when it comes to managing the carbon footprint of our family transport. Like many Canberra residents I know, we are just itching to get hold of a new generation EV – until this happens, I think we will simply be in a holding pattern. That said, there are a few areas where I think I can now do work that will help to lay some foundations for the advent of low carbon transport both in our family and across the ACT.

Buying a new EV

There is little new I can say on this topic. Despite a lot of promises it has been several years since we have seen affordable latest generation EVs for sale in Australia. We could have some debate around this (eg Is the Renault Zoe a 'latest generation' EV? Is the BMW i3 'affordable'?) but in my view there hasn't been a great deal of advancement since the introduction of the Mitsubishi i-MiEV and the Nissan Leaf about five years ago.

The promise is certainly there for new EVs to appear in 2019 – the Hyundai Ioniq and Kona; the new Nissan Leaf; and the Kia Niro EV are the four new EVs that seem to be getting the most attention. If the new Nissan Leaf had been available in early 2018 (the time I was initially told it would be available) I would probably have bought the 40kWh version of the car, but I believe this model of the Leaf has now been overtaken by events and I have essentially lost interest. I think I now need to go for an EV with a 60kWh battery. At present, the Kia Niro is my favourite of the crop mentioned but as yet we have no details around price; delivery date; etc so the situation could well change.

Having an EV with a 60kWh battery would give us greater opportunity to avoid charging with grid electricity at home (albeit that over 90% of our EV energy came from our solar PV system in 2018). For example, with the larger battery capacity of a new EV, it is likely that I would not need to charge the car each day and could avoid charging it from the grid when we have a very cloudy day in winter. We could also most likely be able to use the 'long range' EV on trips that we now use our ICE car for. I can see it being quite feasible for us to do day trips to Sydney and to the coast provided there are fast chargers in place at key locations.

Enhanced monitoring of our petrol car

To date I have not closely monitored the petrol use in our Hyundai i30 – I have focussed my efforts on closely following our energy use in our EV. However, I am now at the stage where I feel I need to get a better handle on our petrol usage since this is clearly our major problem area as far as our carbon footprint is concerned. It would be nice to better understand which trips are using up the petrol – is it the work/school run; how important are our occasional day trips to Sydney/Batemans Bay? Having said that, I cannot see us being able to make any serious reductions in our petrol use until we get a new, 'long range', EV and can start substituting the petrol car on our 'regional' trips.

This is a priority for 2019.

Electric Bikes

We bought an electric bike in 2014 which my wife uses to commute to/from work when our children are on holiday (**Figure 38)**. Over the years this has displaced quite a number of fossil fuel based car trips and has vacated a car parking spot in Canberra on many days. It would be great if electric bikes had a greater uptake. In Canberra, of course, we have a wonderful bike path system which means in most areas you can travel from the suburbs to the work centres on an e-bike without mixing it with the traffic (we have a bike path right outside our house). I always try to promote the use of e-bikes for commuting whenever I can.

Figure 38: My wife's electric bike

E-bikes are not only good for commuting. Canberra has a great culture of bike riding for recreation, fitness and socialising. I have been a cycling enthusiast most of my adult life and have been involved in many aspects of the activity over that time (eg commuting, bicycle touring, mountain biking and triathlons). I am hoping that 2019 will be the year that I make my next cycling move – I plan to buy a lightweight, 'just enough', electric bike. Conventional e-bikes have big batteries and are heavy (my wife's bike weighs about 26kg) – they are essentially designed to transport the rider without them having to make any effort or generate a sweat. Lightweight e-bikes on the other hand (some of the bikes in this new breed weigh around 11kg) have small batteries which are there, more or less, as a back-up; these are aimed at the 'exercise' cyclist. The idea is that the rider gets their usual workout but has some e-power in reserve if needed (eg they are slowing up their riding group; they get injured or tired; etc). I think this type of e-bike has enormous potential to keep ageing riders active for much longer – again hopefully in the end more bike use and less car use. The Orbea Gain is probably the lightweight e-bike that is attracting the most attention in Australia.[21]

Australian Electric Vehicle Association (AEVA)

At the end of 2018 I became involved in the local branch of AEVA. I guess my main motivation was to try and get involved in some sort of government EV lobbying activity. Like many, probably most, EV owners the glacial level of EV adoption in Australia, and the apparent lack of government interest in promoting EVs, has become a particularly frustrating issue. I plan on doing whatever I can in 2019 to work through AEVA (and independently) to promote EVs. This year, as it is a Federal Election year, will be particularly important.

[21] Gain Road. Orbea: https://www.orbea.com/au-en/ebikes/road/gain-road

Other Actions

Personal heating/cooling

I remain passionate about personal heating and cooling. To me this is the future for so many reasons and I fully intend to keep looking to buy and test new products and also to promote this form or heating/cooling over space heating/cooling whenever I can.

Politics

2019 is a Federal Election Year and I will endeavour to be active in promoting EVs, personal heating/cooling, renewable energy, etc as best I can so that we maximise our chances of having governments (both Federal and State/Territory) that recognise climate change imperatives and are committed to action.