Household Electricity Use in Australia – More Heat Than Light?

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Summary
This essay reviews the current state of the "electricity supply debate" in Australia. It looks at the sources and trends of electricity supply, the present way it is used domestically and the measures that can be taken to reduce household power bills. It concludes that although individual households can reduce their power bills significantly (perhaps 80% or more), the difficulty remains in paying for the electricity distribution system – the "poles and wires" – and its administration. Even with increasing use of renewable sources it is unlikely that power bills will reduce to less than 50% of their present levels and these costs are most likely to be spread across all households, similar to water rates.

Skyrockets in sight?
Domestic electricity (power) costs have become a major public issue in Australia. Political parties have blamed each other for "skyrocketing power costs", promises of "alleviating" these costs by "up to $500 per year" have been made and there is even a Federal Minister whose sub-title is "The Minister for getting power costs down" with "big stick" legislation being introduced by this Minister.

As Fig. 1 shows, power prices did "skyrocket" from about 2006 until 2013 – prices more than doubled on average across the Eastern States grid (the NEM). Prices (on average) were quite stable for about 4 years after 2013 years, but from 2017 they have continued on a predictable upwards trajectory.

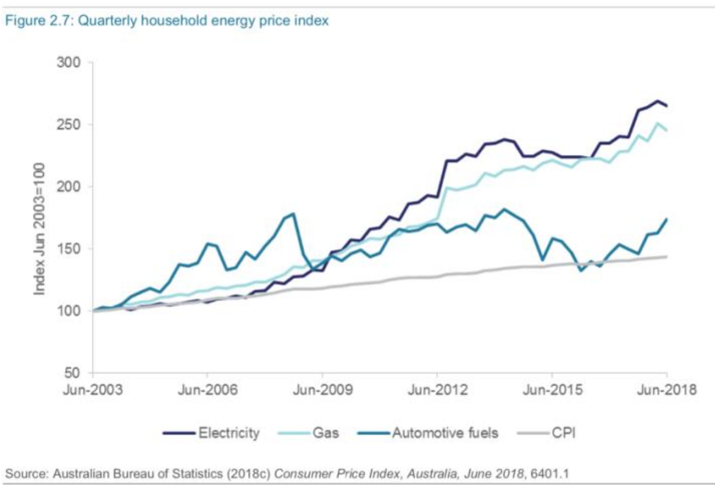


Fig. 1: Australian household energy price index 2001-2018[1].

The average NEM household electricity cost in 2019 is about $1,500-$1,600 for about 6,000 kWh – that's about 25 cents/kWh, on average. Of course, there is considerable variation around this average, depending on the number of occupants (about 3,500 kWh for one occupant plus 1,200 kWh per extra occupant), the local climate, the general usage of appliances and importantly, the availability of gas (which reduces electricity demand for heating (particularly in Victoria). For the purposes of this paper, we will assume a household of three people and some gas, giving about 6,000 kWh and a bill of about $1,500/year. This is about average for Sydney.

Did those historic price increases cause a kind of political PTSD? Or has it been the profusion of power suppliers (oddly, all using the same poles and wires). Or has it been "conventional" power generators (mainly coal-powered) creating a climate of fear over the increasing competition from "renewables" (wind and solar)? Or all of the above?
The good news, though, is that all of the (considered) predictions of future prices do not suggest further "skyrocketing".

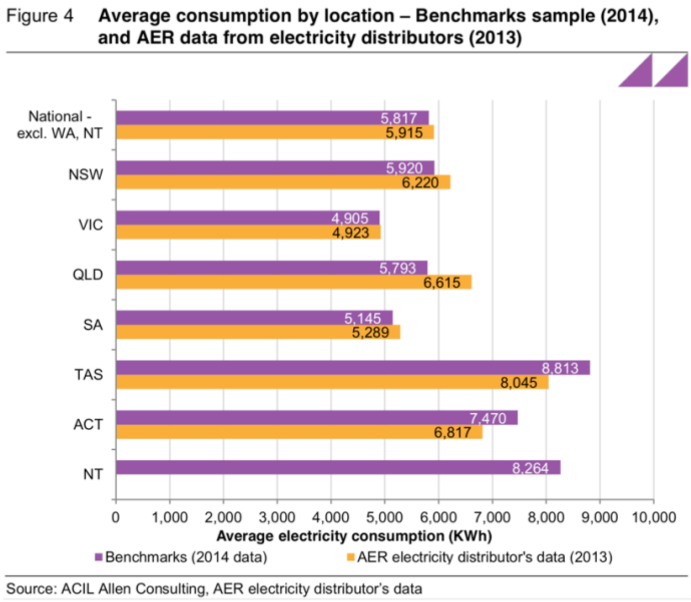


Fig. 2: Average electricity consumption by State2.

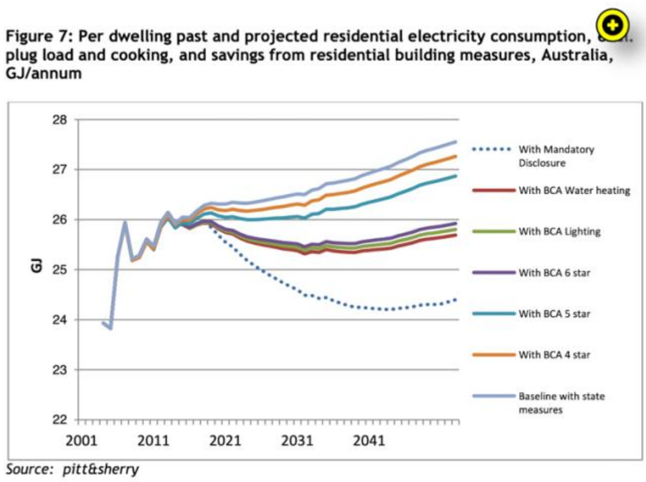


Fig. 3: Per-dwelling electricity consumption estimates to 2050 under various scenarios.

Are power costs significant?
So, we can agree that power prices have increased a lot in the past two decades – but so what? Are power costs really a significant issue in the average household? Not really. Fig. 4 shows the top sources of expenditure in the average household, according to the ABS (6530.0). Electricity and gas (combined) rank #12 – well behind housing, food and transport and even low in the cluster of medical, communication (equivalent to Foxtel plus two streaming services), education, clothing and superannuation – and about the same as combined alcohol and tobacco. At the same time, the average family income (after tax) in Australia, according to the ABS, is now about $50,000 per year (about $1,000/week). Electricity and gas costs therefore comprise about 4% of the average family income. Again, these are averages, but it is averages that make for general policies.

Fig. 4: Household spending priorities
(from the ABC website[3], based on ABS data)

Of course, not everybody is "average" and although there is probably some positive correlation between income and power consumption, there are undoubtedly some below-average households consuming above-average amounts of power. But, to some extent, Governments – both Federal and State – already have a range of schemes to significantly mitigate the power costs of low-income households. Payments of up to about $600/year are available from various levels of Government for low-income households. For a range of reasons, some people fall through these "safety nets" – but not enough to create the perennial hullabaloo over power costs.

If power prices aren't increasing dramatically, can we reduce them – and is it worth the effort? The answers are yes – and yes. But – the amount that the price can be reduced may be proportionally less than the corresponding environmental improvements. The following will explain both the financial and the environmental issues.

Environmental issues
First – a quick look at the environmental issues, to which we will return later. Fig. 5 shows that *more than one-third of greenhouse emissions in Australia come from electricity generation* and

Fig.6 shows that about a quarter of the electricity is used in residences. In round figures, about 10% of our greenhouse gas emissions come about from the use of electricity at home. This can readily be reduced to about 2%.

The cost issues are more complex, but let's have a look at where those costs arise in the system and how we might reduce them by our own actions.

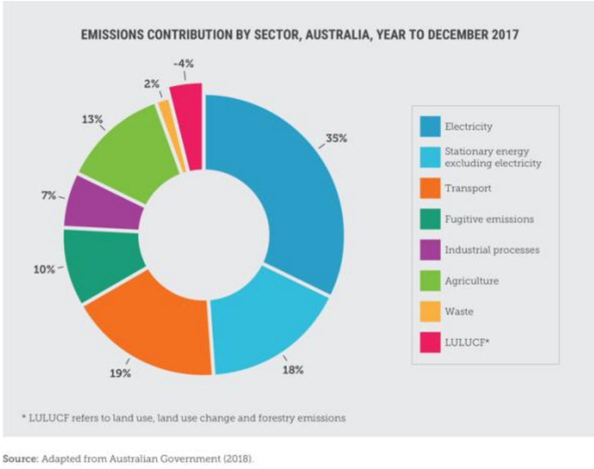


Fig. 5: Australian greenhouse gas emissions by sector, 2017[4].

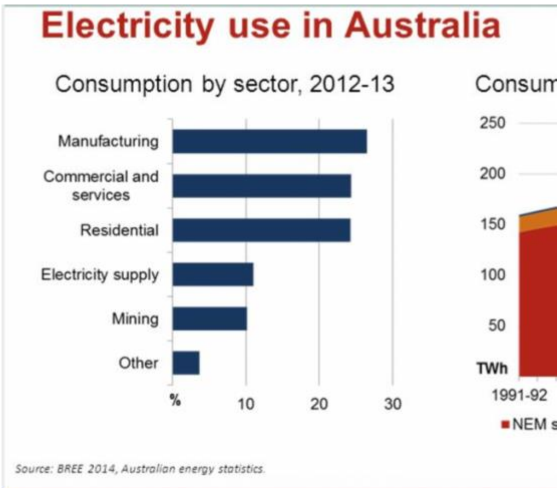


Fig. 6: Electricity use in Australia, by sector, 2012-13

First, let's look at how these costs arise. Fig. 7, provided by the ACCC ("What makes up your power bill"), shows a typical breakdown of the major cost components. Contrary to much of the acrimonious debate between "fossil-fuel" and "renewables" proponents, Fig.7 shows that only about 20% of the cost of electricity generated by the NEM is due to the power stations – about 80% of which are coal and gas (most of the "renewables" at this stage are hydroelectricity). This means that even if the source of electricity was free, the average power bill would only be reduced by about $300. Although there is no free source, what are the prospects of this component of the cost being changed significantly in the near future? Not much, I'm afraid.

The ACCC's preliminary findings are that, on average across the NEM, a 2015-16 residential bill was $1,524 (excluding GST). This average residential bill was made up of:

- **network costs (48 per cent)**
- **wholesale costs (22 per cent)**
- **environmental costs (7 per cent)**
- **retail and other costs (16 per cent)**
- **retail margins (8 per cent).**

In real terms, average residential bills increased by around 30 per cent (on a dollars per customer basis) between 2007-08 and 2015-16. Average residential prices (as measured by cents per kWh measure) have increased by 47 per cent in real terms during the same period.

After considering wholesale price increases in 2016-17, the ACCC estimates that average bills in dollars per customer increased in real terms by 44 per cent since 2007-08, while prices in cents per kWh have increased in real terms by 63 per cent.

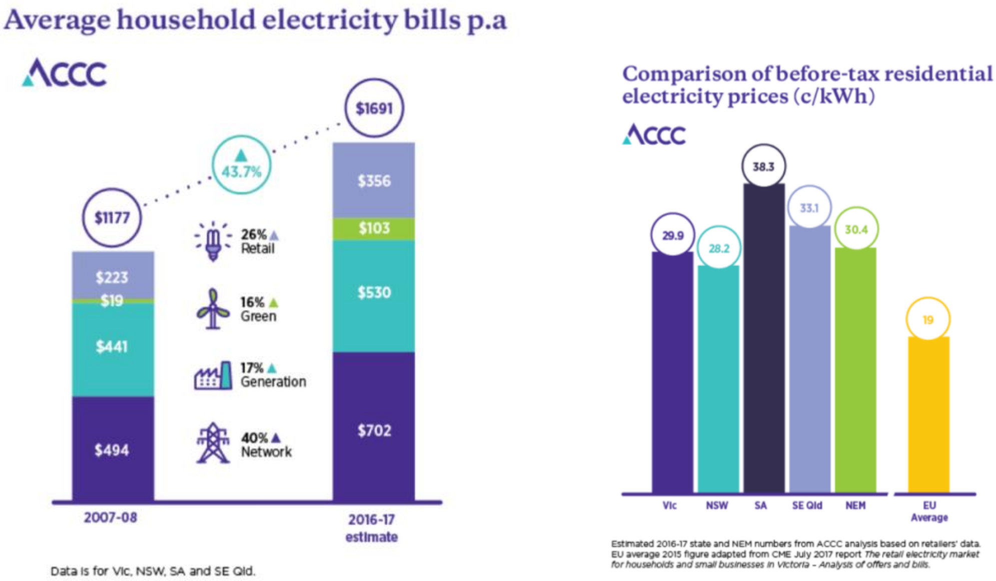
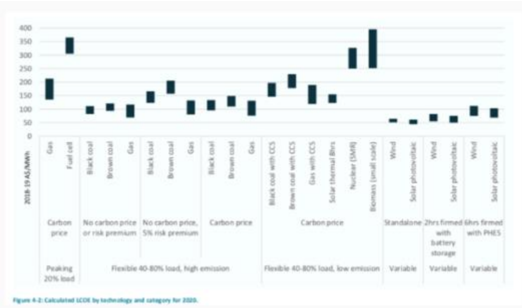
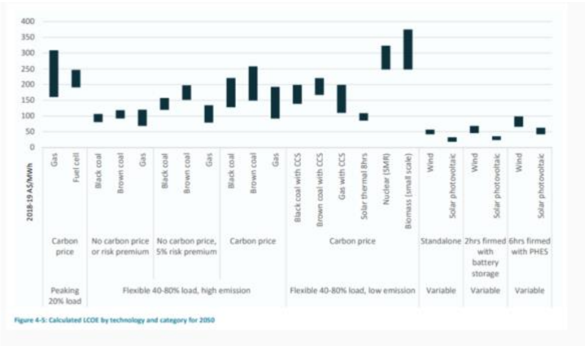


Fig. 7: The major cost components of supplying electricity in Australia and per kWh prices in NEM States (From ACCC)5.

As Fig 8, from ARENA show, most of the sources of power (from new carbon-based systems without a carbon-abatement price) presently have costs around $100/MWh – that is, whether it's black or brown coal or gas. Note that the present- mainly antiquated coal-fired systems are priced at about $50-$75/MWh. At present, wind and solar PV prices are about the same. Fig. 9, also from ARENA, guesses at the prices for 2050, which puts the carbon-based prices at about $150/MWh and wind and PV at about $50/MWh. So, depending on the uptake of renewables, the price may vary by plus or minus $150 of that $300 component of the $1,500 bill. I'll return to the renewables issue later.





Figs 8 & 9: Present and estimated 2050 electricity generation cost per Mwh (From ARENA[6])

What about the other 75-80% of the costs? What sticks out in Fig. 7 is the almost 50% for “poles and wires”– ranging from the giant steel pylons striding across the landscape (the “transmission system”) , to the wooden power-poles in your street – or, if you’re lucky, the underground power lines that are now common in new suburbs and are slowly replacing above-ground in older suburbs (the “distribution system”). Under grounding certainly adds to the cost in the short-term - about $10,000 per household, but the benefits are estimated[7] to outweigh the costs by about 2.5/1.

Poles and wires, we are told[8], are the principal cause of the major increases from 2005 to 2013.What seems to have happened is that the Australian Energy Regulator[9] – who determines allowable price increases for these somewhat monopolistic suppliers (both State and private), agreed to price increases on a “cost-plus” basis. There wasn’t much scope for costs to increase at the generation end, so vast amounts were spent on the poles and wires to “future-proof” them. “Gold-plating” it was called – whatever the power companies spent on poles and wires, the EPR would allow an extra percentage to be added. Anybody who has allowed their house renovations to be done on a cost-plus basis knows what a mistake this usually is. But what is done is done and we hope that the “gold-plated” poles and wires don’t corrode or fall over any time soon and allow the normal processes of depreciation reduce this component of the cost over time.

Then there’s the 26% (on average) of “Electricity company costs”. This combines the costs of marketing, advertising and general administration of getting the power from the generator to your meter and reading the meter (but not, I think, the administration cost of running the generators). This is where there seems to be some flexibility, as there are benefits from scale in this labour-intensive cost-component. But, again, there is not huge amounts of fat in the system – administration costs can reduced by general efficiency improvements (like monthly average billing and combined billing with gas) and automation, but not quickly – probably 1%/year (of the 26%) on average. Although some people have found discounts by shopping around, they have generally come from the removal of discounts to other users, thereby maintaining the average in a zero-sum game.

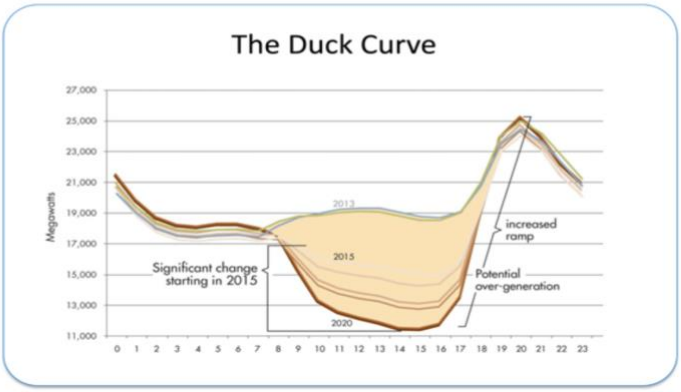
Lastly, what about that 16% “Environmental costs”? these are the costs that the Government imposes on the power companies in order to meet the “Greenhouse gas abatement targets” or “Renewable Energy Targets” (RET). There is much contention over this, and the subsidies given to households and companies that install solar, wind or conservation measures, with the main claim that the households that don’t use renewables are paying for those that do[10]. Strictly speaking, this is true – but the same can be said of almost every Government program. For example, the Federal Government subsidises private health cover by 30% for the 45% of Australians who have it; private schools get public funds, both per-student and capital grants, partly paid for by the taxes of parents of students at public schools and partly by taxpayers who don't have children at school or at all and by taxpayers who were, or intend to be educated overseas. The same can be said for pretty well any government program- the disbursements are uneven to reflect the needs of the particular group of recipients. That's what governments do. In this case, the tax is to encourage the uptake of renewables to abate greenhouse gases.

"In total, environmental schemes comprised about 6 percent or $106 per annum of an average customer bill in the NEM in 2017-18, although this percentage varies from 4-10 per cent across NEM jurisdictions. According to the ACCC, these costs have increased from about 2 per cent of the overall customer bill in 2007-08, driven by a range of factors including the rapid uptake of rooftop solar PV and associated increases in the cost of the SRES. Note that these figures also include the cost of the large-scale renewable energy target (LRET) and state based energy efficiency schemes, so are not reflective of costs related to rooftop solar PV alone. We therefore conclude that there is no reliable evidence of a net cost to non-solar households from the SRES." (Ref. 9)

Can we reduce our bills?

Are there other ways of reducing power bills? Certainly. There are four main ways – time-of-use, conservation measures, storage and solar.

Time of use: All States have optional tariff structures that reflect the time at which the electricity is used. These tariffs reflect the fact that if demand is smoothed over the day and week, then less generating infrastructure and fuel are needed. For example, if extra generating capacity is needed for a few hours each day – (usually breakfast time and early evening in winter and late evening in summer in NSW). These time-of-use curves are changing rapidly with changes in technology and the introduction of renewables. The shift to LED lighting and more energy efficient TVs and other devices are reducing evening demand, but increases in air-conditioner use is increasing demand late at night. A downside of time-of-use tariffs is that, while there are significant savings if electricity is used "off-peak" there are usually large penalties for using electricity "on-peak". Fig. 10 shows a typical "Duck Curve" of time-of-day use of electricity across a city.



(image courtesy of Green Tech Media)

Fig. 10: The "Duck curve" – the electricity demand across the time of day.

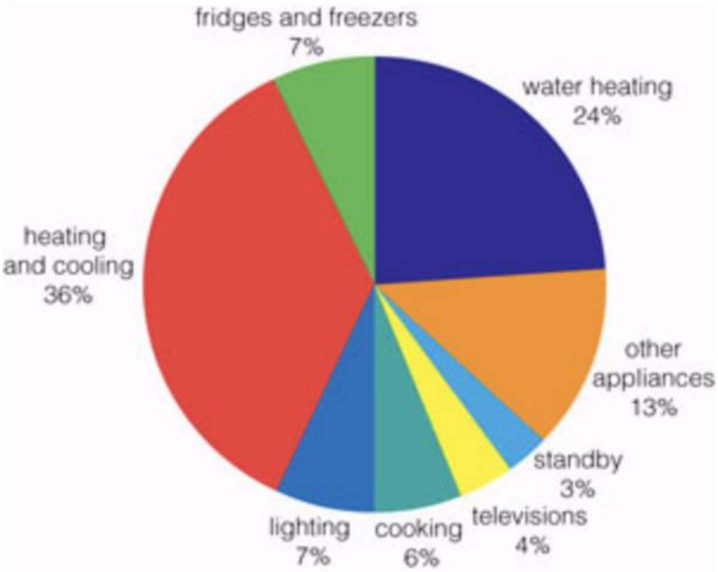


Fig 11: The various uses and proportions of electricity in a typical Australian dwelling.

***Conservation* :** Sometimes called "nega-watts", energy conservation can be a greater power and cost-saver than any other measure. While the proportion and amount of power used for various purposes varies from household-to-household and from region-to-region, Fig. 11 is a reasonable average example. It can be seen that the "big two" energy uses are "heating and cooling" (36%) and "water heating" (24%). Heating and cooling can be combined if one uses a reverse- cycle air-conditioner – ducted, window-mounted or "split'. These are now the most cost-effective as they "multiply" the amount of electrical energy by about 3 for cooling and 4 for heating, thereby making the cost of a unit of energy between 10 and 6 cents/kwh. While there is no economic substitute for cooling by RC air conditioner in most regions (evaporative is now expensive to install as it needs ducting), RCAC heating can replace gas and radiant heating cost-effectively. However, the use of air-conditioning is likely to continue to increase with increasing climate extremes and an ageing demographic seeking greater comfort for their increased hours at home. Cooling costs can be reduced by switching on the AC during the day if the dwelling has a high thermal mass to store the "coolth".

Insulation: High levels of ceiling insulation are now mandatory in Australia and following the "pink batts initiative" of the Rudd government in 2008-9, practically all Australian dwelling have some level of ceiling insulation, although very few have wall insulation.

Water heating: is at present about evenly split between gas and electricity in Australia with electric water heating declining. The increased use of PVs can be used to good effect with electric water heaters by using a switch/timer to coincide heating with daytime sunshine.

Lighting: is generally stated as requiring about 7% of domestic electricity. This needs review, as most houses are now mainly LED lighting, which are about 5-6 times more efficient than incandescent globes but only a bit more efficient than fluorescent tubes. (Check: 7% = 400kWh/yr = 1kWh/day = 100hrs @10w/globe = 10hrs/day x 10globes! Suggest 2% max).

This means other appliances together use about 5% more than estimated. "Halogen downlights", which became popular late last century, are, in fact, just incandescent lights that are only marginally more efficient than incandescent "Edison bulbs" and should be replaced wherever possible.

Televisions: TVs are becoming more energy efficient with the shift from early-century plasma to LED and LCD screens. A typical 2004 model 42-inch plasma was rated at almost 500W – a 2019 model 43-inch LED is rated at about 100W. However, many consumers are now opting for much larger screens – 65-inch and 75-inch are now becoming the norm, with power ratings of about 150W and 220W, respectively, thereby conceding some (up to half) of the energy efficiency gains.

Fridges: There have been significant gains in energy efficiency of fridges in the past 20 years– estimated at 40% improvement on a per-volume basis. This is often offset by increases in fridge volumes of new purchases.

A note on energy conservation: Although there have been very significant improvements in the energy efficiency of domestic appliances and building envelopes in the past 20 years, this has hardly shown up in the overall per-dwelling energy demand. Why is this so? The most likely answer is that householders are accustomed to a certain level of power costs and will make new purchases which offer greater amenity if they fit within their *expected* expenditure. This is a version of what is called "Jevons coal paradox". For example, decreased power demand per light fitting has often led to an increase in the number of light fittings, an increase in illumination levels and a relaxation of the custom of switching off the light when one leaves the room. Similarly, TVs and fridges are larger, as described above, split air-conditioners have become cheap to buy and easy to install and ceiling insulation has increased their effectiveness, thereby heating and cooling a greater space than previously.

Domestic use of solar energy

So – will we ever see the cost of household power reduce, economic catastrophes notwithstanding? Quite likely. The answer is solar.

The following is a brief analysis of the costs and benefits of buying and using solar PVs in Australia:

	Sydney	Melbourne	Perth	Brisbane	Hobart	Adelaide	Darwin
Annual Average (kWh/m2/Day)	3.9	3.6	4.4	4.2	3.5	4.2	4.4
Tot Annual (kWh/m2/Yr)	1,423	1,314	1,606	1,533	1,277	1,533	1,606
Rad on 5KW System (kWh/Yr)	7,115	6,570	8,030	7,665	6,385	7,665	8,030

Fig. 12: Solar Radiation in Australian Capital Cities

The following section will describe how much solar energy we can get, what it costs and what we can do with it at home.

First, how much can we get on our rooftops? Fig. 12 shows the daily average (taken over the year) and the annual average total per square metre and the annual average total for a "5kW" PV system, which is the most popular at present. Different sources give slightly different figures, but the differences are within 5%. The actual area taken up by the panels is about 5 times the area of the average radiation, because the panels are about 20% efficient at collecting the sunshine. Improvements on this efficiency are incremental, but the average free-standing dwelling of 150 square metres (Sqm) has enough area to take the 25-30 Sqm of panels.

We can see from Fig.12 that the total electric power collected by 5 Sqm is more than the average 6,000 kWh used by the average household. So, if you could use all of this electricity, then your ongoing bills would be zero (except for connection, metering and admin charges – see below). But as we all know, a lot of our power use isn't when the sun is shining – on average, only about half of it. So, the arrangement we have with the power supplier is that we sell our unused half of solar electricity to them during the day and buy back our night-time (or very dull-day) power from them. The "Feed-in-Tariff" – FIT as it's called, is usually about 5-7 cents/kWh, compared with the average 25-30 cents/kWh that the power corporations charge us.

Why the big difference? Several reasons, but essentially the deal is that we get compensated for "avoided costs". Those "avoided costs" are a bit contentious, but it is argued (by the power corps) that it is generous, as the avoided fuel costs are about 3-4 cents/kWh (for coal at $100/tonne) and one could argue for reduced wear and tear on the generators and a bit for reduced admin. But 5-7 cents/kWh is what we have at the moment, so we'll use 5 cents/kWh for our analysis here.

The challenge, then, it to use as much of the half of the solar power that we sell at 5 cents to avoid buying it back at 25-30 cents/kWh. To do this, we need to have another look at Fig. 11.

First, our *water heating* – assuming that you are part of the half of the population using electric water heaters[11], then about a quarter of your electricity bill is for water heating. The long-term decline in the use of electric water heaters is at least partly due to reducing peak-demand on the grid (Fig. 13). The following relates to electric water heaters using rooftop PV electricity, not "hydronic" solar water heaters that have a tank on the roof and lots of plumbing. Hydronic solar water heating is about 10% of the total market at present, but is likely to reduce with decreasing PV costs.

If you are using gas, then consider the following when you next have to get a water heater. (There's little point changing if your gas heater is fairly new, as the capital costs would outweigh the savings – check it out on the assumption of a 10-year lifetime for you water heater). The trick is to use your electric water heater as a "battery" for your solar panels. This entails ensuring that the storage tank is as cold as possible at 9.00 am – this means morning showers will save you money! Alternatively, a timer on your electric water heater that switches it on during the day and off at night helps. Some companies are now selling electric water heaters with timers and I know of one company that is about to release a long-lasting PV-powered water heater. How much could you save from this? Maybe all of that 25% on the pie chart- but at least 80% of it – reducing that 25% to 5% and saving about $300 of your $1,500 power bill.

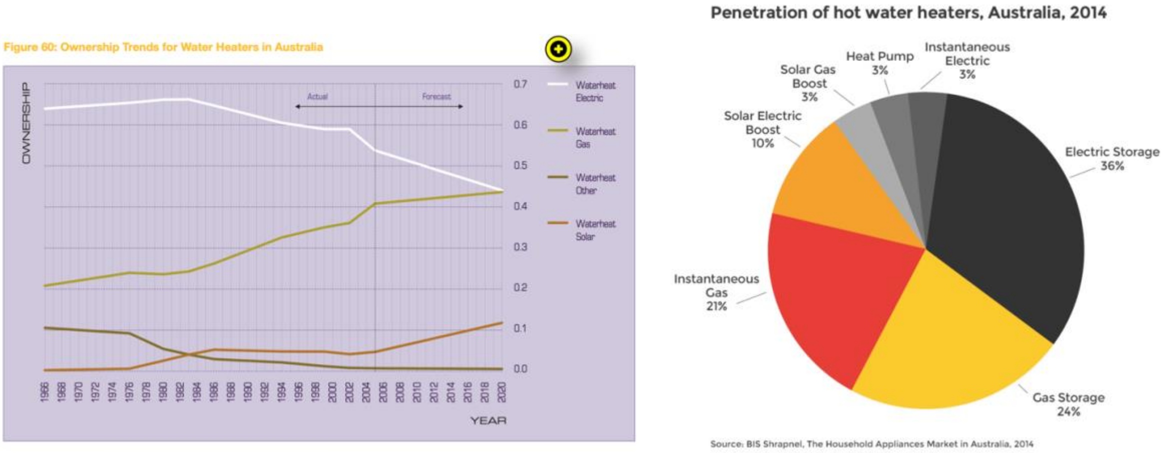


Fig.13: Ownership trends for water heaters in Australia.

Next, heating and cooling: First, heating. Aside from "passive solar gain" through windows, your solar panels can be put to work in a number of ways. Cold nights correlate strongly with sunny days in winter, as it is generally clear skies that make the air temperatures fall quickly at night. So – if you have a reverse-cycle air conditioner, you could turn it on during the day – even if you are out working, so that your house is warm in the evening. The effectiveness of this strategy will vary, depending, particularly, on the "thermal mass" of your house. If it is "double brick", as most Perth houses are and various percentages of other cities[12] [13](see Fig.14), the warmth stored during the day should see you through until at least bed-time. There are "heat-bank" devices that are designed to store up to about 20 kWh of off-peak power, costing about $1,500 that could be used in light-frame houses[14]. Fans to distribute the warmth would then be enough and are relatively low-powered.

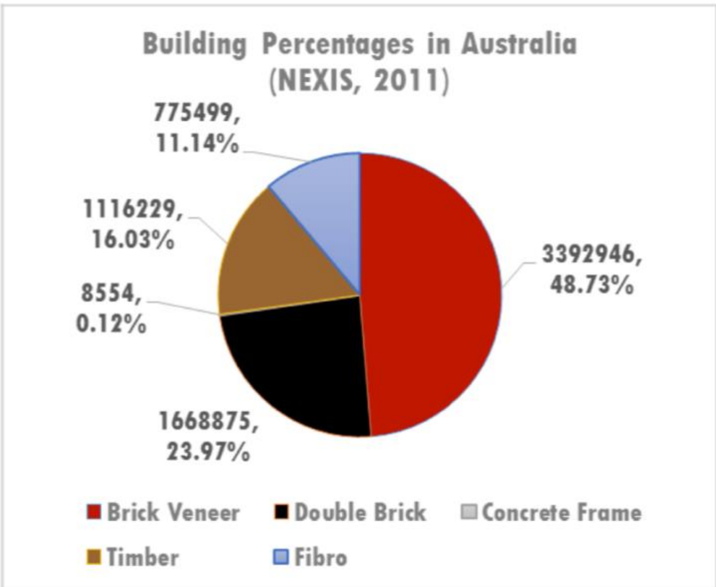


Fig. 14: Building materials of walls in Australian dwellings (Ref. 11).

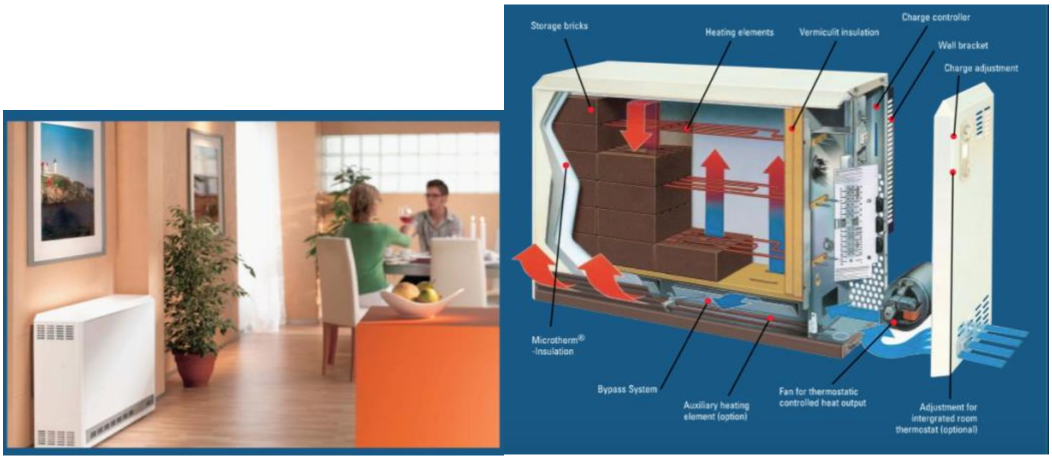


Fig 15: An electric "heat bank" system for low thermal mass dwellings (Ref. 14).

Summer cooling is a bit trickier. Again, using the thermal mass of the house as a "coolth store" (yes- coolth is a thing!) is possible. In any case, leaving your split aircon on during the day is a better proposition than selling surplus solar power at 5-7 cents/kWh. Coolth storage systems, like the above-mentioned off-peak power thermal storage devices, are yet to appear. I can imagine one being a re-purposed deep- freezer full of ice with a coolth-transfer coil and a fan would do the trick.

Again, I'd estimate that about 80% of heating and cooling costs could be avoided like this- there's another $400 or so off the bill.

What's left? The big one is "other appliances" at 13%. This often includes the dishwasher. And clothes dryer, microwave and perhaps the pool pump.

The *clothes dryer* is a tough one, as it requires a lot of energy over a small period of time- typically about 3kW for 15 minutes. Unfortunately, clothes dryers have become increasingly necessary for apartment-dwellers, due to lack of clothesline's and body corporate rules forbidding wet clothing to be displayed on balconies. We will return to this issue below.

Dishwashers- are in about 60% of homes[15]. Dishwashers are easy- simply change your habit from putting it on last thing at night to before you leave for work (if you work!) or preferably after 9am to catch the sunshine before your heating or cooling kicks in.

Swimming pools can use 10-13% of household electricity. About one in every seven dwellings in Australia have a swimming pool[16], so their electricity use for filter-pump can be significant. In recent years "ECO" pumps, with variable speed motors have been replacing single speed pumps, with claims of saving up to two-thirds of the pumping energy[17]. Again, using the pump during the day is prescribed.

Other Appliances are "rats and mice" as a proportion of the total and might be hard to squeeze into daytime use. A reasonable estimate of the proportion that could be relegated to the sunshine hours is 75-80% of the total. That is, reducing the annual power bill to $3-400. Of course, there are caveats, depending on lifestyle, age and the shape and size of your dwelling- but we're dealing with averages here as a guide. If you are "Joe and/or Flo Average", you can either be satisfied by knocking a lazy $1,000 or so off your power bill, or going the whole-hog and buying a battery system to supply the residual requirements. An excellent website for checking out all domestic appliances is energyusecalculator.com.

Battery storage

At present, the most popular system is a Tesla “PowerWall”, that stores about 14 kWh and costs about $10,000 (installed)[18]. Assuming a daily draw-down of 10kwh, this would, on average, meet the half of the electricity used at night throughout the year. Over 10 years (estimated lifetime) this would be about 30,000 kWh, meaning an extra cost of 30 cents/kWh. As this is approximately the cost of grid electricity, it is not really economically sensible at present. However, if one has an electric vehicle, its batteries can be used to power the house, thus saving on the battery cost.

What about electric vehicles (EVs)? EVs presently consume about 20kWh/100km (less than half the energy consumption of a comparable petrol-powered car). At an average 10,000km/yr (30 km/day), this is about 2,000kWh/yr or 6kWh/day on average. At full-price, an EV would add about $500 to the present $1,500 annual electricity bill. This is about two-thirds of the presently surplus power that is exported to the grid, or, put another way, the average output of about 1.5kW of PV panels. Of course, like the power-consumption patterns of most of the existing electricity appliances, the day-to-day variability can be high, leading to variable demand (such as short week-day commuter trips and long weekend trips).

A lot has already been written on the power supply issues presented by EVs, including charging rates, location of chargers and the source of the electricity, including how domestic solar PVs can be used when the car is at the work location. Given the present and probable future capabilities of smart metering, it is not hard to imagine an EV plugged in at a work location being charged according to the surplus electricity being generated at home at that time. Whether the charge would be the (average) 25cents/kWh or the FIT of 5-7cents/kWh or something in-between is open to discussion.

It is worth noting that a new EV costs about $60,000 in Australia and has about 60 kWh of batteries. In other words, the cost of the car is about the same as the cost of the batteries if bought as separate modules.

Looking forward, if all of the present 14 million passenger vehicles were EVs, then it would add about 30,000 GWh to the total National electricity demand, or about 10-12% of the total 2020 electricity generation of about 250,000GWh.

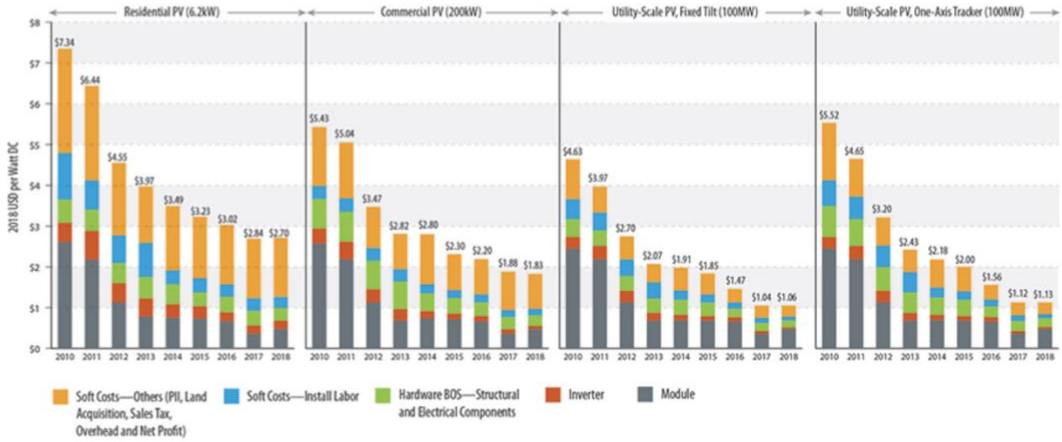


Fig. 16 (a): (US) PV system component costs decline 2010-2018[19].

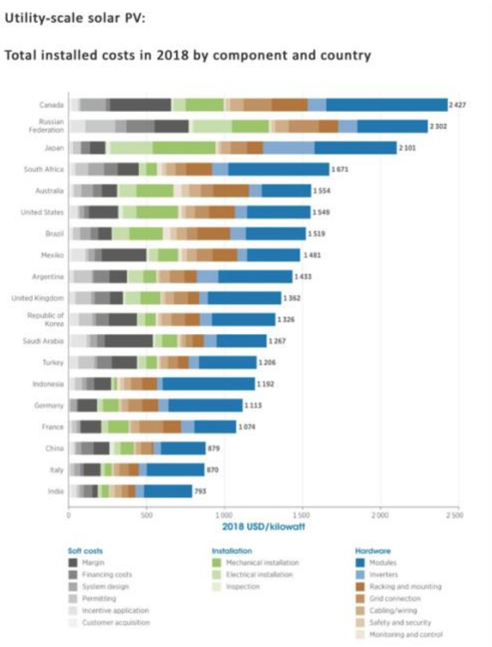


Fig 16(b): Total installed costs for utility scale PV Systems (From IRENA)[20]

The future

The continuous – and highly predictable – decline in the cost of PVs will make them even more attractive in future. Fig. 17 shows the long-term panel costs (globally)[21], being at about 30cents/watt and total rooftop systems in Australia now being, on average, at about $A1.00 per watt (Fig. 17), with many vendors now offering installed systems for $A0.50/watt (giving a cost of about 2 cents/kwh for a 20 year lifetime). As Fig.16 from NREL shows, the panels are only part of the total system cost and have declined more rapidly (in the USA) than "soft costs"– the approvals, marketing and installer profits. These are much higher on a per-watt basis for systems than utility-scale systems. Note that the US costs for rooftop PV are much higher than in Australia. (I have not been able to source comparable rooftop data for Australia).

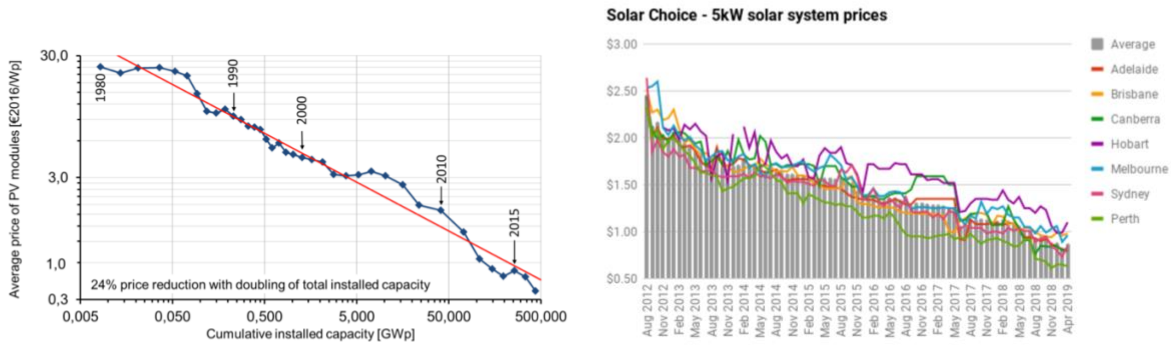


Fig. 17: Historical price development of PV modules; (a): The straight line shows the price development trend. (Ref. 18) (b) Total system prices in Australia (from Solar Choice)

It is quite likely that rooftop PV will be able to meet most of the domestic demands for most Australian dwellings within several decades – including powering of electric vehicles. However, the catch here is the word "most", as, for a range of reasons, "some" householders will not be able to – particularly apartment dwellers. As a consequence, the electricity grid and some of the administration costs will still be necessary. This means that, even if rooftop renewables are meeting most of the domestic power supply, *at least half of the total cost of the system – the "poles and wires" and "administration" will remain.* The poles and wires will still be needed for commercial, industrial and many general public purposes as well.

The following scenario is most likely: for a while, individual households will enjoy much-reduced power costs as the install solar PVs and utilize most of their domestic production, as described above. At present, this cost could be as low as zero for per-unit costs plus about $4-500/year for "supply charges" – that is, the present poles, wires, environment and admin charges – at a bit of a discount. As more dwellings take up solar, the fixed charges would be spread over fewer users if the present formula was maintained. This is unlikely, so it means that the "supply charges" will increase to – what? – probably at least double at present – maybe $1,000/year. The public electricity supply system will then be priced in the same way as housing rates, water and roads – the main cost is the "sunk" cost of the infrastructure, with a relatively smaller incremental cost for the "per-unit" use.

It is also likely that the grid-power suppliers will insist on rooftop PV owners maximising their "behind the meter" use of the electricity (as described above) that they generate – for three good reasons. First, even at 30% of dwellings with rooftop PV, there are problems with "grid over-voltage" during sunny weekdays as a large proportion of the rooftop electricity is fed back into the grid to gain FITs. This problem can probably be solved with new technology – but at an increased cost to all concerned.

As described above, it is not difficult to arrange for most of the rooftop-generated electricity to be used "on-site" or "behind the meter", by better management of water heaters, space heating and cooling and appliances, plus, perhaps, an electric vehicle. This would markedly reduce the rooftop export and thereby reduce grid-stability problems.

How could this be done? As described, the FIT, at 5 cents/kWh only comprises about 15% of the total value of the maximum value of the electricity generated, but, perversely, probably serves to blunt the householder's resolve to minimize the export. Part of the solution would be to reduce the FIT to “avoided fuel costs” of about 2-3 cents/kWh, or even eliminate it altogether. The latter solution may be too politically unpalatable to implement.

Secondly, in Australia, rooftop solar is already a big business, quite separate from industrial-sized solar farms and should be encouraged.

So – rooftop solar can reduce domestic power costs – ultimately to about half the present costs if the “supply charge” costs are spread (equally) across all users. That would be a saving of $500– $1,000/year. But is it worth it for the all the fuss that is being made? Seeing that we probably have to retain the poles and wires and services, couldn’t all of this be left to large corporations to install solar and wind farms?

Although the “greenhouse gas abatement” from one rooftop is miniscule, compared with the National total, the collective effect of many rooftops is significant. As Fig.18 shows, rooftop solar is already making a significant contribution to emissions reduction – about 20% of the total to date. Looked at another way, as indicated in Fig. 6, above, residential electricity demand comprises about 25% of all electricity demand, which, in turn, contributes about 35% of the National greenhouse gases, *meaning that total domestic electricity emissions are about 10% of all emissions.* A much higher percentage may be possible with gas-users switching to PV and with electric vehicles included.

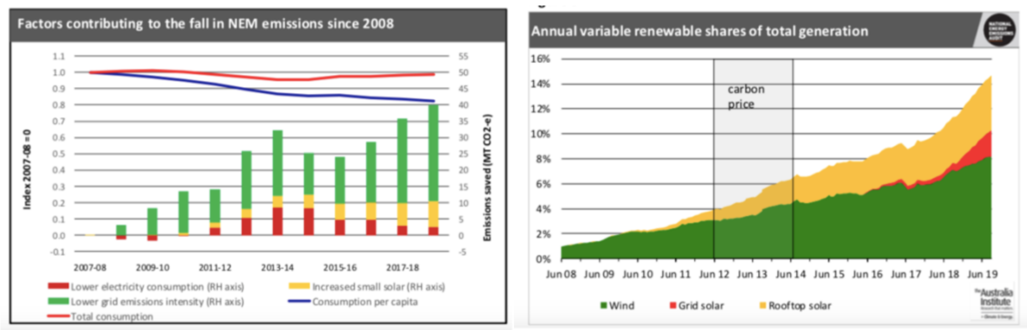


Fig. 18: The monthly National Emissions Audit, produced by energy analyst Hugh Saddler on behalf of The Australia Institute22

People who have dreamed of having their “autonomous house” will be disappointed – well – they can still get it if they “tree-change”, but even there, they will find that the local Shire Council will load them up with a range of similar fixed costs. I see it a bit differently. The poles and wires are a fairly durable asset – particularly as they are undergrounded. They can be used by micro-grids – local grids that might be disconnected from the present main grid (with a few cost reductions for reduced switching stations). Solar- and wind-farms will also need the grid for connection to urban and industrial users.

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8 (https://grattan.edu.au/wp-content/uploads/2018/03/903-Down-to-the-wire.pdf
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10 See, for example: Total Environment Centre and Renew: *Cross about subsidies: the equity implications of rooftop solar in Australia discussion paper December 2018.*

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