Solar sizing: Bigger is Better

Discussion Paper

May 2017

Document Information

Document Version	Date	Prepared By	Reviewed By	Comments
BiggerIsBetter02A	24/5/17	Andrew Reddaway – Energy Analyst	Damien Moyse – Policy & Research Manager	
BiggerIsBetter02D	14/6/17	Andrew Reddaway – Energy Analyst	Damien Moyse – Policy & Research Manager	Also widely circulated within ATA staff.

For general release

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Promoting Renewable Energy, Energy Efficiency and Water Conservation since 1980

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1. Executive Summary

People often ask the Alternative Technology Association (ATA) what size grid-connected solar system they should have installed on their roof. Traditionally the ATA has advised people to consider this carefully based on their electricity consumption. Nowadays we generally recommend a big solar system, even if consumption is low.

This change is due to two main factors:

1. Per panel, large residential solar systems are cheaper than small ones. Since August 2012 larger systems have halved in price, while smaller ones have only dropped by a quarter.
2. Feed-in tariffs are increasing, due primarily to rises in the wholesale electricity price.

Economics now favour larger systems, such as 5 kilowatts (15-20 modern panels). After modelling a wide range of scenarios, we found very few cases in which a 2-kilowatt solar system (six to eight modern panels) achieves economic payback quicker than a 5-kilowatt one. Five-kilowatt systems often achieve payback in six to seven years, and only a few outlying scenarios see a payback longer than 10 years. Where feed-in tariffs have risen to 11 cents per kilowatt hour or greater, it can even be worthwhile installing solar on unoccupied buildings.

As well as providing economic benefits, larger solar systems are also more beneficial to the environment, as they directly displace more generation by centralised fossil fuel power stations.

We recommend that households:

- Aim to install a big solar system, subject to constraints such as budget, suitable roof space and approvals.
- Don’t ignore energy efficiency changes to a home, as these may pay off even quicker than solar.

Some types of households such as renters and apartment dwellers face barriers to installing solar, but options do exist for these people to benefit from solar too.

2. Introduction

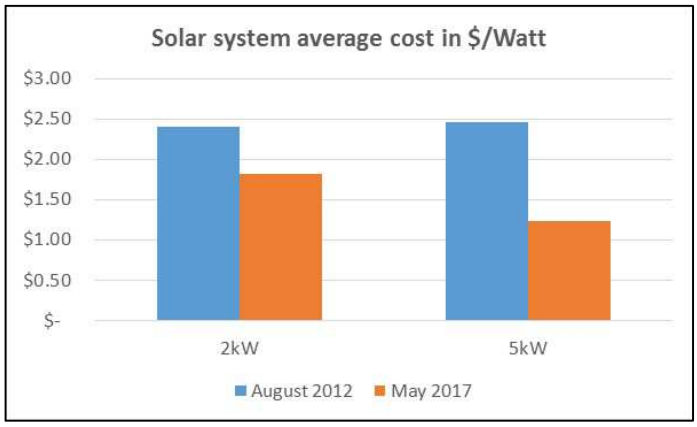
The Alternative Technology Association (ATA) has for many years advised people to consider carefully the size of the grid-connected solar systems they want installed on their roof. If you primarily want to help the environment and cost is of little concern, it has always made sense to have as many panels installed as possible, as all their generation displaces electricity from dirty, centralised power plants. But most people have budgetary constraints, so their solar system needs to make economic sense as well as helping the environment. To achieve this, we've previously recommended people size a solar system based on their electricity consumption and maximise other opportunities, such as energy efficiency.

However, things have changed. **Nowadays we generally recommend a big solar system** even if electricity consumption is low.

3. What's changed?

3.1 Solar system prices

The past five years have seen significant price reductions, especially for larger solar systems. Prices vary with component quality and location, but on average a 5kW solar system (15-20 modern panels) now costs around $6,200 according to Solar Choice's residential price benchmark data[1]. Let's compare a 5kW system to its smaller 2kW cousin (six to eight modern panels). To compare these two system sizes, the cost is presented in dollars per Watt.

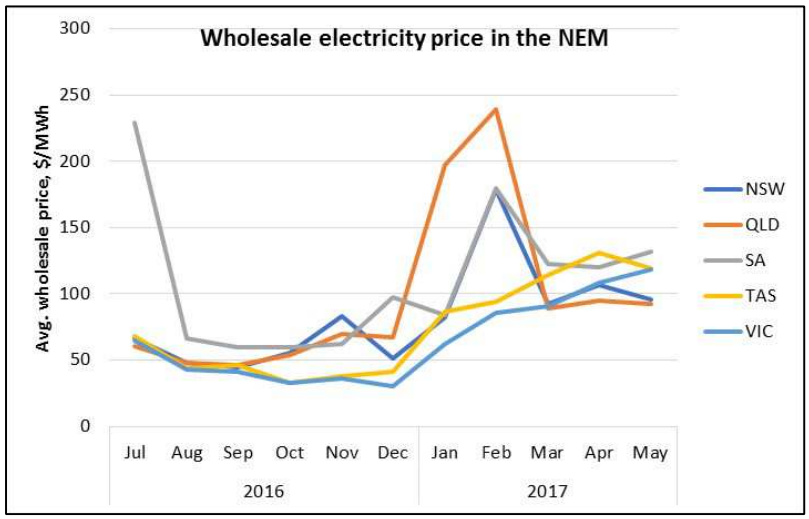


This chart reveals that since August 2012, **larger systems have halved in price, while smaller ones have only dropped by a quarter**.

Why has this price gap opened up? Larger systems have always enjoyed economies of scale compared to smaller systems because while the installer is on the roof it's relatively easy for them to add more panels. One reason is that the price of solar panels has fallen faster than other components. The industry has also become more familiar with large systems, as they are now more frequently installed than small ones.

3.2 Wholesale electricity prices

Over the past year**, the wholesale electricity price in the eastern states of Australia has roughly doubled** to around $100 per megawatt hour, or 10c per kilowatt hour, as shown in the chart[2].



This wholesale price rise of roughly 5c per kWh may well be passed on to the retail bills. For example, households paying 25c/kWh may see a 25% increase.

Big companies often pay much lower tariffs, so the same 5c increase will have a proportionally higher impact on them. They often have long-term energy contracts, so their cost won't rise until these are renegotiated.

This profound change in the market has several causes. One is the recent dramatic rise in the price of natural gas burned to generate electricity. Also, the closure of Hazelwood Power Station in Victoria with little notice has created a short-term tightening of electricity supply, compared to the over-supply prior to that event.

In WA, no similar rise has occurred. However, prices might rise due to the state government winding back its subsidy to electricity prices.[3]

3.3 Feed-in tariffs

The Victorian Government recently announced that solar feed-in tariffs in that state will rise to 11.3c per kWh from July 1, 2017, **roughly double their previous level**[4]. This change is primarily due to the increased wholesale electricity price. We expect other states to follow suit, as feed-in tariffs below the wholesale electricity price are clearly unfair to people with solar. In NSW, a draft recommendation has already been made for a range of 11.6 to 14.6c, compared to the current range of 5.5c to 7.2c[5].

Our solar payback calculations assume 11.3c/kWh in Vic, and in other states a doubling of feed-in tariffs from current levels of 5-8c, phased in over the next five years.

3.4 Tariff trends

Our solar payback analysis looks 20 years into the future, and allows for different electricity tariffs in each future year. We used AEMO's retail tariff forecasts[6], however since they were based on Hazelwood closing in 2020, we pulled them forward by three years. This allows for annual tariff rises between 1.5% (QLD) and 3.4% (Tas).

4. Solar system economics

If you're planning a solar system, is it "worth it" to upsize from say 2kW to 5kW? The extra panels will be relatively cheap but more of their generation will be exported, only earning a low feed-in tariff.

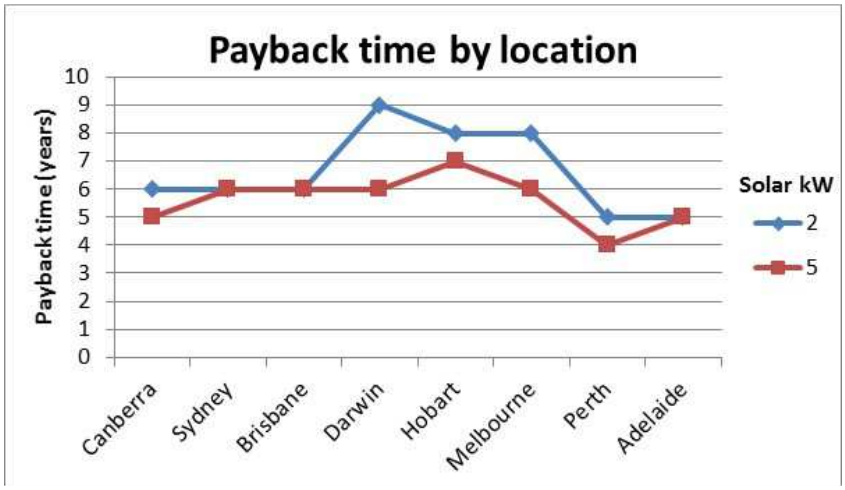
Over a year, all grid-connected solar systems supply some of their electricity directly to household appliances, and export (feed-in) the remainder to the grid[7]. If you install a larger solar system, a greater proportion of its annual generation will be exported. For example, depending on household consumption a solar system rated at 5 kilowatts (15-20 modern panels) might export 80% of its generation. This doesn't help the economics, because electricity exported to the grid only earns the feed-in tariff, which currently range from 5c to 14c per kilowatt-hour depending on your location and electricity plan[8]. On the other hand solar electricity used on-site, rather than exported, saves you paying the grid tariff, which is typically around 20c to 35c per kilowatt-hour, but can be even higher for some people.

We studied these economics by simulating a large number of scenarios in half-hour intervals for a whole year using Sunulator, our free solar feasibility calculator[9]. We considered common grid tariffs in each capital city for a variety of household consumption profiles. Our analysis also included panel degradation over time and likely tariff changes (see below). Panels are assumed to be north-facing with a 20-degree tilt.

Our primary economic measure was payback time, i.e. the number of years until bill savings recoup the installation cost, with the fewer years the better. Payback times shorter than 10 years are generally considered attractive to solar customers, as the system is likely to pay for itself before any significant expenses, for example replacing the inverter. **The panels should last at least 20 years, so cumulative bill savings are large, especially for a larger system.**

4.1 By location

The first chart is for a stay-at-home family using 23kWh per day on average, on a flat tariff. For this example, **in no location did a 2kW system pay back quicker than a 5kW one.** We also ran scenarios for 3, 4 and 6kW systems, and found these to obey the same trend.

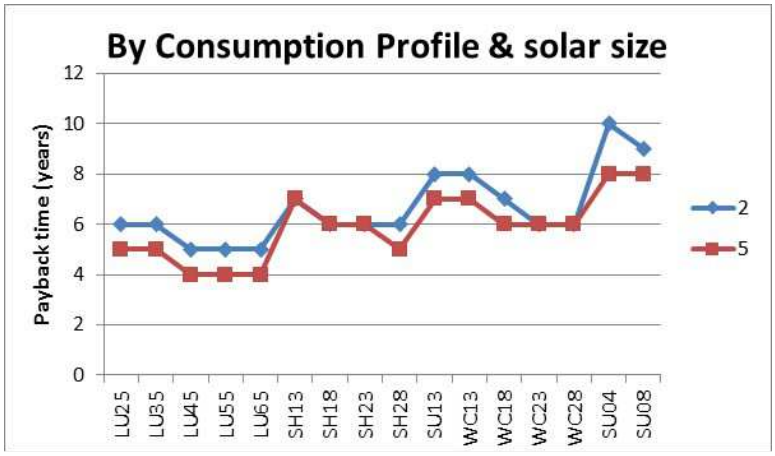


The Northern Territory is a special case as solar installations are particularly expensive, but this is counteracted by a relatively generous feed-in tariff, equal to the import tariff. Bigger is better here too!

4.2 By household type

The next chart shows different households in Sydney on a flat tariff. “LU” is a large electricity user, “SH” is a stay-at-home family, “WC” is a working couple and “SU” is a small user. The following two digits denote their average daily electricity consumption in kWh.

For a 5kW solar system, payback time varies from four to eight years depending on consumption profile. Households with higher consumption achieve payback more quickly. **Again, there are no cases in which a 2kW system pays back quicker than a 5kW.**



The above scenarios give annual returns of 10-25% when converted to an “equivalent interest rate” or Internal Rate of Return. This is **attractive compared to some financial investments**, for example stock market returns were reportedly around 10% over the past ten years[10].

We found that a 5kW system achieved payback in less than 10 years in all but a few scenarios. The exceptions were the lowest-consumption households in some Tasmanian locations.

4.3 Low-consumption buildings gain too

With feed-in tariffs at the new higher levels, **a solar system can now be economic *even if it exports all its generation to the grid***. For example, an export-only 5kW system in Melbourne should generate around 7000kWh and earn $790 per year. If the system costs $6400 on the simplest calculation it achieves payback in less than nine years! Because of this, low-consumption buildings such as holiday houses and storage sheds have become a new market for solar systems.

4.1 Making the most of a big solar system

Solar electricity is the cheapest source of energy for households[11]. To make the best use of it, run appliances while the sun is shining where practical. Also, as gas appliances wear out you can install efficient electric appliances instead. If you can stop using gas altogether, this will also save you hundreds of dollars per year by eliminating the daily supply charge to have gas connected.

Batteries are getting cheaper – in a couple of years it may be cost-effective to store excess solar energy for use at night-time. A big solar system will support this. Similarly, in the future you may want to charge an electric vehicle from solar power too.

5. Other considerations

5.1 Good for the environment

This is good news for the environment. Economic and environmental priorities have aligned; for both reasons it's generally better to "go big" with your solar system. However, there may still be competing demands on your capital. In particular, when building a home it's best to prioritise items that are difficult to install later, such as efficient windows and wall insulation. If you have to make such a choice, it may be wise to delay the solar installation until funds become available.

Some people worry about environmental credentials such as the energy required to create and transport the solar panels. We've found that this is not a problem, as a solar system only takes one or two years to save as much energy as it consumed. After that its energy contribution is all positive[12].

5.1 Constraints on a big solar system

If bigger is better, how big can we go? Roof space is an obvious constraint. Panels with the latest technology tend to be relatively expensive, but can generate more energy from the same area. These might be worthwhile if your roof space is limited.

As noted above, most people have budget constraints and have to prioritise their spending. **Don't ignore energy efficiency investments** that may pay off even quicker, such as insulation, gap sealing, window shading, LED lights and efficient appliances.

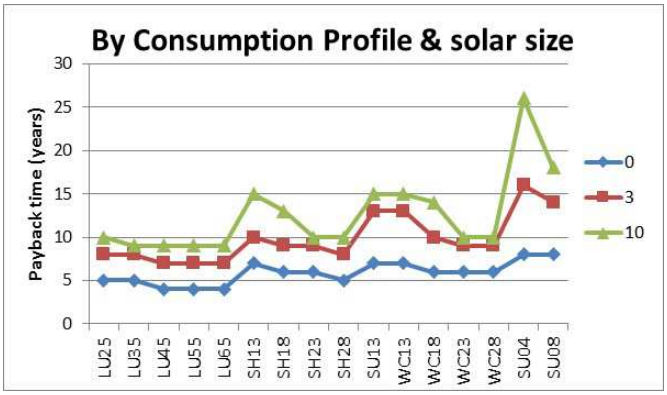
Electricity distributors limit the size of solar systems connected into their grid. If you've got a normal residential single-phase connection, solar systems up to 5kW in size are usually no problem. Going larger often requires extra paperwork and may not be allowed. One good strategy is oversizing, eg connecting 6kW of panels to a 5kW inverter. The distributor treats this as a 5kW system, as that's its maximum power output. Another option to allow a larger solar system is to install a three-phase electricity supply, which would normally support a 15kW solar system. However, upgrading your electricity supply involves additional cost.

Some people who installed solar around 2011 or earlier are still getting a high feed-in tariff such as 60c per kWh. These contracts require that no extra solar is installed on the property. In such a case you'd have to weigh up the value of higher feed-in tariffs on the small solar system, compared to a lower feed-in tariff from a large system.

5.2 Battery economics

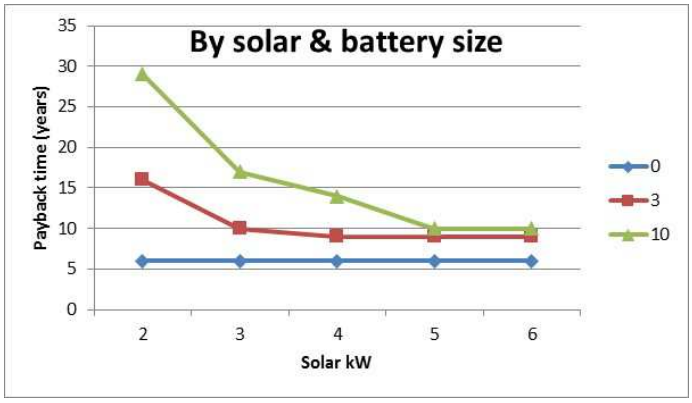
A battery is an optional extra to a grid-connected solar system**. In our view it's not yet really a mainstream product** because it's not particularly economic, and the options are fast-changing. They're also not directly beneficial to the environment. If we look ahead four years, batteries will be economic in many cases for bill savings, and the technology should be more settled.

Batteries are already worthwhile in specific situations, for example if your electricity distributor has limited your solar exports to the grid, or if you require power in a blackout. We support early adopters installing batteries, as they're helping to develop this industry, which will become important to buffer higher levels of wind and solar generation in our grid.



In our economic analysis, we considered solar systems that include both a small battery (3 kilowatt hours of usable capacity) and a large one (10kWh).

The chart above shows the payback time for those two battery sizes (and no battery) installed in 2017 as part of a 5kW solar system in Sydney, on a flat tariff. In all cases, faster payback is achieved with a smaller battery, and fastest with no battery at all.



The next chart shows the payback time for a stay-at home family in Sydney using 23kWh of electricity per day. It shows that if you've decided to include a battery, it makes even more sense to install a big solar system.

5.1 Is it now worthwhile to quit the grid?

Although grid tariffs are getting more expensive, a proper off-grid solar system is a very big investment, and **we don't generally advise going off-grid if a connection is easily available**. Here's some further information: http://www.sanctuarymagazine.org.au/ideas-advice/quit-grid/

5.2 What if tariffs don't rise?

If you install a big solar system based on future rises in feed-in tariffs and import tariffs, there is a chance this might not eventuate, causing bill savings to be less than planned and delaying payback. **We think this risk is low**. Future prices are notoriously hard to predict, but the current wholesale electricity price appears to be the "new normal".

Previous low wholesale prices were only possible because most energy was generated by old coal-fired power stations that had paid off their financing costs. Any new-build generation won't have that advantage.

Over the next year or two, new generation[13] is expected to re-balance supply with demand and ease wholesale prices. On the other hand, as wholesale prices reduce, financial pressure on generators will hasten closure of the next ageing coal-fired power station. We may see a saw-tooth trend with steady price declines punctuated by periodic upward jumps.

As usual, the big unknown is government policy. With coal-fired power stations closing and wind and solar booming, the transition to renewables is clearly well underway. This is acknowledged even by big coal generators[14] and electricity networks[15]. If properly-managed, this transition promises long-term benefits for Australia[16]. But if planning is poor, short-term disruption will trigger rushed, expensive policies leading to tariffs rising higher than necessary.

Even if tariffs don't rise, a big solar system still has good economics. For the Sydney example mentioned above, payback is delayed by one year for the 5kW system, and not at all for the smaller one.

5.1 Renters, apartment-dwellers and vulnerable consumers

Many people face barriers to installing solar. Renters must negotiate with the landlord, and if you live in a property with a shared roof (e.g. a block of flats) you have to negotiate with the owner's corporation. Some people have no prospect of saving the capital to pay for a solar system, and others have an unsuitable roof.

With grid electricity (and gas) becoming so much more expensive than solar, this will **further entrench the disadvantages** that many of these groups already experience in our society.

To make cheap solar power more accessible to these groups, we advocate for initiatives such as Environmental Upgrade Agreements (eg the Solar Savers program)[17] and Virtual Net Metering within blocks of units.[18] New technical solutions are becoming available to share solar electricity among multiple residents, for example as recently trialled at Nicholson Gardens[19]. In addition, we support community energy projects, in which people can receive regular returns from investing in a solar system installed on a local building.

References

[1] Includes installation and STC rebate. Averaged over capital cities excluding Hobart and Darwin. https://www.solarchoice.net.au/blog/solar-pv-system-prices-may-2017
[2] Source: AEMO Average Price Tables. Accessed 21/5/17, so May is a partial month.
[3] http://www.abc.net.au/news/2017-03-27/wa-could-see-power-price-increase-under-new-labor-government/8390070
[4] https://www.ata.org.au/news/ata-congratulates-vic-govt-on-solar-feed-in-tariff-rise
[5] https://www.ipart.nsw.gov.au/Home/Industries/Energy/Reviews/Electricity/Solar-feed-in-tariffs-201718/01-May-2017-Media-Release/Draft-Recommended-NSW-2017-18-Solar-feed-in-tariffs
[6] 2016 NEFR report: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/National-Electricity-Forecasting-Report
[7] Unless your distributor has imposed export-limiting. Even if you have a big battery, it will be full at times.
[8] Some people who installed solar around 6 years ago are still on contracts with higher feed-in tariffs (eg 66c/kWh), but these are closed to new entrants. If you were on the expired 60c gross tariff in NSW, you should probably switch to net metering. https://www.ata.org.au/ata-research/life-after-feed-in-tariffs-report
[9] http://www.ata.org.au/ata-research/sunulator
[10] http://www.asx.com.au/education/investor-update-newsletter/201506-what-return-can-you-expect-in-this-market.htm
[11] Gas may be cheaper per unit of energy, but the inefficiency of gas appliances mean you need up to 7 times as much gas to do the same job as electricity. https://www.ata.org.au/news/are-we-still-cooking-with-gas
[12] "How green is your solar", ReNew 135.
[13] http://www.cleanenergycouncil.org.au/news/2017/May/2billion-renewable-energy-investment-2017-unprecedented.html
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[19] Page 67, Sanctuary Magazine issue 38.