Battery storage – a large step closer

Dr Martin Gill

The price of domestic battery storage systems was expected to fall rapidly over the next couple of years. Even optimistic estimates did not forecast the dramatic decreases. The future of battery storage looks bright.

Powerwall

When Tesla announced the original Powerwall® it was seen as a major turning point for domestic battery storage. Hardly surprising given the widely published headline price of only $3,000!

Unfortunately the headline price did not include the price of the inverter needed to use the battery. It also overlooked installation costs, retail margins, Australian taxes (GST), shipping to Australia and conversion from US$ to AU$. In Australia the original Powerwall was available from a number of installers for an uninspiring $15,000.

In the fiercely competitive battery storage market the Powerwall quickly become one of the more expensive options. This has been addressed when Tesla announced the second generation Powerwall. The Powerwall 2 includes the inverter (lowering installation costs), is available directly from Tesla (lowering retail margins) and offers twice the storage capacity of the original.

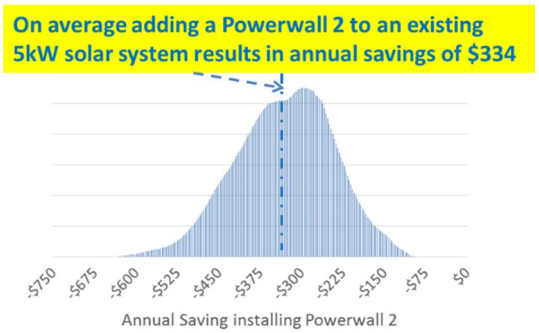
A comparison of the new Powerwall 2 to the original shows:

	Powerwall 1	Powerwall 2
Power Output	3kW	5kW
Usable Capacity	6.5kW	13.5kW
Installed Price	~$15,000	$10,400[1]

The table shows multiple improvements including double the usable capacity and a continuous power output of 5kW (up from 3kW). All of these improvements come with an installed price 30% less than the original.

Summary of findings

Modelling the addition of a Powerwall 2 to an existing 5kW solar system suggests all household can lower the annual cost of electricity.



Annual savings adding a Powerwall 2 to a 5kW solar system

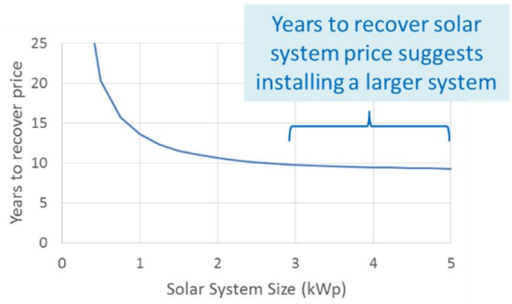
The analysis reveals adding a Powerwall 2 to an existing 5kW solar system results in a maximum saving of $600 a year (on average households save $334). Even assuming this maximum saving reveals it takes over 17 years to recover the price of the battery (ignoring electricity price rises). Unfortunately the Powerwall battery warranty only extends to 10 years. Further warranty details suggest the battery will reach end-of-life before any of the analysed households recover the current purchase price.

The Powerwall 2 announcement is still significant as it highlights of how rapidly battery storage system prices are falling. Modelling is therefore undertaken to suggest if prices continue falling at current rates then delaying the purchase of a solar and storage system 3 to 6 years should provide a financial benefit for the majority of households.

[1] At the time of writing the Tesla website lists a lower price. The Solar Quotes website (solarquotes.com.au) clarifies the price on the Tesla website does not include GST.

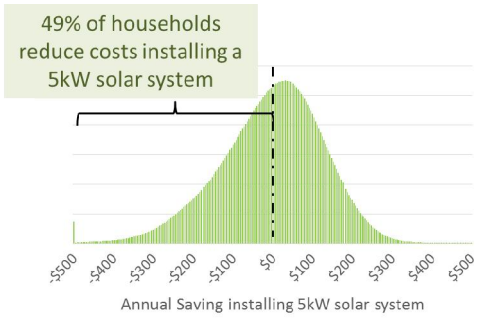
Solar System Prices

From Feb to Oct 2016 the average installed price of a 5kW solar system in Sydney has decreased from $7272 to $6046. As the price of larger systems has become cheaper (and smaller systems relatively more expensive) it makes the decision to install a larger system easier. The following figure shows the number of years for electricity savings to recover the average price of solar systems of differing sizes.



Years to recover solar system cost (Sydney)

Recovering the price of a solar system in less than 10 years requires a solar system larger than 3 kW. When considering the possible addition of battery storage it is recommended households consider installing a larger solar system. The analysis shows the average household will also recover the price of a 5kW solar system in just under 10 years. The following plots annual savings from installing a 5kW solar system for the 300 Sydney households for which data is available.



Annual Savings from installing a 5kW solar system

Recent falls in the price of 5kW solar system means almost half of the analysed households benefit financially after installing a solar system. While almost half the analysed households reduce their electricity costs this does not mean they should immediately install a large solar system intending to add battery storage when battery prices fall. The reason is compatibility with future battery storage systems.

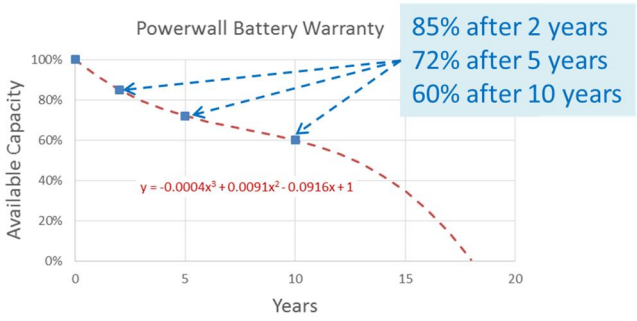
Solutions combining the solar and battery storage systems have the potential to lower the total system price while also improving their efficiency (for a technical discussion refer to the Appendix).

The Powerwall 2 is currently only available as a stand-alone battery storage solution meaning households do not gain these benefits.

Battery Lifetime

The Powerwall uses Lithium-Ion (Li-Ion) batteries to store energy. These batteries are similar to those used in mobile phones. Daily charging and discharging degrades the usable capacity of the battery, as anyone with a mobile phone more than 2 years old can readily confirm.

Powerwall warranty documents suggest the warranty does not cover “normal degradation of energy capacity over time”. When the Powerwall 1 was first released the warranty stated the guaranteed usable battery capacity. These figures are shown in the following figure.



Yearly Powerwall Usable Capacity (from earlier warranty)

Warranty details are currently unavailable for the Powerwall 2, but it predicted it will allow “normal degradation”. The presented modelling therefore uses the battery capacity as stated in the original warranty.

Battery Recycling

No costs have been included to recycle the Li-Ion batteries at the end of the system’s useful life. The cost to recycle almost 100 kilograms of Li-Ion batteries is likely to be significant however without a reliable estimate the cost was excluded.

Electricity Tariffs

The majority of households installing a solar/battery system should choose a Time of Use (ToU) tariff. The solar and battery systems significantly reduce electricity use during peak periods and the price of

electricity during both shoulder and off-peak periods is less than a fixed tariff.

Energy Made Easy was used to select the cheapest ToU tariff assuming the household qualifies for all discounts (e.g. pay on time). The comparison assumes daily average use of 16kWh with 50% falling in the shoulder period and 25% in the peak and off-peak periods. The same tariff was used once the solar and battery storage systems were added.

The discounted electricity rates for the selected ToU tariff are shown in the following table:

	cents / kWh
Peak	40.744
Shoulder	17.116
Off-Peak	9.592
Daily Charge	91.52
Credit for Export	6.5

So far the modelling has assumed electricity prices rise at the same rate as the Consumer Price Index (CPI). This assumption aligns with forecasts prepared by the Australian Energy Regulator (AER) over the next 5 years. The CPI rose less than 2%, however:

St Vincent de Paul analysis shows Sydney electricity prices rose 9% last year

The AER only controls price rises caused by distribution businesses. The 7% price rise above the CPI was caused by electricity retailers.

The Australian Energy Market Commission (AEMC) assumes market competition forces retailers to offer lower prices. This is based on the assumption electricity consumers are willing and able to compare prices. Both assumptions are incorrect. Many consumers are still unaware cheaper tariffs are available, indeed some reports suggest only 50% of NSW consumers have switched electricity retailer. The main barrier is the complexity of electricity pricing and a lack of tools simplifying electricity tariff comparisons.

Estimating annual retailer electricity rate rises is purely speculative. Several reasons are cited to support predictions prices will continue to rise above the CPI for several more years, including maintaining profitability as more consumers switch from high margin 'standing offers' to discounted 'market offers' and to pass on costs associated with supplying smart meters to all their customers.

Putting it all together

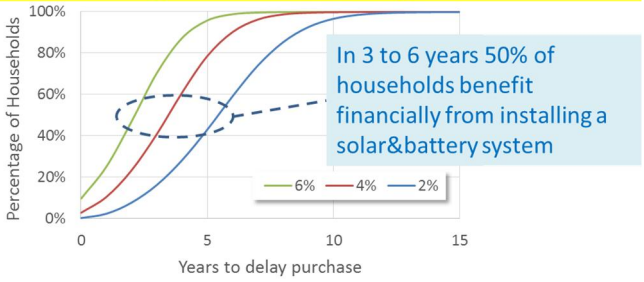
Analysis shows solar system and storage battery system prices are falling, while electricity prices are rising. This suggests more detailed financial modelling is required.

The following table summarises the current situation and predictions for future price movements. Note each of the price increases/reductions is stated above/below the CPI:

	Value
Price 13.5kWh Battery System	$10,400
Price 5kW Solar System	$6046
Saving DC Connected	10%
Yearly price reduction Solar	4%
Yearly price reduction Battery	7%
Yearly electricity price Increase	2 to 6%

The following shows the percentage of households benefitting financially from the purchase and installation of a solar and battery storage system starting in the current year and delaying the investment up to 15 years.

The faster electricity prices rise the sooner battery storage becomes financially beneficial



Percentage of households benefitting financially from the installation of a solar and battery storage system

Three curves show electricity price rises of 2%, 4% and 6% above the CPI. As noted on the figure the faster electricity prices rise the sooner households benefit from the installation of solar and battery storage.

The left hand side of the graph (Year 0) corresponds purchasing the system today. As expected very few households currently benefit from the installation of a solar and battery storage system.

This result is predicted to change rapidly with 50% of the analysed households receiving a financial benefit from installing battery storage by simply delaying the purchase 3 to 6 years.

Perhaps the most interesting result of the analysis is show on the top right.

If current solar and battery price reductions continue, within 10 years almost all households potentially benefit financially from their investment in battery storage

Conclusion

I will admit to having dismissed claims by some sources battery system prices would decrease by "20% per annum". I may have been wrong with the Powerwall 2 effectively decreasing the price by 60% (compared to the Powerwall 1) in only one year!

The effect of the price reduction is dramatic with 29% of the analysed households benefiting financially from the addition of battery storage to an existing 5 kW solar system.

Analysis shows households without a 5kW solar system (or with a smaller system) should delay their investment in a solar/battery system for another 3 to 6 years. Over this time prices are anticipated to continue falling ensuring the majority of households benefit financially from their investment.

The delay also allows manufacturers to offer systems with a lower combined price and higher efficiency. Hopefully future systems will extend the usable battery capacity which is currently a limiting factor.

Citation

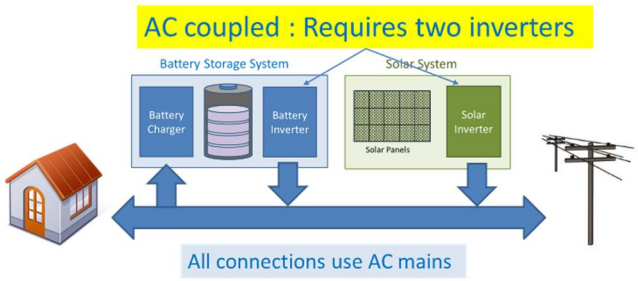
Comments or Questions?

The author is happy to receive comments or questions about this article. He can be contacted at martin@drmartingill.com.au

Appendices

AC coupled v DC coupled battery/solar systems

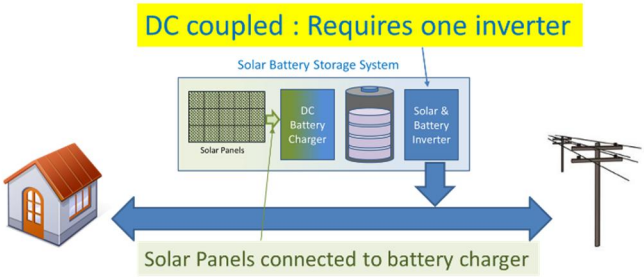
The Powerwall 2 is connected to the solar system using the household's existing AC wiring. This is referred to as AC Coupling and is shown in the following figure:



AC Coupled Battery System

As noted in the above figure AC coupling is requires two inverters, one for the solar system and one for the battery system. Both inverters basically do the same job suggesting it is possible to remove one.

By connecting the solar panels directly to the battery system the household only has to pay for one inverter. The output of the solar panels is direct current (DC), hence this configuration is referred to as DC coupled:



DC Coupled Solar and Battery System

The solar inverter accounts for 10 to 15% of the total cost of the solar system. Choosing to install a DC coupled solar/battery storage system potentially reduces the price by nearly $1000.

DC coupled solar/battery systems are also more efficient. The conversion from DC to AC results in an energy loss of around 6%. A DC coupled battery storage system has one less inverter meaning the solar panels effectively produce 6% more electricity than those in an AC coupled system.

Analysis using Interval Data

The modelling simulates the charging and discharging of the battery system using three years of 30 minute measurements of household consumption and solar system output.

- When solar system output exceeds household consumption the excess is stored in the battery. If the battery is already fully charged the excess is sent to the network.
- When solar system output is less than household consumption the battery attempts to supply the shortfall. If the battery cannot supply the shortfall because it is fully discharged or the shortfall exceeds the battery inverter power output then electricity is purchased from the network.

The calculation is repeated for each of the 10 years with the useable battery capacity reduced each year as shown on the original Powerwall warranty details.

The analysis is repeated for all 300 Sydney households included in the dataset.

Limitations of the modelling

Electricity tariffs remain the same

The analysis uses existing electricity tariffs. The Australian Energy Market Commission's mandate requiring retailers to offer smart meters to all their customers is intended to support new electricity tariffs, in particular demand tariffs. Major changes to electricity tariffs will affect financial outcomes.

Cost of Capital

The price of a solar and battery storage system is over $16,000. Most households will require a loan to afford the investment. The modelling does not include interest rate payments on this loan.

No Maintenance Costs

Experts recommend annual inspection of battery storage systems to ensure continued safe operation. The cost of these inspections has not been included in the modelling.

About Dr Martin Gill

Dr Martin Gill is an independent consultant specialising in the provision of consumer advice. This advice is based on a deep understanding of the Australian energy industry and strong analytical skills. As a consultant he has prepared advice for consumer advocates, government regulators, electricity distributors, electricity retailers, asset operators and equipment vendors.

Dr Gill is a metering expert. During the National Smart Metering Program he facilitated the development of a specification for Australian smart meters. Innovative metering products developed by his teams have been externally recognised with the Green Globe Award, NSW Government's Premier's Award and Best New Product by the Australian Electrical and Electronics Manufacturers Association.

He has a broad technical background having personally developed advanced communication modems, burglar alarms, electricity meters, high voltage fault monitors and power quality analysers.

References

Powerwall 2 (tesla.com/en_AU/powerwall)

Price of solar systems (solarchoice.net.au)

St Vincent de Paul Tariff Tracking Project (vinnies.org.au)

Interval data used in the analysis (ausgrid.com.au)