Return on Investment when adding battery storage to an existing solar system

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Adding a battery storage system to a solar system allows households to control when they use the generated electricity. Using current prices the following analysis considers if the investment is justified.

Introduction

Adding a battery storage system to a solar system allows consumers to control when they use the electricity generated by the solar system. This control can reduce the annual cost of electricity used. The critical question is therefore:

Battery storage solutions are expensive
Do savings justify the cost?

Interval data from 300 Sydney households equipped with a solar system has been used to calculate the savings each household would achieve from the addition of a battery storage system.

Return on Investment Calculation

The installation of a battery storage system can result in annual savings. The question is whether annual savings over the lifetime of the battery storage system are sufficient to recover the installed cost. This calculation is best performed using a Return on Investment (ROI) calculation.

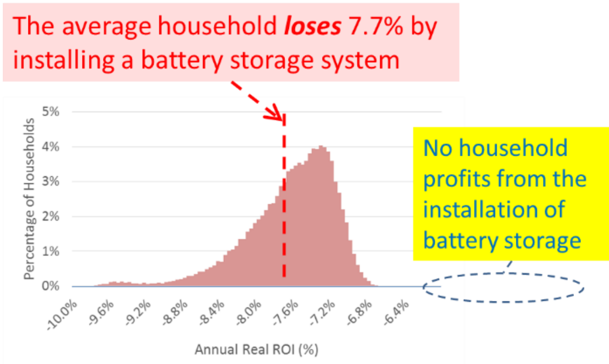
$$ROI = \frac{Saving\ Over\ Lifetime - System\ Costs}{System\ Costs}$$

The ROI is presented as a percentage. Most consumers are used to comparing annual interest rates (e.g. bank interest rates or loan interest rates) so the above equation is divided by the anticipated system lifetime to calculate the Annual ROI.

Please refer to the following pages for a discussion of the specific details of parameters used in the presented financial modelling.

Results of Modelling Current Prices

The modelling calculates the ROI from installing a 7.2kWh battery storage system on 300 Sydney households. The calculations assume each household has an existing solar system of 2.5kWp.



ROI from 300 households installing a 7.2kWh battery storage system with an existing 2.5kWp solar system

The results show:

- Across the 300 households the average ROI is an ***annual loss of 7.7%***
- None of the 300 households would receive a positive ROI from an investment in a battery storage system

The cost of battery storage systems continues to decrease however for a positive ROI the installed cost must decrease to around 25% of their current cost.

Future articles will discuss how to increase the ROI arising from the installation of a battery storage solution.

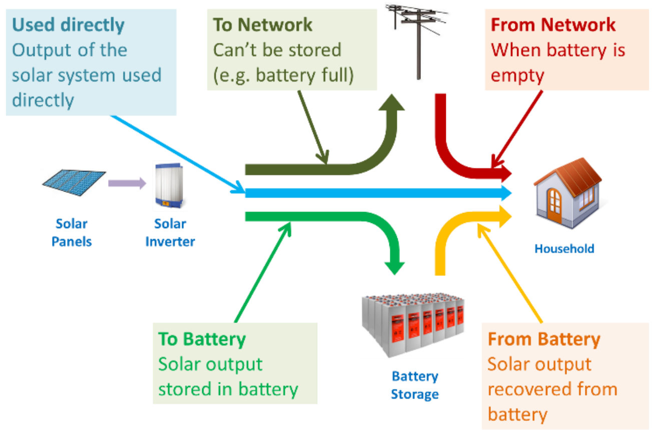
Finally a word of warning:

Households in Queensland and South Australia who have locked in a subsidised feed-in tariff should *not* install a battery storage system.

Details of the Modelling

Energy Flows with Battery Storage

Solar systems only produce electricity during daylight hours. At other times households require another source of electricity with most households choosing to remain connected to the electricity network.

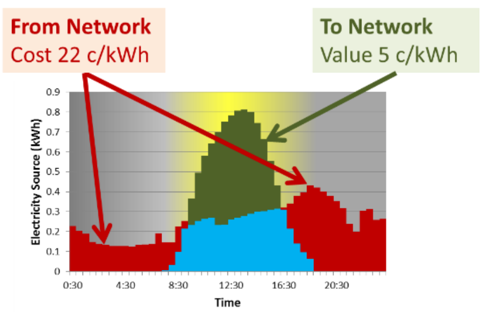


Energy Flows after adding Battery Storage to a Solar System

The above figure shows electricity flows with a battery storage system. The battery storage system stores excess solar output which would have flowed to the network. Storing the excess solar output allows it to be used at other times reducing the amount of electricity purchased from the network.

Valuing Battery Storage

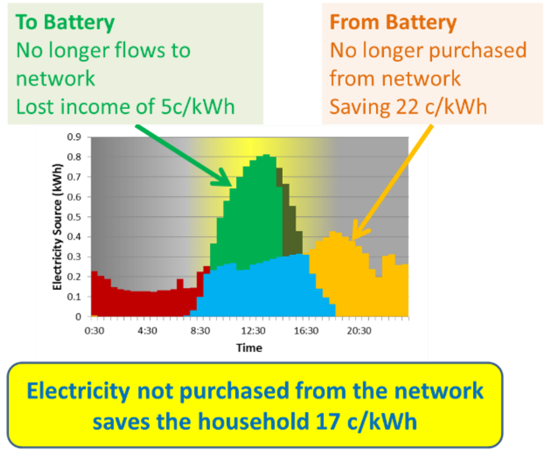
The following figure uses the average daily profile and a single rate tariff to demonstrate the value of electricity produced by a solar system.



Value of Solar Output before adding Battery Storage

On current NSW electricity tariffs electricity purchased from the network costs the household 22 c/kWh. In the middle of the day excess electricity generated by the solar system flows to the network earning the household a credit of 5 c/kWh.

When a battery is added the values change:



Value after adding Battery Storage to a Solar System

After adding battery storage excess solar output no longer flows to the network so the household does not receive the credit of 5c/kWh. When energy is recovered from the battery the household avoids paying 22c/kWh. On this tariff the result of installing battery storage is to save the household 17 c/kWh.

If a sufficiently large battery is installed to capture all solar excess then the average household analysed above saves 82cents/day. Over 10 years the total saving is a less than $3000.

Note: The average daily profile should never be used to estimate the financial benefit from installing a battery storage system. The average profile will overestimate the value of the battery storage system. All financial calculations should use interval data.

Battery Storage System Details

At a recent public forum the details of a battery storage system were presented. The details are summarised in the following table.

Presented details of the Battery Storage System

Details	
Installed Cost	$10,000
Battery Capacity	7.2kWh
Usable Battery Capacity	6kWh
Nominal Output Power	3kW
Nominal Input Power	4.5kW

Installed Cost

The presentation indicated this was the fully installed cost including the inverter and control system. Similar systems are being offered by other vendors for $12,500 to $15,000 suggesting the installed cost is at the lower end of what is currently available.

Usable Battery Capacity

The usable capacity is the maximum amount of energy that should be removed from the battery without (significantly) reducing the usable lifetime. Fully discharging the battery bank shortens the economic lifetime

All financial calculations should be based on Usable Capacity *not* Battery Capacity

Nominal Output Power

Specifies the amount of power the inverter can continuously supply to the household. To avoid damage most inverters can supply more than this value for short time periods (typically several seconds).

Nominal Input Power

Specifies the maximum amount of power the battery charger can handle. This value is related to the maximum size of the solar system.

Assumed Battery Parameters

Usable Capacity is calculated from the Battery Capacity using the “Depth of Discharge”. For the above system the Depth of Discharge is 6/7.2 = 80%.

An 80% Depth of Discharge suggests the system is using Li-Ion batteries. Li-Ion batteries are well suited for use in battery storage systems and several other popular storage systems use this battery type.

Based on the assumption the storage system is using Li-Ion batteries several other important technical parameters required in the modelling can be estimated.

Estimated details of the Battery Storage System

Details	
Battery Type	Li-Ion
System Lifetime	10 years
Battery Capacity after 10 years	80%

System Lifetime

Each time the battery bank is charged and discharged the available capacity reduces slightly. At the stated 80% depth of discharge high quality Li-Ion batteries retain 80% of their capacity after roughly 3,000 cycles (just over 8 years).

Depending on overnight electricity use the battery may be discharged to less than 80%. The lower depth of discharge extends the battery lifetime so the modelling assumes battery capacity reduces to 80% after 10 years.

The other limiting factor on system lifetime is the electronics used in the storage system. Both the battery charger and battery inverter are high power electronic devices. High power electronic devices have a lifetime of around 10 years. Modelling beyond 10 years must include the cost to repair or replace these devices.

Modelled Tariff

The financial benefit of battery storage systems depends of the difference between energy purchased from the network and energy sent to the network. Both prices are determined by the current electricity tariff.

The Energy Made Easy website was used to select the lowest cost single rate tariff available to a Sydney household with solar.

Single Rate Tariff used for the analysis (including GST)

Tariff	Price (cents per kWh)
First 10.9589kWh/day	22.24376
Second 10.9589kWh/day	21.94016
Remainder	21.6568
Feed in (Credit)	5.1

Most of the 300 analysed households use between 11 and 22 kWh / day. On the above tariff each kWh of stored energy is worth approximately 17 cents.

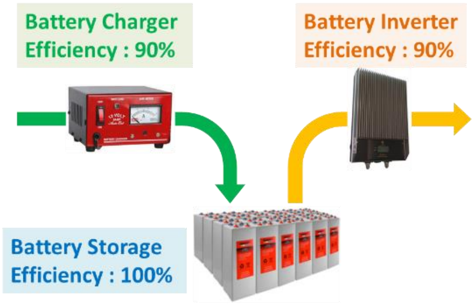
Solar System Size

Data published by the Clean Energy Regulator was used to estimate the average installed size of a solar system in Sydney. Assuming Sydney households are covered by post codes 2000 to 2299 reveals the average solar system size of 2.3kW (up to 2013). While the number of solar systems being installed has reduced since the subsidised feed in tariffs ceased this analysis has used an average solar system size of 2.5kWp.

Losses in Battery Storage

Energy is lost when the Battery Charger converts alternating current to direct current for storage in the battery bank. More energy is lost when the Battery

Inverter converts the output of the battery into alternating current.



Losses when using battery storage

Inverter manufacturers often state the maximum efficiency of their device, which can approach 94%. This is like stating the fuel use of a car being driven at a constant speed on a flat road. When driven at different speeds the fuel use increases. Similarly the battery charger and battery inverter must operate over a wide range of input and output power levels where the efficiency will be lower. The modelling has assumed that both devices have an average efficiency of 90%.

There are minimal losses when charging and discharging quality Li-Ion batteries. For simplicity the modelling has assumed no loss in the battery.

Modelling using Interval Data

The modelling uses 30 minute interval data. For each half hour the difference between household use and solar system output is calculated.

- When solar system output is less than required the battery is checked to determine if it can meet the short fall. This is limited to the nominal output power and maximum depth of discharge.
- When solar system output exceeds household use the battery is checked to determine if it can store the excess. If the battery is already fully charged the excess is sent to the network.

Three years of household use and solar system output are used to calculate each point. The calculation is repeated twice, once for the first year with 100% Usable battery capacity and again for the 10th year with the battery capacity reduced to 80%.

Important Notes

Cost of Capital

The ROI calculations assume the household does not borrow money to pay for the system. If the household borrows money then loan repayments must be included in the System Cost or the required ROI value adjusted to account for the interest rate.

The presented ROI already includes an adjustment for the Consumer Price Index (CPI). Financially sound investments must provide a ROI greater than the interest rate *less* the CPI. For example if the interest rate on the loan is 6% the ROI must be greater than 6% - 2% (CPI) = 4%.

It is acknowledged that savings arising from the installation of a battery storage system are tax free. Calculating taxation benefits depends on many personal factors but even at the highest tax rate the benefits are unlikely to make the ROI positive.

Subsidised (Preferential) Feed-In Tariffs

The financial benefit of battery storage systems arises from the cost difference between energy purchased from the network and energy sent to the network. Solar equipped households in Queensland and South Australia on the subsidised tariff are paid more for excess electricity than they pay at other times. They will make a financial loss from installing battery storage.

Conclusion

Battery storage systems allow households to control when they use the electricity generated by their solar system. This control can reduce annual electricity costs.

The high price of battery storage systems means they are not currently a financially sound investment. The installed cost of the systems needs to decrease to around 25% of the current figure before they will become financially sound investments.

Future articles will consider ways to increase the ROI from the installation of a battery storage system.

Comments or Questions?

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

Citation

References

Battery Details : Future Grid Forum (www.futuregrid.org.au)

Average Solar System Size : Post Code Data (www.cleanenergyregulator.gov.au)

Source of Interval Data : ausgrid.com.au

Source of single rate tariff : Energy Made Easy (energymadeeasy.gov.au)

About Dr Martin Gill

Dr Gill is an independent consultant specialising in the provision of advice and data analysis to the energy industry. He has provided this advice to government regulators, distributors, retailers, consumers, asset operators and equipment vendors.

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

Dr Gill is a metering expert. His innovative products have been recognised with the Green Globe Award, NSW Government's Premier's Award and Best New Product by the Australian Electrical and Electronics Manufacturers Association.

Points of Clarification

Cost of Electricity

The ROI calculations assume that over the battery lifetime the price of electricity rises at the same rate as the Consumer Price Index (CPI). Using this assumption the ROI presented above includes an adjustment for the CPI.

Electricity Use

The calculations have assumed the household does not significantly alter their use of electricity after installing the battery storage system.

The output of quality solar panels decreases each year. For quality solar panels the decrease is around 0.5% per year.

Largely due to Government energy efficiency initiatives household electricity use has been declining a trend which is expected to continue. To simplify the ROI calculations this analysis has assumed household electricity use and solar system output decrease at the same rate.

Value as a Back Up Supply

The analysed battery storage system is able to provide "emergency backup". This means that during a power outage (blackout) the household is able to generate its own electricity (up to the nominal output power).

The ROI calculations have not attempted to value continued access to electricity during system outages. Most households enjoy access to a reliable electricity network, with most blackouts only occurring for short time periods. This suggests the value would only be small.

Maintenance

Some experts recommend annual inspection of the battery system to ensure continued safe operation. In addition to checking the individual batteries in the battery bank, the inspection also checks all connections and safety equipment for signs of damage. The cost of this inspection has not been included in the calculations.