Adding Battery Storage to Solar Systems

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The following introduces the components needed to add battery storage to a solar system and the energy flows.

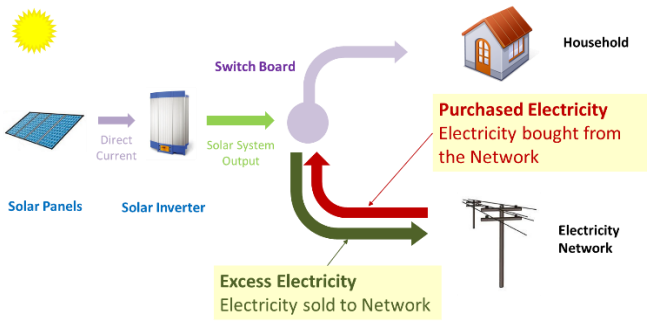
Introduction

Adding Battery Storage to a Solar System allows households to store the excess electricity generated by their solar system. They can then use the stored electricity when the solar system is not generating sufficient electricity to meet their needs.

Storing electricity requires the installation of additional equipment which is discussed in the following sections.

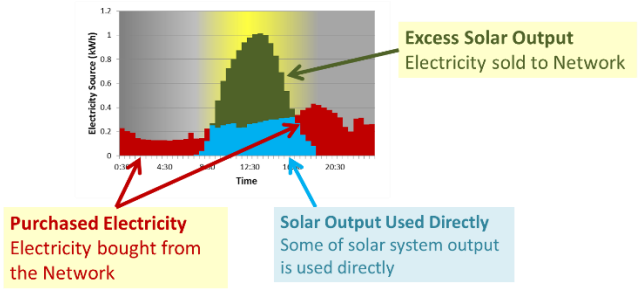
Flow of Electricity with a Solar System

The following figure shows a network connected solar system before battery storage is added. The two important energy flows are: Excess Electricity (sold to the network) and Purchased Electricity (bought from the network).



Flow of electricity to and from the electricity network with a solar system

The energy flows can also be shown on the average daily profile of solar generation and electricity use.

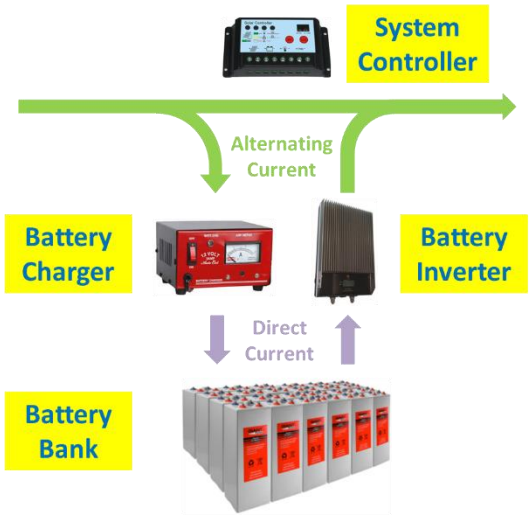


Electricity flows with a network connected solar system

Households not on a subsidised feed-in tariff pay more for the electricity they purchase from the network than they are paid for electricity flowing to the network. Adding battery storage allows the household to reduce the amount of electricity purchased from the network lowering their electricity costs.

Components of a Battery Storage System

A battery storage system comprises more than a set of batteries. The other (major) components are shown in the following figure.



Components of a battery storage system

Battery Bank

The battery bank stores the solar energy and makes it available at other times. Different types of batteries can be used, the best known being lead-acid and Li-Ion. A critical factor in any battery storage system is the amount of energy available from the battery bank.

Battery Charger

The battery charger converts the output of the solar inverter (alternating current) into direct current to charge the battery bank. The battery charger should be chosen to match the battery type.

The battery charger ensures that all batteries in the battery bank are correctly charged. Incorrect charging, (for example charging the battery bank too quickly) can significantly shorten the usable life of the batteries.

Battery Inverter

The battery inverter converts the direct current stored in the battery bank into alternating current for use by standard household appliances.

Fully discharging the battery bank can significantly shorten its useable life. To avoid this the battery inverter should be chosen to match the battery type and automatically shut down when the amount of energy in the battery bank reaches a minimum value.

System Controller

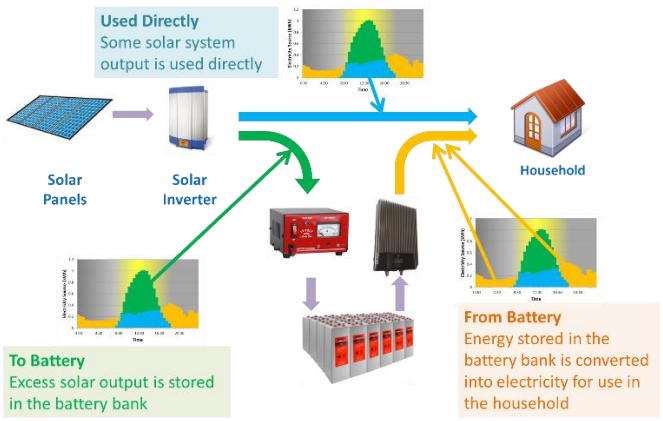
The system controller manages the flow of electricity to and from the battery bank.

When the solar inverter is producing more electricity than the household is using the controller attempts to store the excess by turning on the battery charger.

When the solar inverter is producing less electricity than the household requires the controller turns on the battery inverter to generate additional electricity.

Energy To and From the Battery

The following figure overlays daily solar system output over household use. The figure highlights three energy flows:



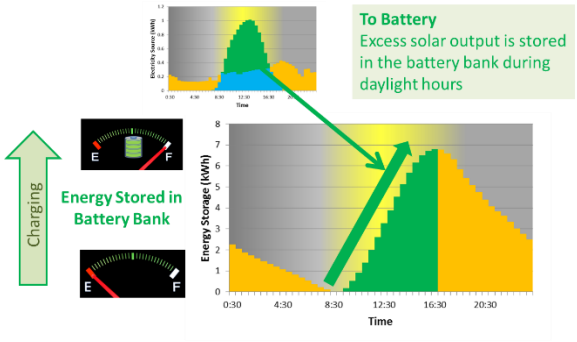
Electricity Flows for a solar system with battery storage

Used Directly

In the middle of the day households can use the output of the solar system directly. One advantage of direct use is it avoids energy losses in the battery system.

To Battery

When the output of the solar system exceeds household use the system controller turns on the battery charger sending energy to the battery:

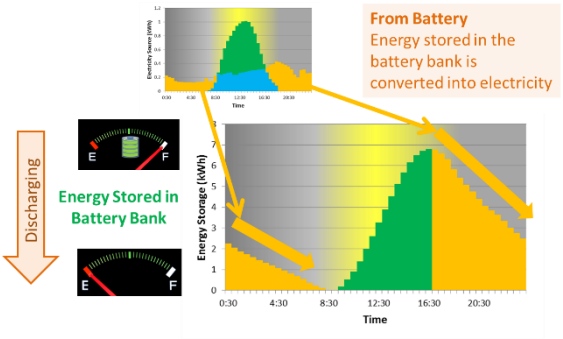


Charging the battery bank

Some energy is lost when converting and storing the Solar output.

From Battery

When household electricity use exceeds the output of the solar system the system controller turns on the battery inverter to supply more electricity to the household.

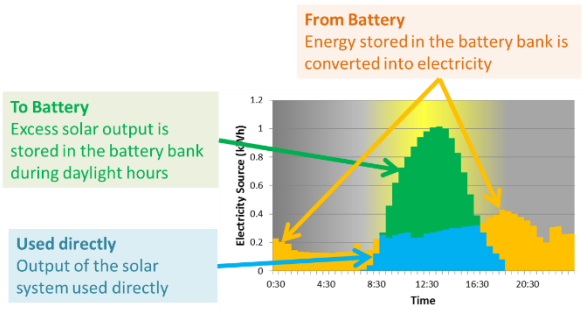


Discharging the battery bank

More energy is lost as the batteries are used to generate electricity.

The fantasy

A large solar system and battery storage system may be able to supply all the household's electricity needs.



All household electricity needs met by solar system and battery

Alternative Source of Electricity

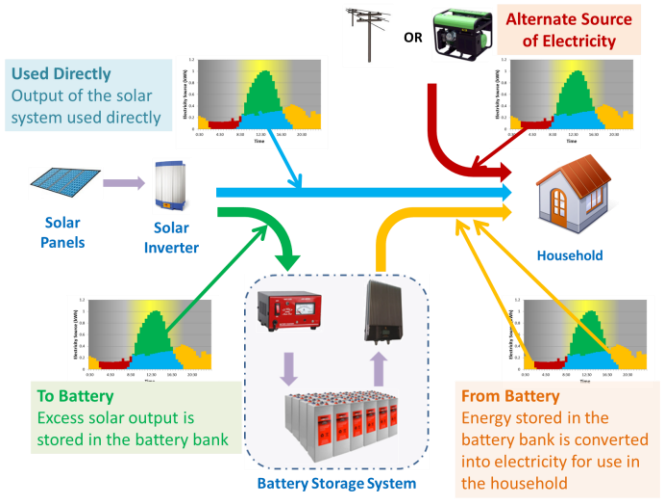
Relying only on the solar system with battery storage has consequences. Most importantly:

If the battery bank reaches empty the household will be without electricity

Several factors may result in the battery bank reaching empty including

- Cloudy weather reducing the amount of electricity produced by the solar system.
- Higher than average household use, for example high use of electrical heating and cooling, particularly heating during winter months when solar output is lower

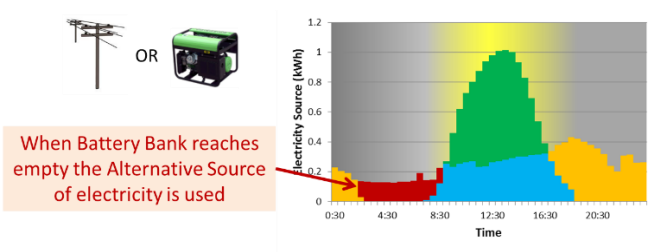
For the majority of households the cost of installing a battery bank large enough to meet all household electricity needs is unlikely to be cost effective. Instead an alternative source of electricity is included.



Showing an alternate source of electricity able to supply power when the battery bank is empty

Suitable alternative sources of electricity include an on-site generator and/or continuing to be connected to the electricity network.

When the battery bank reaches empty the alternative source of electricity can be used to meet household electricity needs as shown in the following figure.



Daily profile when an Alternative Source of Electricity is used

Conclusion

This introduction has described the components of a battery storage system. Importantly it has also shown the energy flows occurring between these components at different times of the day.

Further articles in this series consider the financial benefits of battery storage systems including how the size of the solar system and battery bank influences the return on investment the household receives.

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

Points of Clarification

Reliability of Supply

Households considering disconnection from the electricity network must recognise they are taking responsibility for their continued access to electricity. In the event of an equipment failure, in any component of the battery system, solar system or generator, they may have no (or limited) access to electricity until they rectify the fault.

Safety Concerns

There are numerous safety issues associated with the installation of a battery storage system, including exposure to high voltages and the risk of explosion, etc. Households considering a storage system should seek professional assistance. Qualified professionals can ensure the installation meets all safety requirements and complies with electrical rules.

Average Daily Profiles

While average daily profiles provide a valuable insight into energy flows they should not be used in battery calculations. They will (grossly) overestimate financial benefits and underestimate the required size of the battery bank and solar system. It is recommended these calculations be based on interval data measurements.

Omitted Energy Flows

For households retaining a connection to the electricity network a number of possible energy flows have been deliberately omitted from this discussion.

Sending excess solar generation (not used to charge the battery bank) to the electricity network can still earn the household a credit.

Some battery storage systems deliberately send electricity to the network when the wholesale market price of electricity is higher than the battery storage system's long term cost of energy (LCoE). For example the current maximum spot price in the wholesale electricity market is $13.80/kWh well above the LCoE.

It is also possible to use the electricity network to top-up the battery bank. A major advantage of this approach is it allows the use of a smaller battery bank. The top up should leave sufficient spare capacity in the battery to store the anticipated output of the solar system (requiring accurate weather forecasting). Note: Due to losses in the battery system this is only beneficial when on a time of use tariff.

About Dr Martin Gill

Dr Gill specialises in the provision of advice and data analysis to the energy industry. As a consultant he has prepared advice for government regulators, distributors, retailers, consumers, asset operators and equipment vendors.

Dr Gill has lead teams researching and developing new products across a broad range of industries, including advanced communication modems, burglar alarms, high voltage fault monitors and power quality analysers. One of his teams developed the first in home display and web-portal providing Australian customers the ability to view their electricity use. This innovation was recognised with the Green Globe Award, NSW Government's Premier's Award and Best New Product by the Australian Electrical and Electronics Manufacturers Association.