

THE BUSINESS CASE FOR INDUSTRIAL-SCALE BATTERIES

TECHNOLOGY OVERVIEW

Batteries store electricity as chemical energy so that it can be recovered for later use. There are many different battery types; the most common being lead-acid, lithium ion and nickel-metal-hydrides.

Flow-batteries, where the reaction agents are stored in separate tanks until required for electricity production, are becoming available at smaller sizes. Units are available for integration with residential solar photovoltaic systems. Flow batteries and sodium-sulphur batteries are considered a mature technology and have been used in many grid-support applications. Refer to Table 1 for more detail on the range of different battery types available.

Type	Description	Status
Lead-acid	A commercially mature battery type. Relatively low cost and have been used in automotive and small power storage applications for many years. Use in energy management has been limited due to short life cycle, particularly when fully discharged. The largest application is a 40 MWh system in Chino, California, built in 1988.	These batteries have reached their full commercial potential.
Lithium-ion	Li-ion batteries have typically been used in mobile applications due to their excellent energy density. The cathode in these batteries is metal oxide containing lithium (LiCoO ₂ , LiMO ₂ , etc.) and the anode is made of graphite. The electrolyte is made up of lithium salts (such as LiPF ₆) dissolved in organic carbonates. Lithium-ion batteries have a high energy density (300 - 400 kWh/m ³) and long cycle life (3,000 cycles at 80% depth of discharge).	Several companies are working to reduce the manufacturing cost of lithium-ion batteries. The high cost comes from the special packaging required and internal overcharge protection circuits.

Type	Description	Status
Metal-air	<p>These are the most compact and, potentially, the least expensive batteries available. They are also environmentally benign. Electrical recharging of these batteries is however very difficult and inefficient. The anodes in these batteries are commonly available metals with high energy density like aluminium or zinc. The cathodes or air electrodes are often made of a porous carbon structure or a metal mesh covered with catalysts. The batteries work by transferring oxygen from the air as OH^- through a conductor such as KOH to the metal anode where the metal is oxidised and energy is released.</p>	<p>While the high energy density and low cost of metal-air batteries may make them ideal for many primary battery applications, the problems with recharging limit use. Development effort is focused on this issue.</p>
Sodium sulphur cells	<p>A sodium sulphur (NaS) battery consists of molten sulphur at the positive electrode and molten sodium at the negative electrode as active materials separated by an alumina ceramic electrolyte. The electrolyte allows only the positive sodium ions to pass through it. The sodium ions combine with the sulphur to form sodium polysulfides. As with ZEBRA batteries, the temperature must be kept near 300°C to keep the electrolyte liquid.</p> <p>These batteries are an effective means of stabilising renewable energy output. NaS batteries have been demonstrated at over 190 sites in Japan totalling more than 270 MW with stored energy suitable for 6 hours daily peak shaving. The largest NaS installation is a 34 MW, 245 MWh unit for wind stabilization in Northern Japan. U.S. utilities have deployed 9 MW for peak shaving, backup power, firming wind capacity and other applications.</p>	<p>The application of these batteries for peak shaving, backup power, and firming wind capacity will develop further with the global push to renewable energy.</p>
Vanadium Redox Batteries	<p>Vanadium Redox Batteries store energy using vanadium redox couples. During the charge/discharge cycles, H^+ ions are exchanged between the two electrolyte tanks through a membrane.</p> <p>Vanadium Redox Batteries are an example of a flow battery. The key feature is the use of liquid electrolytes to store the energy. The stored electricity is released as the electrolyte is pumped through an electrolytic cell. The electrolyte is stored in tanks and the size of these tanks is not linked to the size of the cells. Therefore, the power and energy ratings of Vanadium Redox Batteries are independent of each other. Vanadium Redox Batteries were pioneered by the University of New South Wales in the early 1980's and the technology is currently licensed to Sumitomo Electric Industries.</p>	<p>Vanadium Redox Batteries storage of up to 5MWh have been installed in Japan.</p>

Type	Description	Status
Zinc-Bromide	<p>Zinc-Bromide batteries are another example of flow batteries. In each cell of a ZnBr battery, two different electrolytes flow past carbon-plastic composite electrodes in two compartments separated by a microporous polyolefin membrane.</p> <p>This chemistry is being explored at both residential and grid support scales. The net efficiency of this battery is about 75%.</p>	ZnBr batteries are used in integrated energy storage systems.

Table 1: Battery types

HOW CAN BATTERIES BE USED AT YOUR MEAT PROCESSING FACILITY?

Batteries can be used at your facility to maximise the value of on-site renewable energy production. For example, they link well with solar photovoltaic systems to shift generation to match load and higher cost electricity. Additionally, batteries can be used to reduce peak electricity demand at a site, or to manage peak demand if the alternative is adding extra capacity (which can be very costly).

DEVELOPING THE BUSINESS CASE

The main factors to consider when developing a business case for a battery storage system include the electricity cost and consumption profile at the site, power quality delivered to the site, and availability of financial incentives.

ELECTRICITY COST AND CONSUMPTION PROFILE

Batteries can be used to store cheap electricity for later use to offset more expensive electricity. If solar electricity is used, this will be generated during the day and ideally used to offset peak electricity in the evening. Determine how much peak electricity is typically used and how much it costs, to calculate total cost savings for the project.

POWER QUALITY

Some equipment, such as IT equipment, is sensitive to power quality or the consistency of voltage supply. While few industrial machines have this problem, it is worth considering as it may impact the final equipment choice.

FINANCIAL INCENTIVES

At this point in time, batteries do not qualify for financial incentives available through the State or Federal Governments. However, Germany and California have both recently introduced incentives for battery storage and Australian programs have typically been guided by the experience in these jurisdictions.

EXAMPLE COST-BENEFIT ANALYSIS

Storage is most attractive when low-cost power can be captured to offset high-cost power. An emerging and common example of this is using batteries to extend the delivery of intermittent renewable energy (generated from solar photovoltaics (PV) for example) to periods when the renewable energy supply is not available, and/or when grid-sourced electricity is most expensive.

Consider the illustrative site profile for a small abattoir, shown in Figure 1. This represents a site with daytime operation only. Energy use rises in the morning as the shift commences at 6am, then drops off after 5pm. Peak period is from 2pm until 8pm weekdays and shoulder period is from 7am to 1pm and from 8pm until 10pm. The peak rate is 35c/kWh, shoulder rate 20c/kWh and the off peak rate is 10c/kWh.

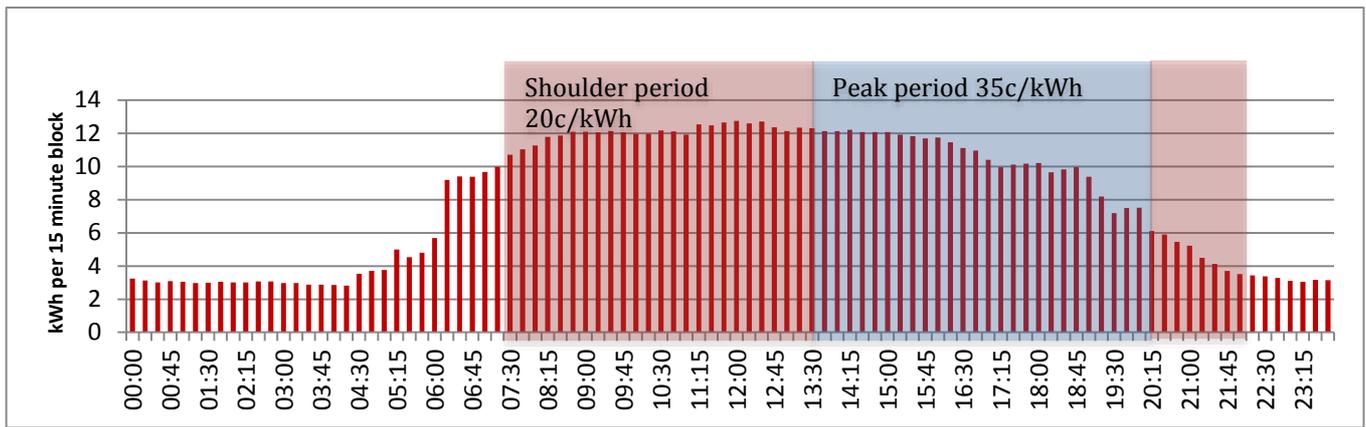


Figure 1: Illustrative site profile. Peak demand is approximately 50kW.

If a solar PV system were installed at this site, it would generate electricity between about 7am and 5pm. A very simple solar electricity generation profile can be modelled and laid over the sites electricity consumption profile to determine interaction between the two profiles.

For illustrative purposes, an 80kW system is shown in Figure 2. The system starts generating electricity at 7am and stops at 5pm, with peak generation occurring around midday. The system offsets 341kWh of purchased electricity each day.

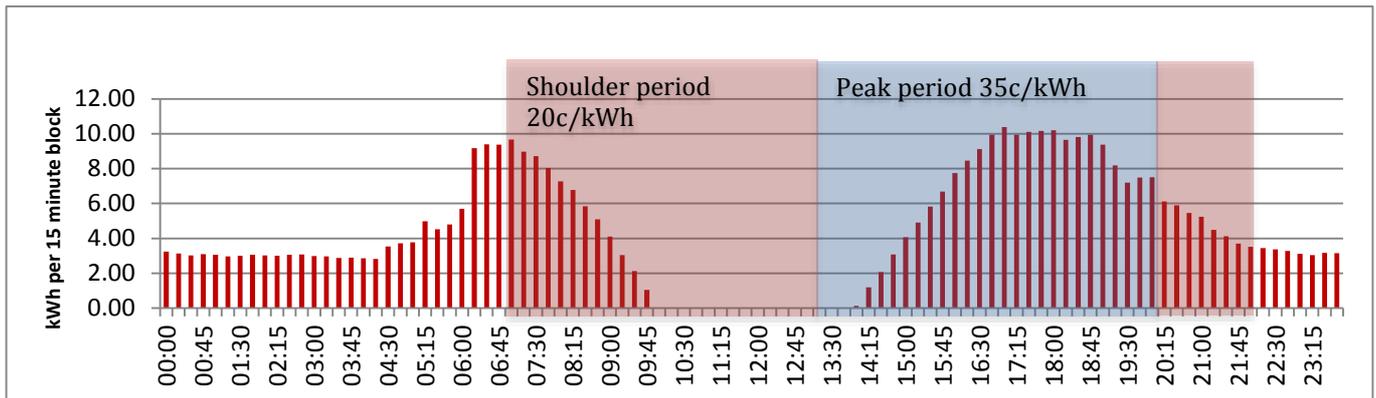


Figure 2: Purchased electricity profile, with illustrative solar profile deducted.

The value of the solar PV generated electricity over a year is shown in Table 1. The value of the electricity generated, taking into account electricity cost reductions and sale to the grid of excess electricity generated between 10am and 2pm, is \$30,885 (assuming 365 days of operation). An 80kW solar PV system would cost about \$160,000 installed (based on current market prices). This equates to a simple payback period of around 5 years. Note that this simple example has not accounted for different peak, shoulder and off-peak times at weekends.

	Electricity (kWh p.a.)	Value (c/kWh)	Annual Total (\$)
Peak electricity offset	28,470	35	9,964
Shoulder electricity offset	95,995	20	19,199
Exported electricity	21,535	8	1,722

Table 2: The value of the solar PV generated electricity from an 80kW system.

If a battery with a 64kWh capacity was added to this site, the excess electricity generated between 10am and 2pm could be stored for later use. This effectively transfers the exported electricity to the peak period offset (i.e. 21,535kWh p.a. / 365 days). This situation is shown in Figure 3.

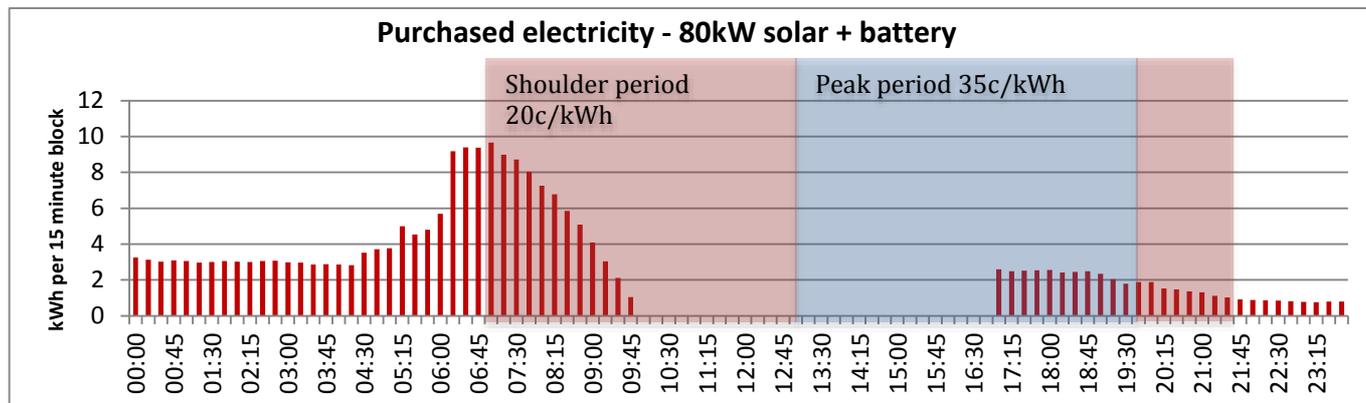


Figure 3: Purchased grid electricity with the addition of 80kW solar and a 64kWh battery.

Adding a battery to this system saves the excess electricity generated by the solar PV system, which was previously exported, for use during the peak period. The table below shows the value of the solar PV generated electricity, with battery storage. Adding a battery to this system generates additional value of \$5,815 in a year, for a total of \$36,700 each year. A battery of the size assumed would cost around \$64,000, depending on the battery type.

	Electricity (kWh p.a.)	Value (c/kWh)	Annual Total (\$)
Peak electricity offset	28,470 + 21,535 = 50,005	35	17,501
Shoulder electricity offset	95,995	20	19,199
Exported electricity	0	8	0

Table 3: The value of 80kW solar PV system with a 64kWh battery