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Supply Chain Intelligence

ENERGY STORAGE TECHNOLOGIES

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Energy storage, what is it, and how is it used? Simply put, energy storage is short to long-term storing of energy in electrical, mechanical, chemical, and electrochemical forms. It is a broad term that encompasses everything from AA batteries to hydroelectric dams and even elevated mass. Anything that you can put energy into then recovers at a later point is energy storage. While these all store energy in one form or another, not all are useful in the renewable energy space.

This article will begin with an overview of the current state of renewable energy storage in the global market, and then discuss various types of storage technologies and finish off with a discussion of current costs and how Australia is competing in this environment.

Renewable energy storage has seen explosive growth since 2013, going from a global yearly growth of around 0.3 GW to a high in 2018 of 3.3 GW, representing an annual 11-fold increase [1], shown in Figure 1. The sector is predicted to further grow from an estimated 11 GWh of storage in 2017 to between 100-167 GWh by 2030 [2], with growth expected to continue strongly in the long term.

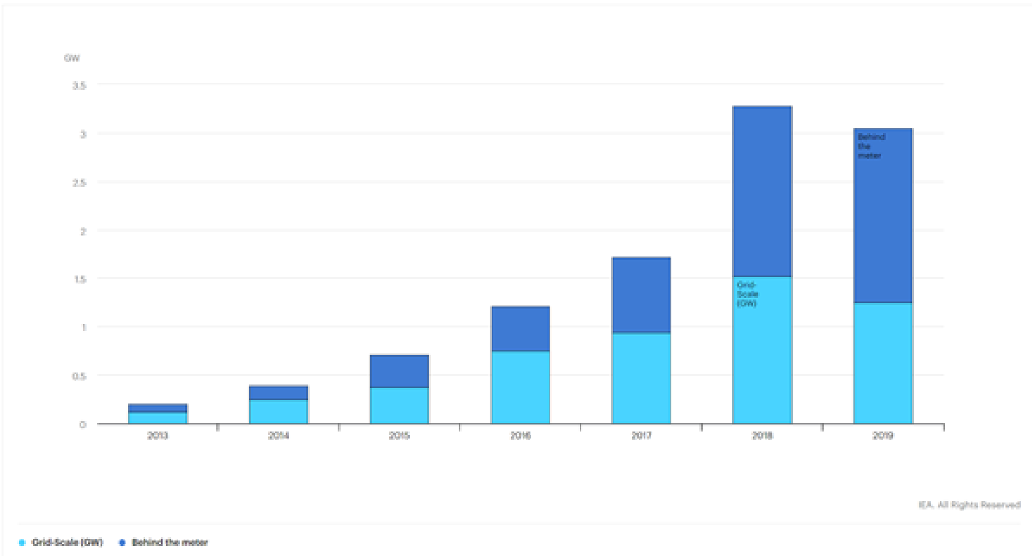

Figure 1 Global Storage Capacity Additions per year [1]

The first question is, why do we measure some values in Gigawatts (GW) and some in Gigawatt hours (GWh)? When the Hornsdale Power Reserve in South Australia was installed, there were leading titles saying 100MW and 129 MWh battery, worlds largest etc. But what do these values mean?

These are two crucial factors for any energy storage system. The Wattage rating measures how much energy the battery system can sustain, while the Watt-hour rating is how much energy the battery can store.

For example, the Hornsdale reserve can provide 100MW of power for 1.29 hours or 50MW of power for 2.58 hours etc.

Think of a water bottle pouring out. The water that flows out of the end is the Wattage, limited by the bottle opening size (power output), while the amount of water it can hold is the Watt hours (energy capacity) limited by the bottle volume.

The water pouring out the opening (Wattage) and volume (Watt hours) are not always in a fixed ratio. There can be a larger or smaller amount of water pouring out at any time, and this can increase or decrease the time it takes for the remaining water to empty the bottle.

Another key metric for energy storage is energy capacity (usually defined as energy density or specific energy) compared to the power output (usually defined as the specific power).

This is where battery technology becomes application dependant and balances durability, power output and energy capacity. For example, in power tools and mobile phones, a high-power output and energy capacity are required for the device's operation, which comes at the expense of durability (lots of power but does not last very long).

WHAT ARE THE TECHNOLOGIES USED?

Like any good problem, the solutions are varied and case-dependent, leading to many different energy storage technologies.

These technologies can be broken down into four main categories, with sub-categories for each one:

1. Chemical
2. Electrochemical
3. Electrical
4. Mechanical

We will only be looking at Lithium-ion (Electrochemical) and Flow batteries (Electrochemical).

For residential and commercial use, lithium-ion technology is market dominant. This has been assisted by the continuing uptake and expansion of electric vehicles requiring more production capacity and lowering costs.

However, what makes for an effective electric vehicle battery does not necessarily make for a good grid storage battery.

Lithium-ion is an umbrella term for six primary chemistries manufactured.
Our focus is:

- Lithium Nickel Manganese Oxide (NMC)
- Lithium Iron Phosphate (LFP)
- Lithium Nickel Cobalt Aluminium Oxide (NCA)
- Lithium Titanate Oxide (LTO)

Table 1 demonstrates the main differences between these.
With the specific energy (how heavy the battery is, compared to how much energy it can store), the cycle life (how many times it can be charged and discharged before disposal) with predicted increases in cycle life shown for 2030 from advancements in technology and typical uses.

Note that these are average values as performance can vary between manufacturers.

CHEMISTRY TYPE	NMC	LFP	NCA	LTO
Specific Energy (Wh/kg)	150-220	90-120	200-260	70-80
Cycle life (2016)	2,000-4,000	1,000-10,000	1,000-2,000	10,000-20,000
Cycle life (2030)	3,800-7,600	4,700-19,000	1,900-3,800	19,000-38,000
Common Usage	E-bikes, medical devices, EVs, industrial	Stationary with high currents and endurance	Medical, industrial, EV (Tesla)	UPS, EV, solar street lighting

Table 1 Comparison of Lithium-ion Chemistries [2]–[4]

This information represents a common trend in lithium-ion technology. Higher specific energy chemistries that are useful for lightweight applications such as electric vehicles and non-stationary devices tend to have shorter cycle lives, requiring more frequent replacement.

For stationary applications such as grid storage and behind the meter solar residential storage, the specific energy is not as crucial since there is typically no limiting factor of space (lower specific energy requires more cells for an equivalent storage capacity).

This allows for the higher cycle life chemistries to be used, extending the battery system's useful life. Currently, the most utilised chemistries for renewable energy storage, such as the behind the meter solar PV are NMC and LFP.

Even though LTO seems like the perfect solution for stationary storage due to its high cycle life, it is still a relatively new technology manufactured in low quantities, making it a high-cost option. An interesting project currently underway in Australia compares manufacturer claims for battery systems against measured results.

For anyone interested in getting a system for home use, I would recommend investigating the results before committing to a purchase, the link can be found here.

Detailed additional information on the life of batteries, how they decay with use and how warranties are measured is available via our resource centre.

Although many manufacturers use NMC, LFP is fast becoming the chemistry of choice for home, commercial, and utility-scale. This is due to higher cycle life, safer chemistry against thermal runaway (when the battery overheats and combusts) and cheaper raw materials (no need for expensive Cobalt and nickel). No matter what chemistry the lithium-ion battery is, they all come in one of 4 geometries, as shown in Figure 2.

Power tool batteries are typically a bunch of cylindrical cells stuck together in a battery pack, while mobile phones typically use pouch design. For renewable energy storage, the types used are cylindrical and prismatic, with dozens or hundreds connected to make a battery pack that connects to upwards of thousands of battery packs to make the battery system.

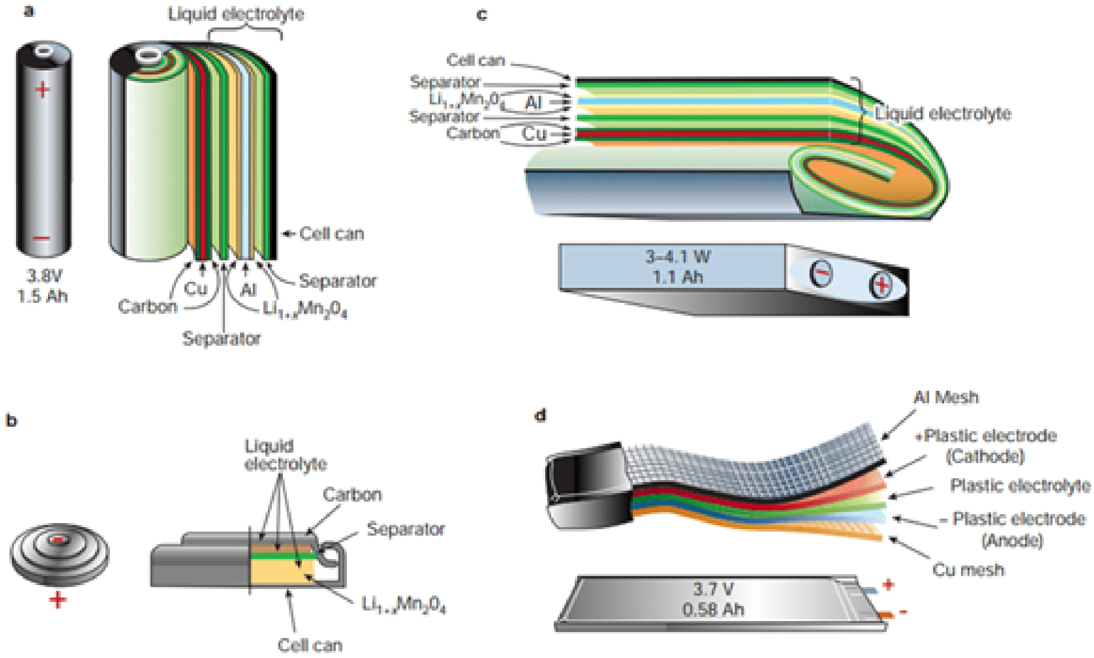

Figure 2 Different Lithium-ion cell geometry a) cylindrical b) coin c) prismatic d) pouch [5]

In conclusion, relative to cell design, to increase storage capacity (Wh), more cells need to be added, more battery packs etc. This can quickly become expensive, but is there another option? Let me introduce you to flow batteries. The way a flow battery works is complicated, but the vital thing to know is they use fluid known as electrolyte to store energy.

This fluid suspends a material, Vanadium ions (in a Vanadium redox flow battery), that cycle through the battery to produce power.

The fascinating thing about them is they show almost zero degradation with use, meaning the cycle life is 20,000+ with no loss in storage capacity. Furthermore, the electrolyte can be recycled and used in new batteries, so a flow battery that has reached the end of its life can receive some maintenance and be good to go for another 20,000+ cycles.

This sounds fantastic right? So, what is the catch? There are a few, such as the technology being in early deployment, making it expensive.

The system requires pumps and sensors, which are higher maintenance than lithium-ion, and it is far less energy-dense, requiring much larger volume for the same storage capacity. This volume requirement is due to the storage tanks of electrolyte but is also a positive of the technology. Since the storage capacity (Wh) is directly related to the volume of electrolyte, larger tank sizes increase the storage capacity rapidly.

To increase lithium-ion storage capacity, many more cells need to be added, for flow batteries the storage tanks (typically made of plastic) need to be made larger, which is relatively cheap to do. This is where flow batteries can shine, in large capacity storage.

THE BOTTOM LINE

How do key technologies in the renewable energy storage field compare in cost, and how is the deployment of these technologies coming along?

IRENA, the International Renewable Energy Agency, a leading expert body, investigated research potential, market growth, manufacturing potential and other aspects to determine how the costs of various technologies will decrease by 2030.

Figure 3 shows this study's results with cost reductions per kWh expected to average 50-60% compared to 2016 values. When you look at existing prices, as shown by the ITP battery testing centre in Figure 4 the current AUD cost is around $700/kWh.

In summary then, by 2030, these costs are likely to reduce to $350/kWh or less, drastically changing the economics for residential and commercial users.

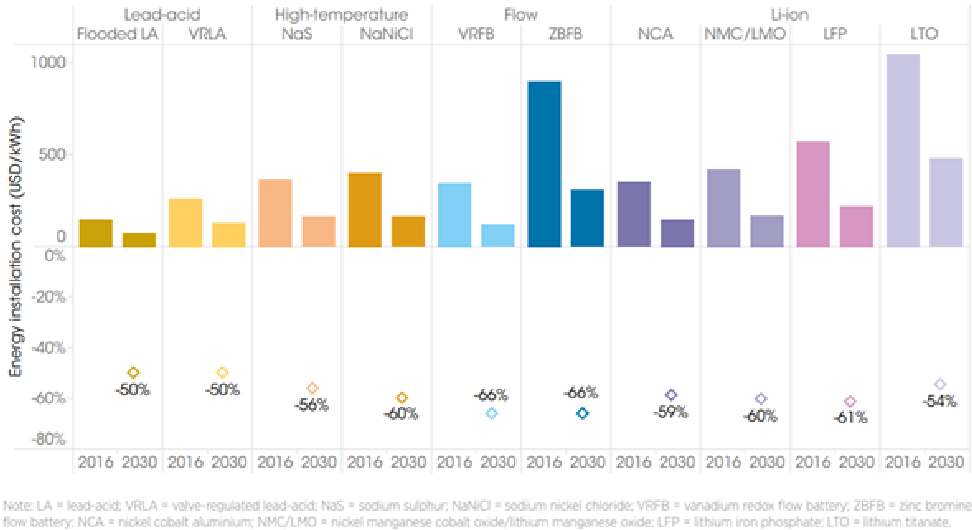

Figure 3 Battery storage system installed cost predictions 2016-2030 [2]

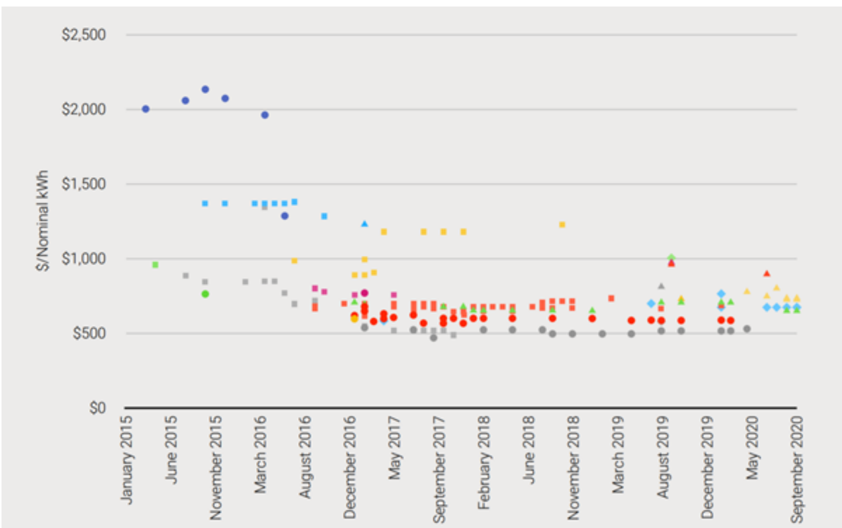

Figure 4 Wholesale prices for lithium-ion battery products installed in the Battery Test Centre [6]

We have the costs now and estimates for expenses in the future. But, should I buy a battery, and if so, when? This is not a straightforward question to answer as it is case dependent on energy usage trends, cost of electricity from the grid, whether you have solar PV installed and many other aspects.

Battery storage technology is being adopted by market enthusiasts, and people willing to accept a payback period of 5-10 years. To put storage technology development into perspective in 2010 solar PV had a payback period of 5-10 years, now it is not uncommon for 3 years or less.

This demonstrates how fast the market can move and costs plummet with upgrades to technology and manufacturing output.

Figure 5 shows a comparison on how the most used technologies stack up on cost and cycle life (how many times it can be used before disposal), these are averaged values from the 2016 report by IRENA.

There is a trend of higher installation costs (USD) for longer cycle life technology which rings true the adage “you get what you pay for”.

Now we have a breakdown of how long a technology will last and how much it should cost, the best one should be easy to identify right? Well, much like the question of should I get a battery, it is intended use and size dependent for which one works best.

For example, lithium-ion will typically be the best choice for residential use due to the low maintenance requirements and high energy density. When scaled up to commercial then utility size, flow batteries and high temperature batteries start to become attractive, but this is still dependant on intended use.

The best solution is to consult an expert that will go through your requirements and arrive at the cost optimal solution.

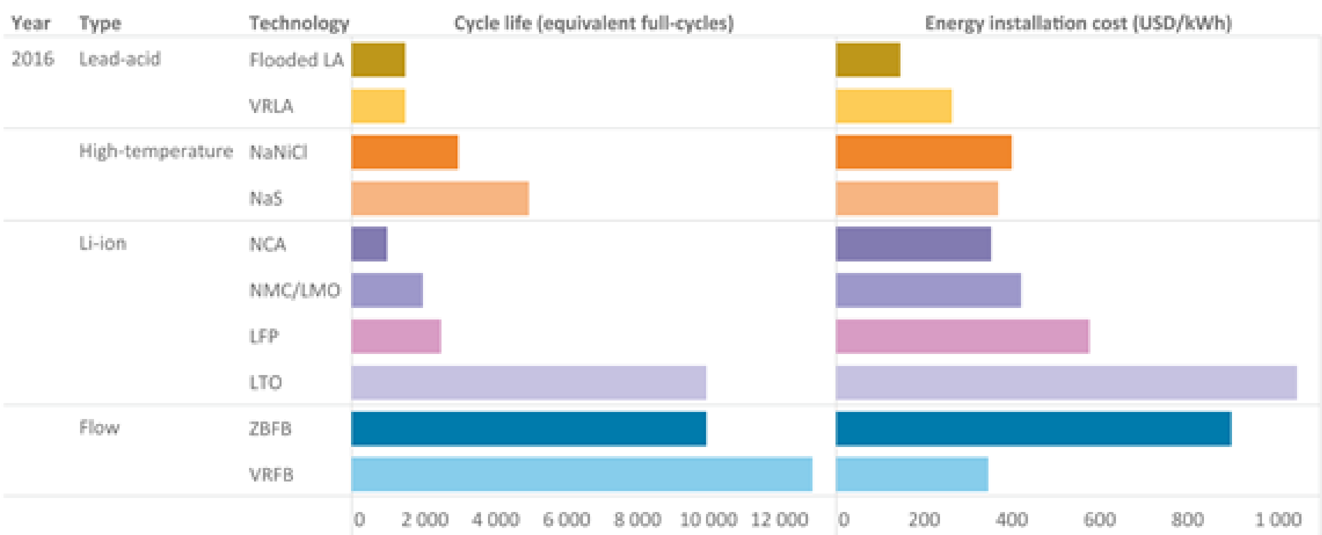

Figure 5 Cycle life and installation costs of battery technology (2016) [2]

HOW ARE WE GOING IN AUSTRALIA?

It may surprise some that Australia is in many respects' world-leading in battery uptake and at the cutting edge of new uses for them.

According to the International Energy Agency Australia is the 5th largest battery market globally as of 2019.

This is rather impressive considering the countries in front of Australia include South Korea and the USA, which have considerably larger market populations.

What does that 5th place mean in numbers? In 2019 22,661 small-scale batteries where installed (mostly for residential use), compare this to the 7,500 installed in 2016, representing a 3-fold increase in installations [7].

In 2020 AGL announced plans to roll-out 850 MW of energy storage across the nation energy market by 2024. ARENA announced a utility-scale 2 MW/ 8 MWh

Flow battery to be built in South Australia to assess potential of the technology for widespread use, the first of this size in Australia. Not only are we installing a lot of batteries, but we are also world-leading in how to use them across the grid. Virtual Power Plants (VPPs) is a concept where battery systems are linked together across the grid to help smooth out demand and reduce overall price peaking.

From a residential view, the base idea is your solar PV and battery system will sell energy in real time when it is profitable to do so and only sell battery power down to a specified level, 75% capacity for example.

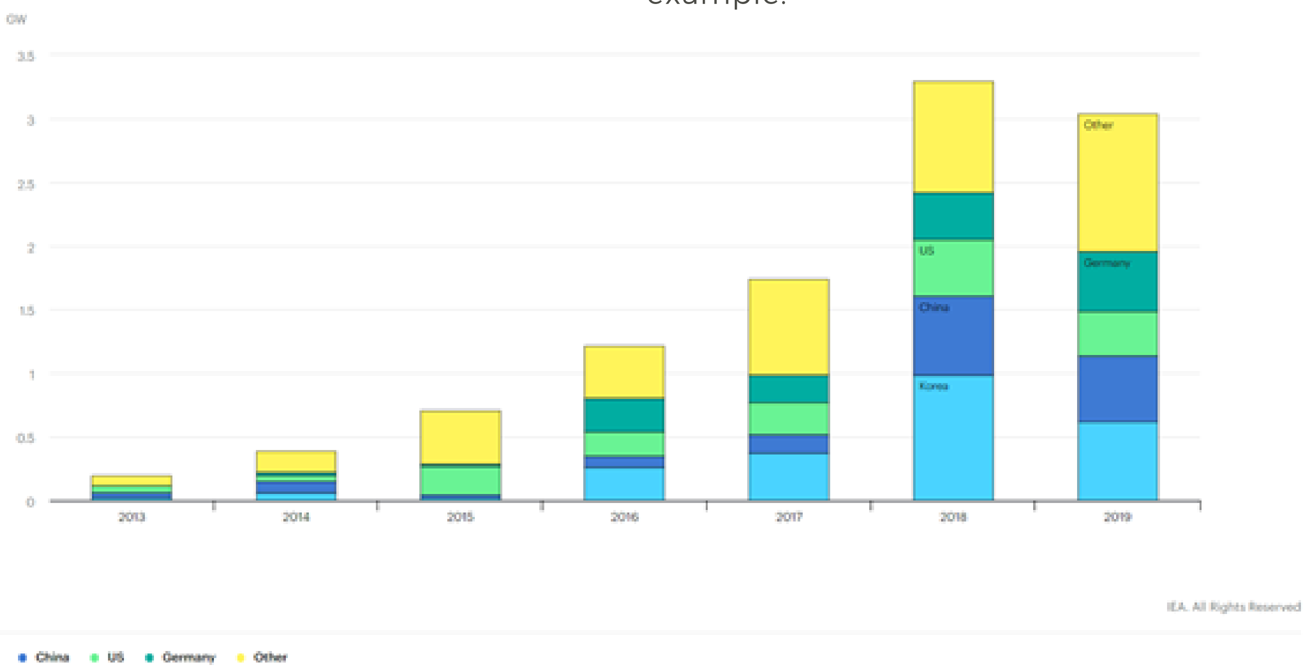

Figure 6 Annual global storage deployment by country 2013-2019 [1]

This allows the residential owners to assist in grid stability and make a profit while still having ample electricity for their own use. To further this concept AGL and ARENA have launched a trial program as of November 2020 that will investigate electric vehicles for use in VPPs.

This takes advantage of electric vehicles' growth to provide further stability to the grid with growing renewable mix, giving electric vehicles a secondary use while not operational providing a revenue stream (internal combustion cars do not earn you money sitting in the garage like that).

Australia installs a lot of batteries, but we do not make any right? It may come as a surprise that there are several companies manufacturing batteries in Australia.

Here is a short-list of batteries that are either Australian made or Australian designed by Australian companies (note this is not an exhaustive list).

- Century Yuasa Batteries PTY. Limited
- RedFlow International PTY.LTD
- ZENAJI
- SONNEN
- POWERPLUS ENERGY
- Deep Cycle Systems (DCS)

Whoever said Australia does not make anything anymore?

To put it into a statement **energy storage is here to stay**. Although the costs can be prohibitive to people in the current state the same was true for solar PV and now every man and their dog is either getting a solar PV system or talking about getting one. Watch this space as battery prices are already looking good for most cases and will only come down in the future.

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