# RTT TECHNOLOGY TOPIC
# October 2016

## 5G Energy Storage

Over the past 15 years, the reducing cost of memory bandwidth has transformed the telecommunications industry.

In our January 2000 Technology Topic, 3G Memory we highlighted the introduction of data warehouses and the growth of low cost memory in user devices as two significant trends that would define and determine future added value in mobile networks with Vodafone's 10 terabyte data warehouse (which seemed a lot of memory at the time!) as an early example.
http://www.rttonline.com/tt/TT2000_001.pdf

We failed to grasp that memory added value would be realized from search algorithms rather than the memory itself. Google was two years old with less than 20 employees and largely invisible to the telecommunications industry.

It can however be observed that a similar transformation is now taking place in the energy supply industry based on the reducing cost of energy storage.

At a macro level this is enabling the industry to use solar and wind power and tide power and hydroelectric power more effectively, storing energy when it cannot be absorbed by the grid, increasing load shedding efficiency.

At a micro level it is allowing householders and office and industrial premises to store energy from PV panels during the day for use in the evening.

In the telecommunications industry energy storage is presently financially attractive in markets where the electricity grid is unreliable, unavailable or expensive. Reliance Jio in India for example use lithium ion batteries to supply power to their telecom towers. In countries such as Australia, high domestic tariffs provide the basis for relatively fast consumer investment payback.

Assuming energy costs increase over time it is likely that energy storage will become increasingly important for mobile operators. This month's technology topic reviews some of the present and future storage options and considers the possible implications for 5G infrastructure design.

**Read on**

The telecommunications industry has used batteries for 150 years as a source of backup power and to supply DC line voltage through the fixed copper network. The lead acid battery remains the work horse of the industry but needs to be able to withstand a higher number of deep discharges when compared to a car battery. This requires heavier and stronger lead plates which add weight and cost.

Deep cycle lead-acid batteries are also used for off-grid solar & wind power systems, marine and industrial power applications. 'Solar' batteries are optimised to be able to charge with very little current to take advantage of any available energy. Solar batteries also normally have a very high charge & discharge efficiency of around 90 to 95%.

There has been a shift to Valve Regulated Lead Acid (VRLA) batteries due to their minimal maintenance. VLRA batteries limit the flow of gas to the cell (hence valve regulated) and stabilize the electrolyte in a gel or mat of micro glass fibre so they are not sensitive to orientation (they will work sideways or upside down!) and are available in a range of voltages from 2 to 48 volts.

The disadvantage is that they cannot be stored in a discharged condition, have relatively low energy density, can suffer thermal runaway and have a short life if working in high ambient temperatures.

Their main advantage over lithium ion is cost. The individual cell cost of lead acid is of the order of \$80- \$100/kWhr. The individual cell cost of lithium is four times higher with additional circuit management costs.

There are also (as always) interesting technology innovations that promise to extend the viability of ‘old technologies’. The coupling of lead acid batteries to ultra-capacitors is a contemporary example.

http://www.ultrabattery.com/

Lithium ion however has three times the energy density per unit weight and six times the energy density per unit volume, tolerates higher temperatures (does not require air conditioning), has a faster recharge time, more discharge cycles and a deeper discharge tolerance.

There has been some discussion that there may be a shortage of lithium due to its use in electric cars and smart phones and that this will reverse the present decrease in cost.

This is however unlikely. 70% of the world’s lithium comes from brine lakes (salt lakes) in Bolivia, Argentina, Chile, Australia and China. There is no prospect of a shortage of supply and if we run out of salt lakes, techniques to use sea water are possible.

In practice the lithium raw material in a Li-ion battery is less than 1 percent of the battery cost. A \$10,000 battery for a plug-in hybrid car for instance contains less than \$100 worth of lithium (about 4 kg). It can also be recycled an unlimited number of times. If there is a cost problem it is likely to be the rare earth materials used in other parts of the energy storage system with China controlling 90% of the world’s supply. Supplies of good quality graphite for battery anodes and battery grade cobalt for the cathodes also need to be secured but this is not generally considered as being particularly problematic.

The Tesla car company are the most visible company presently investing in the mass production of lithium ion cells with much of the core battery technology sourced from Panasonic but this is definitely not just about the automotive industry

The Tesla Powerwall is an energy storage product targeted directly at the domestic, commercial and lower end industrial storage market designed to be used with PV (**p**hoto **v**oltaic) cells.

In bigger grid applications, Panasonic are implementing large scale (1 MW) energy storage arrays in India. Tesla and Panasonic will be sourcing batteries from their new Gigafactory in Nevada with economies of scale and manufacturing efficiency yielding a 30% reduction in per kilowatt hour cost.

Interestingly just like our memory bandwidth example, the added value is not being realised from the underlying energy storage technology but from the associated system management software.

For Tesla cars this is all about how to manage cell heat rise during fast charging and maximising battery life when the batteries are exposed to regular fast charge cycles. For Panasonic, a significant percentage of the added value of their industrial scale storage is realised by the associated system software and control.

Batteries are not the only form of energy storage. Solutions capable of converting electricity into types of energy that lend themselves well to storage, include heat, cold, hydrogen and other chemicals. Chemical synthesis can also be used to produce other chemical raw materials such as ammonia, used in fertilizer manufacture

Electrolysis avoids the energy heat loss of batteries and pumped storage systems. Electrolysis is the mechanism used to turn water and renewably-generated electricity into hydrogen. The hydrogen can later be burned to generate heat or can be converted back into electrical current by means of a fuel cell. Hydrogen can be used in conjunction with carbon dioxide to obtain methanol, used as a green fuel for use in cars and trucks.

At a pressure of 200 bars, the energy density of hydrogen gas is comparable to that of a lithium-ion battery. Large quantities of the gas could be stored in the underground caverns of salt domes of the sort used by natural gas suppliers as reservoirs, or in the existing natural gas grid, which can accommodate up to five percent hydrogen without dangerous implications. There are presently no turbines that can burn pure hydrogen though Siemens are working actively in this area. Toyota have their first hydrogen car, the Mirai, on the market but it is twice the price of a 'normal' car and dependent on having access to refueling stations which are presently rare.

The big bug bear is conversion efficiency. Most hydrogen at the moment is produced from fossil fuels. Shifting to wind power would be possible but half of the energy produced would be lost during electrolysis (though wind farms would no longer have to be shut off because of overcapacity). A new generation of electrolysers could reduce the cost of hydrogen production by at least a factor of five which would make the whole process substantially more sustainable.

**Is energy storage an opportunity for 5G?**

While it would be theoretically possible for every base station to have a fuel cell this seems an unlikely scenario at least for the immediate future.

However the more narrowly defined battery based energy storage industry has similar market segmentation to 5G with a focus on vertical market requirements across domestic, commercial, industrial and automotive applications.

Our May 2016 technology Topic, **5G Vertical Markets** highlighted the ambition to serve electricity grid vertical market requirements as a specific target application.

**http://www.rttonline.com/tt/TT2016_005.pdf**

But it might be worth reflecting on the practical rather than theoretic value of existing mobile broadband assets.

The mobile broadband industry is adept at matching bandwidth availability to demand. This is not dissimilar to matching energy to demand.

The mobile broadband industry has physical assets, Pico, micro and macro sites, that can accommodate solar panels and wind power and back-up power. Operators already buy large numbers of lead acid batteries and smaller but still significant numbers of nickel cadmium and lithium ion batteries. Reduction in the cost of lithium ion batteries will allow operators to store and use energy across a 24 hour duty cycle and could potentially allow them to provide load smoothing for the grid particularly in markets with relatively high ratios of supply side renewable energy.

**Summary**

From a user device perspective, there is a need to run IOT devices on local power sources. A lower cost of energy storage would improve the operational economics of IOT connectivity.

From a network perspective, the mobile broadband industry could turn a power problem into a power opportunity or rather a cost (power consumption) into an asset (power storage, load shedding and load smoothing).

Telecommunications has a long tradition as a power distribution network. For the 5G mobile broadband industry, increasing the energy storage footprint of Pico, micro and macro cells could facilitate a range of added value power services to domestic, commercial and industrial customers.

Though Google might get there first.

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