Energy storage solutions in South Africa

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As the cost of renewable energy is becoming increasingly competitive and the cost of electricity from Eskom and the municipalities constantly rising, increasing numbers of energy users are considering alternative means of supply. Where renewable energy is considered, such as PV or wind energy, which are intermittent, it is necessary to look for energy storage options that can provide power during all hours where the energy is consumed, in order to provide a similar if a similar quality of power supply.

As published recently by Bloomberg, (*A. Hirtenstein, 22 May 2017*) the cost of lithium ion battery based energy storage is reducing at a surprisingly high rate; not unlike the continued trends we have seen of the cost of PV modules.

Based on the information above, it is worth looking into the energy storage solutions available in the South African market. While pumped storage, compressed air and flywheels have a number of useful applications, this article is focused on the electrochemical storage options available that are considered more applicable to household or small industrial/commercial consumers.

Types of batteries available

Lead acid

Traditionally, lead acid batteries have played an important part in the energy storage market, with the most automobiles currently using a lead acid battery of 0,8 kWh to 1,5 kWh. A number of new technologies are currently being developed, and two technology options available on the market today are flow batteries and lithium ion battery technology.

Lead acid, as a mature technology is relatively inexpensive and simple to manufacture, leading to a lower cost per watt-hour. One of its benefits is that it doesn’t lose its charge quickly when stored in a charged state. It also performs well in a wide range of temperatures. It has a high cell voltage that is related to its ability to provide a high surge current and a high specific power, the ability to deliver a high discharge current. Being an older technology, it comes with some disadvantages though. It has a low specific energy density, meaning that the units are relatively high in volume and heavy for the energy stored, and it charges relatively slowly, especially when compared to modern technology. It can take 14 to 16 hours to reach a fully saturated charge. In order to prevent sulphation – a process that degrades the battery – it is necessary to store the units in a charged state, with some types of units requires watering and special transport methods. However, the biggest drawback is that it has a limited cycle life, which is reduced further if used in a deep cycling mode, in other words draining the battery to below 50% of the maximum power.

Lead acid batteries are a good choice where weight is not a significant factor, where the input cost is a deciding factor and when calendar life is not a main concern.

Lithium ion

Lithium ion batteries are well-known for their use in mobile applications, specifically in cellphones, electric vehicles and other mobile devices. These range in size from 1 to 210 kWh.

Lithium ion technology has a number of advantages, such as its high specific energy and energy density and energy efficiency. Compared to lead acid batteries, lithium ion batteries can be roughly a quarter of the weight, for the same energy storage capacity. It has the ability to deliver a high voltage per cell, and can handle high load currents. One of the main benefits of lithium ion batteries is the fact that it has a long cycle life compared to lead acid and other technologies available on the market. However, one of the drawbacks is that it requires a protection circuit and thermal regulation, as it could react to overcharge or very high temperatures. This is currently being addressed by control systems that are designed to protect the battery from unfavorable conditions. Another challenge is the higher initial cost of lithium ion batteries compared to lead acid batteries; however, due to the increased production of the units globally the costs are reducing rapidly.

Flow batteries

Flow batteries convert chemical energy into electrical energy by pumping the electrolyte though a membrane that creates a reaction to release electrical energy. The capacity and the power available is defined by size of the tank and the layout of the internal components, so the battery capacity can be designed for any application. The electrolyte and electrodes do not undergo a physical or chemical change, meaning that the lifetime of the battery is not limited by years or cycles, and the conversion efficiency is very high, and delivers a high cell voltage. On the downside, this type of system is currently limited to large scale, (generally 50 MWh or more) stationary applications which are often custom designed, which inhibits possible cost reduction opportunities presented by the mobile applications industries. However the technology is maturing and scalable configurations in the 20 kWh to 50 MWh scale are becoming available.

Selecting a battery

The choice of battery to be installed for a specific application is dependent on a number of factors. This includes the amount of energy and power required, which will affect the size and type of battery that will be used. The battery capacity required is determined by a number of factors, including the daily energy demand, depth of discharge, number of days of autonomy required, the maximum power demand, surge demand and maximum charge current. Other factors that have to be considered are the operating temperature, voltage, discharge rate, self-discharge, recharging (number of cycles) and reliability.

The cost of energy storage and solar PV

In terms of cost considerations, there are a number of capital and operating cost factors. For capital costs it is important to take into account the expected battery use, in other words the number of full or partial cycles per day and year, battery lifetime in years and cycles, battery performance, round-trip efficiency, installation and delivery. Operational cost contributors are the location of installed battery system, application, additional equipment needed, vendors, commercial availability and system size.

To enable a comparison of lead acid and lithium ion battery systems, Arup undertook a study comparing two different grid connected PV and battery systems, for three different load scenarios.

For the scenarios, we considered the load profiles of three different types of energy users: industrial, commercial and a community residential. It was found that, depending on the type of the energy user, the levelised cost of energy (LCOE) over a twenty five year period will vary according to how closely the PV generation curve matches with the user's load curve. In all three load scenarios the LCOE of lithium-ion was found to be approximately 30% lower than the lead acid case. Looking at the different considerations, the main cost difference is due to the lower maintenance and replacement cost of lithium-ion units. It was also found that, excluding financing costs, the cost of grid connected PV and storage is currently approximately double the daytime Eskom Megaflex tariff; however, in municipal areas, the modelled LCOE is approaching, or is already similar to the daytime tariff for residential areas, depending on the municipality and the tariff structure of the user.

Conclusion

With the downwards trajectory of the cost of PV as well as of batteries, and the upwards trend of Eskom and municipal electricity tariffs, it has been shown that excluding financing costs, PV plus storage solutions are already at grid parity costs for certain municipal tariffs, with other municipal tariffs and Eskom rates like to be approached in the not too distant future. Further applications of energy storage are also to store energy when utility power is cheaper or when the PV array is generating electricity, and release it during the expensive peak times to save additional costs, and to use the batteries to level the load in cases where the maximum demand charge is a significant portion of the utility cost.

https://www.bloomberg.com/news/articles/2017-05-22/move-over-tesla-europe-s-building-its-own-battery-gigafactories

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