Introduction to Renewable Energy Storage

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Most countries rely on nonrenewable energy sources such as coal and natural gas for their power needs. A review of the previous 200 years indicates that most global energy demand is and has been supplied from nonrenewable sources (BBC, 2014). With seemingly ever-increasing demand, these nonrenewable sources are running out. Scientists, engineers, business leaders, and government officials are exploring possible renewable energy sources for the future. Renewable sources of energy are either ubiquitous or can be quickly replenished, thus can be utilized again and again. A good example is the sun as a source of solar energy. There are various reasons as to why the world is marching more towards renewable sources other than the depletion of the non-renewable sources. Many of the non-renewable sources are environmentally unfriendly (Yang et al., 2011), since they entail burning and the emission of greenhouse gasses.

Renewable energy sources also have their drawbacks. Wind and solar energy, which are two prevalent types of renewable energy, tend to be uncertain. The sun is not always shining and the wind is not always blowing (Liserre, Sauter, and Hung John, 2010). This issue raises concerns about their reliability as a main source of energy in households or for feeding electrical grids that depend on them. Those concerns have contributed to the increased need for scientists, engineers, business leaders and government officials to focus more on means of energy storage. Storage of energy involves capturing energy produced at a given time, with an aim of using it later. Devices used to store the energy are referred to as accumulators. For decades, the most utilized energy storage method in the U.S has been pumped hydro (Renewable energy world, 2016). More contemporary technologies however, are being developed as the need for storage increases, and the restricted locals available for pumped hydro storage. This report will present new techniques for renewable energy storage. In doing so, it shall focus more on solar energy, and show how lithium-ion batteries represent the best solution.

Energy from the sun is referred to as solar power. It involves the conversion of thermal or electromagnetic energy into electrical energy (SEIA, 2016). This energy is considered as the most environmentally friendly, or rather, the cleanest source of energy. Also, it is the most extensive and readily available source of renewable energy. Much technology has been invested globally for the harnessing of solar energy. Domestically, solar energy is used for lighting, powering electronics, and heating water among other purposes. This type of energy is also used on a large scale basis for commercial and industrial purposes (Denholm et al., 2010). There are various means through which energy from the sun can be harnessed. The most common method is the use of active solar systems which utilize mechanical and electrical devices that convert heat or light from the sun into another usable form of energy.

The amount of energy available to be harnessed from the sun depends on climatic conditions (Solar energy at home, 2016). During cloudy days, or at night, the amount of energy received by a solar system reduces drastically. In turn, this affects the amount of heat or energy produced by the system. Such reduction results in a need to store energy during sunny and warm days so that it can be utilized later when the conditions are not favorable for generation. Various methods are available for the storage of solar energy. The available methods depend on whether the user is utilizing solar heating applications or solar electricity applications. This report shall focus on solar electricity applications. Solar electricity is developed through the utilization of photovoltaic solar power systems. The two main methods of storing energy in a solar electric system are battery banks and grid inter-tie. (Grid inter-tie is not technically storage, but net metering allows it to be treated as such.)

In a grid-tied photovoltaic solar power system, the grid is utilized as the method of storing energy (Solar energy at home, 2016). This is possible through a process known as net-metering. It is a process where whenever an individual produces excess solar electricity, it is sent to the grid and the user's electric meter rolls backward. During periods when the system is not receiving any energy from the sun, it can pull electricity from the grid which will trigger the electric meter to roll forward.

An off-grid, battery bank approach has advantages. For one, the user will have achieved full independence, since this approach is not subject to the terms and policies of the local utility. Also, the owner of the system will not be subject to factors such as brownouts, blackouts, and rate increases. The owner will have energy self-sufficiency, and hence, energy security. The most outstanding feature of the grid-tied systems is net metering. However, this policy has been divisive, and has resulted in political disagreements concerning its use (Mooney, 2015). Therefore, as the costs of solar panels and batteries continue to decline, it appears that the more viable approach appears to be an off-grid battery bank. The main focus of this report will be on battery banks. Solar energy storage of can be accomplished through the utilization of battery banks to store electricity generated by the photovoltaic solar power system. The batteries can also be used as a backup in grid-tied PV systems (Solar energy at home, 2016). The main components of a solar system with batteries as the storage include:

- *Battery Bank*. Either one battery or a group of them wired together. These batteries are manufactured in such a way that they can survive the means of charging and discharging they will experience from the solar system.

- *Charge Controller*. Circuitry which ensures that the battery bank does not overcharge. Once the battery bank is full, this circuitry interrupts the flow of electricity from the solar panels.
- *System Meter*. It is responsible for measuring and displaying the status and performance of the solar photovoltaic system.
- *Inverter*. It is a device responsible for converting electricity from the batteries from DC to AC so that it can be used by household appliances.
- *Main DC Disconnect*. It is a breaker which is placed between the battery bank and the inverter. It allows for a quick disconnection of the solar system and the home circuitry.

Battery Types:

Battery storage remains the mainstream frontier for storage of solar energy (Achaibou, Haddadi, and Malek, 2012). Batteries can be categorized according to their storage solutions or according to their chemistry types. This report shall restrict itself to categorization based on chemistry types. The two common types of batteries available for use with solar systems are Lead batteries and Lithium batteries. Other, more esoteric types include flow batteries and ‘saltwater’ batteries.

Lead Batteries

These are rechargeable batteries which were introduced in the 1850s. Currently, they are the most common type of battery, especially on a commercial basis (Yamaguchi, 2014). Lead acid popularity can be attributed to the fact that they are the most affordable on the basis of dollar per nominal kilowatt-hour. It main application is in automobiles, large uninterruptible power supply (UPS) systems, and forklifts. The three most common types of lead acid batteries are absorbent glass mat, flooded, and gel (Achaibou, Haddadi, and Malek, 2012). As compared to modern rechargeable batteries, lead acid batteries have the lowest energy density and hence are not suitable for portable devices which require small size batteries.

These batteries are most suited for households requiring an energy storage system but with low upfront costs. They are not expensive and also easy to manufacture. Also, the technology used to make the batteries is reliable, mature, and also well-understood too. The batteries provide dependable service when utilized well. As compared to other discharge systems, these batteries have the lowest discharge rate (Yamaguchi, 2014). Maintenance costs for the batteries are also relatively low. That is because they do not have any memory, or electrolytes to fill.

The batteries have a couple of disadvantages too. For one, they cannot be stored in a discharged condition, and doing so can lead to damage (Solar choice, 2016). Also, their energy density is low than other types of batteries. That means they have a poor weight to energy ratio, where it requires a very large battery to store considerable amounts of energy. This type of batteries only allows for a limited number of discharge cycles. They are also not environmental conservative given the polluting nature of lead. The main disadvantage is that they require a great deal of care for them to survive (Yamaguchi, 2014). Misusing them can affect their lifespan greatly. For instance, charging them improperly can lead to a thermal runaway.

‘Saltwater’ Batteries

This type of batteries present a solution intended to maximize environmental cleanliness (Solar choice, 2016). That is because of their environmental friendly nature. Unlike lead acid batteries, the saltwater batteries are designed for full discharges, and they function just well even when used in partial stages (Solar choice, 2016). That means that an individual does not have to worry about failing to keep charging the battery regularly. They are most applicable for off-grid or standalone power systems. They can be used in place of lead-acid batteries, especially for individuals who are environmental cautious.

The downside of this batteries is their weight to energy ratio. They are very large and heavy, weighing around 118 kilograms and 1m tall (Solar choice, 2016). Also, they suffer from a low functioning discharge rate. Drawing power from them quickly drops efficiency significantly.

Flow Batteries

The technology involved in these batteries is relatively new in the market. Unlike the other types, these batteries contain moving parts whose role involves pumping an electrolyte across a membrane (Solar choice, 2016). The electrolyte in these batteries do not break down, but instead, it is the moving parts which get worn out. Environmentally, they are considered non-corrosive, and hence, safe (Renewable energy world, 2016). These type of batteries are best suited for commercial usage due to their weights. Also, they can be considered by individuals who are up for cutting-edge technologies.

Lithium Ion Batteries

These are batteries which have lithium as an anode. Li-ion batteries have a low self-discharge rate and a tiny memory effect (Oswal, Paul, and Zhao, 2010). Due to increasing demand for batteries, scientists and engineers have successfully focused on improving energy density, safety, operating temperatures, charging times, cost, and output power. Lithium batteries are used widely for various functions. They are used in portable devices, power tools, and electric vehicles (Oswal, Paul, and Zhao, 2010).

Currently, Lithium-Ion batteries are the most promising type of batteries for standard and renewable energy storage applications. Although Lithium-Ion batteries can sometimes have higher up-front costs, and may require special shipping instructions.

Reasons to Consider Lithium Ion Batteries

- Li-Ion batteries are light compared to other rechargeable batteries of related charging capacity
- Due to their high energy density, high amounts of energy can be stored in these types of batteries. A 1-kg lithium ion battery can store as much charge as a 6-kg lead-acid battery.
- Li-Ion batteries have a very low self-discharge rate.
- Li-Ion batteries do not have a memory effect unlike other types of batteries. That means they do not have to be discharged completely.
- Li-Ion batteries can handle hundreds of charge and discharge cycles.
- Li-Ion batteries can be recycled
- Li-Ion batteries have a higher charging rate as compared to other types of batteries
- Low maintenance

Reasons not to consider Lithium Ion batteries

- Up-Front Expense
- Transportation / Handling

Conclusion

Li-Ion batteries have multiple advantages as compared other energy storage methods. If you have interest in Tenergy's TenDura and TenFlex Li-Ion battery packs, or other Li-Ion offerings, please contact a Tenergy representative via e-mail at sales@tenergy.com, phone at 510.687.0388, or online at www.TenergyBattery.com.

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