Electrical Energy Storage

Eamon Keane

Electricity is unique. Unlike oil or gas in a pipeline, electricity is produced the instant it is needed. Power must be produced for your kettle the instant it is turned on. Electric energy storage (EES) can help to smooth the peaks and troughs of energy demand. Electricity demand peaks when people come home from work and hits the low point during the night. EES stores electricity as different forms of energy such as chemical, kinetic, or potential energy. This energy is converted back to electricity when it is required.

Global EES capacity is 90 gigawatts which is 3 percent of total electric power production capacity. Ireland has 292MW of storage at Turlough Hill, representing approximately 5% of power production capacity. The low level of storage is due to the high capital cost of EES compared to natural gas power plants. Natural gas can also be used to match electricity supply with demand. The key metrics for EES are the energy efficiency and the average cost per kilowatt-hour ($/kWh) over the lifetime of the storage method. Some EES options are:

Pumped Hydro: Two lakes are needed, with the upper lake higher than the lower lake. As the water falls it drives a turbine which generates electricity. Pumped storage uses low-cost electricity generated during periods of low demand to pump water uphill. The water is released to drive a generator during periods of high demand and high electricity prices. This is by far the most common form of storage and is used at Turlough Hill. The construction price varies by local geography. The energy efficiency is 70-85% and the cost is 0.1-1.4¢/kWh.

Compressed Air: Cheap electricity is used to compress air in an underground cavern. This air is then used in a gas turbine engine to regenerate electricity. Suitable geology near a gas pipeline is required. Energy efficiency is variable but efficiencies in the 70% range are achievable and the cost is 2-4¢/kWh.

Battery: There are many kinds of batteries – lead-acid, vanadium-redox, sodium-sulphur and lithium-ion to name a few. They are presently being used on a very small scale. They are flexible but cannot reach the large capacities that pumped hydro or compressed air offer. Energy efficiencies of approximately 60-95% are achieved and the cost is 5-100¢/kWh.

Fuel Cell: There are a number of types including the hydrogen fuel cell and the direct-methanol fuel cell. In the case of hydrogen, cheap electricity is used to split water into hydrogen and oxygen. This hydrogen is then used to regenerate electricity via a fuel cell. One difficulty is the shortage of platinum which is required for fuel cells. Energy efficiency is 40-50% (for hydrogen) and the cost is 6,000-20,000¢/kWh.

Flywheel: Electricity is used to accelerate a rotating disc to very high speeds in a vacuum. Electricity is recaptured by using a generator to brake the disc. Flywheels can be used to smooth out small power fluctuations. The efficiency is 90-95% and the cost is 3-25¢/kWh.

Thermal Energy Storage: There are three different types.

- The first uses solar panels to focus the sun's energy on a small area which heats up a low melting point salt until it becomes liquid. This hot liquid can be used to generate steam which in turn drives a turbine to generate electricity when it is required.
- The second uses cheap electricity to make ice from water during off-peak hours or by using another material to absorb energy. This ice is then used to cool a building during the daytime. The energy efficiency of these two methods is 70-90%.
- Finally there is cryogenic energy storage which uses off-peak electricity to make very low temperature liquid nitrogen (-196°C). This may then be used in a cryogenic heat engine to produce electricity. The energy efficiency is 40-50%.

Ultracapacitors: Ultracapacitors are electrical devices that consist of two oppositely charged metal plates separated by an insulator. The ultracapacitor stores energy by increasing the electric charge accumulation on the metal plates. Ultracapacitors can rapidly provide short bursts of power and can be used for industrial processes where small power fluctuations can be harmful. The energy efficiency is high.

Superconducting Magnetic Energy Storage (SMES): SMES consists of a coil with many windings at a very low temperature (-270°C). At low temperatures there is very little resistance which allows the electricity to be stored directly as an electric current. The energy efficiency is 95% but this is offset by the energy needed to keep the coil at a low temperature. SMES can be used for short bursts of power for sensitive industries.

Pumped hydro and lead-acid batteries are the only mature technologies, which have been used for over 100 years. Pumped hydro is the only mature large scale storage technology while lead-acid is used for power quality. The rest, excluding fuel cells and cryogenic energy storage, can be described as developed. They work technically and are commercially available but their actual implementation has been limited. In general they require further trials for reliability and economic competitiveness. Fuel cells and cryogenic energy storage are developing technologies which are not commercially mature.

The economics of energy storage depend on the difference between off-peak and peak electricity prices and vary country to country. Whether energy storage becomes more widespread in Ireland or elsewhere will primarily be down to economics.

Eamon Keane is an ME student in Energy Systems at University College Dublin and a member of ENI 2009, an undergraduate summer research project team.
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