Smart grids (Part 3 (II))

Peripheral Smart Grid Technologies

Distributed Generation (DG)

Distributed generation (DG) is typically a small-scale source of electric power embedded in the distribution network. In contrast to the traditional model in which energy generation and delivery originates at a central plant, DG is situated close to the consumers it supplies. Thus, a DG system cuts down on transmission and distribution losses. The associated cost savings typically run to more than 30 per cent of the total cost of electricity. DG includes a broad range of technologies including renewables (wind, solar, hydro) and combined heat and power (CHP) plants. At its smallest scale, DG can include microgeneration (see below). DG presents distributors with both a challenge and an opportunity. If unharnessed, it can cause huge problems with voltage levels, voltage fluctuations, thermal ratings and power flows, but if controlled, it can provide an invaluable tool for balancing the network. A key benefit of smart grids is the ability to master distributed generation and, therefore, encourage more of it.

Dynamic Demand (DD)

Using *dynamic demand (DD)*, electronic appliances (such as the refrigerator in your home) that don't make time-specific demands on the power system, can play a role in keeping the system in balance. *System balancing* is essentially the art of keeping the lights on and is the responsibility of the *transmission system operator (TSO)*. The TSO ensures that there's enough electricity at the right place at the right time and a key indicator used by the TSO in performing this role is the voltage on the network (called *system frequency*) which must be kept within acceptable boundaries.

To continue with the fridge example, DD automatically adjusts the refrigerator's *duty cycle* (the amount of time it consumes power) in response to changes in system frequency on the network. The response is automatic and immediate, providing *TSOs* the potential of a valuable, if uncontrollable, balancing tool.

Freezing the cost of system balancing

Currently, transmission system operators (TSOs) have to call on large power stations, often running in an inefficient standby mode, to keep the lights on in the event of a major loss of generation. Making these power stations available is expensive, both in terms of cost and carbon. A study in the UK in 2008 suggested that 40 million refrigerators fitted with dynamic demand (DD) could provide over 1,000 megawatts of frequency response – the equivalent of a large power station. This represents a total CO2 saving of over 1.7 million tonnes per annum. So, if new fridges were required to include DD as standard (along the lines of the EU directive that will phase out incandescent light bulbs), we have the potential to reduce our reliance on reserves based on expensive, carbon-rich generation plant.

Grid energy storage

An age-old problem for the electricity industry is that storing electricity in large volumes is very difficult, so generation and demand need to be matched in real time. And, with an anticipated increase in generation from unpredictable renewable sources such as wind and solar, the problem is exacerbated. What can you do with all the electricity generated from a wind farm during a storm at 3am? And how do you provide enough electricity to boil the kettles during half-time on a still, overcast World Cup final day?

One solution used for some time is *pump storage* in which water is pumped up to a holding reservoir when electricity is abundant and released through turbines to generate electricity at times of high demand. Trouble is, pump storage facilities are expensive to build and require a suitable location, typically in the mountains – away from areas of high demand. Research is on-going into new grid energy storage technologies including:

✓ **Batteries,** which are expensive to produce, costly to maintain and have a limited lifespan.

✓ **Compressed air,** which requires similar large scale facilities as pump storage.

✓ **Flywheels,** only good for small scale storage.

✓ **Hydrogen,** manufactured using off-peak electricity and then combined with oxygen to produce electricity at peak time but with lower efficiency than pumped storage or batteries.

✓ **Superconducting magnetic energy storage (SMES),** a means of storing energy in the magnetic field created by a direct current flow in a cryogenically cooled superconducting coil. It works only for small amounts of energy and is expensive to boot. It’s fair to say that there’s still a long way to go when it comes to grid energy storage.