Vanadium flow batteries for a zero-emissions energy system

Long duration | Growth in renewables and corresponding market pricing is the key driver for the commercialisation and global adoption for vanadium flow batteries (VFBs) and an important reason why we will see further growth for this technology over the years to come, says Ed Porter of Invinity Energy Systems.

In addition to the predictable seasonal and daily variation in demand, renewables are increasingly adding their characteristic "rhythm" or "shape" to the supply side. This causes both over- and under-supply events to be greater in size, frequency and duration, prompting the market to increasingly value flexibility.

VFBs' primary advantage lies in the ability to deliver vast amounts of energy at low cost over a working life measured in decades, not years. As a form of non-degrading energy storage, it has an extremely low marginal cost of use and is well suited to doing the sort of cycle intensive, deep-discharge flexibility that future energy systems will need.

The past 10 years have shown that initial system-wide carbon reductions are both possible and affordable and have been well supported by short duration storage to date. The challenge now is towards a zero-carbon system, which represents a huge opportunity for VFBs.

Consider solar PV, which has a low levelised cost of energy (LCOE) and is easy to develop at a range of scales. As the proportion of on-site demand or grid connection met by PV increases, it reaches an economic level of curtailment where deploying one more panel does not bring the revenues required to pay for itself. This supports on-site decarbonisation of around 40-50% for behind-the-meter solar.

Beyond that level, local curtailment issues mean that solar PV deployment is beginning to get stuck. For solar to provide more dispatchable low carbon generation, energy storage must be deployed. Storage becomes constrained not by the duration required for discharge, but by the duration of the charging opportunity. With the first and final hours of the day's solar PV generation taken up by demand, this leaves 4-6 hours to charge during the midday generation peak (with seasonal and geographic variation). This would be considered long-duration storage in today's market and, given solar PV's reliance on the diurnal cycle, would require near-constant cycling of any energy storage asset.

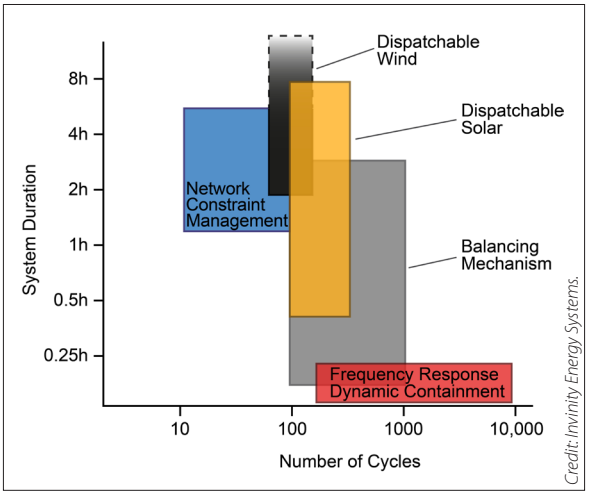

Figure 2: Energy storage services in the UK market

Enter vanadium flow batteries. Energy shifting over a 4-6 hour period is the business case for long-duration, heavy cycling storage technologies like VFBs. Electric system operator requirements are also expanding from shorter duration, power-focussed services, such as frequency response, to longer duration, heavy cycling, energy-focussed services, driven by the need to effectively dispatch renewables at a network level. You can see this demonstrated in the graphic below which uses the UK market as an example, but can be conceptually applied to US, Australian and European markets too.

This deepening of the "energy" (as opposed to power) flexibility market has been a key driver in the rapid commercialisation of long duration energy storage technologies in the last 12 months. As volatility in wholesale markets increases, utilisation (energy storage capacity factor) and consequently, marginal cost per cycle has become more critical in determining activation prices for energy storage assets.

We see a flexibility 'merit order' developing where lithium-ion batteries continue to address high-frequency stability and fast reserve response services (rewarding 'power') with rapid adoption of VFBs to capture growing revenue opportunities for years to come. Fundamentally, VFBs and other longer duration technologies bridge the gap between shorter duration applications, which are suitable for lithium-ion and the ultra-long duration (e.g. 24+ hour) applications where we are likely to see hydrogen and other "power-to-x" technologies make headway.

In front of the meter, VFBs are an excellent fit for large-scale solar projects and network balancing. We will deliver an 8MWh flow battery system to a 6MWp solar array in South Australia. Performing multiple, long duration charge/discharge cycles each day, otherwise curtailed solar output can be made 'dispatchable', allowing it to be deployed to the local grid at the most economically optimal time.

Behind the meter, flow batteries are also being used at a smaller scale, peak shaving and enabling a greater proportion of onsite renewable generation to be consumed, reducing site energy costs.

VFBs are uniquely capable of unlocking further penetration of renewables and capturing the opportunity in the ever-deepening market for energy-based flexibility. Their value lies in their proven ability to de-risk expansive renewable generation projects, effectively matching the changing shape of renewable generation to the changing shape of demand.

Author

Ed Porter is the Business Development Director at Invinity Energy Systems, a provider of vanadium flow battery energy storage systems for commercial & industrial sites, grid network infrastructure projects and off-grid applications, either standalone or alongside renewable energy such as solar PV.