**Use case**
Frequency regulation

# Providing grid resiliency with supercapacitors

A long standing challenge faced by electrical utilities is balancing the supply, or generation, and the demand, or load, when transmitting and distributing electrical energy across connected and isolated grid systems. This balance ensures grid reliability and stable voltage frequency. The risk with a gap of supply versus demand is dropping frequency which can cause grid operators to start load shedding to protect generation assets as the stress increases. When this gap is larger, load shedding is not sufficient which overstrains assets forcing plants to be shut down for protection, resulting in cascading power outages. Conversely, where instantaneous supply is higher than demand, this power could be dissipated as heat via condensers or load banks to keep the voltage surge or increase in frequency from harming generation assets or other connected elements.

Due to the constant variability of grid demand, balancing can be very difficult. However, there are systems and measures that can be implemented. Traditional generation assets, such as fossil fuel, nuclear or hydroelectric plants with spinning turbines, provide inherent inertia to help provide some frequency regulation. There are also other ancillary services that can be dispatched for longer term supply gaps to ensure reliable and quality power.

The increase of grid tied, distributed renewable generation and the retirement of traditional plant assets reduces the inherent grid inertia, introducing increased risk to grid reliability and resiliency on the supply side. Furthermore, the renewable sources can be unreliable, such as scattered cloud cover over photovoltaic arrays or varying weather conditions for wind turbines[1].

Energy storage systems are being deployed to help respond to imbalances in grid supply and demand. The XLM supercapacitor module and XLR supercapacitor module can provide ultra-fast response due to the low ESR construction of the XL60 supercapacitor cells. This feature, along with their maintenance free nature, helps ensure the energy storage system is always available for ultimate resilience.

Eaton's supercapacitor modules are capable of millions of charge/discharge cycles with no replacements or maintenance which can provide up to a 20-year lifetime depending on operating environmental conditions. The physics of supercapacitor construction allow for minimal effects on lifetime and the depth of discharge, from near full discharge to smaller, limited cycles.

The high power density (kW/L) can help reduce the footprint of the energy storage required to meet the needs of the grid when compared to battery or kinetic energy storage. This power density can help reduce capital expenditures by reducing the amount of energy storage oversizing needed to meet the instantaneous power required for improved grid reliability.

With the deployment of energy dense lithium-ion battery systems for longer term services and operational reserves, supercapacitor modules can be installed in parallel to reduce the number and intensity of very high peak discharge currents that can rapidly degrade the lifetime of the batteries. By extending the life of batteries with supercapacitor modules, operational expenses and maintenance costs are reduced for the transmission and distribution assets.

Eaton's XLR and XLM supercapacitor modules provide an ultra-fast response, long lifetime, maintenance free and cost-effective energy storage as a sole solution or by augmenting battery systems to help ensure a balanced and resilient utility grid.

1 Eaton renewable firming use case

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