# Inertia and Grid Stability

## *What Is Inertia?*

If a car, travelling at speed, develops a fault, its momentum ensures that it can slow and stop safely; without momentum it would be like hitting a brick wall. Inertia is the momentum of large rotating equipment, like power station generators. Storelectric's CAES has natural inertia.

Any fault in the system causes a spike on the mains, known as a RoCoF event (Rate of Change of Frequency). Real inertia absorbs and flattens the spike, so as not to harm the rest of the system.

## *Real and Synthetic Inertia*

Synthetic inertia, proclaimed by battery advocates, is not like real inertia. Synthetic inertia is a very fast response time. Any response time whatsoever is a delay. Any delay whatsoever allows the spike through to the next part of the system, or to the customer. Therefore synthetic inertia is excellent for recovering from failures, but only real inertia prevents the failures happening in the first place.

## *Other Stability Issues*

Stability is an entire package of different services, delivered to grids by naturally inertial systems like power stations and most large-scale long-duration storage. These services include:

- Voltage and frequency control / regulation;
- Reactive power and reactive load;
- Phase-locked loops and other more technical aspects.

For batteries to deliver these stability services, a dedicated battery would be needed for each – and it would not be able to defray its costs by trading actively on the electricity system. Large-scale, long-duration, inertial storage would deliver them all in conjunction with normal trading operations, almost as a by-product; and Storelectric's can deliver them not only more cheaply and efficiently, but also 24/7.

## *The UK Black-outs on 9th August 2019*

As is well known, on Friday 9th August the electricity supplies from one wind farm (Hornsea One, 750MW) and one generator set of one gas-fired power station (Little Barford, Cambridgeshire) failed almost simultaneously at 16:54. There was then a cascade of further trips within Little Barford, taking out the entire power station (680MW). The total capacity loss was ~1,430MW at the beginning of the evening peak. While National Grid's power was restored by 18:00, disruption continued throughout the evening on the transport networks. 16:54 is in Settlement Period 33; 18:00 is the end of Settlement Period 36.

## *Batteries and DSR on 9th August*

Battery and Demand Side Response (DSR) advocates have claimed that they provided 560MW power within 5ms to 2 seconds, and had stabilised the grid if only further generation trips hadn't happened – if only there had been more batteries, the country would have been OK. But these trips occurred because of that 5ms to 2 second delay, so batteries were not part of the solution.

While batteries and DSR offer many useful grid services, shortfalls in their ability to provide sufficient grid resilience include:

1. Inadequate scale: typical battery and DSR installations are (even when aggregated) of the order of 1-20MW while the system need was 1.43GW;
2. Inadequate duration: the outage was longer than the duration of most battery and DSR services;
3. Battery state of charge: National Grid's plans appear to assume that batteries are always kept fully charged, whereas in reality they are all cycling in charge-state according to their contracts and commercial optimisation;
4. Battery and DSR activation times: even if perfectly available, the fact that batteries and DSR (and gas reciprocating engine plants) need to be activated actively imposes delays in response of a few seconds, during which delays the system fails, whereas inertial systems are an always-on response;
5. DSR response times: DSR resources need to be polled, signal availability, and then receive and respond to an activation signal, which increases their response times still further.

## *Relaxing Breaker Settings*

Because the spikes on the mains tripped breakers throughout the system, National Grid decided to undertake a large project to relax breaker settings. But breakers are there to prevent damage to customers' equipment and to subsequent parts of the grid. Relaxing those settings enables the spike to be passed through, eventually to end users. Therefore this project to relax breaker settings, rather than procure real inertia, is a multi-million pound dereliction of duty.

## *Delivering Inertia*

What is really needed is real inertia. The true story of August 9th is that there is generally less inertia on the system (proportional to total generation) than there has been since the construction of the grid due to the retirement of fossil fuelled power stations. That day, inertia was low because wind generation was high. Had there been sufficient inertia, only one or two trips would have occurred, not a cascade of many. Storelectric's CAES solutions provide twice the natural inertia of an equivalent-sized power station, and provide it 24/7.

**About Storelectric**

Storelectric (www.storelectric.com) is developing transmission and distribution grid-scale energy storage to enable renewables to power grids reliably and cost-effectively: the world's most cost-effective and widely implementable large-scale energy storage technology, turning locally generated renewable energy into dispatchable electricity.

**Grid-scale electricity storage**
using an innovative form of
**Compressed Air Energy Storage**

- Innovative adiabatic Compressed Air Energy Storage (TES CAES) will have zero / low emissions, operate at 68-70% round trip efficiency, levelised cost significantly below that of gas-fired peaking plants, and use existing, off-the-shelf equipment.
- CCGT CAES technology converts and gives new economic life to gas-fired power stations, reducing emissions and adding storage revenues; hydrogen compatible.

Both technologies will operate at scales of 20MW to multi-GW and durations from 4 hours to multi-day. With the potential to store the entire continent's energy requirements for over a week, global potential is greater still. In the future, Storelectric will further develop both these and hybrid technologies, and other geologies for CAES, all of which will greatly improve storage cost, duration, efficiency and global potential.

**About the Author**

Mark Howitt is Chief Technical Officer, a founding director of Storelectric. He is also a United Nations expert advisor in energy transition technologies, economics, regulation and politics – invitation here.

A graduate in Physics with Electronics, he has 12 years' management and innovation consultancy experience world-wide. In a rail multinational, Mark transformed processes and developed 3 profitable and successful businesses: in commercialising a non-destructive technology he had innovated, in logistics (innovating services) and in equipment overhaul. In electronics manufacturing, he developed and introduced to the markets 5 product ranges and helped 2 businesses expand into new markets.



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