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UK blackout on August 9th: Understanding the cost of reliability

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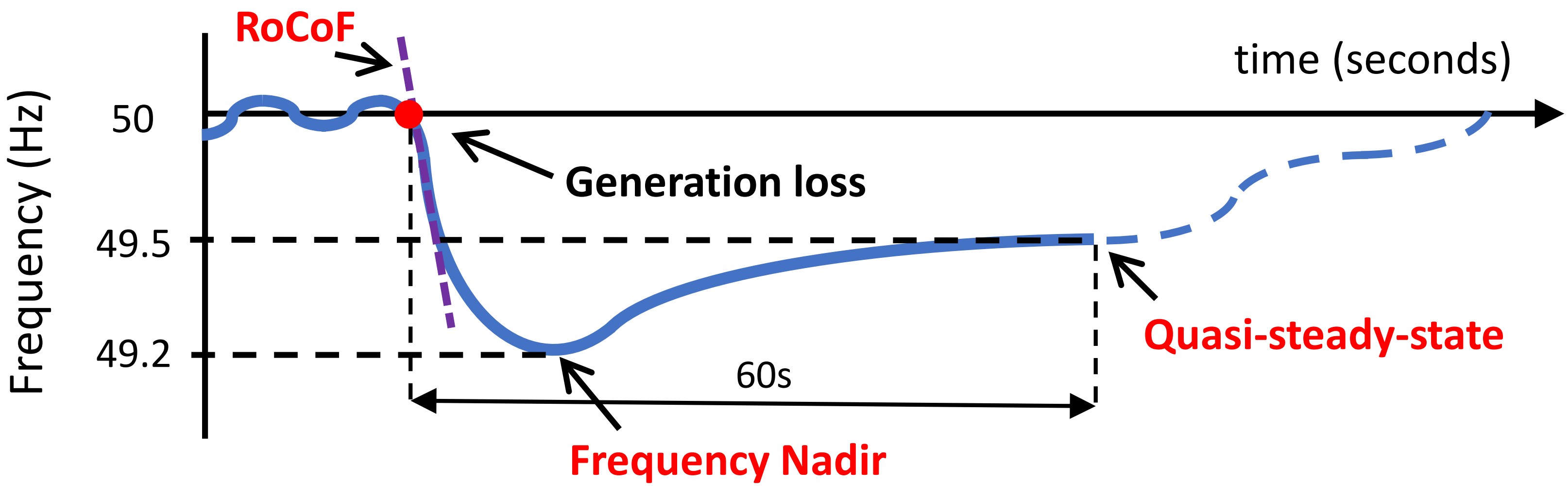
Intro: post-fault frequency evolution



After a generation outage, the electric frequency of the grid drops.

If the frequency drop is not appropriately contained:

- Tripping of **RoCoF-sensitive relays** (cause of the disconnection of distributed generators on August 9th in GB).
- Triggering of **Low Frequency Demand Disconnection** (cause of the disruption to the rail network, Ipswich hospital and Newcastle airport).

Reliability

How do we prevent blackouts caused by frequency drops?

- Using **inertia and different types of Frequency Response**, as they provide an "insurance" against blackouts. More info here.

How much inertia and Frequency Response are needed?

- It depends on the **level of reliability we want to achieve**.

System operators typically aim for an **N-1 reliability**: the system should withstand any single-device outage. For frequency purposes, this means that enough inertia and Frequency Response must be available to cover the loss of the largest power infeed (driven in GB by a large nuclear unit or an inter-country interconnector).

UK blackout on August 9th

Details of the event: National Grid's report

The event was an N-2 loss: 1378MW were lost, 737MW from Hornsea One offshore windfarm and 641MW from Little Barford gas power station.

National Grid had scheduled 1000MW of Frequency Response, to cover the N-1 reliability requirement at the time. These 1000MW included 472MW of battery storage, which provides fast Frequency Response in less than one second.

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Some questions arise:

Was low inertia the cause of the blackout?

- **No.**

  At the time of the blackout, 30% of the energy in GB was provided by wind, so the level of inertia was indeed not very high. However, Low Frequency Demand Disconnection was triggered because not enough Frequency Response was scheduled to cover an N-2 loss.

  In lay terms: inertia buys us time to secure the frequency nadir using Frequency Response, but if we have less Frequency Response than the size of the outage, the nadir limit will be violated in any case.

  More info here

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Some questions arise:

Should we buy enough "insurance" to cover the N-2 reliability standard?

- It's a conversation that we should have, and the probability of an N-2 event happening should be considered when making a decision. But it's **important to understand that the need for Frequency Response increases quadratically if we want to secure against an N-2 loss:**

Quadratic function of the power lost

$$H \cdot R \geq \frac{(P_{\mathrm{L}})^2 \cdot f_0 \cdot \mathrm{T_d}}{4 \cdot \Delta f_{\mathrm{max}}}$$

A simple numerical example and the nomenclature used in the inequality can be found [here].

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Some questions arise:

Would we have avoided the blackout if we had more battery storage?

- **No**.

  Fast Frequency Response from batteries helps solve the low-inertia problem, because it significantly reduces the need for "slow" Frequency Response from thermal units. However, the insufficient amount of Frequency Response scheduled is what caused the blackout, regardless of the speed of delivery of this response: simply not enough Frequency Response was available to cover the N-2 loss.

A simple numerical example on the value of fast Frequency Response from batteries can be found here.

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Get in touch if you want to further discuss!

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