UK’s August 9th Loss of Load and Wider Market Implications of Grid Transformation

REKK Foundation Seminar - Budapest

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UK Event on August 9th

Just the facts, please
What happened on August 9th?

- “...an extremely rare and unexpected event.”
  National Grid ESO Final Report, 6 Sept 2019

- A concurrence of unexpected and independent failures

- Compounded by unnecessary or unexpected load and DER failures

- 3.2% of system load shed for < 45 minutes
What happened on August 9th?

- 3 simultaneous lightning strikes near a 400kV circuit
- \( \approx 150 \text{MW} \) of nearby embedded gen trips on vector shift relay, as would be expected
- Near-simultaneous trips of Hornsea & Little Barford ST-G, unexpected and independent of each other; cum. loss (1131MW) now > planning max (1000MW)
- Resulting frequency drop trips additionall 350MW of embedded gen on RoCoF relay (more on that later)
- FFR working; Little Barford GT1a trips (unexpected); frequency drops to 48.8Hz, LFDD sheds 3.2% of load
What happened on August 9th?

Lightning strikes
What happened on August 9th?

- Circuit fault Eaton Socon-Wymondley [16:52:33.490]
- Fault cleared [16:52:33.564]
- Hornsea loss of 737MW [16:52:33.835]
- Little Barford ST trip 244MW [16:52:34]
- Increase in transformer loadings (Loss Of Mains) ~500MW [16:52:34]
- Frequency response recovers frequency to 49.2 Hz [16:53:18]
- Little Barford GT1a trip 210MW [16:53:31]
- Frequency is restored to 50Hz [16:57:15]
- Circuit closed on DAR [16:52:53]
- Frequency fall arrested at 49.1Hz [16:52:58]
- Embedded gen. loss 200 MW @49Hz
- Little Barford GT1b trip 187MW [16:53:58]
- Frequency breaches 48.8Hz triggering LFDD [16:53:49.398]
- ESO National Control instruct 1,240 MW of actions to restore frequency to operational limits and restore frequency response and reserve services.
What happened on August 9th?

• Unexpected failures:
  • Hornsea Wind: faulty turbine controller & network config
  • Little Barford CCGT
    • ST-G – mismatch in speed signals, still unexplained
    • GT1a – steam bypass over-pressure trip, still unexplained
    • GT1b – tripped manually on high steam pressure reading
  • DERs (200MW trip at 49Hz): relay settings not notified
  • Electric trains: non-compliant; software in mid-update

• Own goals:
  • DERs (RoCoF): [non-]Accelerated LOM Program
  • Loads included in LFDD scheme (Airports? Trains?)
What didn’t happen on August 9th?

- No shortage of available generation
- System inertia was well above minimum required
- No shortage of fast frequency reserve
- No primary causal relationship between the event and the share of wind generation on the system
Takeaways

- DER regulation and operation
  - Visibility to system operator
  - Accelerate Loss of Mains upgrade; pursue islanding stds enabling DERs to increase, not degrade, resilience
- Are protection schemes for critical loads (e.g., trains, hospitals) compliant? Are they appropriate?
- Maintaining minimum system inertia
  - Are sources of replacement inertia appropriate?
  - Is very fast interruptible load adequately exploited?
- Market implications of demand for new ancillary services
Takeaways (cont’d)

• Revisit SQSS in light of changing system?
  • Increase reserves levels? Maybe, though this event alone not definitive (“…should be [reviewed]…to ensure a proper balance between costs and risks.”)
  • Market impacts of maintaining higher levels of reserves

• Reliability stds. say controlled load shedding in such events is a feature, not a failure, of prudently designed and operated power systems – be better prepared
  • Are schemes like the LFDD properly configured?
  • With current ICT, could this have been a non-event?
Market Implications of Grid Transformation

Reliability must be prudently defined and fully priced
Reliability matters – so let’s be clear what we’re talking about

Wholesale system reliability “by the numbers”
It’s *all* about the consumer

Resource adequacy, objectively

Imputed Average Value of Lost Load

Average value of lost load ($/MWh)

Annual duration of firm load curtailment (hours/year)

One event in ten years

24 hours in ten years

Optimal?

Price cap

Source: W. Hogan, Harvard University, Kennedy School of Government
Is there a different way to look at this?

*We’re talking about a fundamental change in the nature of the supply mix*

Can we really afford to continue to build a power system and charge customers based on the assumption that they are happy to pay €35,000-€250,000/MWh for the luxury of not shifting their flexible loads by a few hours?
New paradigm: Value of Shiftable Load

VoSL: The price at which customers will happily shift flexible loads to save money

The VoSL for a given end use is often far less than what it costs to ensure (and far more than the price we’re charging to ensure it)
Fast, reliable and affordable means one thing: Flexible

Flexibility, not capacity, is the new coin of the realm
“How much?” depends on “What kind?”

Considering only generation flexibility... the legacy resource portfolio can require up to 40% more investment in grid and generation capacity than the transformed portfolio.

Source: Adapted from The Power of Transformation (IEA, 2014)
System flexibility: Where can we get what we need at least cost?

Benefit-cost ratios of different flexibility options

New role for responsive demand

Moving from a world where we forecast load and schedule generation, to a world where we forecast generation and schedule load

will now need to shape, not just shave, demand
Innovation: 3rd party access is essential
Priority #1 (and #2 and #3): Get the energy price right

Marginal-cost energy pricing isn’t necessarily what you’ve been told it is
Capital-intensive yes, but value will come from demand for operational capabilities, *not* capacity

...so market model should reflect this
Rapid growth in range of needed services

Current
- Regulation Up
  - Fast-Responding Regulation Up
- Regulation Down
  - Fast-Responding Regulation Down

Proposed
- Regulation Up
  - Fast-Responding Regulation Up
- Regulation Down
  - Fast-Responding Regulation Down
- Fast Frequency Response 1
  - 59.8 Hz, Limited duration
- Fast Frequency Response 2
  - 59.7 Hz, Longer duration
- Primary Frequency Response
  - Contingency Reserves 1
  - Contingency Reserves 2
- Supplemental Reserves 1
  - SCED-dispatched
  - Manually dispatched
- Supplemental Reserves 2
  - SCED-dispatched
  - Manually dispatched
- Synchronous Inertial Response
  - Deferred development

Concept currently under market consideration
Scarcity amidst plenty

ISO supports the Western Grid when the blue bars are above 100% (green line). Performance Target.

ISO leans on other BAs when the red bars are less than 100%.

CPS1 ≥ 100%  CPS1 < 100%  CPS_pass  Net Load

Regulatory Assistance Project (RAP)®
The real supply curve:

- **Marginal cost (€/MWh)**
- **Supply Curve**
- **Value of load**
- **Price cap**
- **Generation merit order**
- **Emergency gen & other**
- **Drawdown of required reserves**
Administrative measures (e.g., reserve shortage function) ensure demand for reliability is priced…

...creating volume & price risks that drive bilateral contracting (e.g., ~95% of energy consumed in ERCOT is under bilateral contracts)

10 years of investment in leading markets

ERCOT

No forward capacity market, but administrative shortage pricing in the energy market, 20% wind share of market in 2018.

PJM

Forward capacity market, but with only 1-year rolling "contracts" for existing & new capacity, scarcity pricing, 36% reserve margin in 2018.

- Source: ERCOT and PJM published data.
When surplus baseload is retired, energy prices reflect true value & consumers are empowered:

About RAP

The Regulatory Assistance Project (RAP)® is an independent, non-partisan, non-governmental organization dedicated to accelerating the transition to a clean, reliable, and efficient energy future.

Learn more about our work at raponline.org