Voltage Deep Dive

Operational Transparency Forum 2021.03.31

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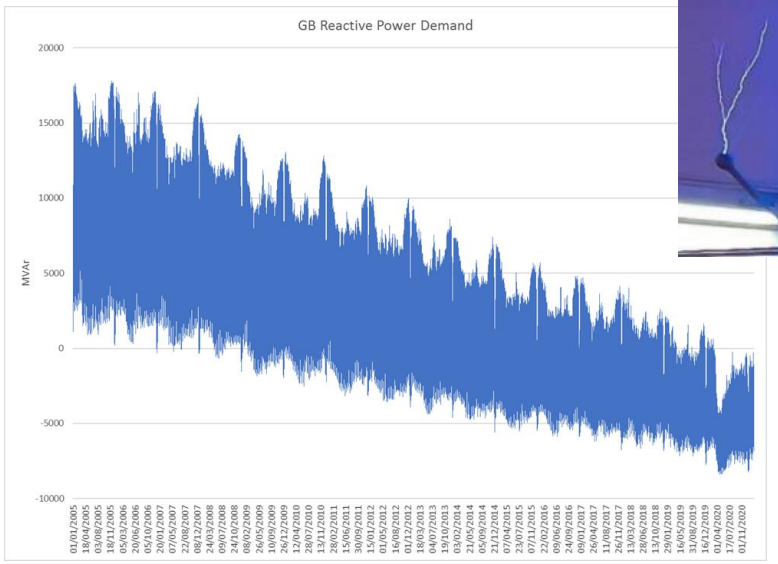
Voltage Constraints



Concerned with the management of ***high*** voltages

- Changes have been seen in demand and generation over the last 15 years
- Defines the need for additional reactive power absorption on top of that provided by TO assets
- Why manage voltages?
  - Need to maintain system voltages within limits set out in:
    - Electricity Safety, Quality and Continuity Regulations
    - Grid Code
    - Security and Quality of Supply Standard
  - /!\ SAFETY /!\ - the bottom line is the safe operation of the system
  - Voltages in excess of equipment ratings can damage equipment and cause flashovers
- Management of other voltage constraints, such as voltage stability, are normally considered through other processes

Voltage Constraints -Timescales

Voltage constraints are assessed across different timescales to different levels of detail

- Year Ahead – considers seasonal minima and generator outage patterns
- 12 Weeks Ahead – considers likely lowest demand within period, along with transmission & generation outages, and likely worst case system conditions
- Week Ahead – consider the forecast lowest demand, with prevailing transmission and generation outages and worst case conditions
- Adhoc studies at day ahead and close to real time – considers updated demands, potential changes to wind generation, interconnector flows and feedback from preceding night(s)

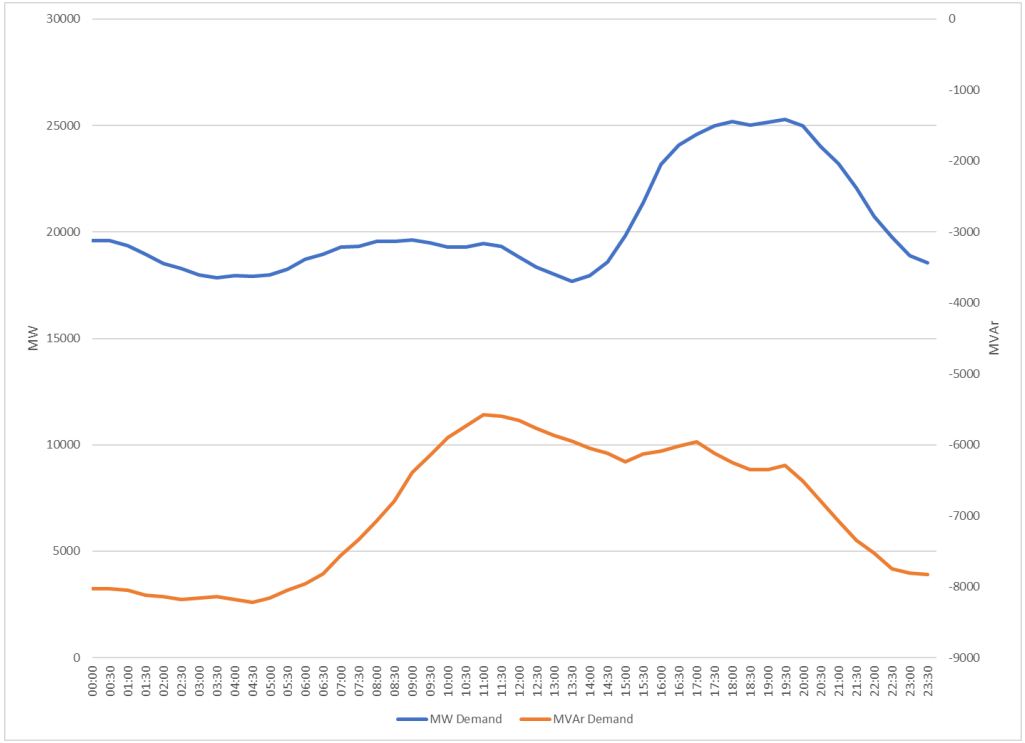
Pathfinders are looking at longer timescales – ambition is for these to form part of the NOA process

Future of Reactive work to look at reforming reactive power market.

Voltage Constraints - How they're derived

Generally, worst case conditions are investigated

1. **Start with low overnight real power demand** – reactive power demands is low as well (actually negative, meaning reactive power flow from LV networks to the transmission network)
    - Typically lowest demands are overnight at weekends
    - Occasionally real demand in day drops below overnight demand, due to solar PV, though reactive demand is still higher than overnight
2. **This means low levels of generation** – less generation means less reactive power support is available.
3. **This leads to low system flows** – reduced reactive (I^2X) losses in transmission lines, so the reactive gain (BV^2) starts to dominate. The point at which this occurs is sometimes referred to as the surge impedance loading or natural loading of a transmission line



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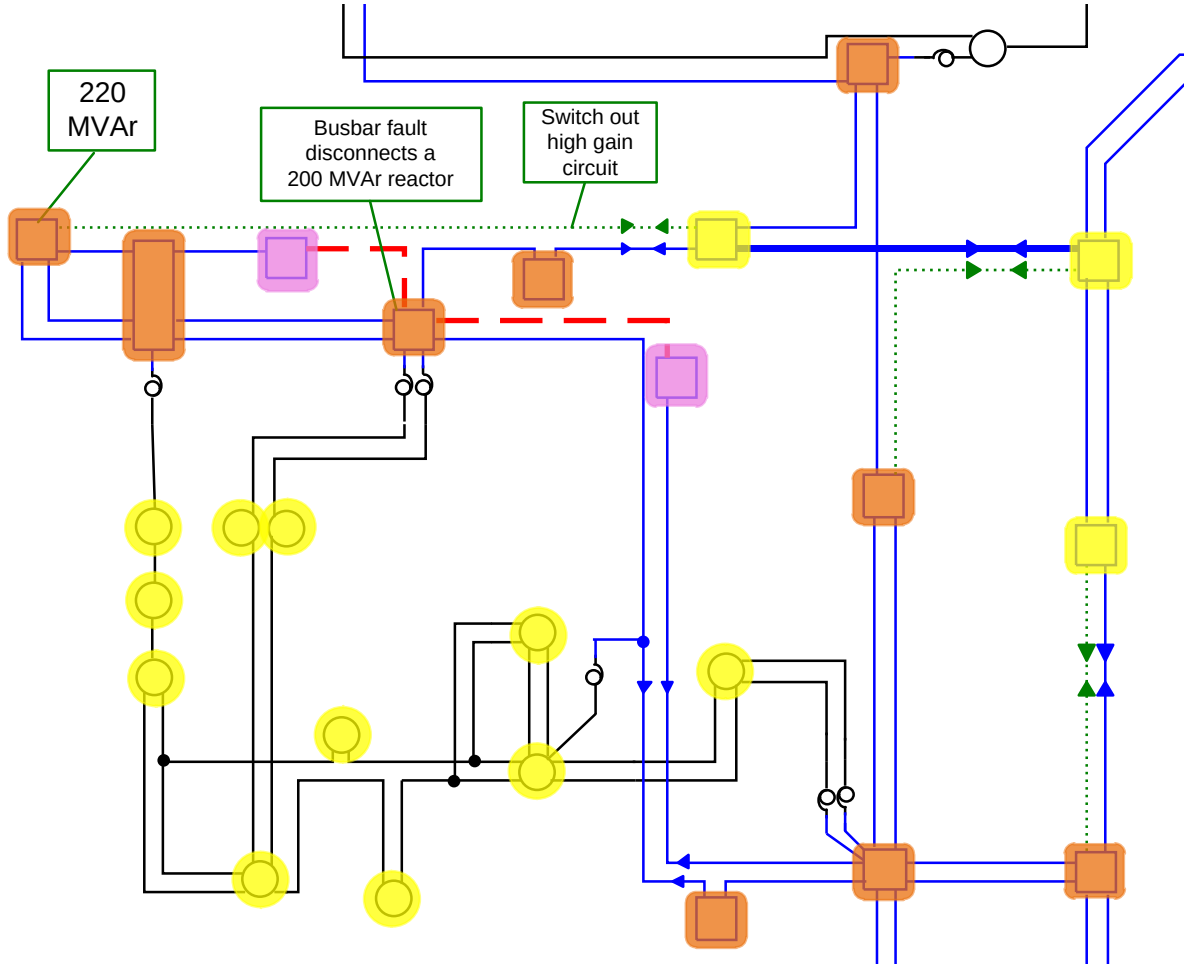
Voltage Constraints - How they're derived

We have to consider voltages pre-fault (or N-state) and post-fault voltages, following secured events. General process is:

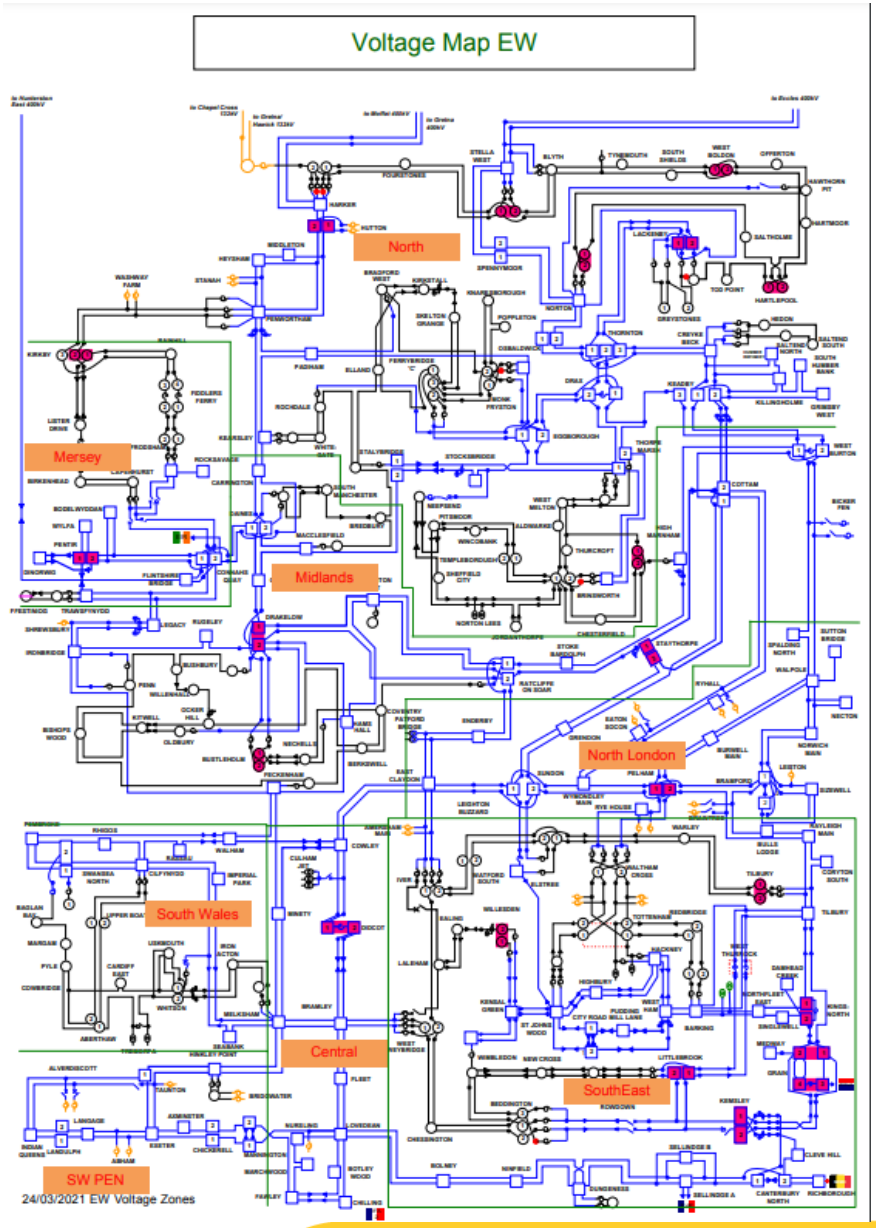
- Pre-fault: identify locations where additional reactive power absorption, or other actions, may be required to reduce voltages within limits
- Run contingency analysis to identify voltages outside limits post-fault
- Identify locations where additional reactive power absorption/other actions may be required to reduce post fault voltages within limits
- Repeat the above until all voltage issues are solved and reactive requirement is optimised;

This process broadly defines the boundaries which are being published



Voltage Constraints - Locational Aspects

- The fundamental physics of AC power systems means that the affect of reactive power flows on system voltage and vice versa is localised.
- Therefore voltage requirements are given by zones
- Requirement in zones is given by number of BMU required
  - This identifies where there is a need to access BMU with MSAs which can provide the required level of reactive compensation to supplement TO provided equipment
- Transmission outages can have an impact on the boundary of a zone where reactive power providers sit close to the boundary.
  - If an outage is taken of a circuit which disconnects a provider from their usual zone, this can greatly reduce their effectiveness within that zone, yet increase their effectiveness in the neighbouring zone
- Significant changes in generation availability or running can also change the requirement in a zone, as there is interaction between adjacent zones.



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