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Revisiting Britain's security standard

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Supergen Energy Networks Risk Day
March 12th 2024

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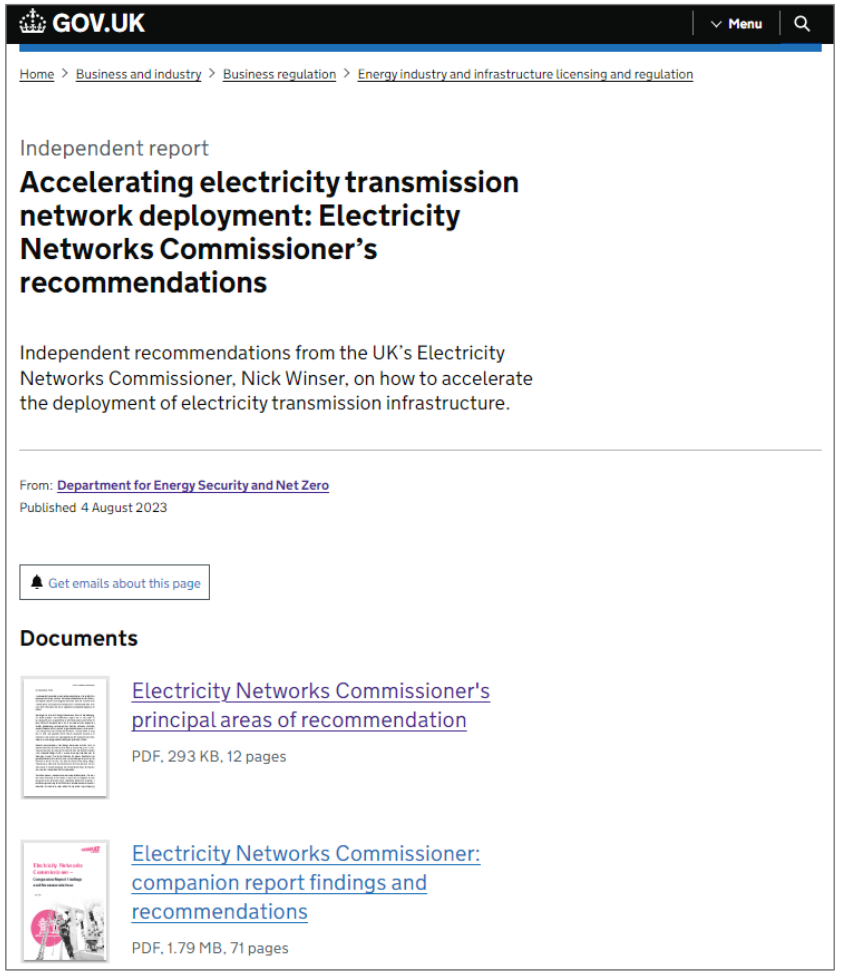
Accelerating the development of transmission to accommodate low carbon generation

- "The Electricity System Operator (ESO) should investigate use case[s] where operational rules can be relaxed to allow outages to go ahead, for example, relaxing network security from network minus 3 circuits (N-3) to network minus 2 circuits (N-2) during the right conditions"
- "The ESO hopes to move to a situational model for allowing outages that would balance failure risk with the economic advantages of having faster access to the network".
- Do we need changes to key industry codes and guidance, not least the Security and Quality of Supply Standard (SQSS), in order to do this?
- What is the basis of the SQSS anyway?

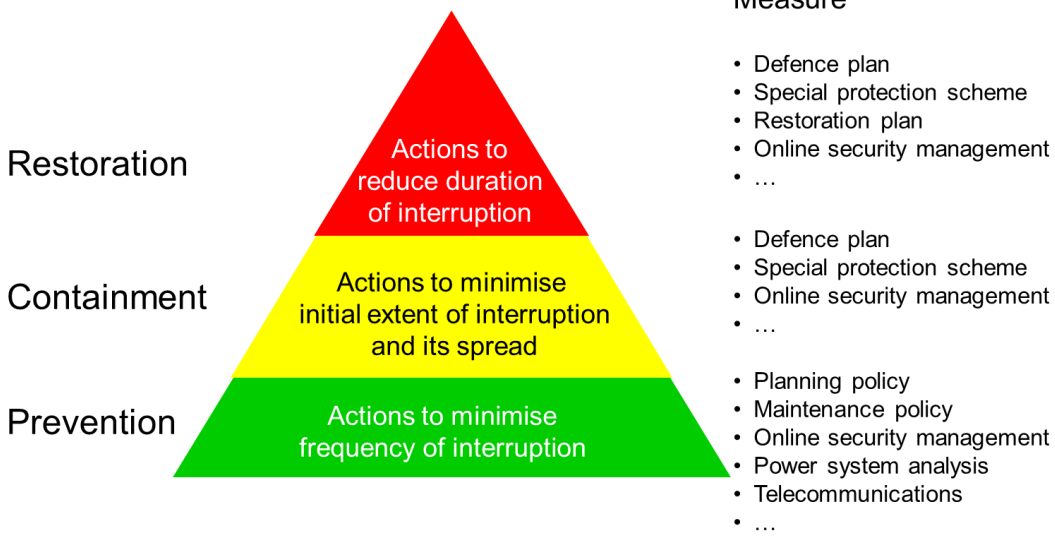


https://www.gov.uk/government/publications/accelerating-electricity-transmission-network-deployment-electricity-network-commissioners-recommendations

Surviving disturbances

Resilience

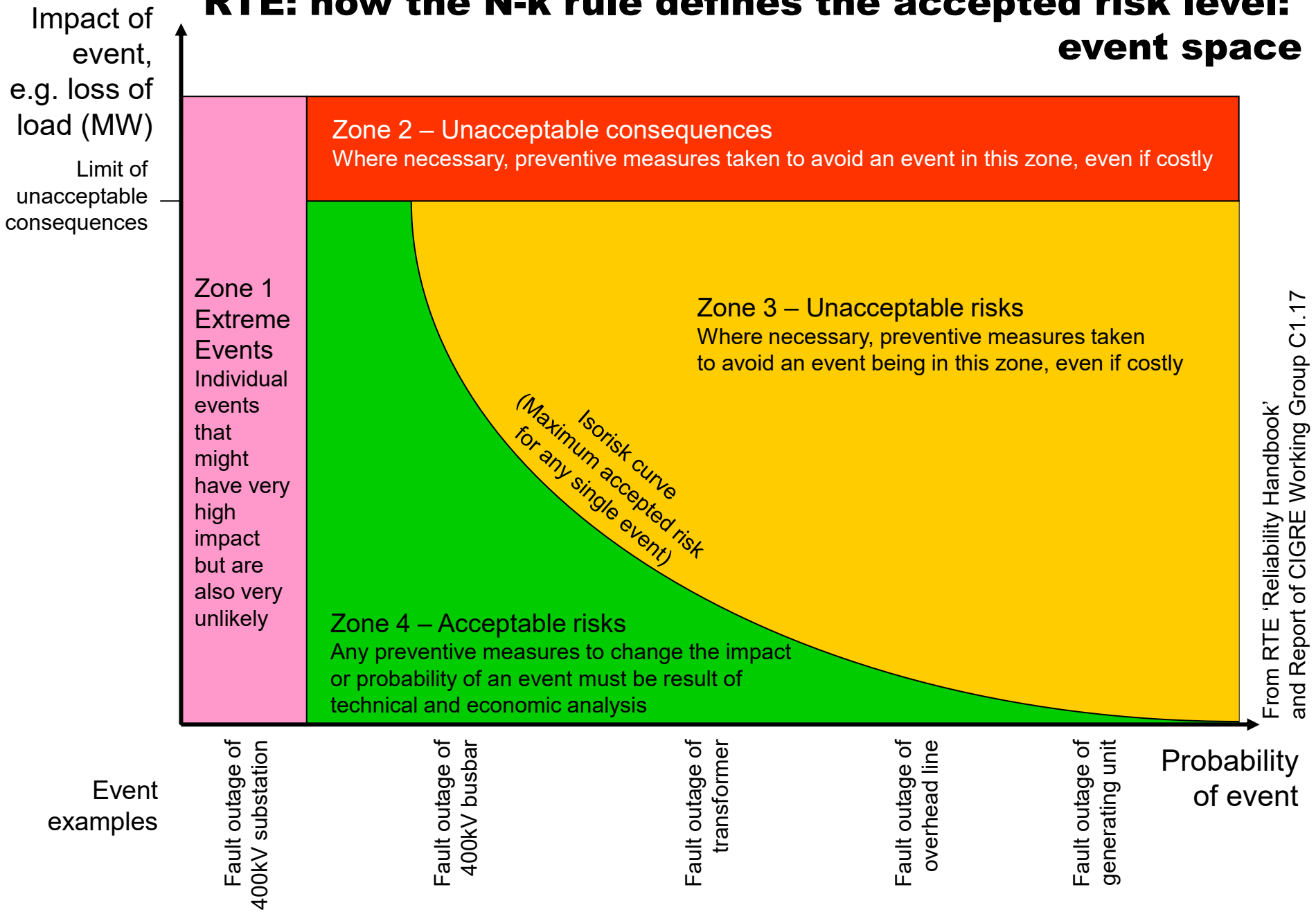
Prevention of
Containment of
Recovery from
} interruptions to supply



- Is there enough generation to meet demand?
  - Can it respond quickly enough?
- Is there enough network capacity to get power from generators to demand?
- Can the system perform a black start?
- *How does the system respond to unplanned changes, e.g. faults?*
  - Are the generation and network responses (protection, reactive compensation, UFLS, …) coordinated well?
  - Frequency and size of supply interruptions?
  - Speed of restoration of interrupted demand?
  - What happens to energy users in the meantime?

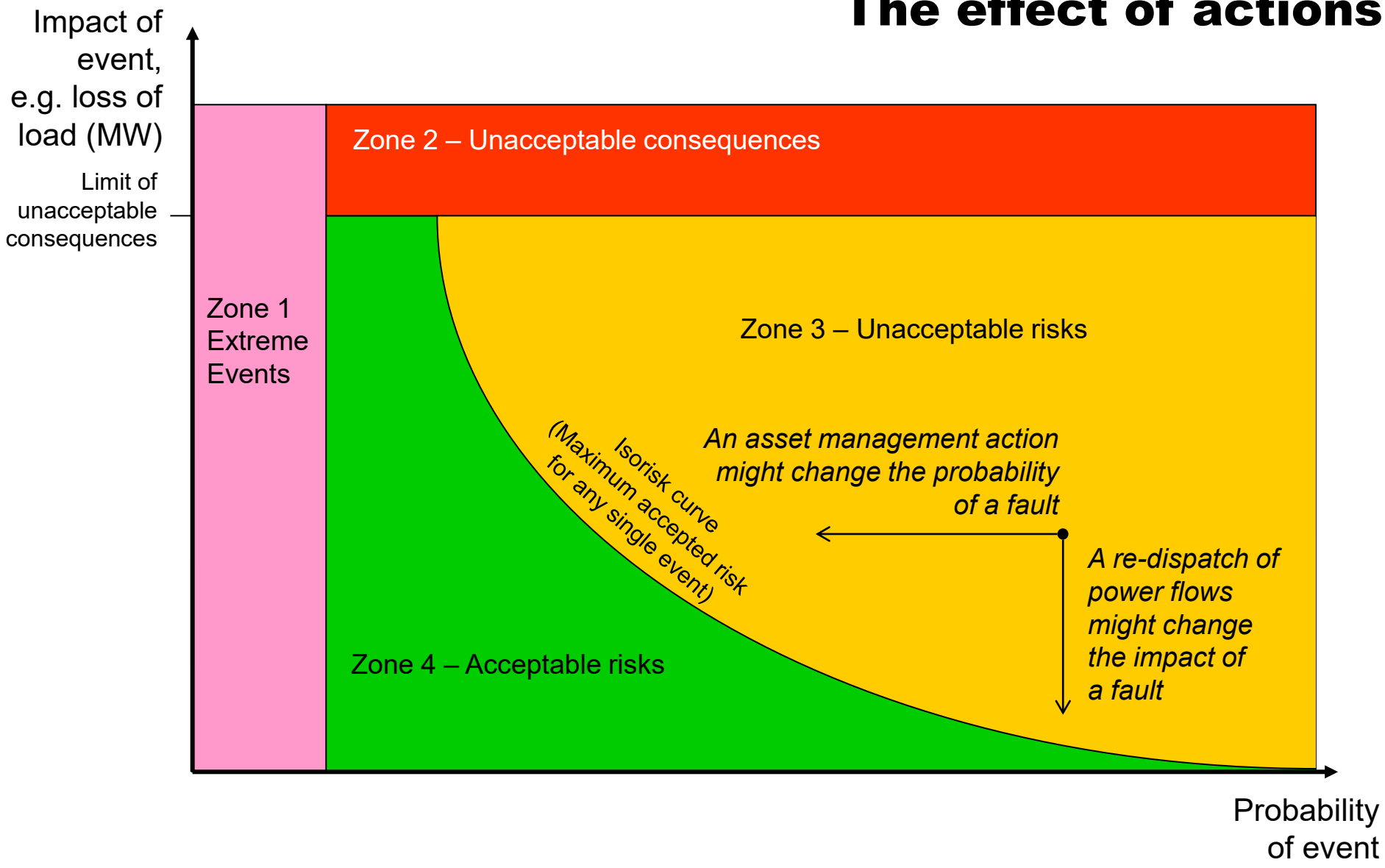
See CIGRE WG C1.17, “Planning to Manage Power Interruption Events”, Technical Brochure 433, CIGRE, Paris, October 2010

RTE: how the N-k rule defines the accepted risk level: event space



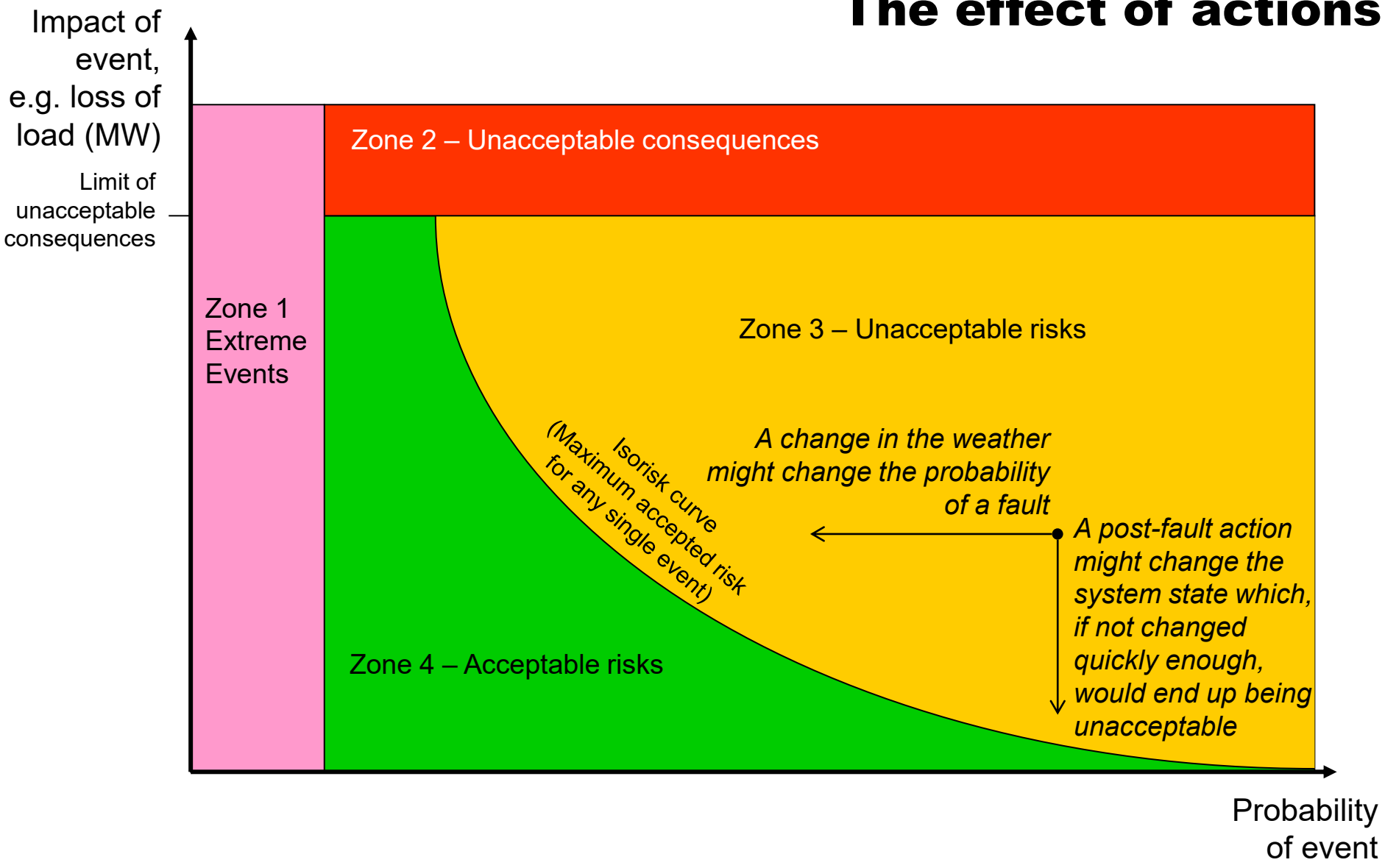
Any single event that might happen can be visualised in the space shown on the chart

The effect of actions



Action by the system operator, e.g. to change the pre-fault states, or by control equipment to change the system state post-fault, can change the location of an event in the chart

The effect of actions



Action by the system operator, e.g. to change the pre-fault states, or by control equipment to change the system state post-fault, can change the location of an event in the chart

How the SQSS limits risk

- For defined **secured events**, system consequences must be contained
  - Connection of demand
  - Frequency
  - Voltage
  - Overloads
  - Stability
- Note the reference to "under *prevailing system conditions*"

5. Operation of the Onshore Transmission System

Normal Operational Criteria

5.1 The *onshore transmission system* shall be operated under *prevailing system conditions* so that for the *secured event* of a *fault outage* on the *onshore transmission system* of any of the following:

5.1.1 a single *transmission circuit*, a reactive compensator or other reactive power provider; or

5.1.2 a single *generation circuit*, a single *generating unit* (or several *generating units* sharing a common circuit breaker), a single *power park module*, or a single *DC converter*; or

5.1.3 the most onerous *loss of power infeed*; or

5.1.4 the most onerous loss of power outfeed; or

5.1.5 where the system is designed to be secure against a *fault outage* of a section of *busbar* or mesh corner under *planned outage* conditions, a section of *busbar* or mesh corner,

there shall not be any of the following:

5.1.6 a *loss of supply capacity* except as specified in Table 5.1

5.1.7 unacceptable frequency conditions;

5.1.8 unacceptable overloading of any primary transmission equipment;

5.1.9 unacceptable voltage conditions;

5.1.10 *system instability; or*

5.1.11 *Unacceptable Sub-Synchronous Oscillations.*

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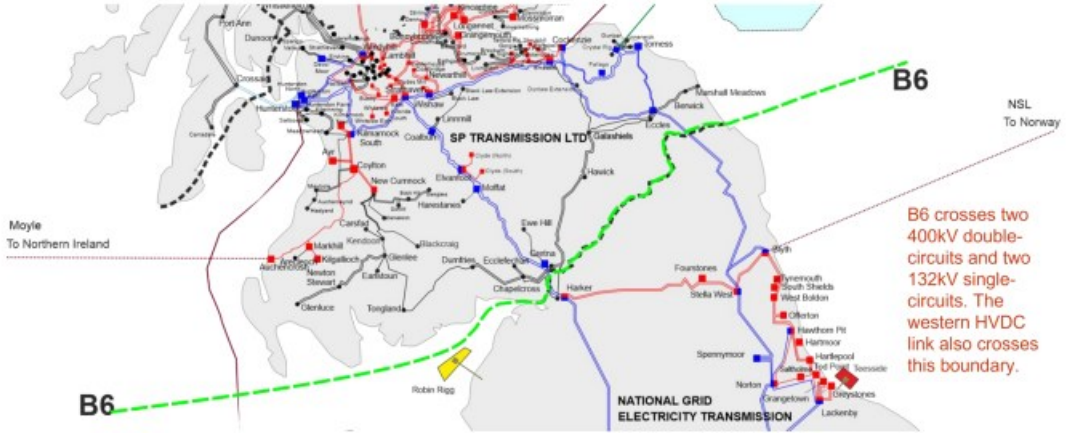
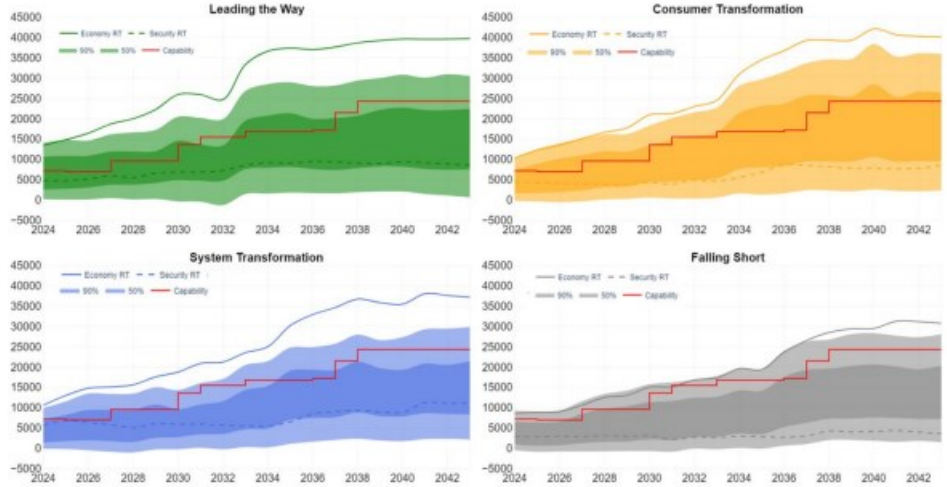
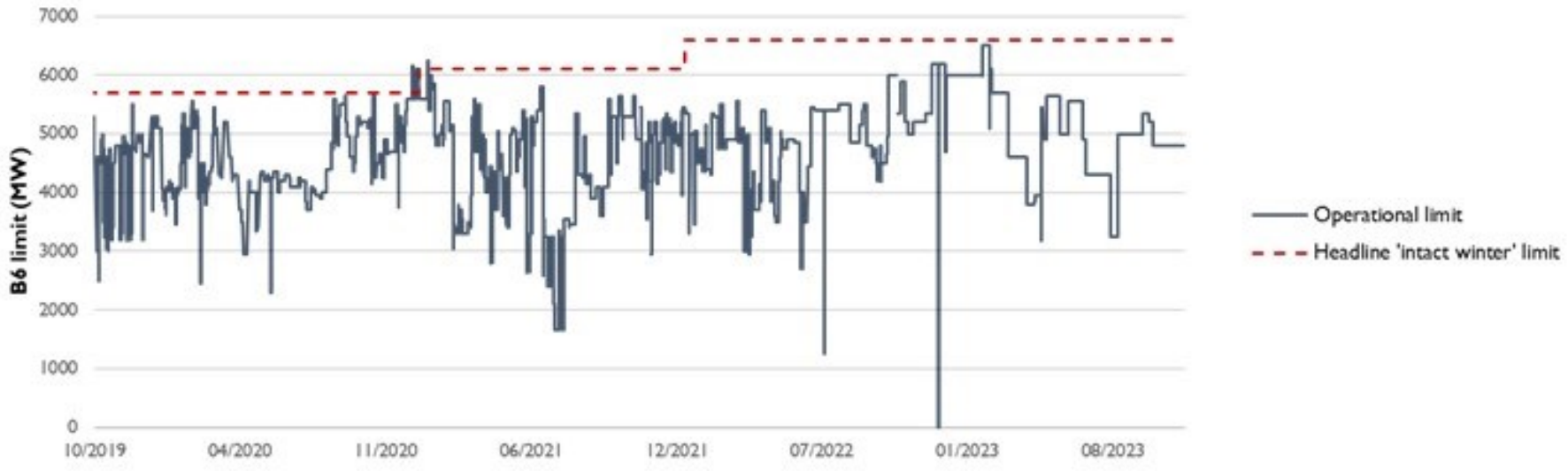
Secure power transfer capability across B6

Map and scenario charts from 2023 Electricity Ten Year Statement (ETYS): https://www.nationalgrideso.com/document/286591/download



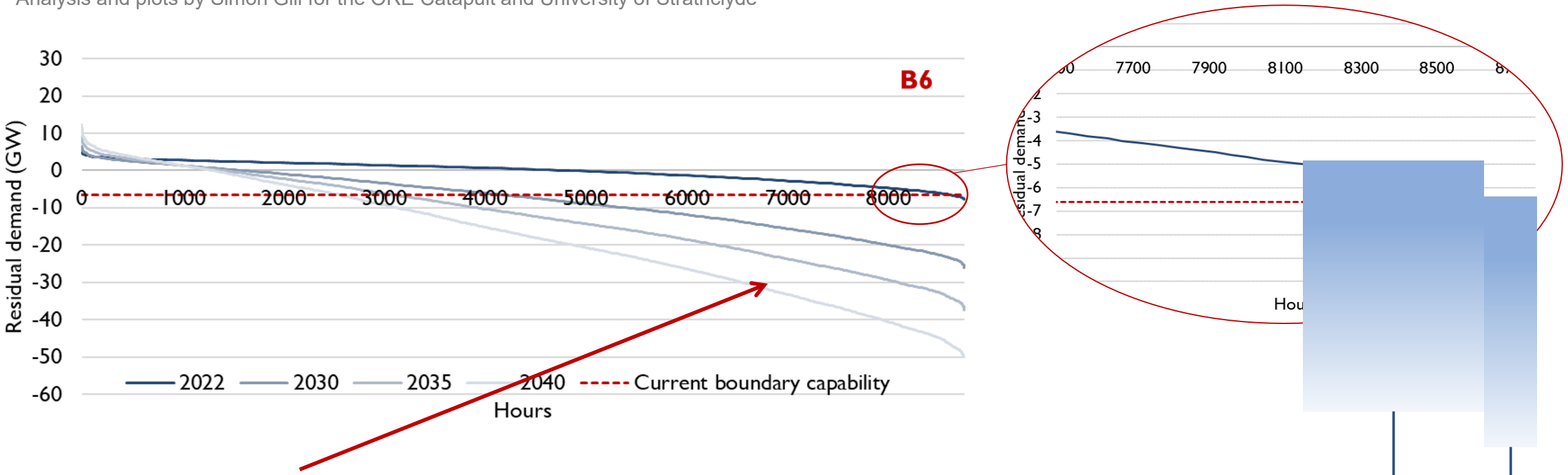




Operational limits from data provided at https://www.nationalgrideso.com/data-portal/day-ahead-constraint-flows-and-limits
Intact winter limits from past ETYS documents

How much of the time does power available for export from a region exceed the network's export capability? Look at the residual demand duration curve

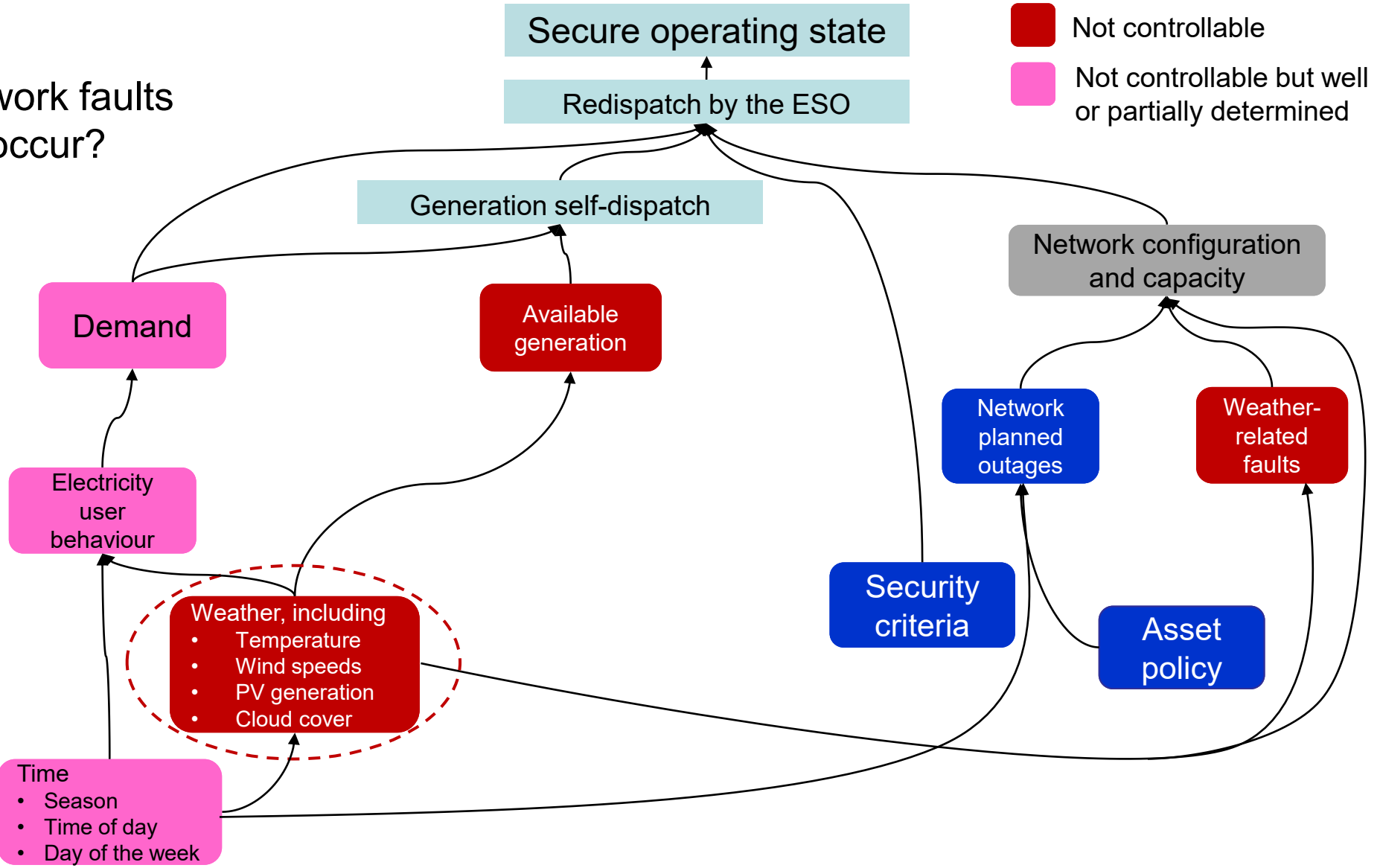
Analysis and plots by Simon Gill for the ORE Catapult and University of Strathclyde



- By 2030, the residual demand duration curve shows many hours of surplus power beyond the export capability of the network.
  - There is a surplus of power available over demand north of B6 relative to planned export capability for 2,800 hours of the year
- In modelling of 2022, only around 133 hours had wind excess in Scotland greater than 6.6 GW (nominal B6 capacity)
- But operational de-rating of the transmission network regularly reduces capacity to the 4 – 5.5 GW range increasing constraint periods to around 800 hours a year

Dependencies of operating states

When are network faults most likely to occur?



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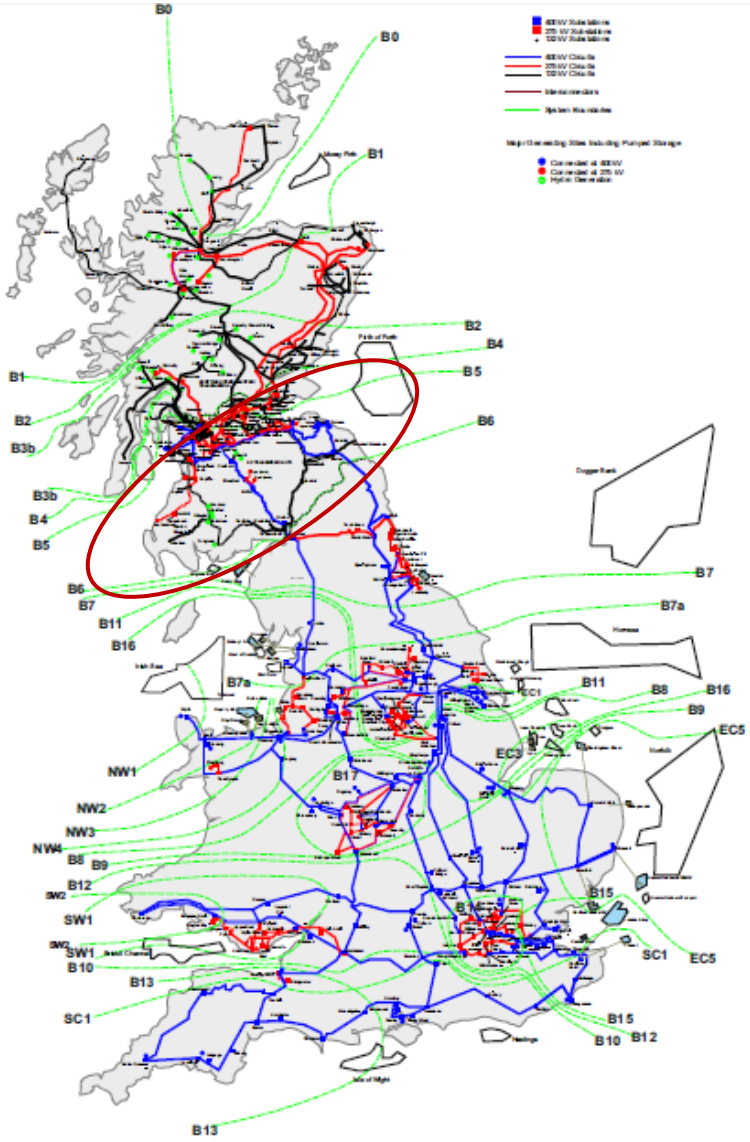
Weather-related faults in Southern Scotland



Analysis focussed on the Scottish Power Transmission area (Southern Scotland)

- Records of faults, 1984-2012 (28 years)
- Clusters of weather-related faulted identified

Year-round average: 0.006 faults/hour

Weather type	Faults/hour
“Ice, snow, sleet and blizzards”	11.4
Lightning	8.4
“Wind, gale, and windborne object”	18.6
“Corrosion, condensation and salt”	6

Morris, E. A., Bell, K., & Elders, I. *Spatial and temporal clustering of fault events on the GB transmission network*. 2016 International Conference on Probabilistic Methods Applied to Power Systems, Beijing , China.

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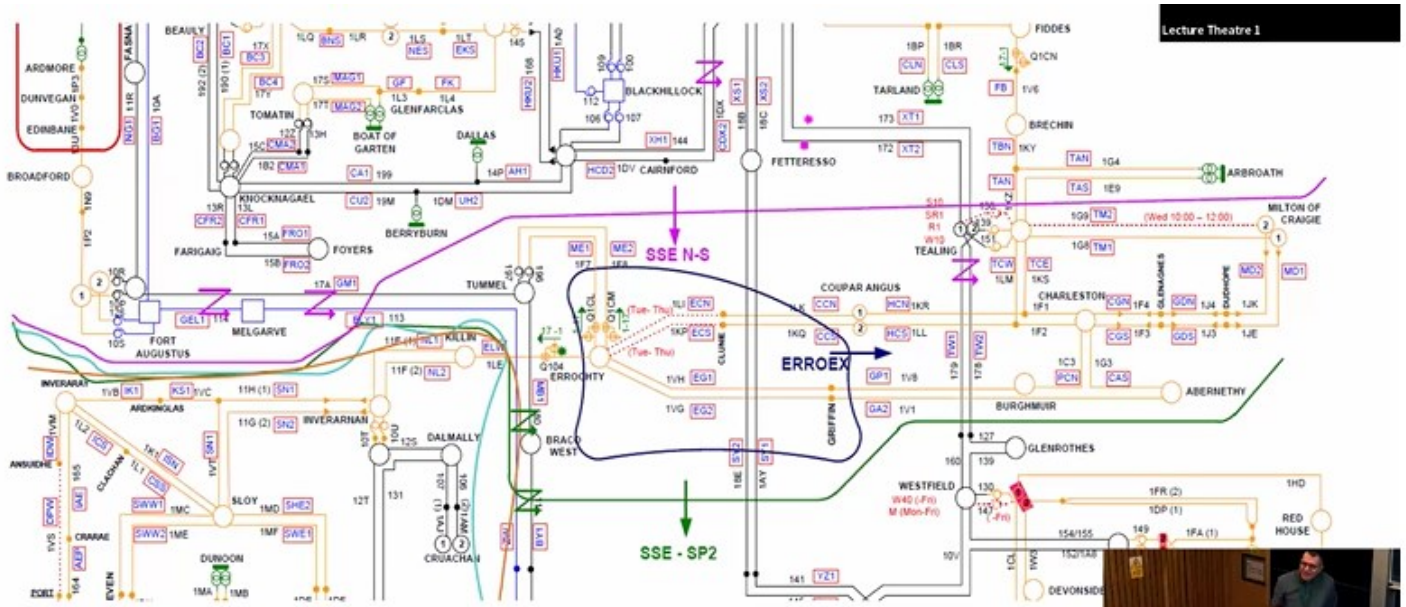
Accommodating outages to make it easier to accommodate generation (and outages)

- How many maintenance and construction outages (and in what combination) is it reasonable to take at any one time?
- Is the system operable in accordance with the SQSS under those planned outage conditions?
- How much would SQSS compliance cost?



Screenshot from G-PST workshop

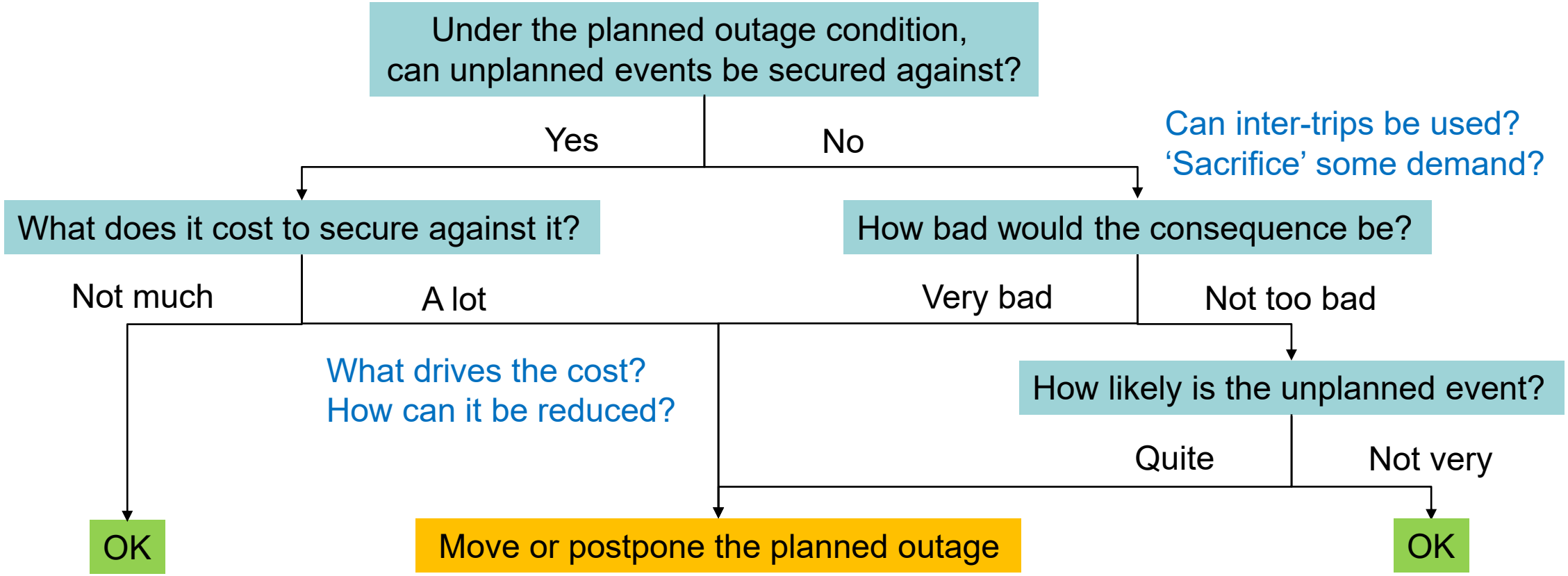
Adaptive security and outage planning

- For rarer secured events, the SQSS only stipulates avoidance of the worst outcomes
  - "recklessness exclusion clause"
- Should the SO have the option of not securing against a particular low probability event?
  - The potential consequences of that event should still be checked
    - Avoid very bad things: how should this be articulated?
  - When assessing the impact of an event, need to follow all the automatic actions through to the end
    - What should be assumed about automatic responses, e.g. fault clearance time?

> 5.3 The *onshore transmission system* shall be operated under *prevailing system conditions* so that for the *secured event* on the *onshore transmission system* of a *fault outage* of:
>
> 5.3.1 a *double circuit overhead line*; or
>
> 5.3.2 a section of *busbar* or mesh corner,
>
> there shall not be any of the following:
>
> 5.3.3 a *loss of supply capacity* greater than 1500 MW;
>
> 5.3.4 *unacceptable frequency conditions*;
>
> 5.3.5 *unacceptable voltage conditions* affecting one or more *Grid Supply Points* for which the total *group demand* is greater than 1500 MW;
>
> 5.3.6 *system instability* of one or more *generating units* connected to the *supergrid; or*
>
> 5.3.7 *Unacceptable Sub-Synchronous Oscillations.*

For further reading on risk-aware, adaptive security, see https://www.sintef.no/en/projects/2013/garpur/

Adaptive security and outage planning



- To plan an outage, you need an idea of conditions throughout the duration of the outage.
- Have the ESO or the TOs been collecting data to allow us to estimate the probabilities of faults under different conditions?