

# Constraint Management

**NESO Network Access Planning**

OC2 Forum March 2026

# What is a constraint?

A way of representing pre- or post-fault network congestion based on the capability of transmission lines to transfer power (MW) from A to B. The degree to which this is possible will be the constraint limit.

## Position of the boundary:

- Cuts through the critical fault
- Cuts through the critical overload
- Encompasses “effective” plant

## “Effective Plant”:

- Generators driving an overload
- Demand driving an overload
- Reactive equipment
- Substations with effective running arrangements
- Quad-boosters & SSSCs

# Types of constraint

## Thermal

Limited by the power capacity of the transmission line

Can be export or import

## Voltage

Limited by SQSS steady-state or step-change limit

More onerous in areas with a lack of reactive compensation

## Stability

Limited by the rotor angle stability of synchronous generators

Is becoming more onerous with lower system inertia

# Post-fault actions

Following a fault, control room will take actions to return circuits below 100% rating

Change substation running arrangement either by closing or opening switch

Reduce generation based on cost order and its effectiveness on the overload and to balance will need to increase generation elsewhere

Change Quad Booster (Phase shifter) tap position

# Definition of short-term ratings

## Concept of Short-Term Rating

Short-term rating enables transmission assets to carry loads above continuous limits for brief, predefined intervals such as (5-min, 10-min, 20-min, 6-hour).

## Thermal Characteristics Basis

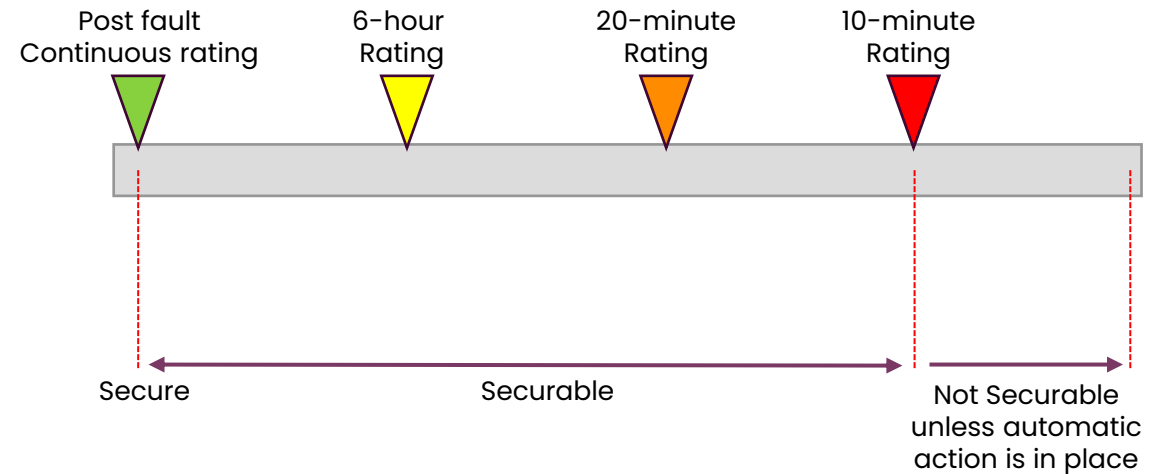
Short-term ratings rely on assets' thermal tolerance allowing temporary higher temperatures without damage.

## Operational Importance

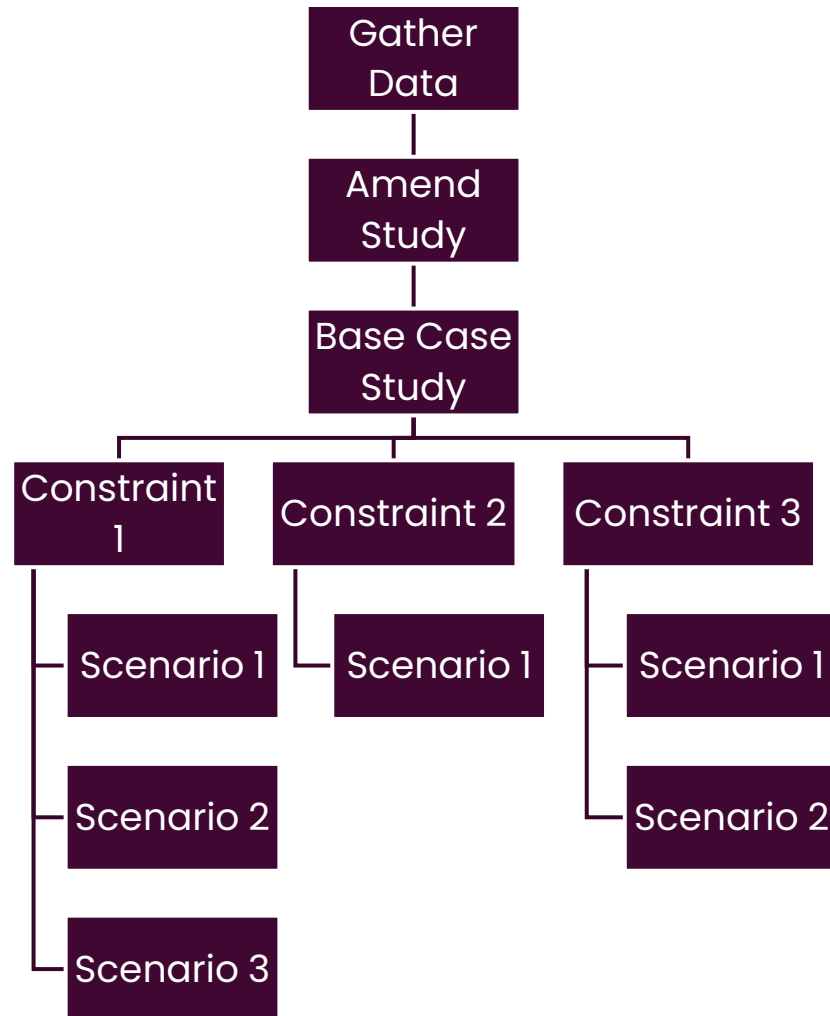
These ratings support system security by permitting short overloads during faults while operators act.

## Formal Declaration and Purpose

Short-term ratings are declared by asset owners to ensure consistent, reliable operation and planning.

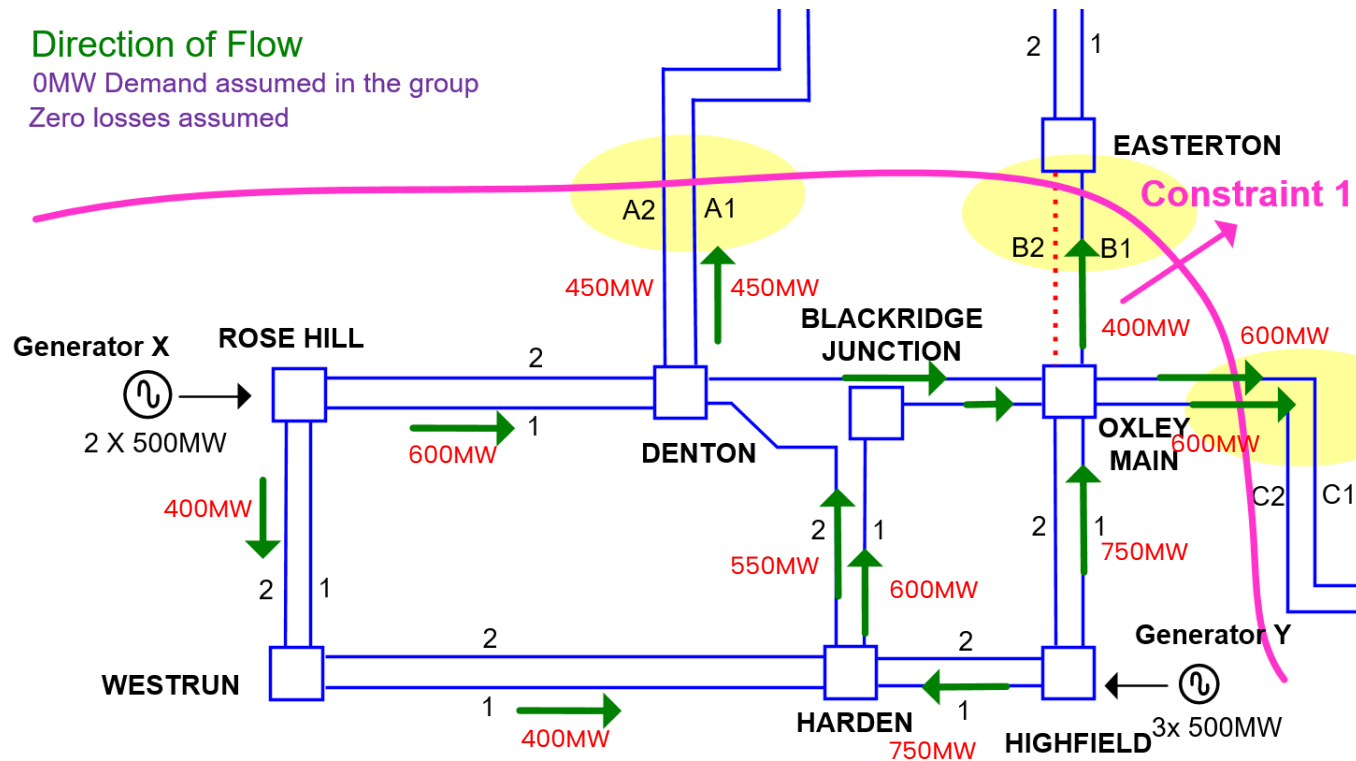


# Calculating constraints



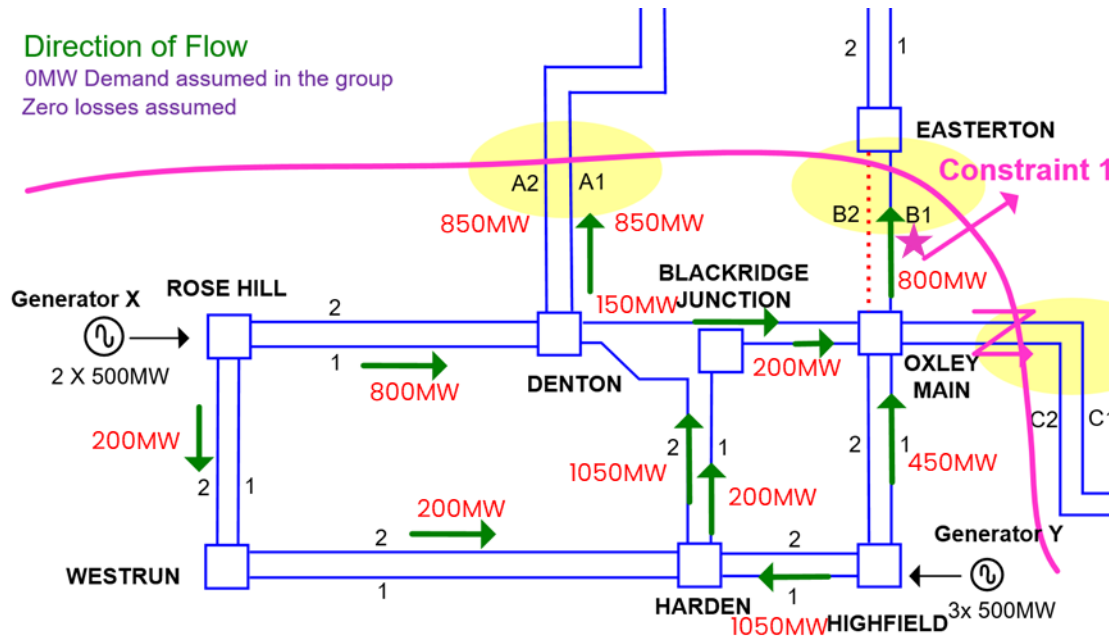
- The workflow for calculating constraints begins with gathering system data, which forms the foundation of the analysis.
- This data is used to build a study model, representing network conditions and assumptions.
- A Base Case Study is created.
- From the base case, multiple constraints are studied (e.g., Constraint 1, Constraint 2, Constraint 3).
- Each constraint is then assessed under several scenarios.

# Constraint 1 Scenario 1



- For this example we have Constraint 1 which is an export constraint.
- It consists of 2 Generators **X and Y**.
- The boundary cuts through 6 circuits:
  - A1,A2,B1,B2,C1,C2
- There is a planned outage on circuit **B2**.

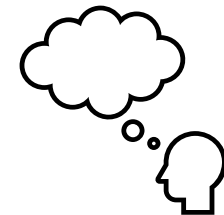
# Constraint 1 Scenario 1



Circuit	Post Fault Continuous Rating	Pre-Fault Flow	Post-Fault Flow
A1	1092	450	850
A2	1092	450	850
B1	750	400	800
B2	750	Outage	Outage
C1	1344	600	Fault
C2	1344	600	Fault

What can we do?

- There is a planned outage on circuit **B2**.
- We now have a Double Circuit fault on circuits **C1 & C2**.
- The amount of flow on each circuit has changed.
- B1 has breached its Post-Fault Continuous rating and gone into its Short-term rating.
- We now must take post fault action to reduce the flow on B1 from 800MW to 750MW.



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# Constraint 1 Scenario 1 (continued)

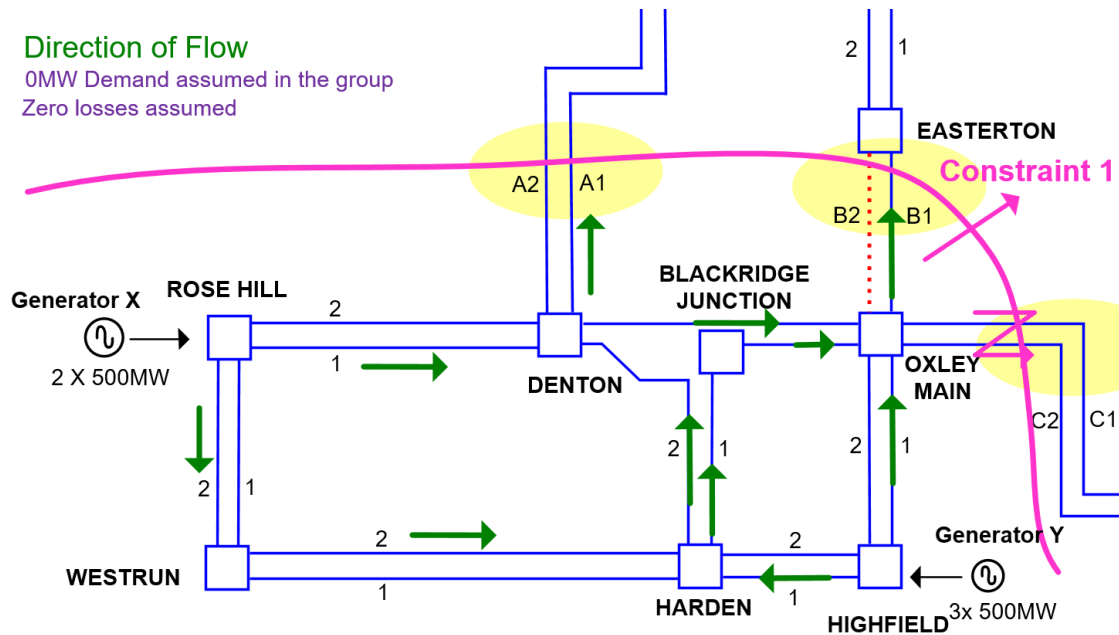
- To reduce the flow on **B1** from **800MW to 750MW** we can instruct generators, **X or Y** to reduce their output.
- In this scenario we can assume that **Generator Y** will 100% effective on the overload at **B1**. So, let's use **Generator Y** as an example.
- Effectiveness is a measure (positive or negative) that tells us the impact of generation on a circuit (or system component). For instance, if **Generator X** is 20% Effective on **B1**. This means every 100MW drop at **Generator X** will relief **B1** by 20MW.

Circuit	Post Fault Continuous Rating	Pre-Fault Flow	Post-Fault Flow
B1	750	400	800
B2	750	Outage	Outage

Can you calculate how many drops we need to take?

- We can calculate the required drops on **Generator Y** by:

$$\begin{aligned} \text{Reduction on Generator Y required} &= 800\text{MW} - 750\text{MW} \\ &= 50\text{MW} \end{aligned}$$

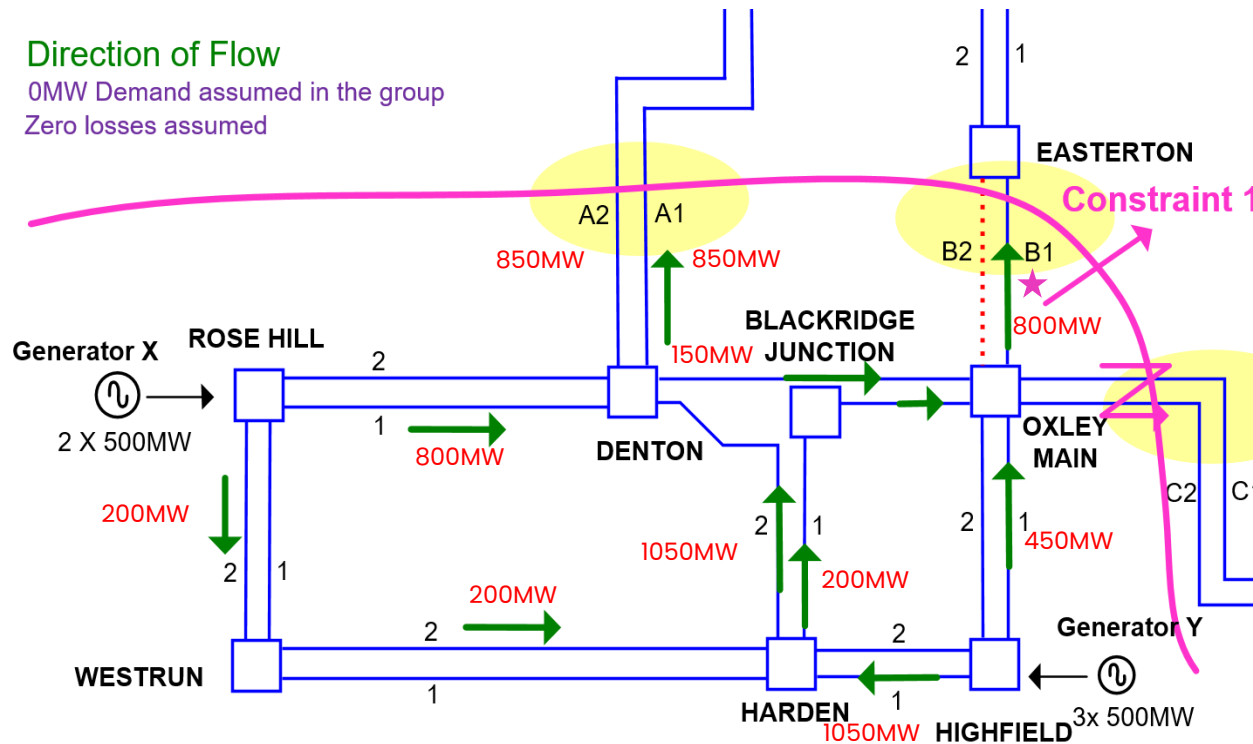


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# Constraint 1 Scenario 1 (continued)

Constraint 1 Limit is 2500MW.



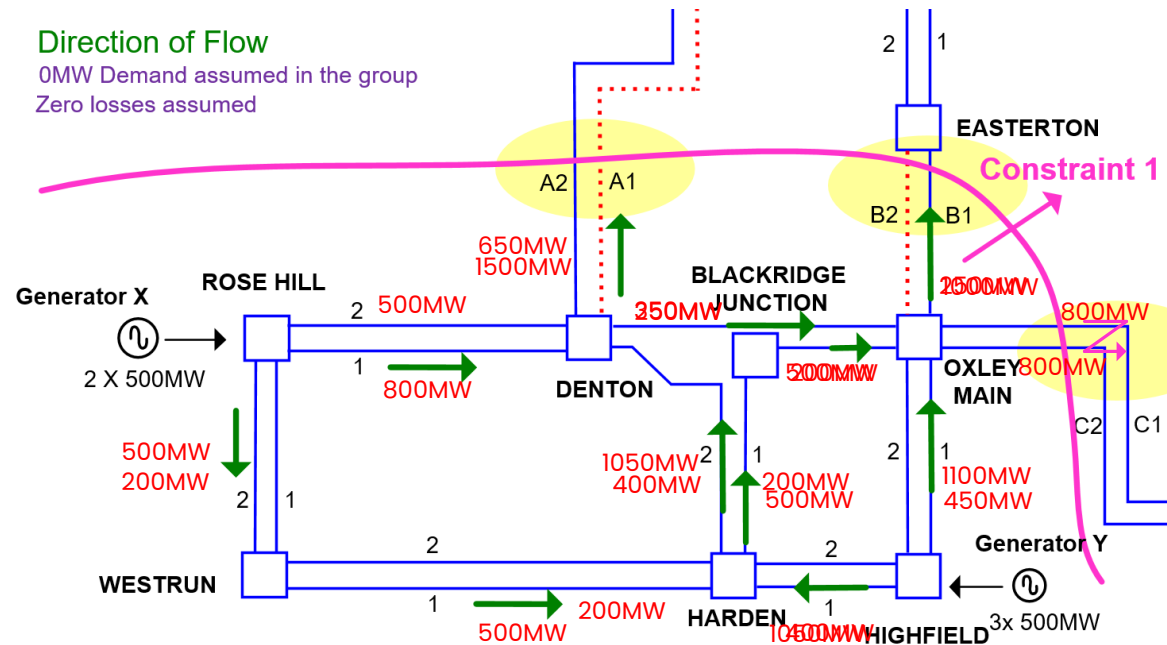
## In conclusion:

- The boundary Limit for **Constraint 1** will be **2500MW** as there is no requirement for pre-fault restriction.
- We have secured for our worst case which is the **C1 & C2** double circuit fault and if it ever happens there is a need to drop **Generator Y** by **50MW**.

# Constraint 1 Scenario 2

## Direction of Flow

0MW Demand assumed in the group  
Zero losses assumed



Circuit	Post Fault Continuous Rating	Short Term Rating	Pre-Fault Flow	Post-Fault Flow
A1	1092	1300	Request	Request
A2	1092	1300	650	1500
B1	750	900	250	1000
B2	750	900	Outage	Outage
C1	1344	1600	800	Fault
C2	1344	1600	800	Fault

- There is a planned outage on circuit **B2** and request to take **A1**.
- We now have a Double Circuit fault on circuits **C1** & **C2**.
- The amount of flow on each circuit has changed.
- Both **A2** & **B1** have breached their Short-Term ratings. This is not tolerable, and action needs to be taken Pre-fault.

What could the worst-case fault be and why?



## Constraint 1 Scenario 2 (continued)

- We now must do 2 things:
  - We need to drop our boundary limit pre-fault because we have breached the short-term ratings on **A2 & B1**. This is not securable and is breach of SQSS.
  - We need to check whether these overloads can be secured from their Short-Term rating to their Post Fault Continuous rating .
- Can you calculate how many drops are required at **Generator X** or/and **Generator Y** to bring back circuits back to their Short-Term rating and then to their Post Fault Continuous rating?
- In this scenario **Generator Y** will be more effective on the overload at **B1** and **Generator X** will be more effective on the overload at **A2**.
- We can calculate the required drops on **Generator X** by:

$$\text{Reduction on A2 required} = 1500\text{MW} - 1300\text{MW} = 200\text{MW}$$


$$\text{Effectiveness of Generator X on A2} = 45\%$$

$$\text{Drops required at Generator X} = \frac{200\text{MW}}{0.45} = \sim 444\text{MW}$$

$$\text{Reduction on B1 required} = 1000\text{MW} - 900\text{MW} = 100\text{MW}$$


$$\text{Effectiveness of Generator X on B1} = 25\%$$

$$\text{Drops required at Generator X} = \frac{100\text{MW}}{0.25} = 400\text{MW}$$



Circuit	Post Fault Continuous Rating	Short Term Rating	Pre-Fault Flow	Post-Fault Flow
A2	1092	1300	650	1500
B1	750	900	250	1000

Generator	Eff. A1	Eff. A2	Eff. B1	Eff. B2	Eff. C1	Eff. C2
Generator X	Outage	45%	25%	Outage	Fault	Fault
Generator Y	Outage	20%	50%	Outage	Fault	Fault



Notice that the overload on **A2** requires **444MW** pre-fault reduction on generation whereas **B1** requires only **400MW**. This means that **A2** is the limiting factor for this boundary and we must drop the boundary limit by at least **444MW**.

# Constraint 1 Scenario 2 (continued)

## We now must do two things:

1. We need to drop our boundary limit pre-fault because we have breached the short-term ratings on **A2 & B1**. This is not securable and is breach of SQSS.
2. We need to check whether these overloads can be secured from their Short-Term rating to their Post Fault Continuous rating .

Can you calculate how many drops are required at Generator X or/and Generator Y to bring back circuits back to their Short-Term rating and then to their Post Fault Continuous rating?

- In this scenario **Generator Y** will be more effective on the overload at **B1** and **Generator X** will be more effective on the overload at **A2**.
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Circuit	Post Fault Continuous Rating	Short Term Rating	Pre-Fault Flow	Post-Fault Flow
A2	1092	1300	650	1500
B1	750	900	250	1000

Generator	Eff. A1	Eff. A2	Eff. B1	Eff. B2	Eff. C1	Eff. C2
Generator X	Outage	45%	25%	Outage	Fault	Fault
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# Constraint 1 Scenario 2 (continued)

- We have now restricted our boundary pre-fault by 444MW and our overloads on A2 and B1 should be within their Short-Term ratings.
- We need to check if we can now bring these circuits back to their Post – Fault Continuous ratings
- We can use **Generator Y** and **Generator X** to clear Post-Fault overloads on **A2 & B1**.
- We can calculate the required drops on **Generator X & Y** by:

$$\text{Reduction on A2 required} = 1300\text{MW} - 1092\text{MW} = 208\text{MW}$$

$$\text{Effectiveness of Generator X on A2} = 45\%$$


$$\text{Drops required for A2 at Generator X} = \frac{208\text{MW}}{0.45} = \sim\mathbf{460\text{MW}}$$

**460MW** drops on **Generator X** will clear the overload on **A2** and will also relieve **B1** by:

$$460\text{MW} \times 0.25 = \mathbf{115\text{MW}}$$

However, we need to relieve the overloads on **B1** by  $889\text{MW} - 750\text{MW} = \mathbf{139\text{MW}}$

$$\text{Remaining drops required at Generator Y} = \frac{(139\text{MW} - 115\text{MW})}{0.50} = \mathbf{48\text{MW}}$$



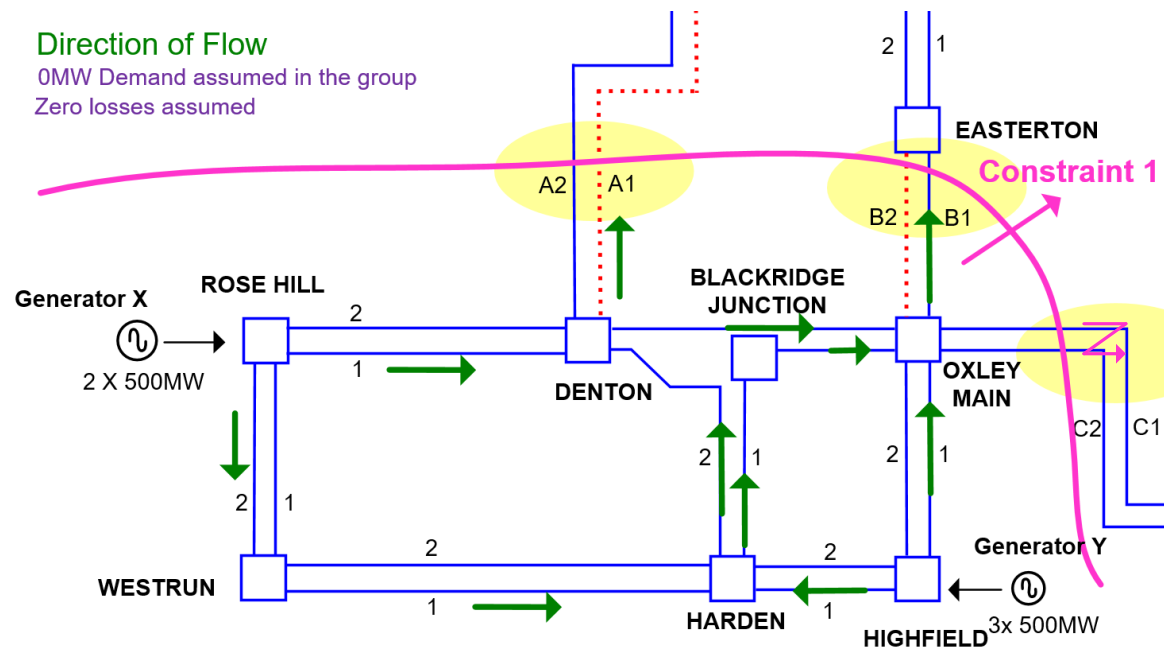
Circuit	Post Fault Continuous Rating	Short Term Rating	Pre-Fault Flow	Post-Fault Flow
A2	1092	1300	650	1300
B1	750	900	250	889

Generator	Eff. A1	Eff. A2	Eff. B1	Eff. B2	Eff. C1	Eff. C2
Generator X	Outage	45%	25%	Outage	Fault	Fault
Generator Y	Outage	20%	50%	Outage	Fault	Fault



# Constraint 1 Scenario 2 (continued)

Constraint 1 Limit is 2056MW.



## In conclusion:

- The boundary Limit for **Constraint 1** will have dropped from **2500MW by 444MW** as we are restricting generation in the group pre-fault.
- We have secured for our worst case which is the **C1 & C2** double circuit fault by taking **460MW** drops at **Generator X** and **48MW** drops at **Generator Y**.

# Things we do to improve constraint limits

- Changing Running Arrangements at substations (pre & post fault)
- Enhancing circuit ratings (pre fault)
- Changing Quad Booster Transformers tap positions (pre & post fault)
- Use Intertrips (post fault)
- Nest outages (opportunity outages)

# Constraint Costs

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# Why do constraints cost money?

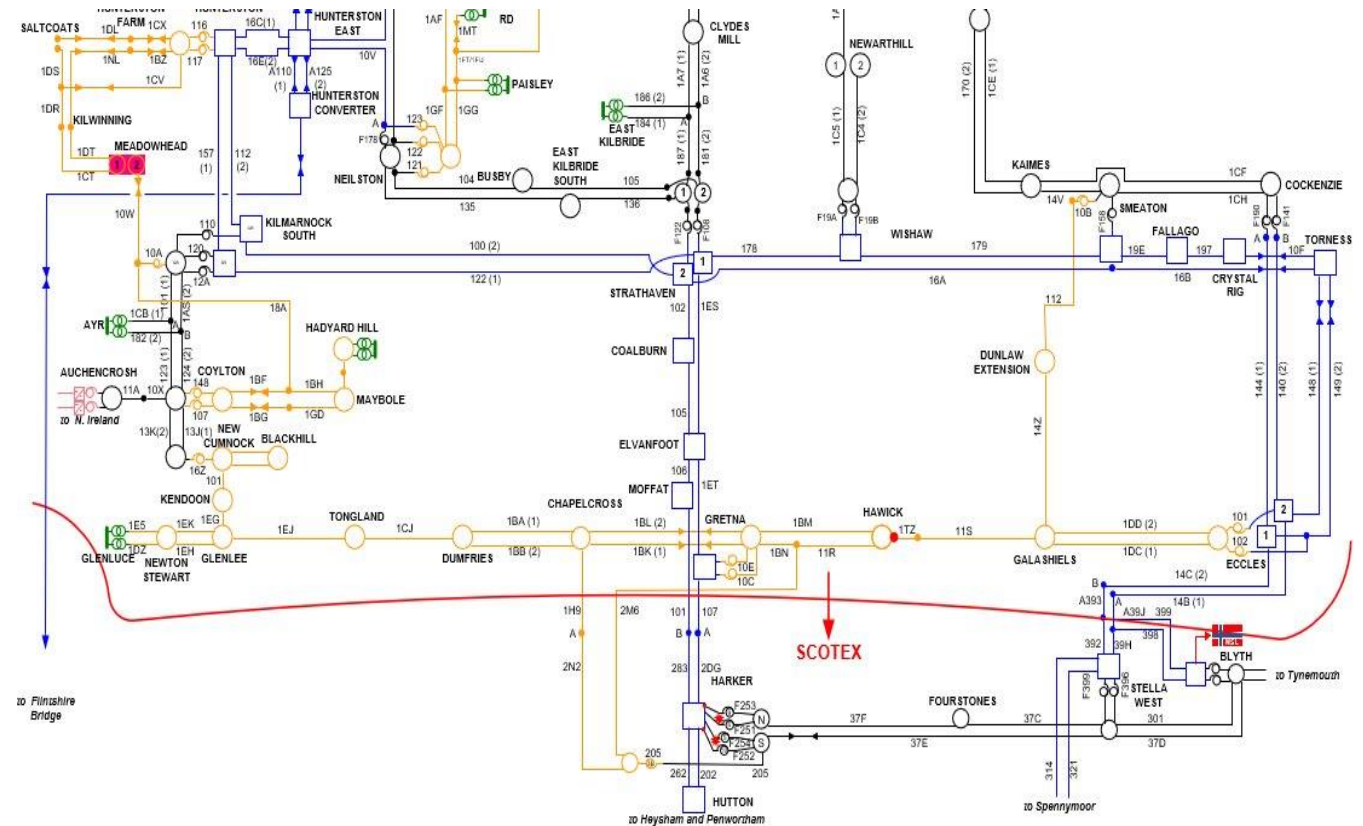
Typical Export Constraint: B6 / SCOTEX

If there is insufficient transmission capacity, generation behind B6 is reduced and the resulting shortfall is replaced by increasing generation in front of B6, ensuring that supply matches demand and the system remains balanced at 50Hz.

NESO must always take the most economical action. Typically, if a gas generator is operating behind the active constraint, it will be instructed to reduce output first, followed by wind generators.

Why gas first? **They pay us** when we instruct them to reduce output ('bid them off').

Why wind second? **We pay them** to reduce output ('bid them off').



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# Why does a gas generator give us money, but a wind generator takes money?

- A Gas generator does not have to use its fuel when we bid it off, and we take responsibility to deliver its contracted MWs to the system.
- A wind generator only gets a subsidy if it generates power. When we bid it off, it forgoes its subsidy payment. Therefore to 'balance its books' it will want that 'missing revenue' to come from NESO, reflected in the bid-price it submits.
- When we buy replacement energy, we buy the cheapest available bearing in mind any technical, system, or security limitations.
- Note that if there is over-supply in the market, we may not need to purchase replacement energy due to the market surplus.

# Why do we allow system access if it increases constraint cost?

**Reducing system transmission capability can incur significant additional constraint cost, BUT:**

- Assets need maintenance, and normally need to be de-energised to facilitate work;
- The grid needs upgraded and improved to meet the changing needs of the future: electrification of heat and transport; changes in location of demand and supply.

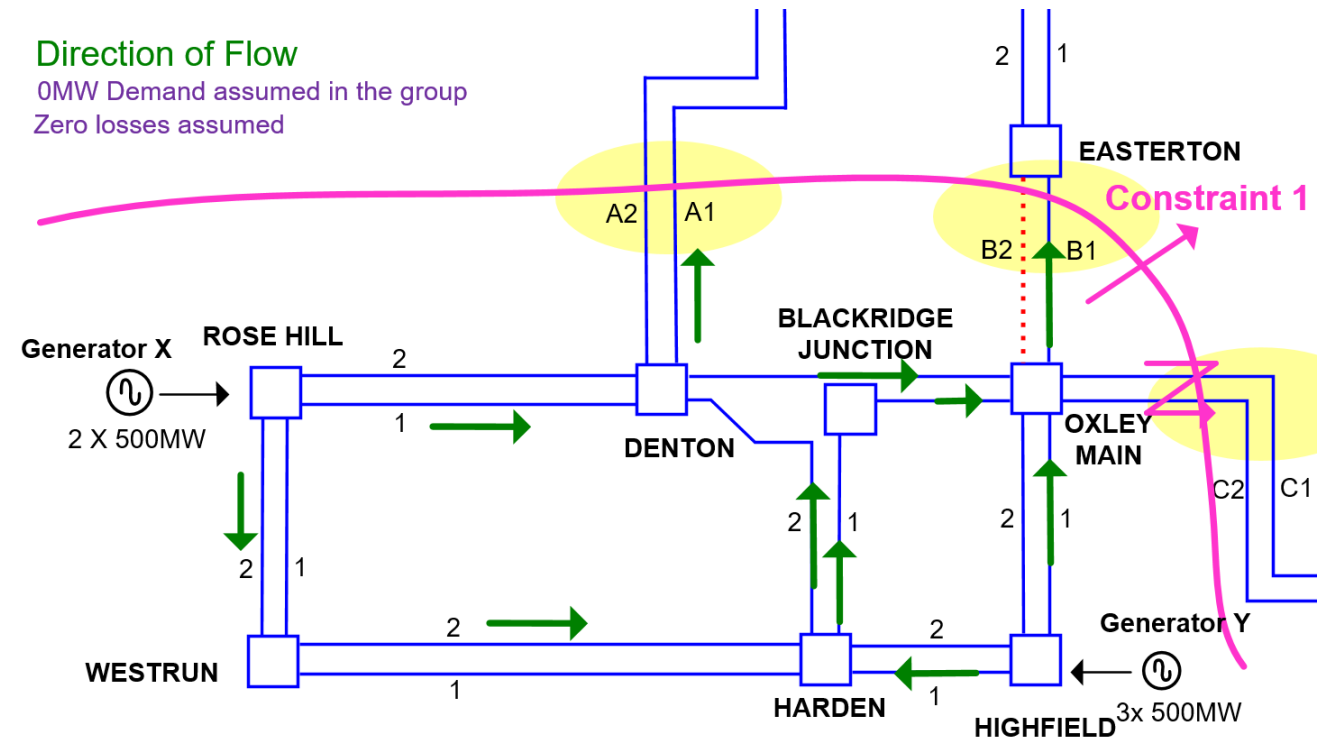
**Why don't we recall outages when it is windy?**

- Often outages have 'ONCOM' (on-commission) Emergency Return To Service time. This means it is impossible to return the outage before its end date, e.g. something may have been permanently dismantled to be replaced by new components.
- If we were to recall outages, this would have knock-on effects for the rest of the activities in the plan-year, causing re-scheduling and re-resourcing problems which would ripple through the year and make the already complex challenge of accommodating all planned system access even more difficult.

# Can we do anything to reduce constraint costs?

**YES!**

- Nest outages: take multiple concurrent outages when one of them reduces a constraint/boundary limit, 'the weakest link in a chain'.
- Take outages concurrent with generation outages, i.e. if a large generator behind a constraint is unavailable to run, then there will be less excess power trying to flow across the boundary.



# New Outage Request Sanction Process

When a network owner requests system access within plan-year, it must be assessed by NESO planners that it does not cause system security issues, and that it is commercially acceptable.

If the request results in a lower boundary limit than is in the year-ahead plan for the duration of the request, then it must be commercially assessed.

The Sanction Team model a forecast cost for the outage, i.e. the additional constraint cost if the outage goes ahead compared with the counterfactual of the expected cost of the outages already in the year-ahead plan. They will also calculate an 'exposure cost', which is the credible worst-case cost, for example if all the wind generation had 100% output for the duration of the outage.

The higher the forecast and exposure costs, the higher level of NESO Management sign-off required. The higher level of Management involvement, the higher level of scrutiny of the outage justifications and need for the work, and the longer it will take to go through internal NESO governance processes. This contributes to why NESO cannot always give fast responses to within-year outage requests, it is often the case that individual outage requests are forecast to incur additional constraint cost of £Ms.

# New Outage Request Sanction Process

