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DSOs' approach to ROCOF and Grid Forming proposals

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Tony Hearne
Vice-chair WG Existing Network Codes

Presentation Outline

- EU DSO Entity introduction
- EU DSO Entity concerns on islanding
- Walk through example: Neutral Earthing
- EU DSO Entity counter proposals and ENTSO-E interactions
- Joint EU DSO Entity / ENTSO-E Proposed legal text
- Summary

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DSO Entity
Brief introduction

Introducing EU DSO Entity

An EU association legally mandated by EU Regulation 2019/943

> Art. 52.1: Distribution system operators shall ***cooperate at Union level through the EU DSO Entity***, in order to promote the ***completion and functioning of the internal market for electricity***, and to promote optimal management and a coordinated operation of distribution and transmission systems.

A body of cooperation and neutral expertise between all DSO in the EU

EU DSO Entity represent the voice of all EU DSOs and has a clear mandate alongside ACER and ENTSO-E for developing NC

Network Codes & Guidelines

Participates in drafting of Network Codes and Guidelines relevant for DSO grids

- Joint proposal with ENTSO-E on **Network Code (NC) Cybersecurity (14/1/22)**
- **Upcoming Network Code (NC) Demand-side Flexibility**
- **Review of existing network codes (NC)**

DSO/TSO cooperation

Promotes optimal and coordinated planning and operation of DSO/TSO networks

- **MoU** with ENTSO-E (DSO-TSO work plan)
- Cooperation on **Network Codes (NC)**
- Joint initiative on **Vision 2050**

Sharing best practice

Expert Groups and forum provide expertise and enable exchange of views

- **Various forms of knowledge sharing** with DSO Entity's members
- Via **project teams** (e.g. events, expert tables)
- **DSO radar reports**

EU DSO Entity welcomes the general approach outlined by ACER for amending current NCs RfG and DC

- **EU DSO Entity** welcomes the review of the current grid connection codes:
  - NC Requirements for generators (NC RfG).
  - NC Demand connection (NC DC).
- **DSOs' experts** have been actively involved in the preparatory work regarding the review of these NCs, namely in several Expert Groups under the European Stakeholder Committee Grid Connection (GC ESC).

- **EU DSO Entity's objective is to collaborate closely with ACER, ENTSO-E and DG ENER** ***(EC's Directorate-General for Energy)*** **on these amendments.**

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EU DSO Entity concerns on islanding

EU DSO Entity concerns on islanding

- Two specific ENTSO-E proposals of concern:
  - the Rate of Change of Frequency (RoCoF) immunity thresholds and associated minimum protection settings and
  - the mandating of grid-forming capabilities (GFC) on Power Park Modules (PPMs)
- Entity view is that taken together,
  - these will make the detection and elimination of unintended islands on the distribution network, through traditional passive means, virtually impossible,
  - islands are more likely to form and once formed, will stay running for longer periods of time,
  - that with regard to mass GFC deployment at scale on Distribution networks, the technical readiness has not been sufficiently established, nor has cost-benefit been evaluated,
  - DSOs will need substantial time and investment to mitigate the effects, to seek alternate solutions and bring them into business as usual.

Illustration of un-intended islanding

- Typical Distribution primary substation
- One large generator connected directly to the lower voltage busbar

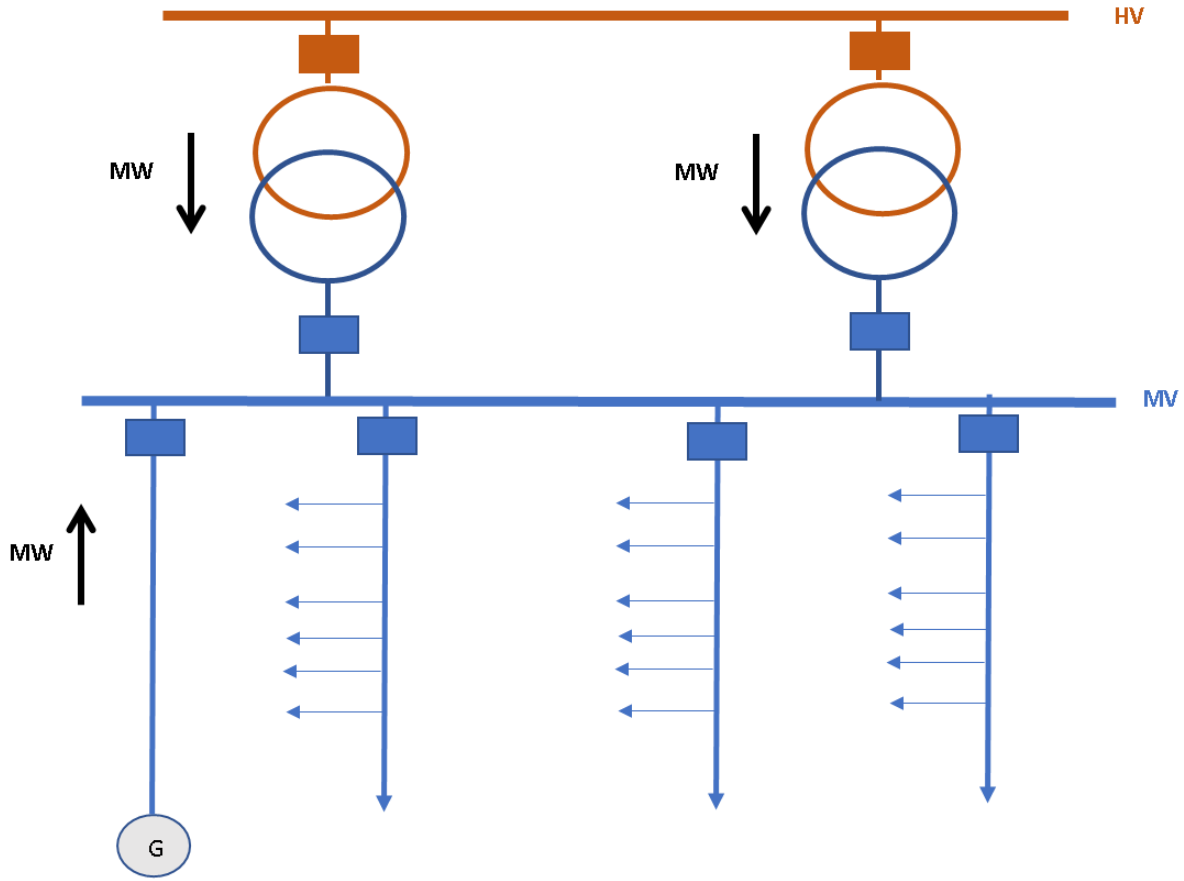
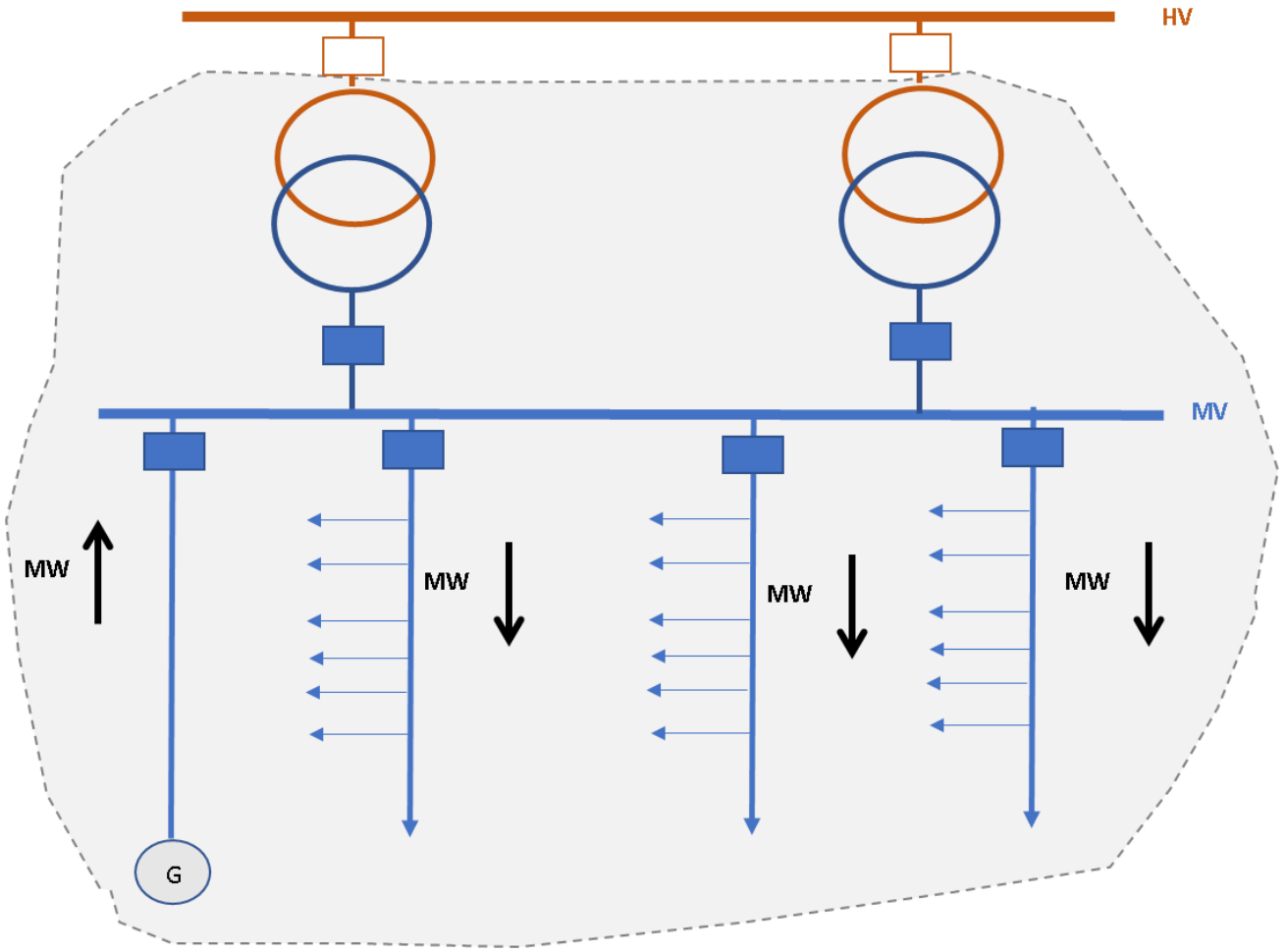


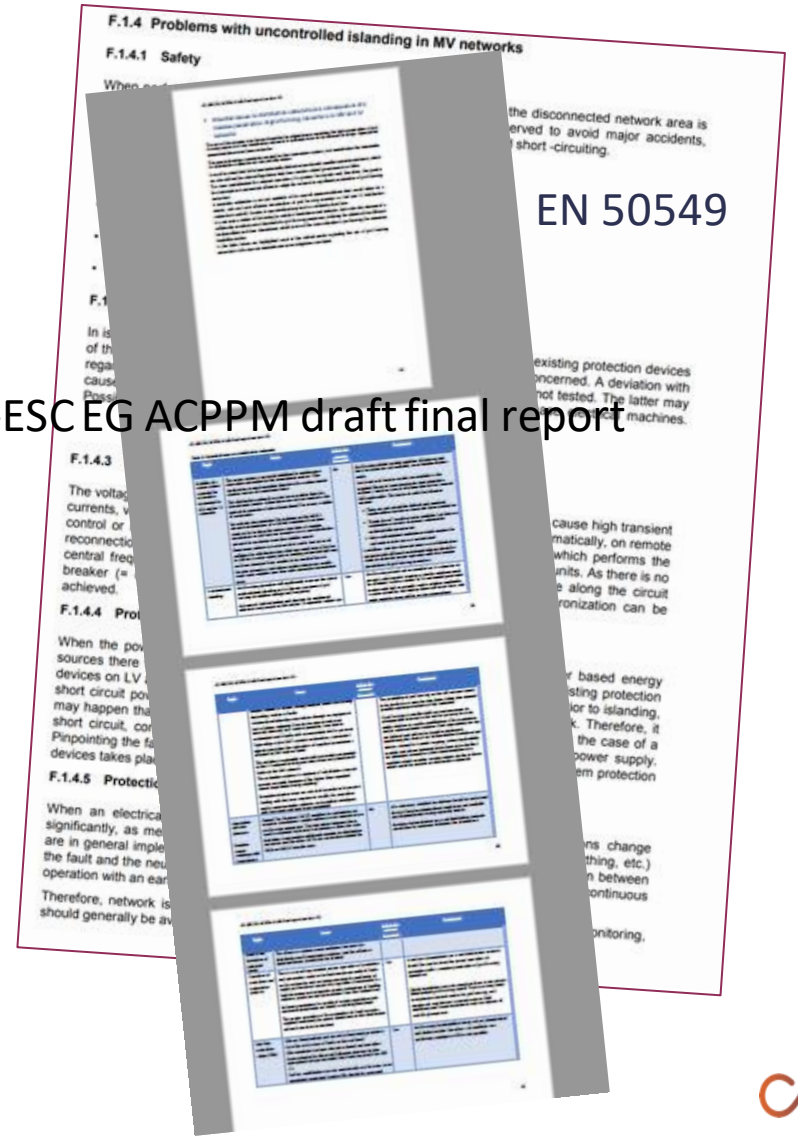
Illustration of un-intended islanding

- Transformer circuit breakers open [for whatever reason]
- All MV load now supplied by the generator.



Reasons why un-intended islands are undesirable

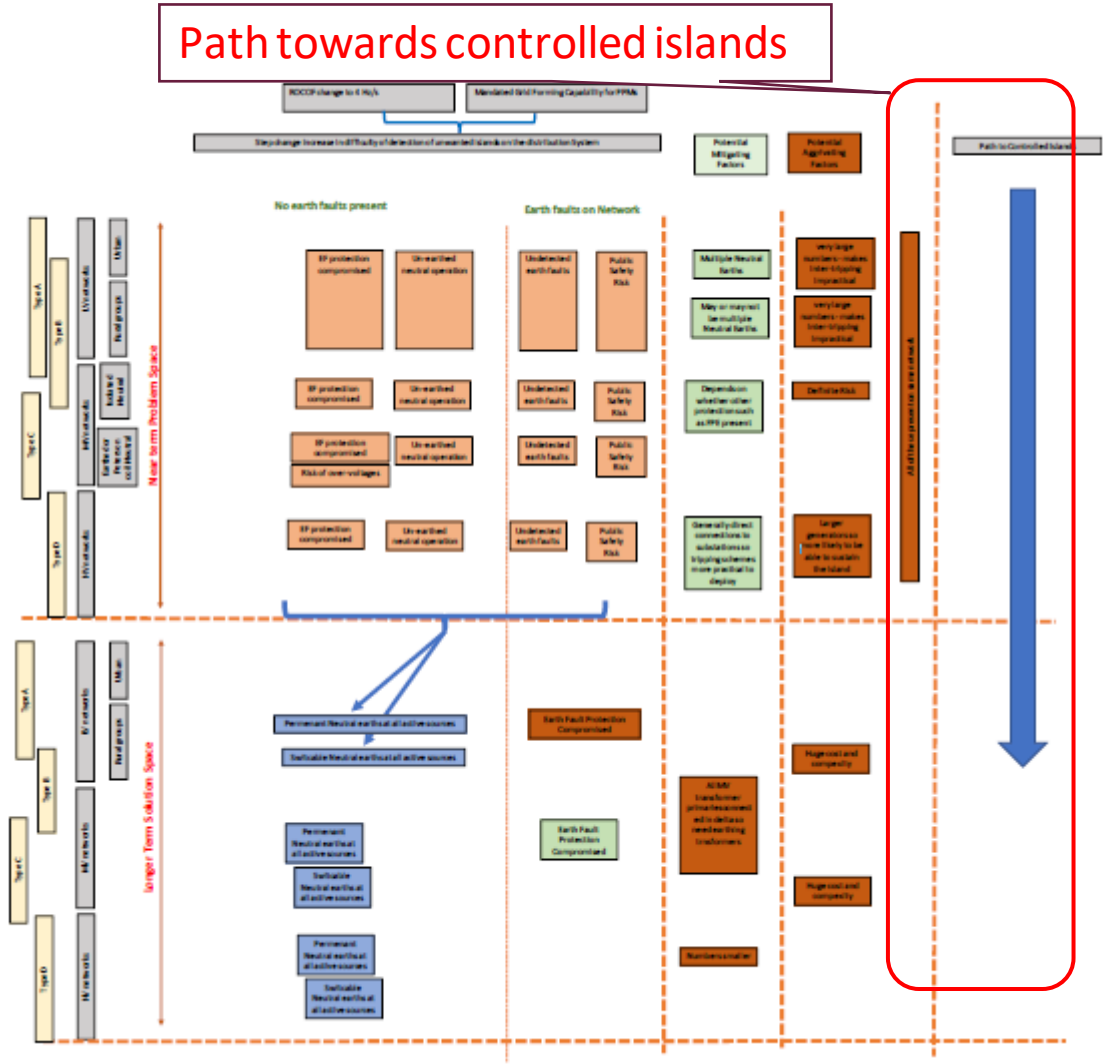
- Neutral earthing and compromising of earth and phase fault protection
- Quality of supply to customers
- Synchronising issues
- Compromising of automatic restoration schemes
- Regulatory and market issues; Supply-dispatch – frequency management responsibility



Path toward intended and controlled islands

Path towards controlled islands

- Some DSOs, who are experiencing high levels of penetrations of renewable generation, have begun exploring means to deliberately facilitate and operate such islands in a controlled manner.
- This work only exists in trials and pilots and is still far from complete.
- Furthermore, this work should not be seen as a silver bullet to solve all these problems immediately.
- DSO Entity does recognise that subject to all of the technical and regulatory issues being overcome, DSOs recognise there are positive benefits from such operation.



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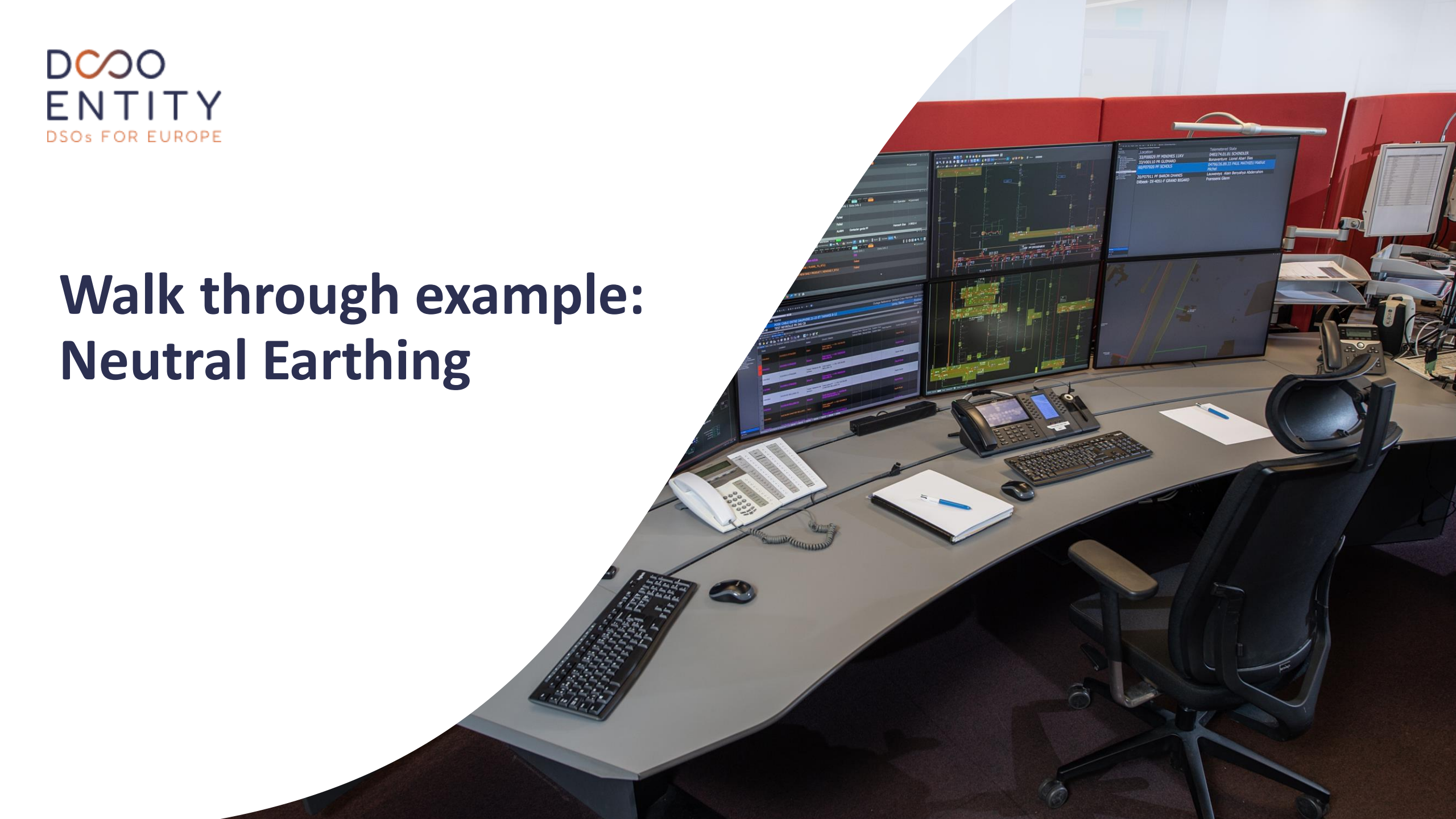
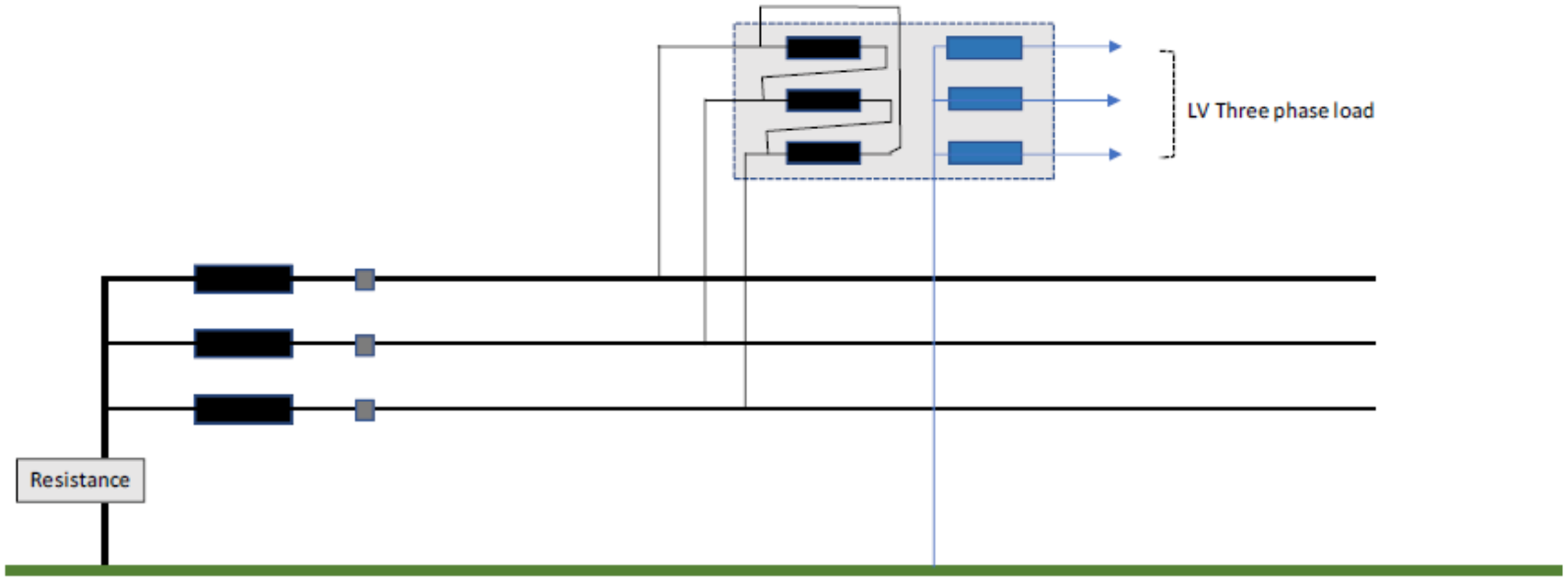
Walk through example: Neutral Earthing

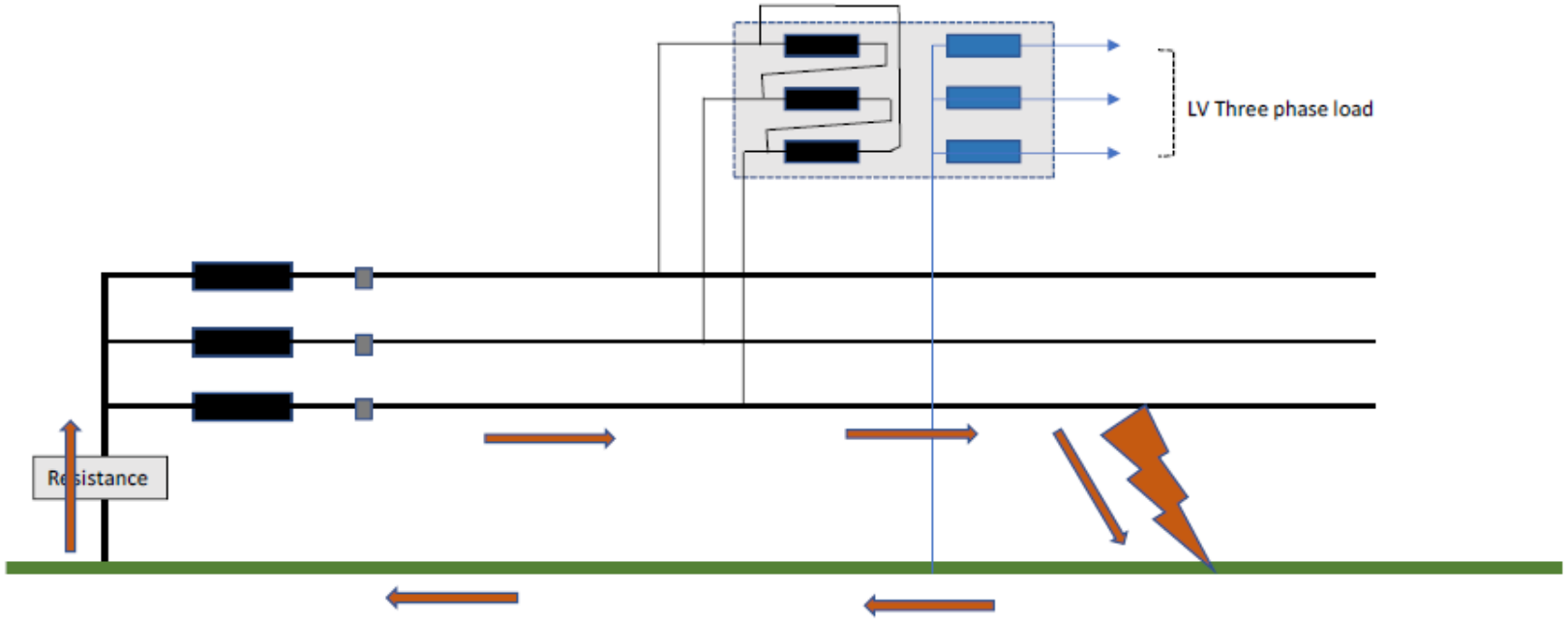


Walk through example: Neutral Earthing - 1



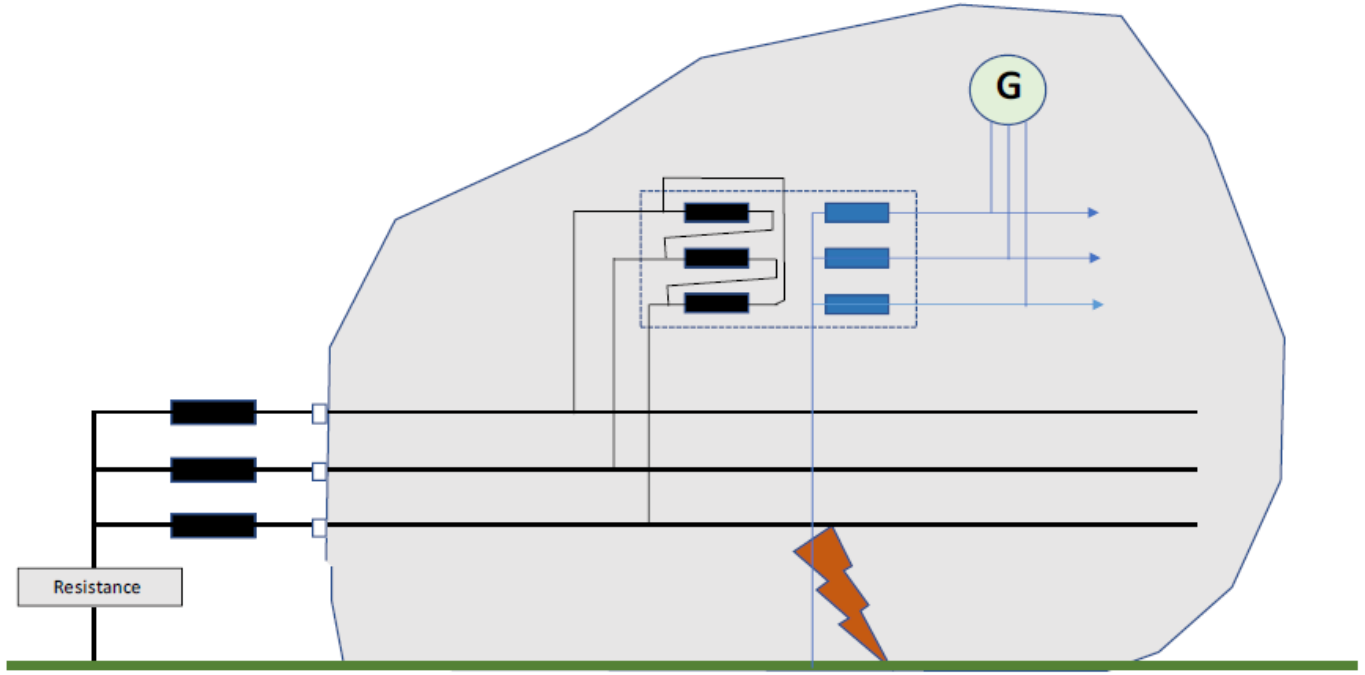
- Medium Voltage [MV] network
- Neutral at primary sub-station is resistance earthed
- Three phase load connected at Low Voltage [LV] via delta-star MV-LV transformer

Walk through example: Neutral Earthing - 2



- MV earth fault occurs
- Earth fault current flows
- Current based earth fault protection operates and clears fault

Walk through example: Neutral Earthing - 3



- Generator connected to LV network
- Island formed
- MV Earth fault occurs
- Fault fed by generator and current based earth fault protection does not operate

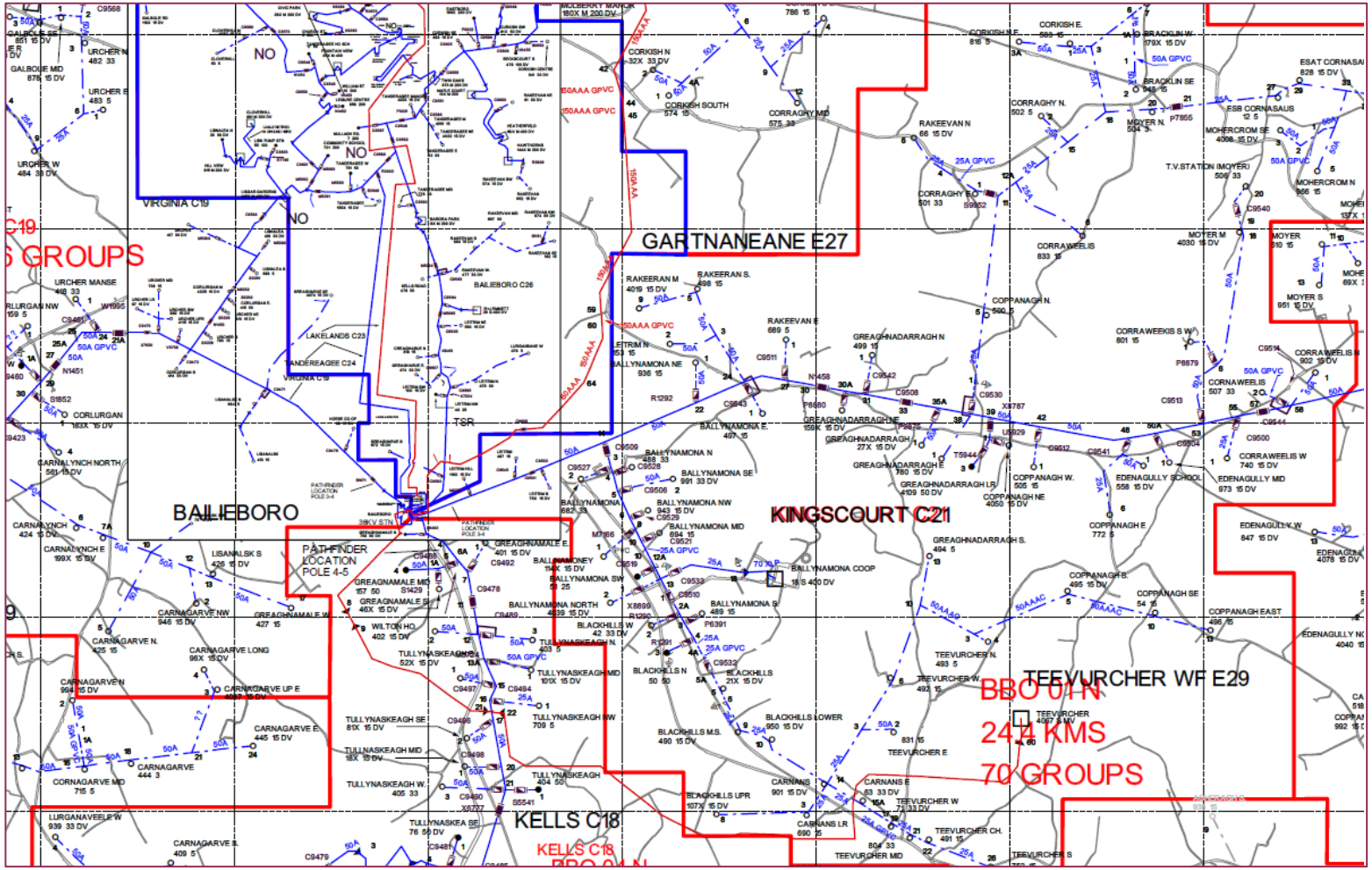
Walk through example: Neutral Earthing - 4

Mitigation:

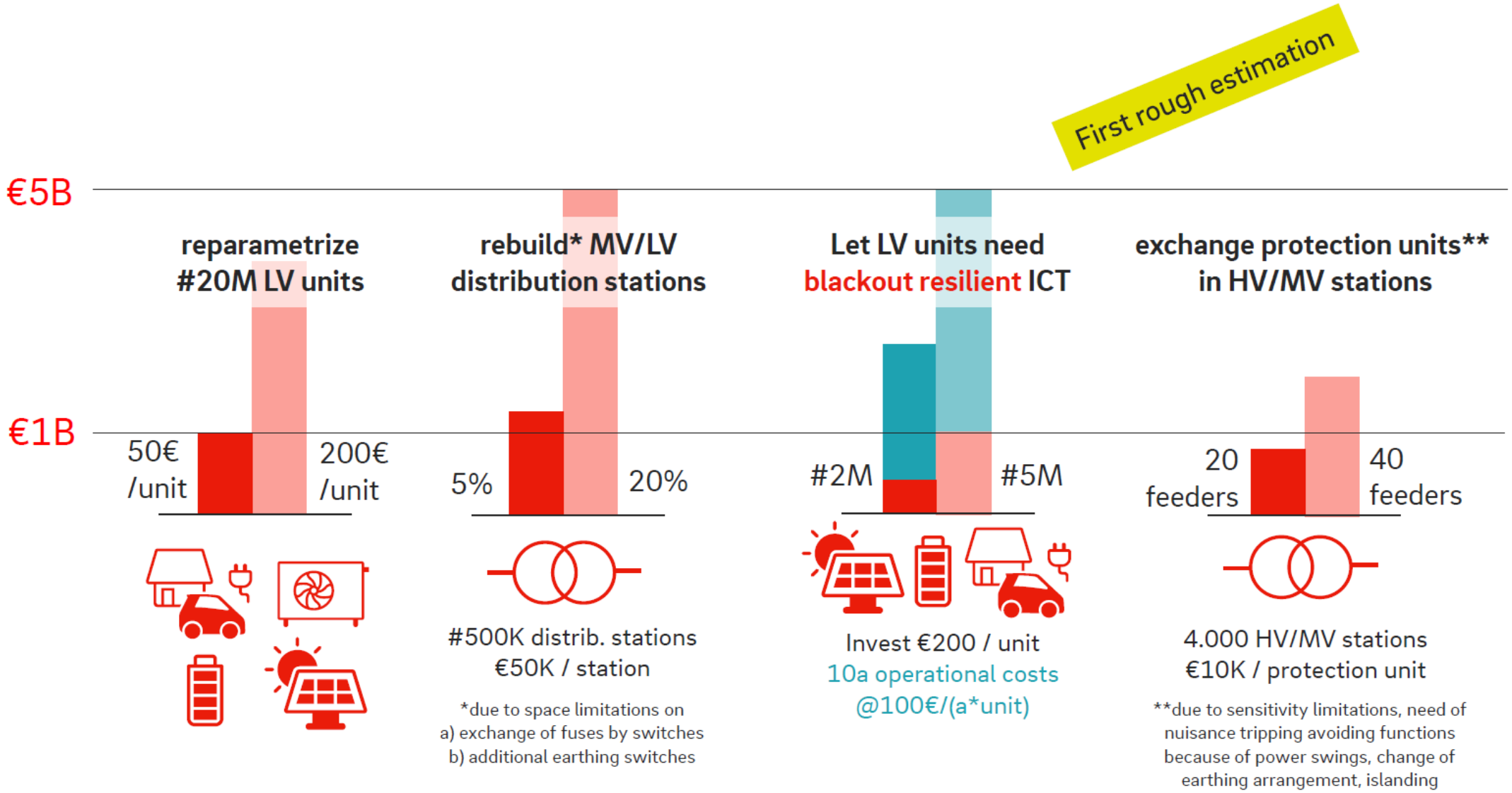
- Earthing transformer
- Means of MV isolation
- MV protection device

on all MV/LV transformers

- Thousands of such transformers
- Millions in Europe



Example from one German DSO



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EU DSO Entity counter proposals and ENTSO-E interactions

EU DSO Entity counter proposals and ENTSO-E interactions

- EU DSO Entity has been engaging constructively bi-laterally with ENTSO on its concerns
- Tri-lateral meetings have also taken place with ACER
- ENTSO-E aware of EU DSO Entity concerns relating to islanding
- EU DSO Entity understands ENTSO-E desire to capture capabilities in a timely manner to preserve overall system stability.

ROCOF

- The Entity does not believe it is appropriate to have a hard linkage in RfG, between RoCoF withstand capabilities of PPMs and RoCoF protection settings where it is used for islanding detection.
- A setting of >4Hz/s would render such relays utterly useless in this regard.
- There is a wide variation amongst relay manufacturers as to how RoCoF measurement is implemented within the relays.
- Article 13 (b) (iii), should either be deleted or made flexible.

Frequency Traces		Relay A	Relay B	Relay C	Relay D	Relay E	Relay F	Relay G	Relay H
Frequency Drop with Fault	RoCoF 0.4 Hz/s	Trip	Trip	Trip by df/dt	1.746	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
Frequency Drop with Fault 5%		Trip	Trip	Trip by df/dt	1.825	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
Frequency Drop with Fault 50%		NO TRIP	Trip	Trip by df/dt / Vector Shift	1.586	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
Frequency Rise without Fault		Trip	Trip	Trip by df/dt	1.825	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
Frequency Rise with Fault		NO TRIP	Trip	Trip by df/dt	1.745	Trip by df/dt	Trip by df/dt	NO TRIP	Trip by df/dt
Frequency Rise with Fault 5%		NO TRIP	NO TRIP	Trip by df/dt	1.824	Trip by df/dt	NO TRIP	NO TRIP	Trip by df/dt
Frequency Rise with Fault 50%		NO TRIP	NO TRIP	Trip by Vector Shift	1.585	Trip by df/dt	NO TRIP	NO TRIP	Trip by df/dt
Loss of Largest Infeed - Typical		NO TRIP	NO TRIP	Trip by df/dt	2.062	Trip by df/dt	NO TRIP	NO TRIP	Trip by df/dt
Loss of Largest Outfeed - Typical		NO TRIP	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP
Loss of Largest Infeed - High RoCoF		NO TRIP	NO TRIP	Trip by df/dt	2.334	Trip by df/dt	NO TRIP	NO TRIP	Trip by df/dt
Frequency Drop without Fault	RoCoF 0.6 Hz/s	NO TRIP	Trip	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	NO TRIP	NO TRIP
Frequency Drop with Fault		Trip	Trip	Trip by df/dt	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
Frequency Drop with Fault 5%		Trip	Trip	Trip by df/dt	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
Frequency Drop with Fault 50%		NO TRIP	Trip	Trip by df/dt / Vector Shift	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
Frequency Rise without Fault		Trip	Trip	Trip by df/dt	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
Frequency Rise with Fault		NO TRIP	NO TRIP	Trip by df/dt	1.745	Trip by df/dt	NO TRIP	Trip by df/dt	Trip by df/dt
Frequency Rise with Fault 5%		NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
Frequency Rise with Fault 50%		NO TRIP	NO TRIP	Trip by Vector Shift	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
Loss of Largest Infeed - Typical		NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
Loss of Largest Outfeed - Typical		NO TRIP	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP
Loss of Largest Infeed - High RoCoF		NO TRIP	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP
Frequency Drop without Fault	RoCoF 1.0 Hz/s	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
Frequency Drop with Fault		NO TRIP	NO TRIP	NO TRIP	Trip	Trip by VS	NO TRIP	NO TRIP	NO TRIP
Frequency Drop with Fault 5%		NO TRIP	NO TRIP	Trip by Vector Shift	Trip	NO TRIP	NO TRIP	NO TRIP	NO TRIP
Frequency Drop with Fault 50%		NO TRIP	NO TRIP	NO TRIP	Trip	NO TRIP	NO TRIP	NO TRIP	NO TRIP
Frequency Rise without Fault		NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt
Frequency Rise with Fault		NO TRIP	NO TRIP	NO TRIP	NO TRIP	Trip by VS	NO TRIP	NO TRIP	NO TRIP
Frequency Rise with Fault 5%		NO TRIP	NO TRIP	Trip by Vector Shift	Trip	NO TRIP	NO TRIP	NO TRIP	NO TRIP
Frequency Rise with Fault 50%		NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
Loss of Largest Infeed - Typical		NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
Loss of Largest Outfeed - Typical		NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
Loss of Largest Infeed - High RoCoF		NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP

Mandating of Grid-Forming capability

- The DSO Entity does not agree with the position articulated, that the same issues would occur with grid-following inverters.
  - High penetration of grid following inverters is existing and still the incidence of unintended islands is extremely low.
  - No significant change in this position is expected whilst the growth of generation remains grid following.
- Time and investment are needed to devise and implement measures to mitigate the islanding risks.
  - A hard three year transition period for Types B, C and D is problematic.
  - Flexibility to cater for variations in progress at Member State level, is required.

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Joint
EU DSO Entity / ENTSO-E
Proposed legal text

ROCOF - protection

- Article 13 (b) (iii)

(iii) If rate-of-change-of-frequency (RoCoF) is used for loss of mains protection, the relevant system operator, in coordination with the relevant TSO, shall specify the threshold of this rate-of-change-of-frequency-type loss of mains protection.

Grid Forming

- Type A:

[…]

(a) *6. The relevant TSO, in co-ordination with the relevant system operator, shall have the right to request grid forming capability from any type A PPM at its connection point as defined by the following paragraphs:*

Grid Forming

- Type B: Article 20 (5) Wording under consideration by both organisations but agreed as a basis upon which to work

After a transition period, proposed by the relevant TSO in coordination with the relevant system operator and adjacent TSOs, a type B PPM shall be capable of providing grid forming …"

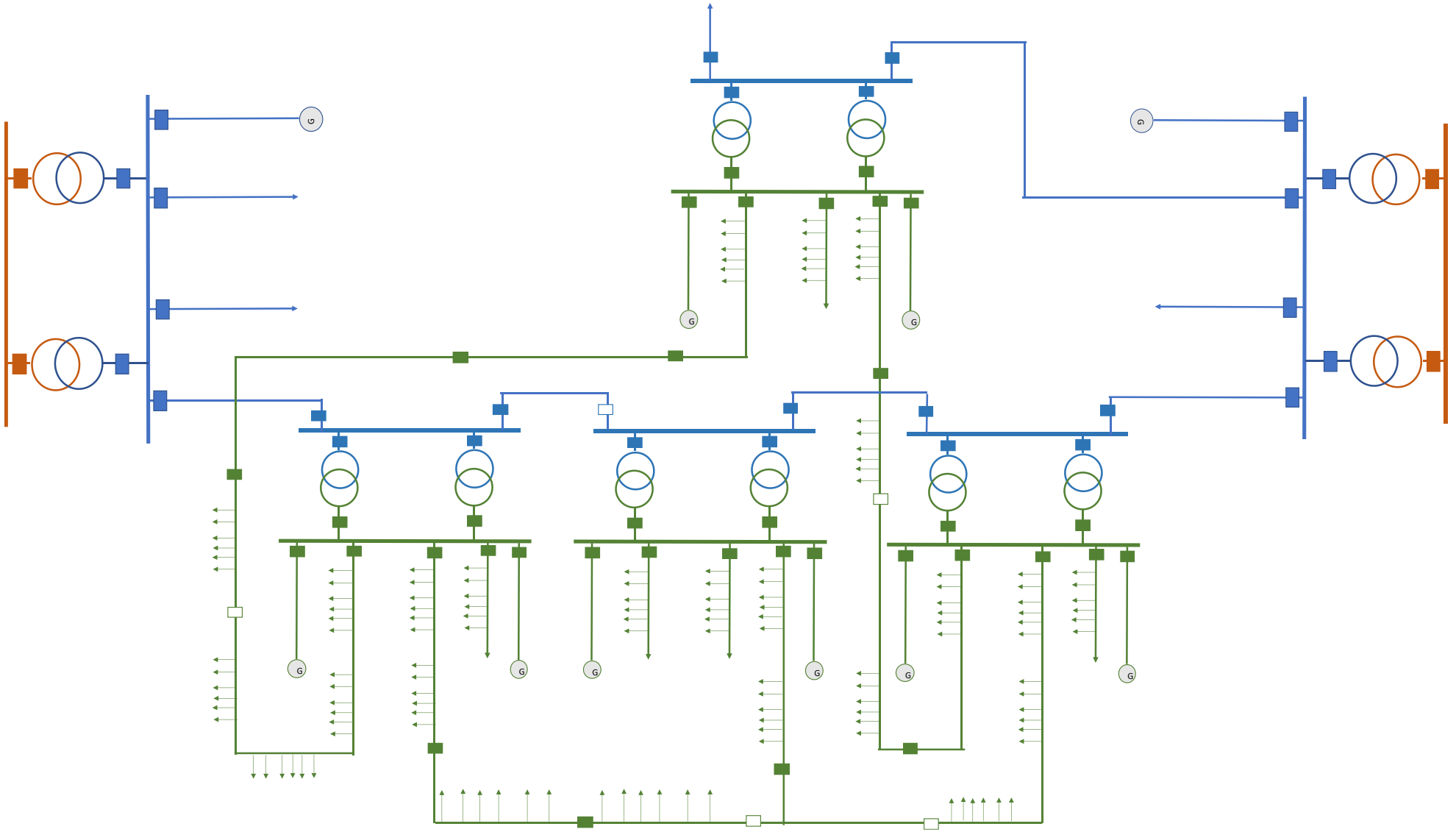
Grid Forming

Type C [and D]

- General agreement in principle, that as size of generators increases, cost and complexity of DSO mitigations for islanding issues decreases. Never the less, they could still be significant, particularly for high penetration networks.
- At time of writing, no agreement between the organisations on wording
- ENTSO-E believe a hard three year transition period is required
- EU Entity believe that there must be some flexibility in this, either in timescale or the MW threshold above which grid forming is to be required.
- The text below for article 21, has not been proposed to or agreed with ENTSO-E and emerged from internal Entity discussions following the last meeting with them;

5. A type C PPM may be capable of providing grid forming capability at its connection point as listed in Article Y. A type C PPM of Pmax greater than a threshold to be determined at Member State level, based on system capabilities, needs and urgency, shall be capable of providing grid forming capability at its connection point. …[]…

Illustration of complexity of inter-tripping



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Summary

Summary

- EU DSO Entity is committed to work constructively with all parties in order to achieve a successful revision to the RfG Network Code.
- The Entity understands the high level reasons for changes proposed by ENTSO-E on these topics.
- The Entity also, however believes that there are issues to be addressed and that a pragmatic approach to enable DSOs to mitigate these issues is required.

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Questions ?