Long term frequency stability scenarios – project results

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Long term frequency stability scenarios – framework (1/2)

WHAT

Cross–committee project set up by System Development Committee and System Operation Committee. It involves:

- TF Planning Standards; StG Connection Network Codes; WG System Protection and Dynamics

The aim is to **assess the decreasing level of inertia and its impact on the future Continental Europe synchronous area**

WHY

- The system trends show a **decrease in the level of Inertia**
- Following an ordinary generation loss, **large RoCoF and frequency excursions** are not expected in Continental Europe. However, these **can be observed in case of a system split**
  - System splits are **realistic and serious disturbances**
  - System split events are **not a new issue**, but the trends show that the **underlying assumptions are shifting to a situation more challenging to withstand**
- It is **important to assess the expected RoCoF** values in a system split and **discuss the possible mitigation measures**
  - A high RoCoF reduces the available time for deploying the necessary fast balancing actions for preventing high frequency excursions leading to unstable behavior in the subsystems or even blackout

Long term frequency stability scenarios – framework (2/2)

HOW

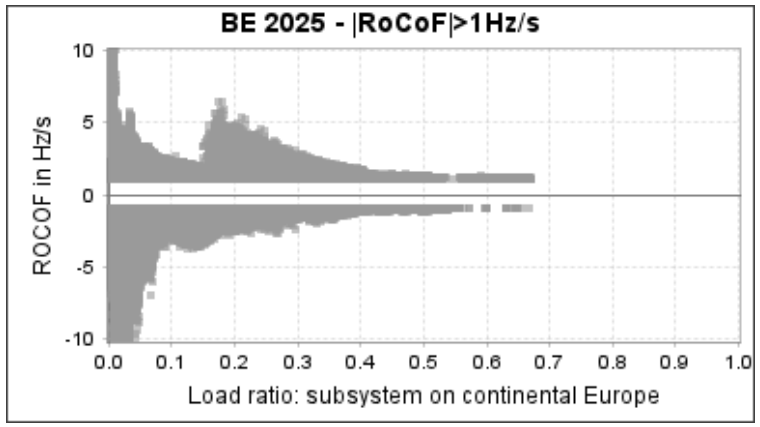
Starting from the **market data of TYNDP2018**, the study defined a **methodology** to enable a comprehensive perspective of the possible Continental Europe synchronous area split cases and the **essential causes** at the base of the **RoCoF values**

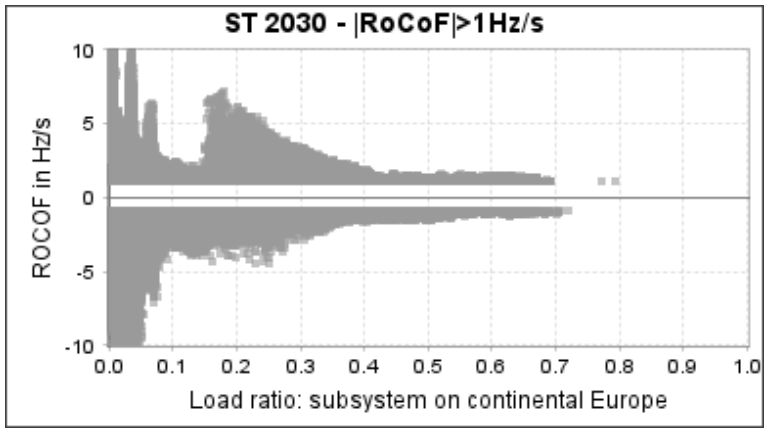
- Calculation of **all possible system split combinations** considering a subset of the TYNDP 18 market nodes
- For each split combination, the **initial subsystems RoCoF is calculated based on the imbalance and inertia for every hour and every TYNDP scenario**
- **The study does NOT assess the probability of occurrence of a system split!**

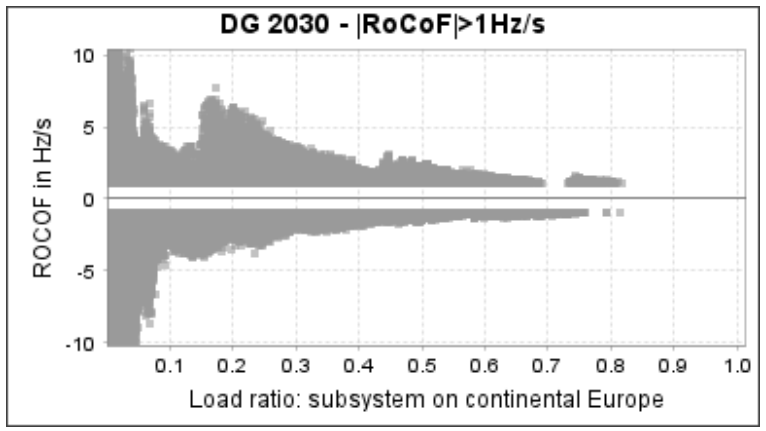
The study considered **initial RoCoF values higher than 1 Hz/s as not manageable,** as per to System Operation Committee WG SPD "Inertia and Rate of Change of Frequency (RoCoF)*"

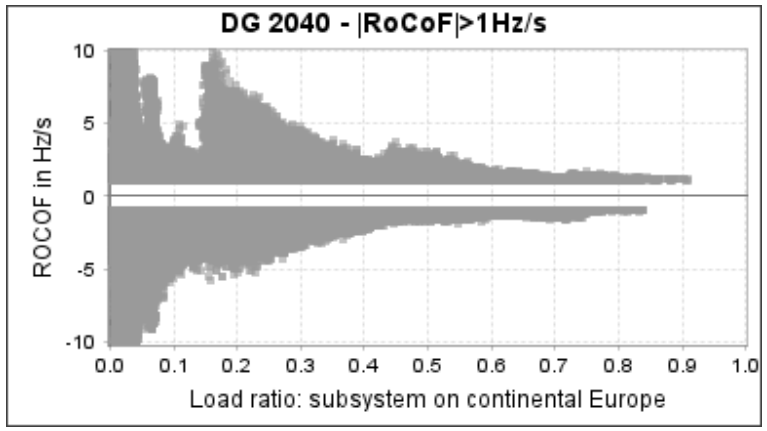
*https://eepublicdownloads.azureedge.net/clean-documents/SOC%20documents/Inertia%20and%20RoCoF_v17_clean.pdf

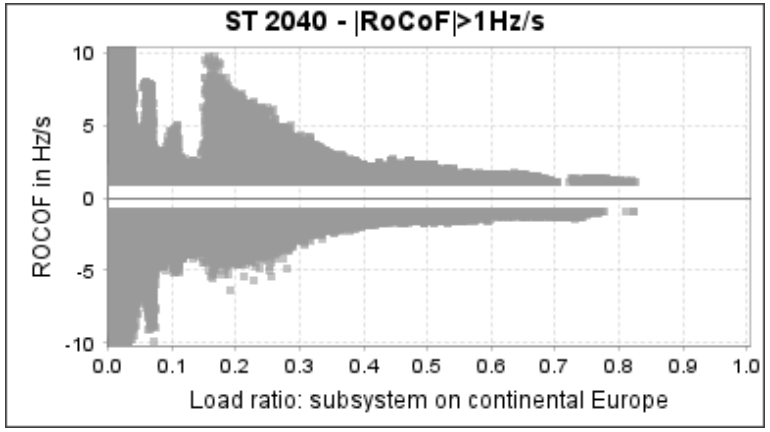
Subsystem RoCoF wrt load ratio: potentially unmanageable cases

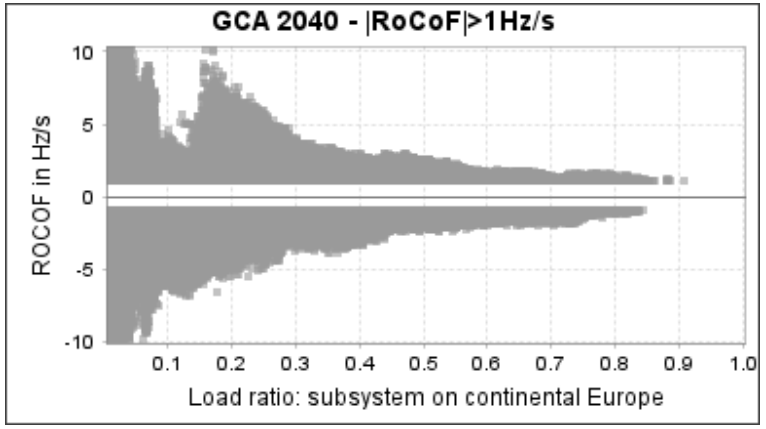






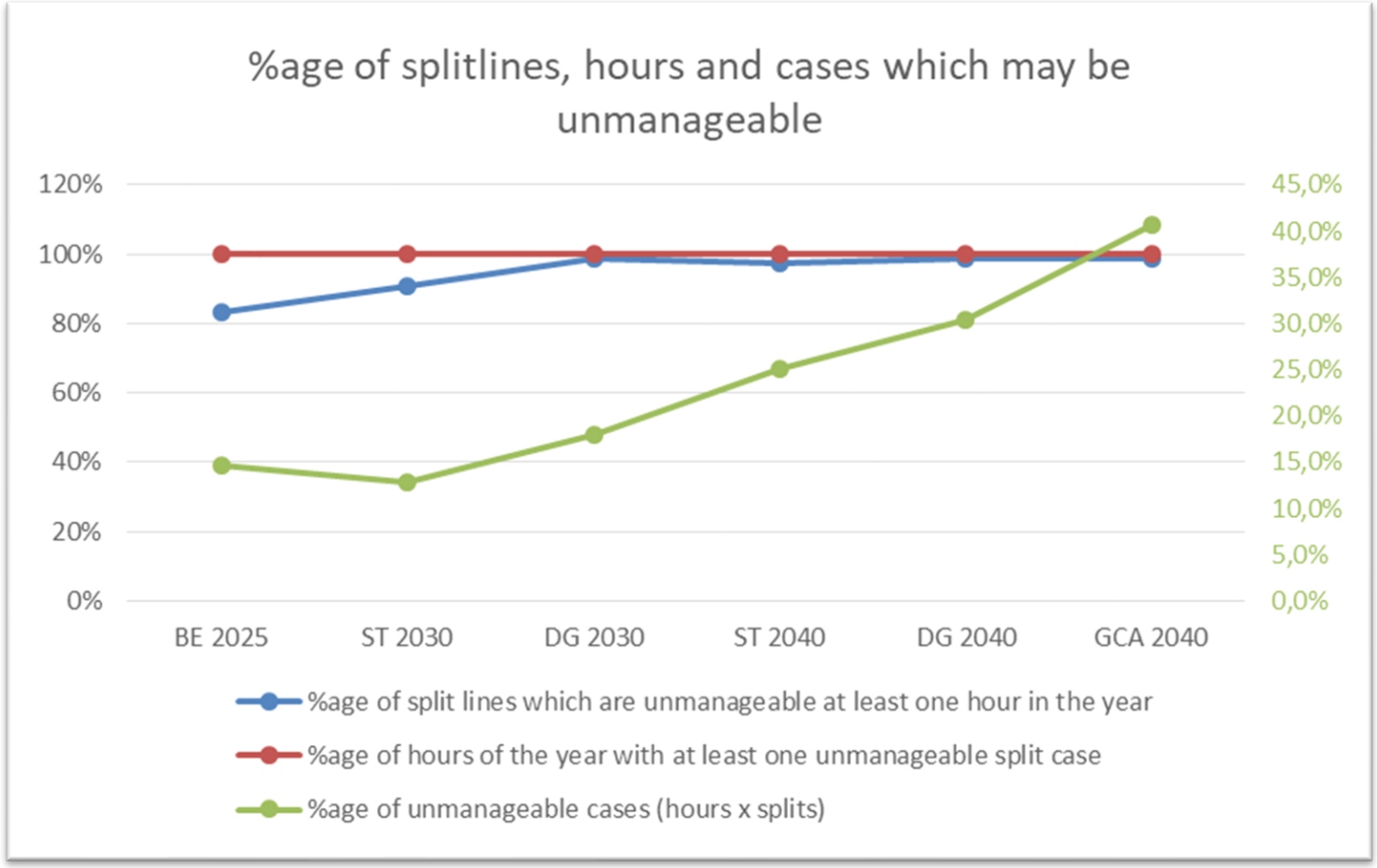






- The highest RoCoFs are related to smaller subsystems
- From 2025 to 2040 there is a RoCoF increase for all sizes of subsystems, an increasing size of the subsystems exposed to |RoCoF|> 1 Hz/s and more cases exceeding |RoCoF|> 1
- **In 2040, 3 times more cases (case= one hour and one split) create RoCoFs higer than 1Hz/s**

Subsystem RoCoF wrt load ratio : potentially unmanageable cases

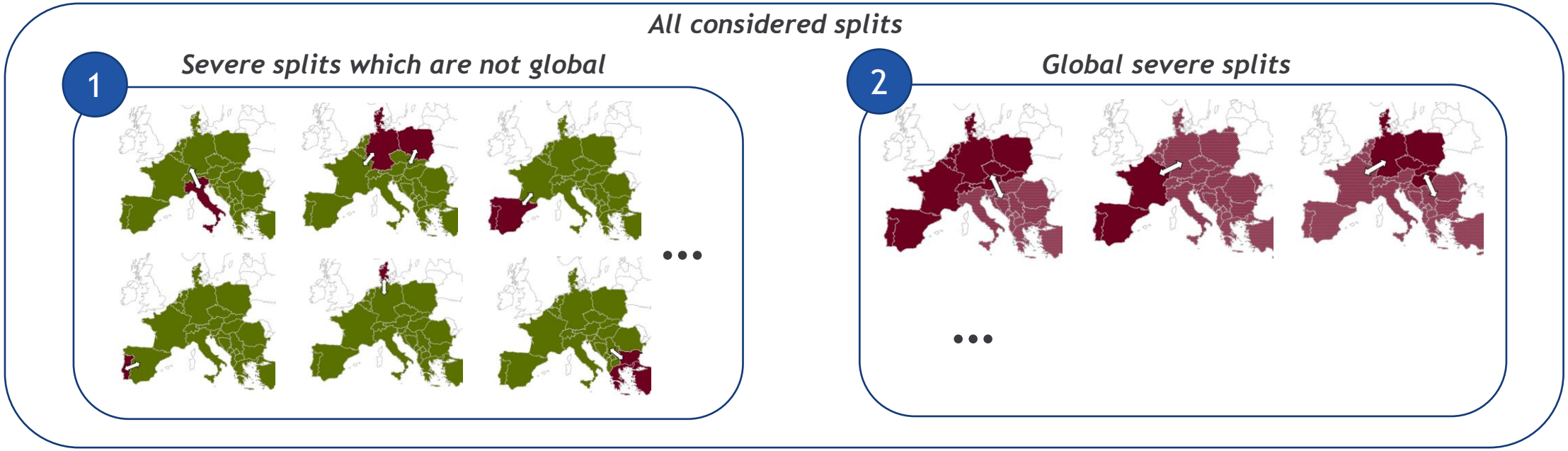


The red line at 100% shows that at any hour of the year at least one split can be unmanageable (RoCoF higher than 1Hz/s)

The blue line between 80% and 100% indicates that almost all splits can be unmanageable at least one hour of the year

The green line means that on all of the 3 800 000 cases (hours x splitlines) from 13% to 41% can be unmanageable depending on the scenario and time horizon

Digging further: The *global severe splits* approach allows a focus on the split cases that affect everyone in the Continental Europe system



System splits that could lead to a RoCoF > 1 HZ/s in one subsystem (red)

- A partial blackout could occur in the CE system

Global severe splits could lead to a RoCoF > 1 HZ/s in both subsystems

- A blackout could occur in the entire CE system

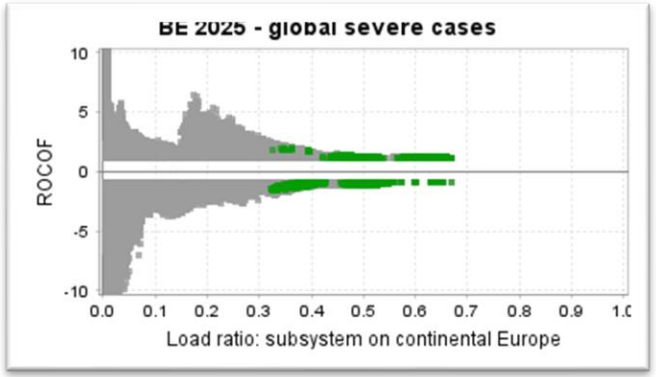
- **Global severe splits represent only a subset of the total challenge, but provide visibility to the global scale of the issue**
- **Severe splits which are not global are also relevant**

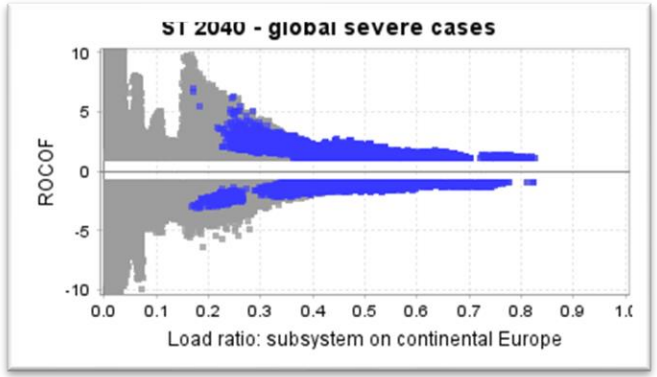
RoCoF WRT load ratio : global severe splits

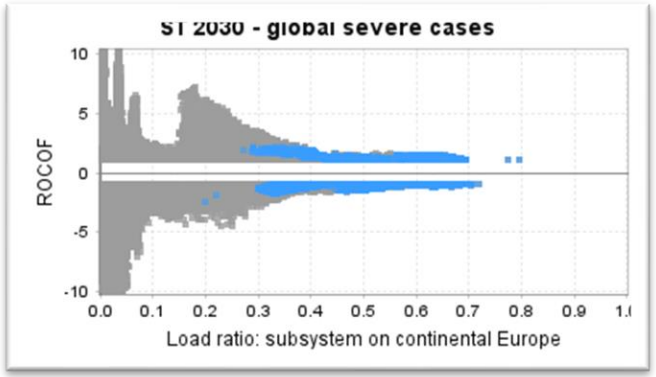
Global severe splits: both island with a |RoCoF| higher that 1 Hz/s. Potential risk for CE blackout

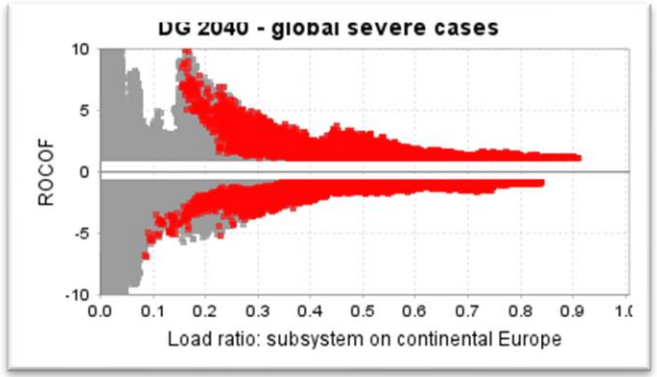
- The **number of cases is much lower than unmanageable cases** but the **consequences are much more serious** (Continental Europe blackout) and the numbers are still significant
- In GCA2040, all the splits isolating more than a third of the CE are globally severe, meaning they would affect the whole CE

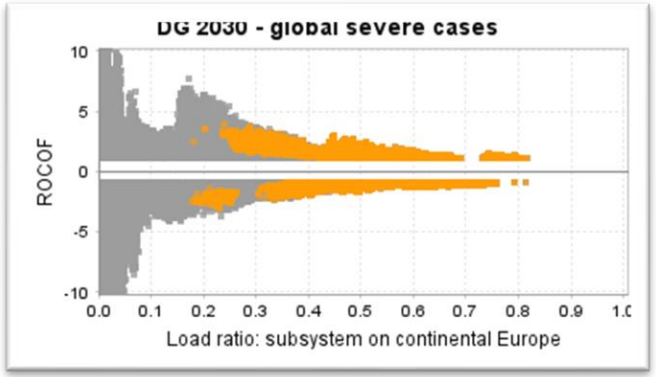
Each global severe case corresponds to two dots: each of the two dots relates to one of the two split subsystems, showing its load ratio and RoCoF for one specific hour and one system split. Obviously, the two load ratios are complementary to 1 and the RoCoF are of opposite sign.

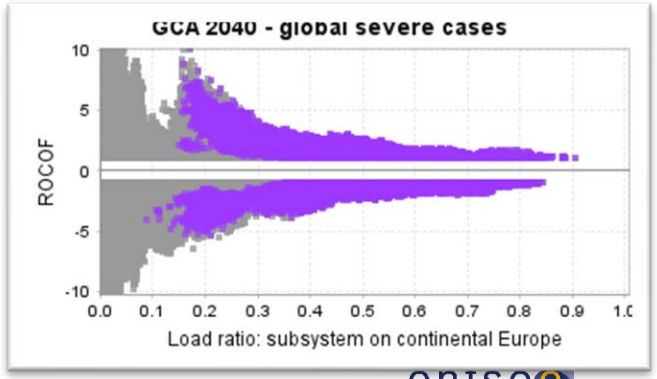




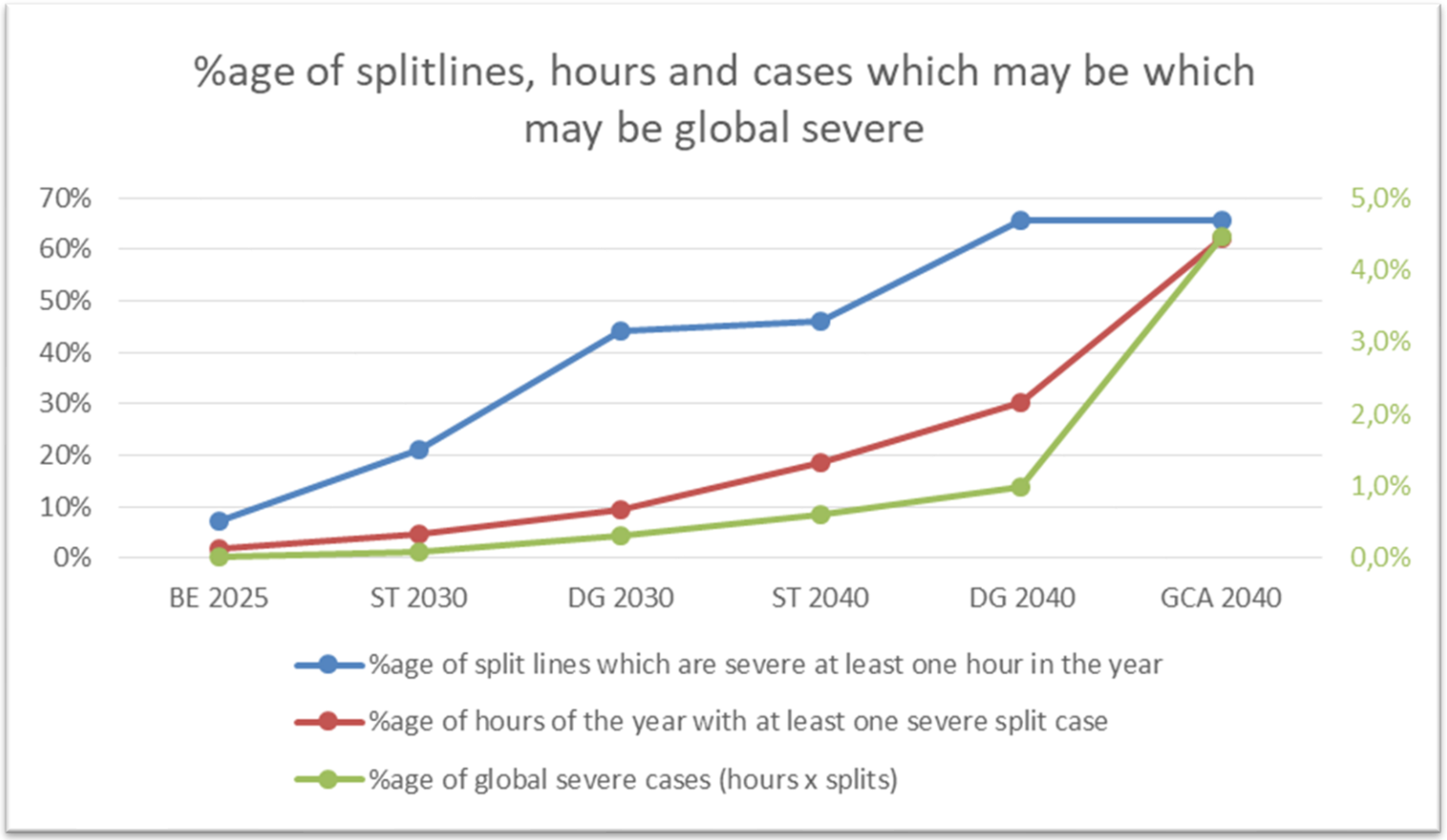








RoCoF WRT load ratio : global severe splits



The red line shows that from 2% to 62% of the hours of the year at least one split can be global severe depending on the scenario and time horizon

The blue line indicates that from 7% to 66% of splitlines can be global severe at least one hour of the year depending on the scenario and time horizon

The green line means that on all of the 3 800 000 cases (hours x splitlines) from 0% to 4% can be global severe depending on the scenario and time horizon

How to address the challenge?

OPTIMAL SET OF SOLUTIONS AND APPROACHES TO BE ASSESSED IN FUTURE STUDIES

Not a single solution: several measures should be considered and weighed

Provide additional inertia by renewable energies and battery storages (the precondition are grid forming and energy storage)

Provide additional inertia through STATCOM (the precondition are grid forming and energy storage), synchronous condenser or market-based procurement

Measures to **avoid a system split** (e.g. grid reinforcement, increased use of DC technology)

Countermeasures to **mitigate the effects of the system splits** (e.g. Special Protection Schemes, …).

As a last resort: **Market restrictions** as reduction of the power exchange or must run

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Main conclusions

The assessment demonstrates that the **challenge posed by the decreasing level of inertia exists and, in the case of global severe splits, might involve the entire CE synchronous area.**

To cope with this challenge, different solutions should be assessed for the future system. **The installation of additional inertia is only one of the solutions.**

Making the system stronger against the impact of these events would mean implementing, even in the current planning phase of European grid, additional measures to **increase the robustness of the system** (infrastructure development and protection systems).

The decision on what is the 'acceptable' risk is not for the TSOs only, but involves all the stakeholders, industrial and institutional.

Possible follow up of the study and synergies with Planning processes

The work developed in the project "Long term frequency stability scenarios" is just a first step

What's next?

- Assessment of the risks of a system split (updating the input data with the one from more recent TYNDPs)
- Evaluation of the most appropriate set of solutions to cope with the consequences of a system split

How does ENTSO-E plan to use this study?

The IoSN already include in its package an assessment of system dynamic and operational challenges. ENTSO-E is discussing how to integrate the work performed in the TYNDP with the methodologies and results developed in the framework of Project Inertia.

The results of this study or updated versions of it can be used and referenced in other any relevant work

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