Project Inertia phase II – Joint GC/SO ESC

Recovering power system resilience for a future ready decarbonized system

Preliminary results from ongoing work

João Moreira – 27 June 2024

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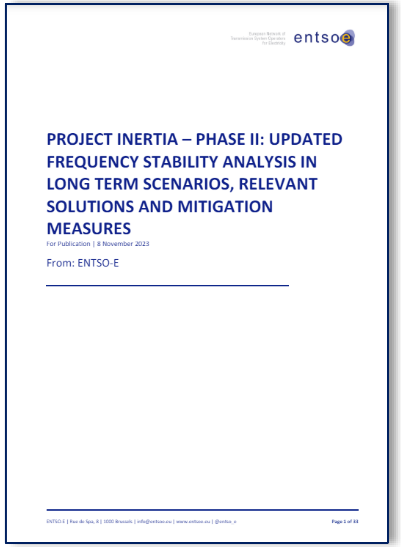
Reliable Sustainable Connected

Introduction

❑ Cross-committee Project Inertia Phase II - Milestones


PROJECT INERTIA – PHASE II: UPDATED FREQUENCY STABILITY ANALYSIS IN LONG TERM SCENARIOS, RELEVANT SOLUTIONS AND MITIGATION MEASURES

From: ENTSO-E

- **Analysis of the impact of system splits** on the future "low inertia" configuration of the **Continental Europe Synchronous Area** including **mitigation measures and proposed solutions**
- **Initial report – Published Report**
  - **updated** the results and solution measures following the analysis of the **impact of system splits** on the future "low inertia" configuration of the **Continental Europe Synchronous Area**
  - **concluded** on the need to **recover the resilience against system splits** based on **foundational measures**, i.e. **keep inertia above a certain limit**
- **Recover system resilience for a future ready decarbonized power system**
  - **Approach towards a recovered level of resilience, the way to allocate the inertia needs**
  - **Solution proposals, roadmap and implementation framework**
  - **Put in place the external internal and external debate in order to trigger decision-making on the approach to a more resilient system**
- **Ongoing work: consolidated results planned to be presented and debated SEP/OCT 2024**

Introduction – Recover lost power system resilience

- **Project Inertia proposes to recover the loss of system resilience due to decreasing levels of inertia and presents decision-making information**

- **How?**

  - **Focusing on the system performance avoiding Global Severe Splits**, rather than defining Global Severe Splits (GSS) as a design incident to be covered. Global Severe Splits are split cases where there is risk of a blackout of the entire CE

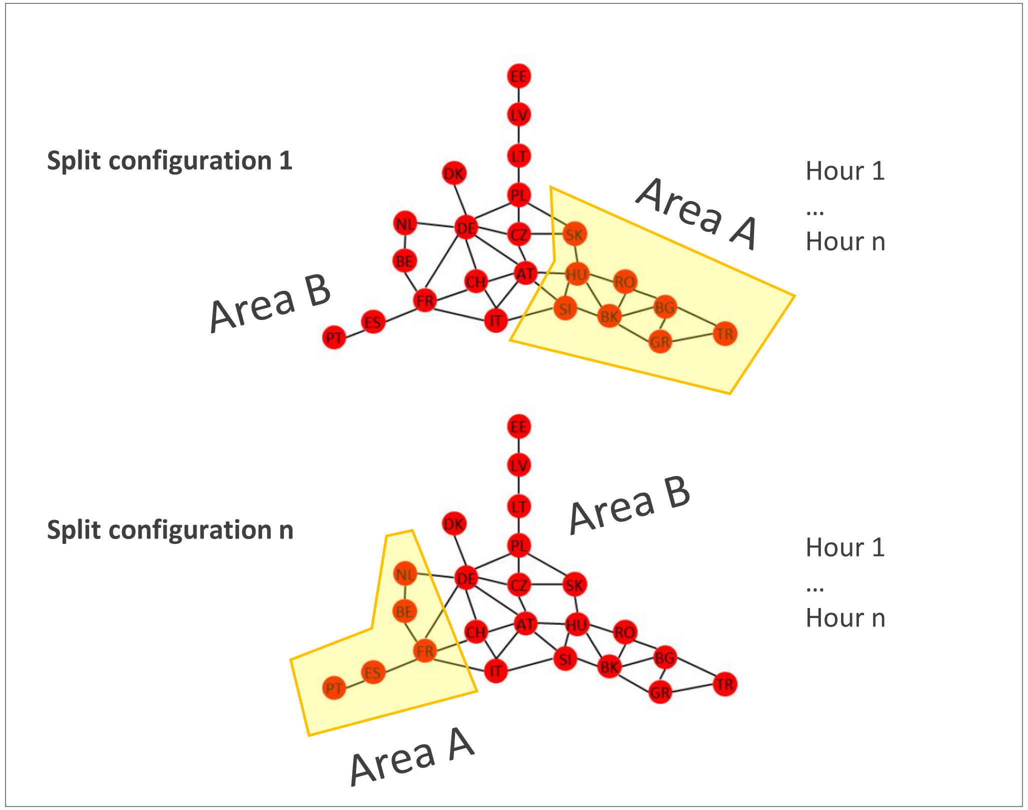
  - Efficiency of the solution proposals is presented in a compared way, **highlighting the additional kinetic energy needs and the resulting increase in system resilience** in terms of avoided Global Severe Splits

- **What does it mean?**

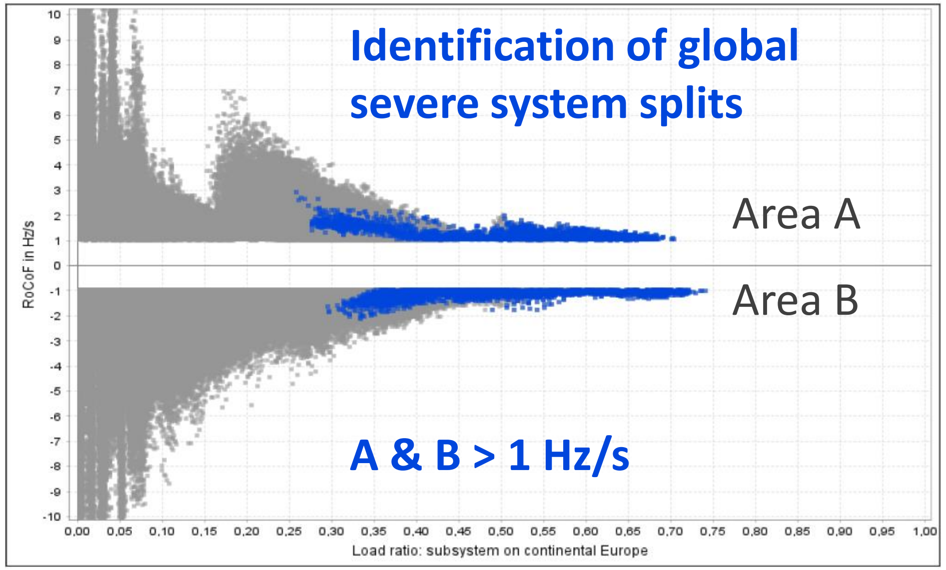
  - Avoiding a significant number of Global Severe Splits situations is not a complete solution or definitive metric per se to avoid total or partial blackouts, but, as a minimum, a very important resilience reference to safeguard

  - The achieved resilience and the means to ensure it are not only a technical decision, since they need agreement also from stakeholders and decision makers

Methodology: General overview



1. Calculation of RoCoF per area depending on system split configuration and hour



Total needed kinetic energy per area required to keep the RoCoF below 1 Hz/s:

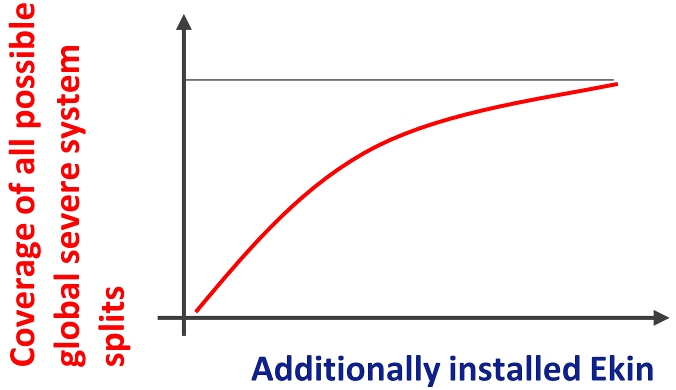
$$\frac{df}{dt} = \frac{f_0}{2}\frac{\Delta P}{E_k} \qquad MinEnergy(hour, split) = \frac{f_0}{2}|\Delta P|$$

2. Allocation of additionally needed kinetic energy per node (country) necessary

Methodology: Main aspects of kinetic energy allocation

Key questions and aspects

- What is the **“design hypothesis” of inertia / kinetic energy needed** in the synchronous area?
- Which **coverage rate of possible globally severe system splits** do we want to ensure? How many non-conform (lack of kinetic energy) cases can we accept?

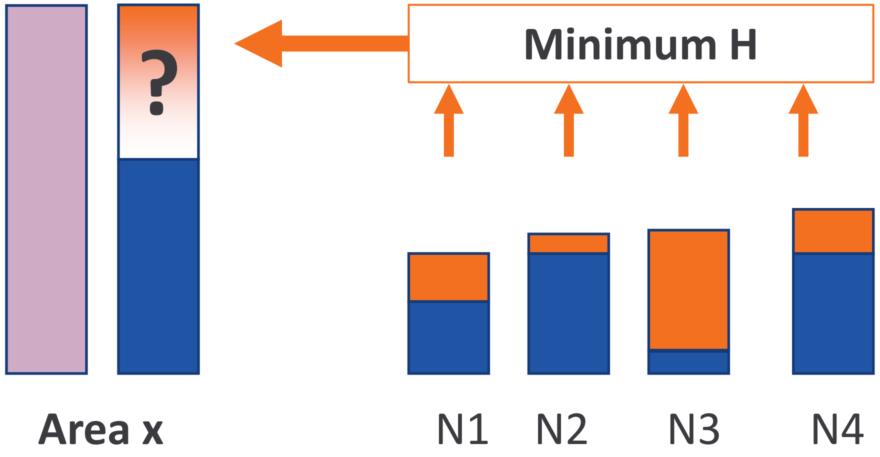


- **Fair and uniform distribution of kinetic energy** among synchronous area nodes must be ensured
- **Allocation methods** to cover globally severe system splits **should not lead to an over-dimensioned system** (i.e., significantly more Ekin than we have today in the synchronous area)
- **Main principles must be transparent and easily communicable** to TSOs and national stakeholders / decision makers

Methodology: Allocation methods (1)

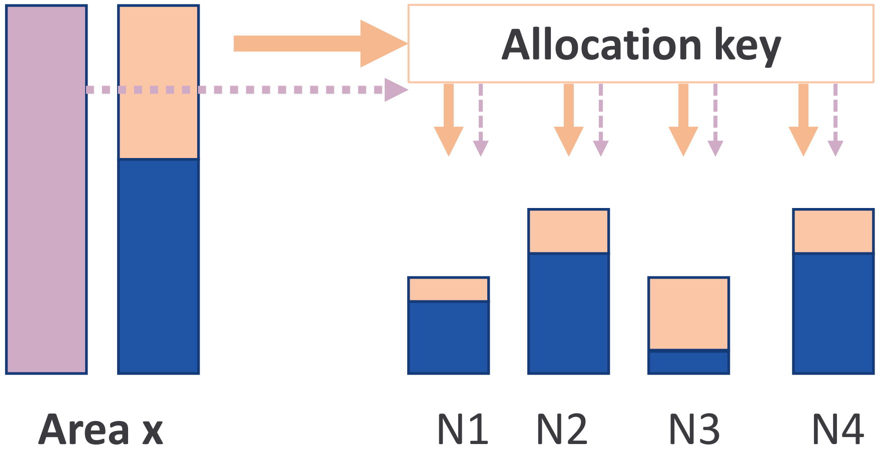
Total needed Ekin < 1 Hz/s
Available Ekin
Additionally needed Ekin

BOTTOM-UP



- Calculation is performed ***independent*** from total needed Ekin to ensure RoCoF < 1 Hz/s

TOP-DOWN



- Calculation is performed ***depending*** on total needed Ekin to ensure RoCoF < 1 Hz/s

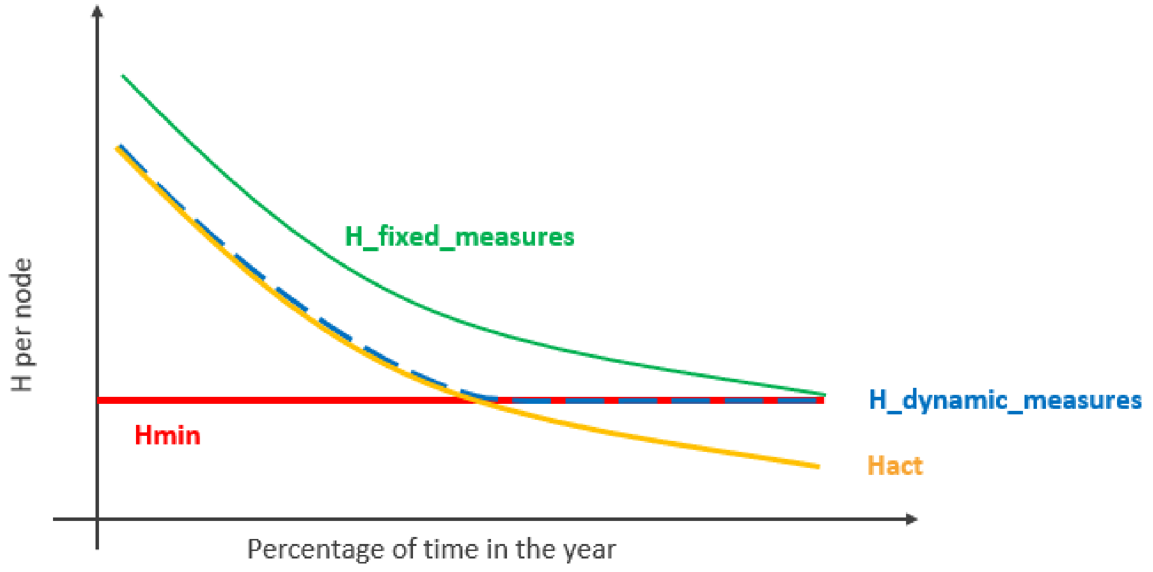
Methodology: Allocation methods (2)

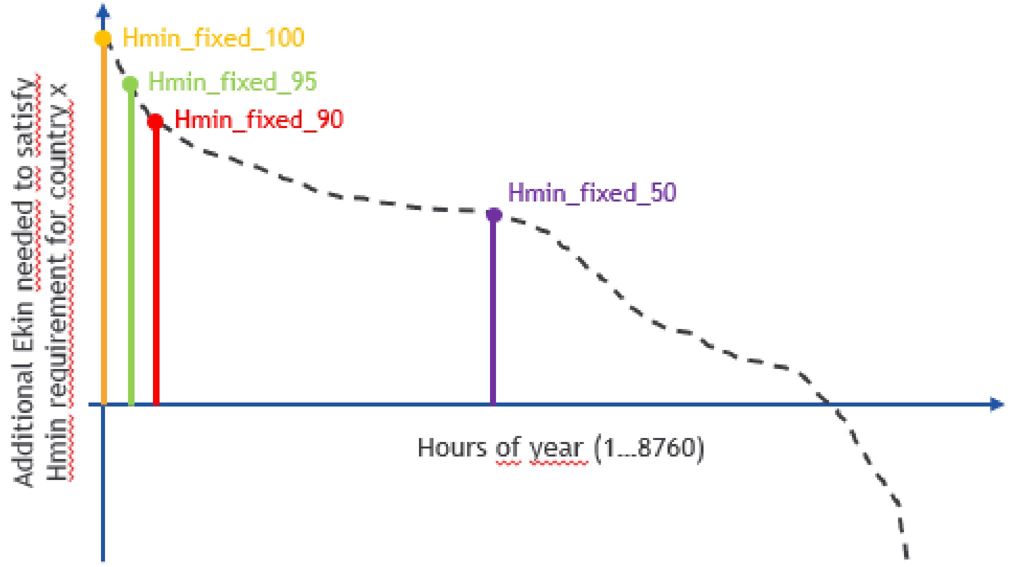
- **TOP-DOWN METHODS**
  - The set of identified global severe split cases can have a significant impact on the additional kinetic energy allocations per node
  - Furthermore, the allocated amounts per node can highly influence each other in the case of the top-down approach
  - The mutual influence also depends heavily on the respective scenarios and underlying market study / generation mix conditions → However, these can change and look different in future updated TYNDP editions

- **BOTTOM-UP METHOD / Hmin**
  - Additional kinetic energy needed per node depends on the current inertia constant in each node
  - Allocations are decoupled from scenarios and set of relevant system splits
  - Main principles of Hmin are transparent and easily communicable. Compliance of each node can be easily monitored in operational planning
  - Effectiveness of Hmin in terms of solved globally severe system splits is basically equal with top-down methods

Investigated measures (1)

- 1: meet requirements as a baseline (through installation of fixed assets, e.g. Synchronous Condenser)
  - Hmin_fixed_100
  - Hmin_fixed_95
  - Hmin_fixed_90
  - Hmin_fixed_50
- 2: meet requirements on hourly basis (depending on hour H, add the exact additional Ekin)
  - Hmin_variable

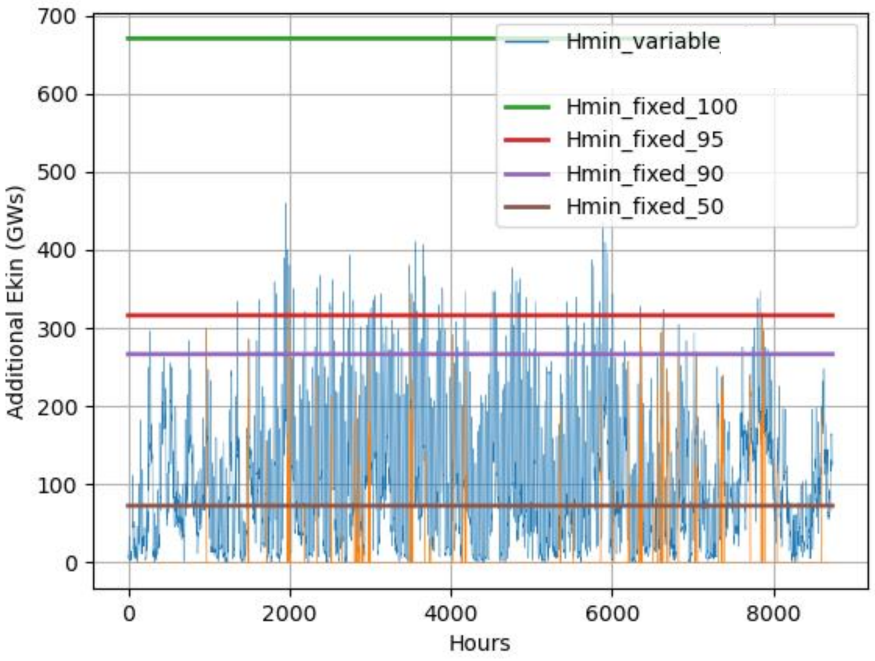


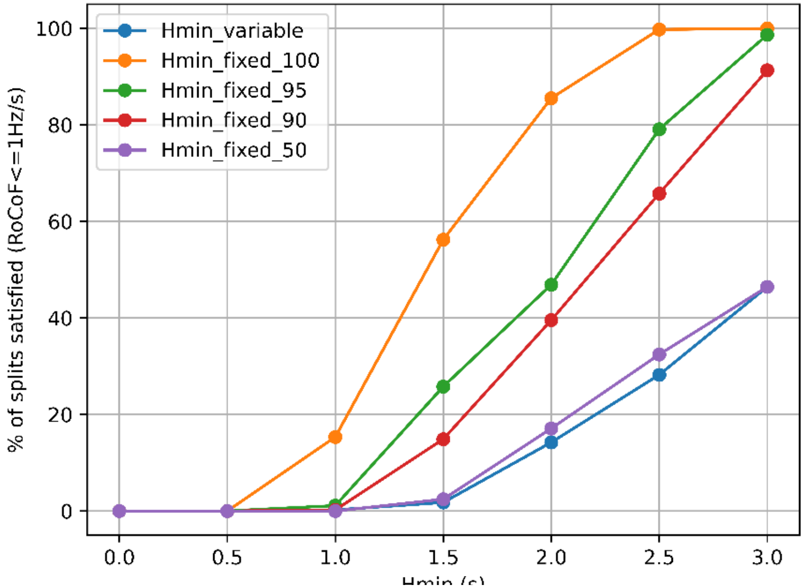


Investigated measures (2)

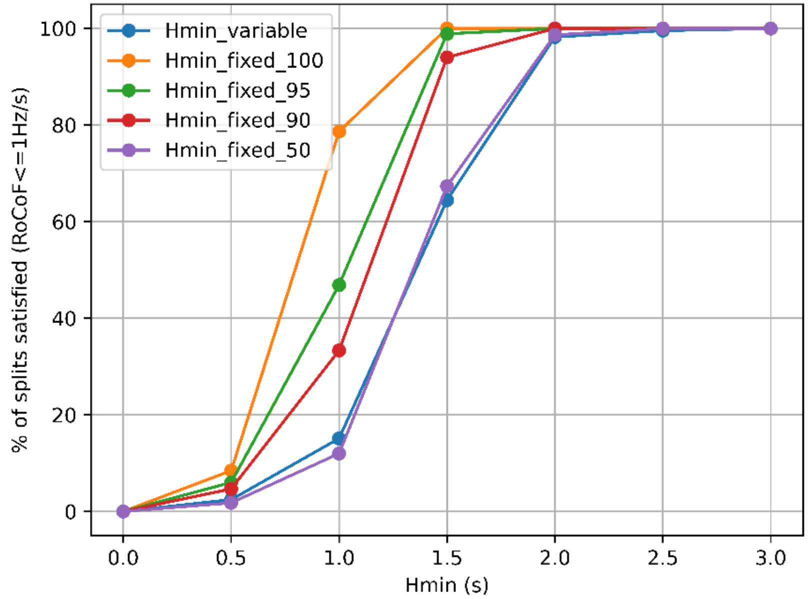
Preliminary results

NT2030





A & B < 1 Hz/s



A | B < 1 Hz/s

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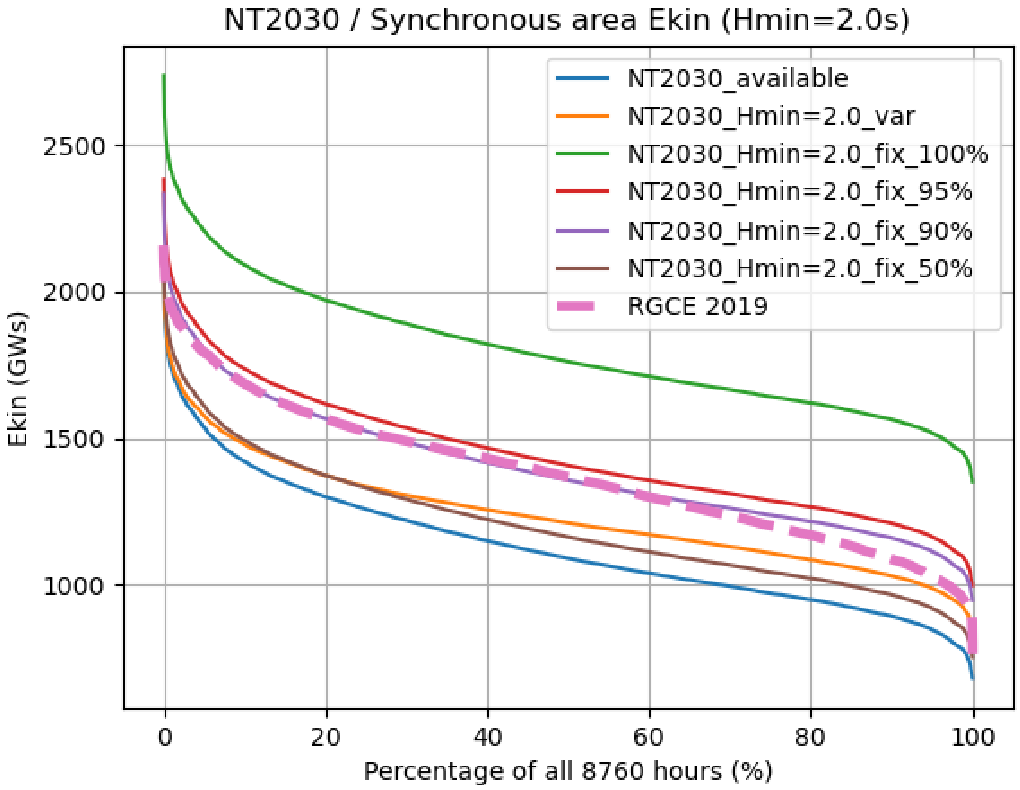
Comparison of Hmin approach with existing kinetic energy levels

Preliminary results

- Exemplary fixed approach Hmin = 2 s and using 95, 90 or 50 % of time leads to quite similar total (CE SA) kinetic energy duration curves compared to the existing levels in the year 2019.
- Pursuing no over-dimensioning of the system (i.e., not significantly more kinetic energy than we have today in the synchronous area).
- Using a 100% percentile as fixed value for each node could exceed the existing kinetic energy levels on a synchronous area level



Complementary remarks – Approach to increase available kinetic energy

❑ Step-by-step

- Project Inertia looks to identify long-term targets, intermediate targets and short-term targets to recover the system resilience, to **create the conditions to cover increasingly larger percentages of Global Severe Splits and other severe splits which are not global**
- Considering different percentages of time (on a year basis) allow for a progressive step-by-step reassessment of kinetic energy needs
- Subject to regular reassessment

❑ No regret

- The **system resilience and the impact of the solution proposals is assessed in TYNDP 2022 NT 2030 scenario**. The results show lower resilience levels in the alternative, more ambitious DE and GA, TYNDP scenarios. Future 2024 scenarios are expected to be even more challenging
- Project Inertia goal is to enable RES. Not to limit in any way. **Methodology does not propose, in any circumstance, decisions on RES limitation**. Assessed solutions will not impact RES penetration or market.

Complementary remarks – All foundational solution measures are necessary

Long-term kinetic energy targets cannot be met without the contribute from all solutions

- Synchronous Condensers, STATCOMs with Grid Forming Capability and storage, Power Park Modules with Grid Forming Capability and Storage will be necessary
- Countries should decide the best mix of solutions to meet the targets
- Grid Forming Technology with storage will be an essential part of solution, as such is necessary as soon as possible

Inertia markets

- Visibility of needs and long-term incentives can encourage investment in relevant user capabilities
- Due to the nature of the system split challenge, inertia markets will be essentially implemented in local control areas creating risks of market liquidity and prices if not properly designed

Complementary remarks – Roadmap for implementation

❑ Regular reassessment

- Using relevant assessment references for Continental Europe Synchronous Area – Presently, do not exceed the 1Hz/s RoCoF operational threshold
- Long term needs and global resilience level reassessed every two years in the regular TYNDP IoSN
- Ex-post monitoring of minimum equivalent H on a comparable basis between all countries

Thank you!