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ABS FÜRS STROM-NETZ

Market potentials for new flexibility products for the European power system

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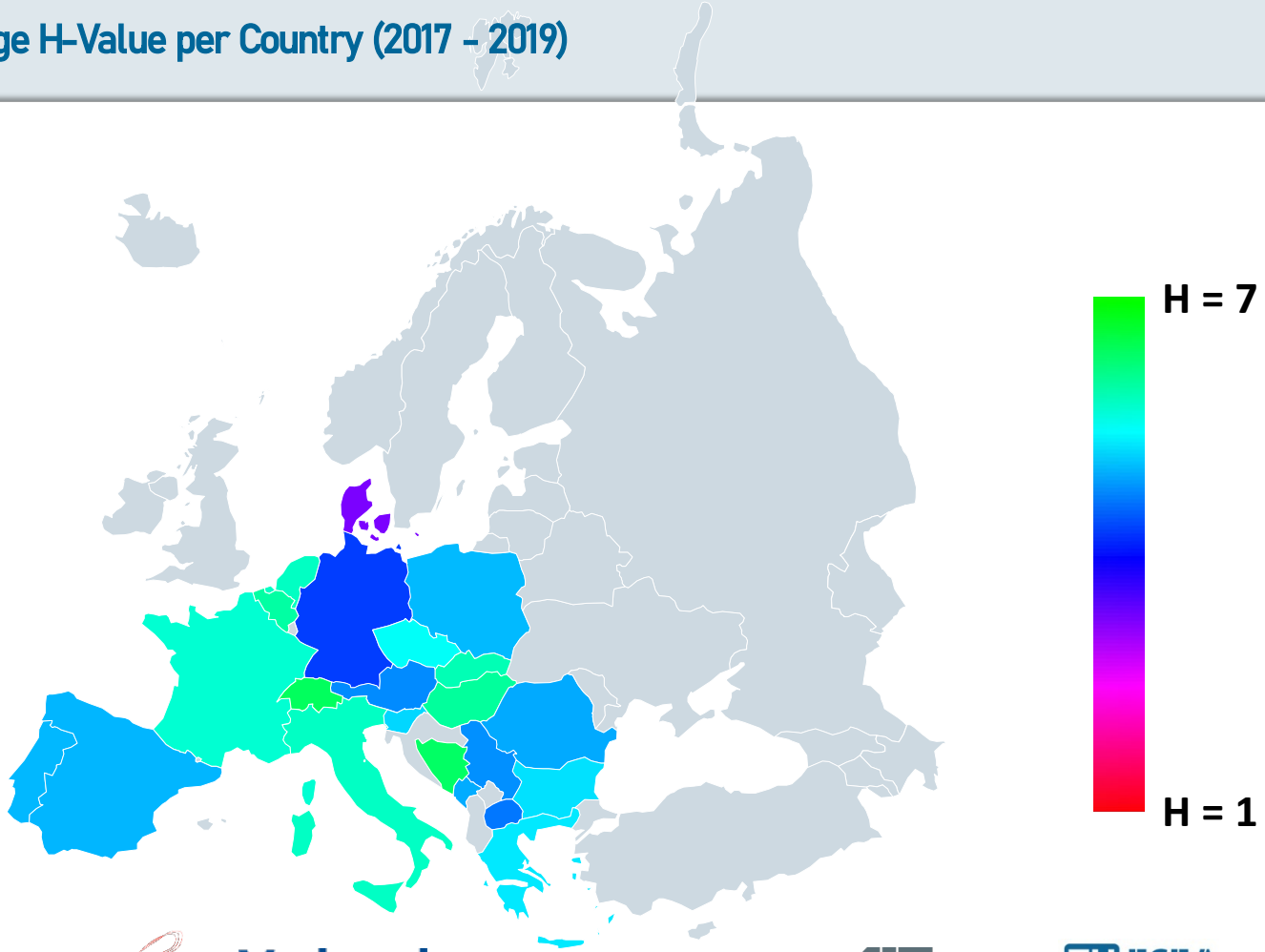
Agenda

- Motivation
- Evaluation of present and future inertia constant in the Central European power system
  - EDisOn+ market model
  - Analysis results
- Description of new fast products of control reserves
- Market potential analysis
- Conclusion

Motivation

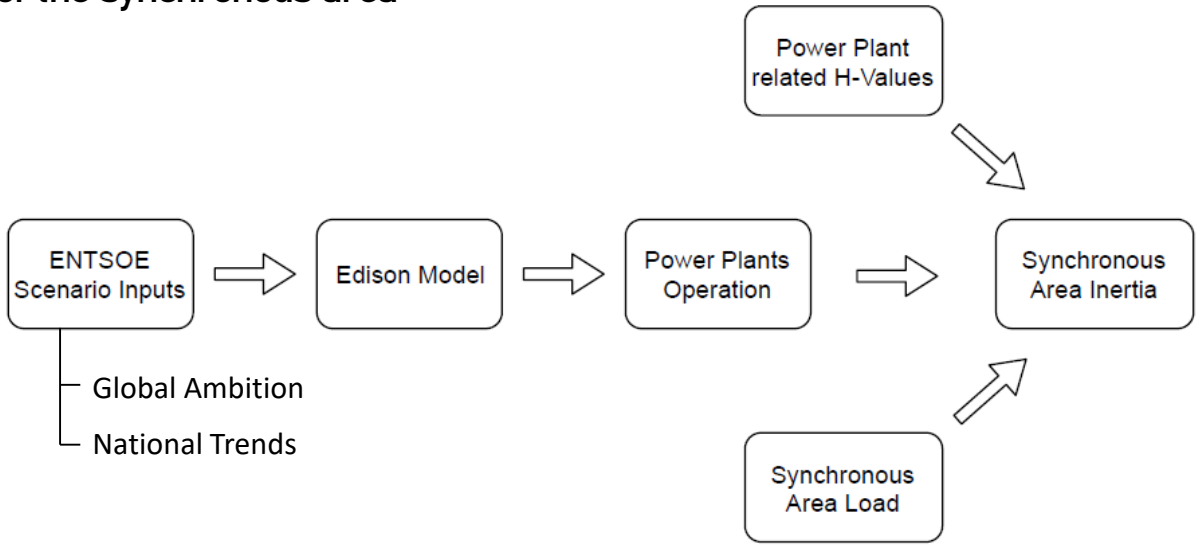
- Increasing share of inverter-based generation plants and associated reduction in the number of conventional plants with synchronous generators and a related decrease in the network time constant
- Power grid stabilization as a future challenge whether the current primary control is still sufficient
- Analysis of future inertia time constants
- Design of new fast products of control reserves
- Elaboration of market potentials of new control reserve products

Average H-Value per Country (2017 – 2019)



Evaluation of present and future inertia constant in the Central European power system

- Operation of the power plants based on different scenario inputs and historical data
- Power plant related inertia values (H-values) and the load are then considered to calculate the inertia of the synchronous area



EDisOn+ Market Model

= Electricity Dispatch Optimization: Linear Programming (LP) developed in MATLAB®

- objective function:

  minimising (wholesale generation costs) + (procurement costs of aFRR & mFRR)

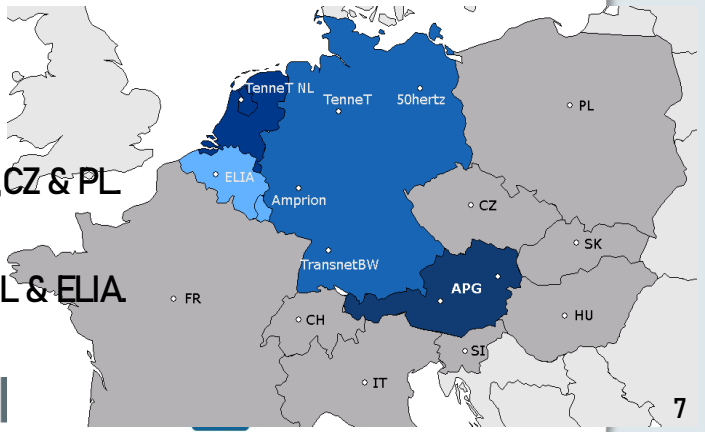
- constraints:
  - electricity generation & DSM: demand = supply
  - heat: demand = supply (power-to-heat & CHPs)
  - balancing procurement: required = supply
  - capacity restrictions of power plants
  - ramping limits and start costs of thermal power plants
  - reservoir level equations for hydro storages and other storages
  - spillage of RES-E (solar, wind, RoR, natural inflow) and Not Supplied Energy
  - power flows, injections and exchanges via NTC or DC power flow approach

FRR = Frequency Restoration Reserve (automatic & manual), DSM = demand side management, CHP = combined heat and power, RoR = run-of-river, NTC = net transfer capacity

EDisOn+ Market Model

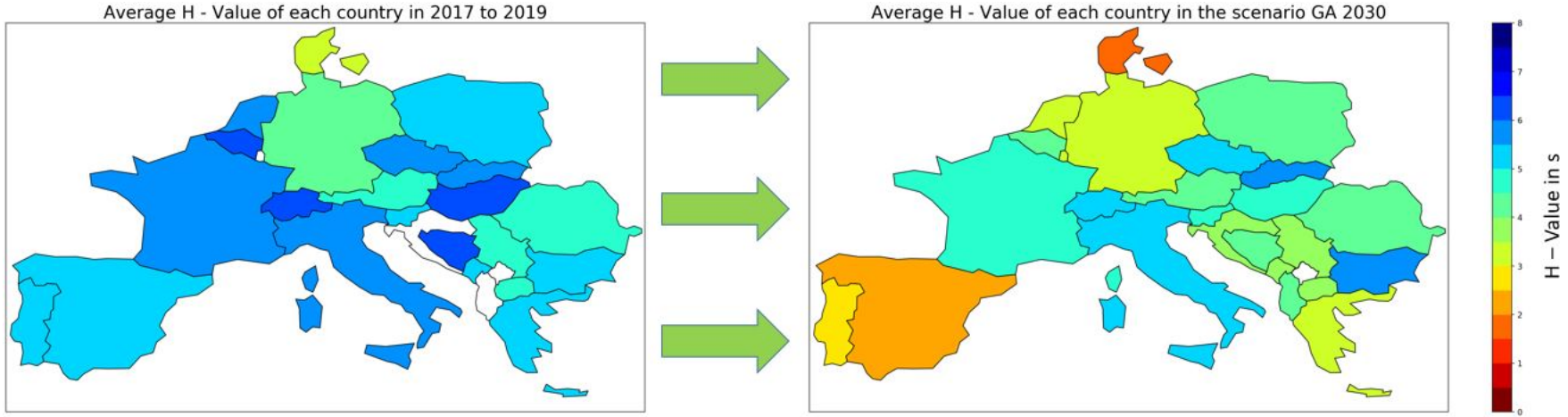
- functionalities:
  - deterministic and assumes a perfectly competitive market with perfect foresight
  - hourly resolution of a whole year at country or control area level for Central Europe
  - control areas can be split into balancing groups
  - rolling horizon optimisation (monthly, biweekly, weekly or daily)
  - different product designs for aFRR (weekly, daily P, OP, WE → 4h) & mFRR
  - thermal power plants, (pumped-) hydro storages and other storages (like batteries) can procure balancing capacity (incl. ramping)
  - implicit allocation of transmission capacity for balancing

- geographical scope:
  - Wholesale (NTC or DC power flow): AT,DE,NL,BE,FR,CH,IT,SI,HU,SK,CZ & PL
  - Wholesale (NTC): RG CE Region
  - balancing: APG, TransnetBW, Amprion, TenneT, 50Hertz, TenneT NL & ELIA

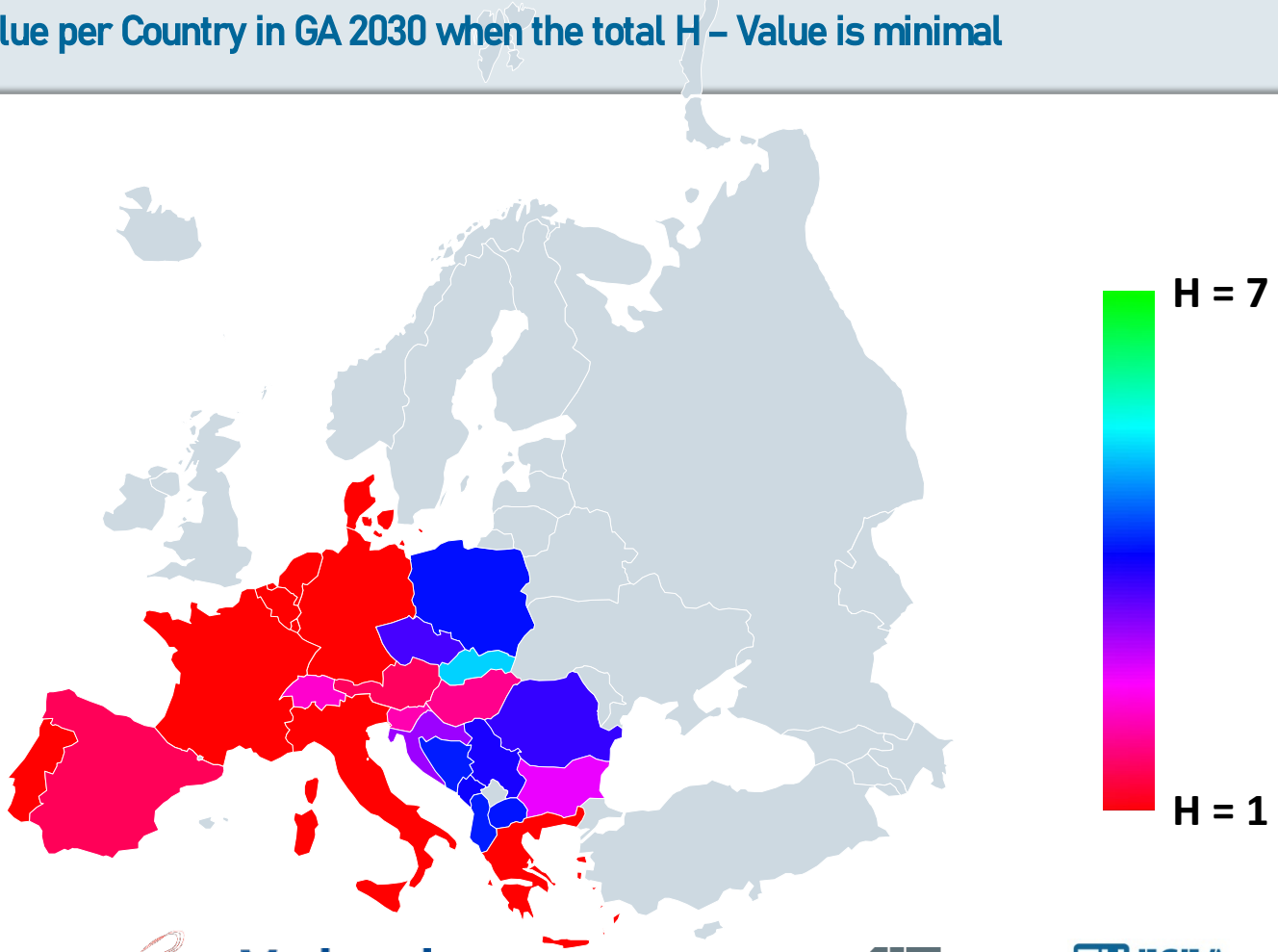


FRR = Frequency Restoration Reserve (manual and automatic)
P = Peak, OP = Off-Peak, WE = Weekend, 4h = 4-hour-products

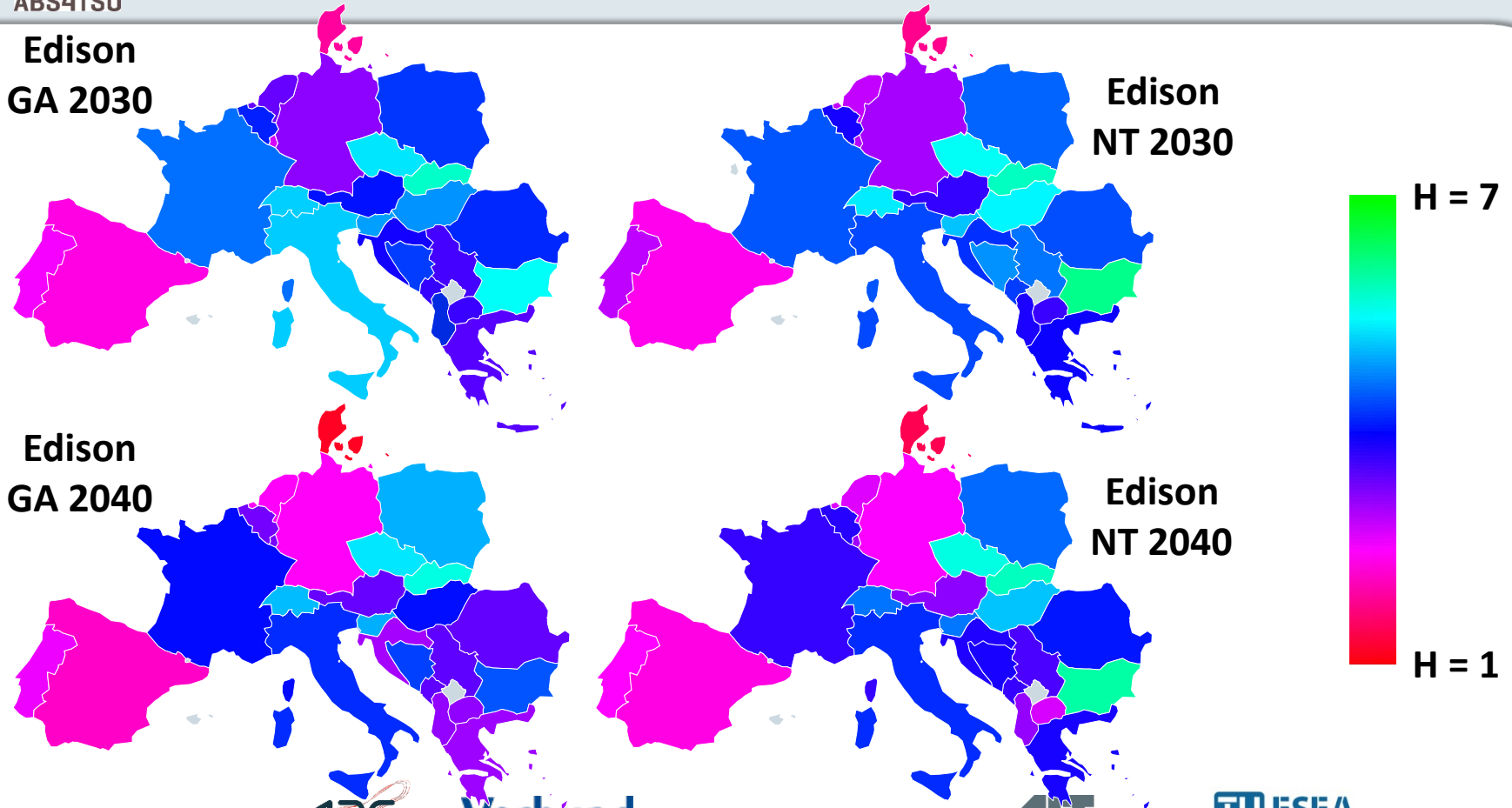
Average H-Value per Country (2017-2019 vs. scenarios)



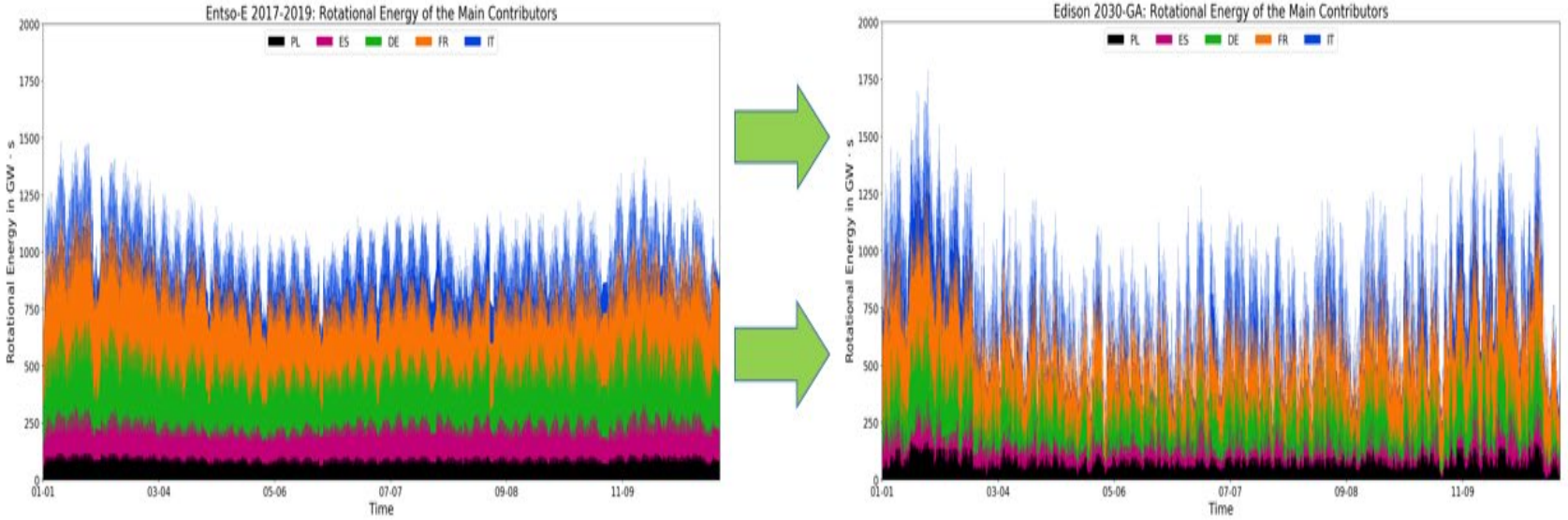
H – Value per Country in GA 2030 when the total H – Value is minimal



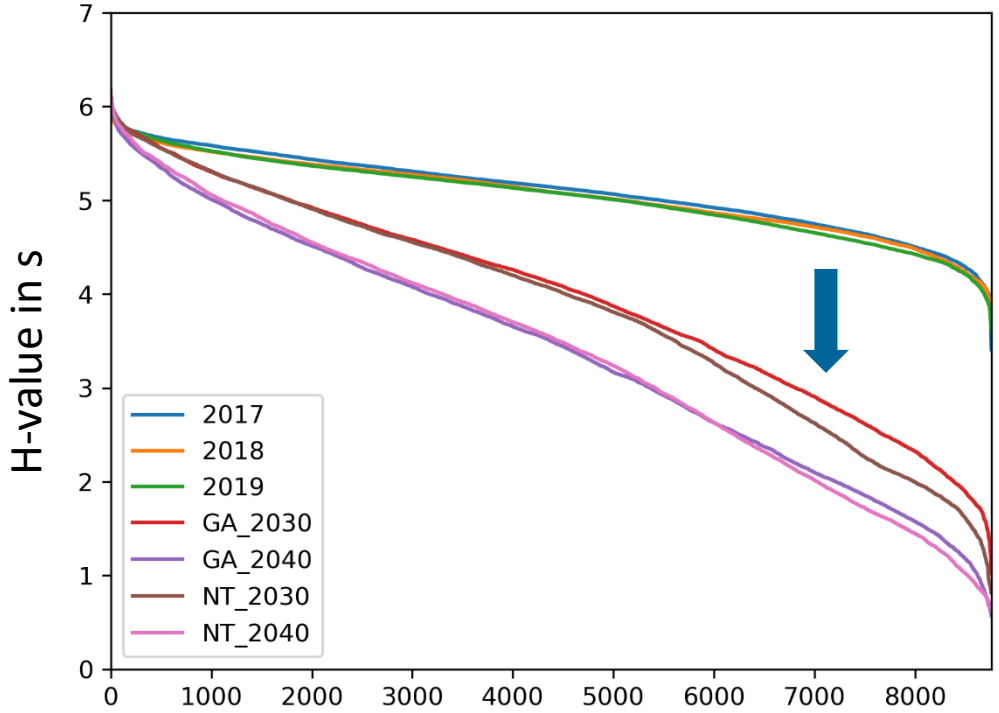
Average H-Value per Country (2030 vs 2040)



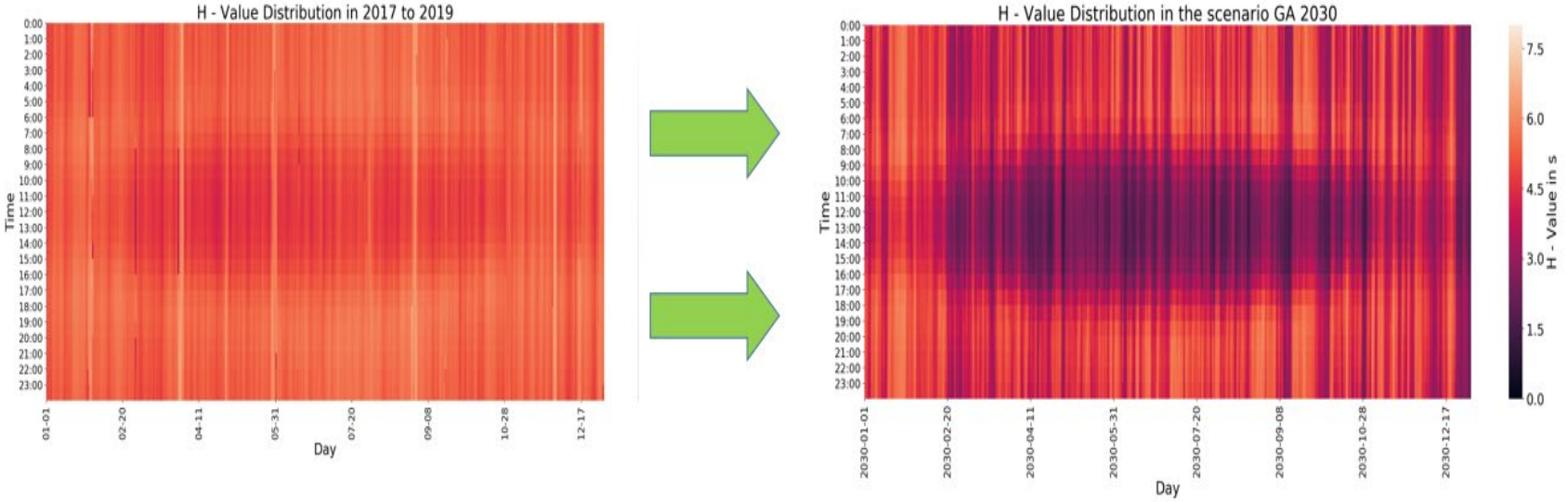
Rotational energy of the main contributors (2017–2019 vs. scenarios)



Annual Duration Curve of the H-value (2017-2019 vs. scenarios)



H – Value Distribution (2017–2019 vs. GA 2030 scenario)



Description of new fast products of control reserves

Working title	Short	Control mechanism
Enhanced Frequency Response	EFR	Δf-proportional
Frequency Containment Reserve PLUS	FCR+	Δf-proportional
Fast Active Power Injection	FAPI	f-trigger
Synthetic Inertia	SI	Δf/Δt-proportional

Description of new fast products of control reserves

- EFR / FCR+
  - Basic idea: Complementary reserve acting much faster than conventional frequency containment reserve (FCR)
- Options:
  - EFR as separate reserve, that acts outside of the frequency band of FCR (if frequency deviations are greater than 200 mHz)

  - FCR+ as part of FCR, that acts faster than conventional FCR

Description of new fast products of control reserves

- FAPI
  - Basic idea: Support of conventional frequency reserves by adapting active power output triggered by a predefined frequency threshold
- SI:
  - Basic idea: Emulation of real inertia; Improvement of system answer to frequency changes („Inertial Response“)

Market potential analysis

Product	Base scenario (…/B)	Alternative scenario (…/A)
EFR	Procurement with symmetric products analog to existing control reserve products	Procurement with asymmetric products analog to existing control reserve products
FCR+	Procurement within the framework of the existing FCR market	No alternative scenario defined
SI	Procurement with symmetric products analog to existing control reserve products	Inertia certificate trading
FAPI	Procurement with symmetric products analog to existing control reserve products	Procurement with asymmetric products analog to existing control reserve products

Market potential analysis

Market criteria	Detail criteria	Requirement	Premises
Market integration	Market area	Creation of uniform market areas	Consistent market goals, time schedules, product requirements, and replacement of capacity.
	Synergy	Synergies with existing markets	Use of existing processes and platforms
	Product range	Meaningful addition to the existing product range	DayAhead, IntraDay, Reserve markets, Congestion management, …
Market liquidity	Level-Playing-Field	Uniform requirements and market design	Product requirements for different technology options
	Incentives	Revenue potential must cover costs and offer opportunities compared to alternative markets	For existing and new power plants
	Technology-neutral	As many different technologies as possible suitable	Different technology options
Market entry	Product requirement	Prequalification and quality of service should be possible with different technologies	Different technology options
	Product complexity	Product definition as simple as possible and only necessary product differentiation	Product differentiation: product time steps, energy direction, bid size, bid timing, dynamic sizing,
	Process effort	Market participation possible with minimal process effort	Market entry economical even with low transaction volume
	Automation	Interface for fully automated trading	For service providers with high transaction volumes
Price evaluation	Costs	Price evaluation takes into account all cost components	Cost components: Investment costs, fixed costs, variable costs, opportunity costs, price risk.
	Revenues	Revenue potential assessable in the medium term	Market entry and investments are made on the basis of revenue potential estimates
Market rules	Trading procedure	Decision between auctions or continuous trading	Continuous trading only makes sense with strong intraday price movements and high transaction volume
	Trade products	Combination of commercial products only if absolutely necessary	Trading products: Certificates, options and energy
	Pricing	Decision between pay-as-bid or marginal pricing	Marginal pricing only makes sense in the case of a high supply bids

Market potential analysis

Market criteria	EFR/B	EFR/A	FCR+/B	SI/B	SI/A	FAPI/B	FAPI/A
Market integration	1,7	2,0	1,0	2,3	2,3	2,3	2,3
Market liquidity	1,7	1,3	1,3	2,3	1,3	2,3	1,7
Market entry	1,5	1,3	2,3	2,8	2,3	2,3	2,0
Price evaluation	2,5	2,0	2,0	2,0	2,0	1,5	2,0
Market rules	2,0	1,7	1,0	3,0	1,3	2,0	1,3
TOTAL	1,9	1,7	1,5	2,5	1,9	2,1	1,9

Highly applicably	1
Possible applicably	2
Less applicably	3
Not applicably	4

Conclusion

- FCR+ could be procured as a subset in the existing FCR tenders, opening up synergies regarding market integration and market rules.
- EFR could be particularly suitable for suppliers that have difficulties to participate in the currently existing primary control reserve markets. In the case of an asymmetric product design, even controllable loads could participate in such a market.
- Due to the complexity of the concept of SI, certificate trading appears to be more advantageous than a tender concept via a symmetrical product design.
- A combined evaluation of market aspects, operational aspects and the underlying concept (activation based on a static frequency trigger) shows that FAPI is the least favorable option for a market implementation

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