ERAA 2023 Stakeholder workshop: Methodological Insights and Improvements

Part II - 29 June 2023

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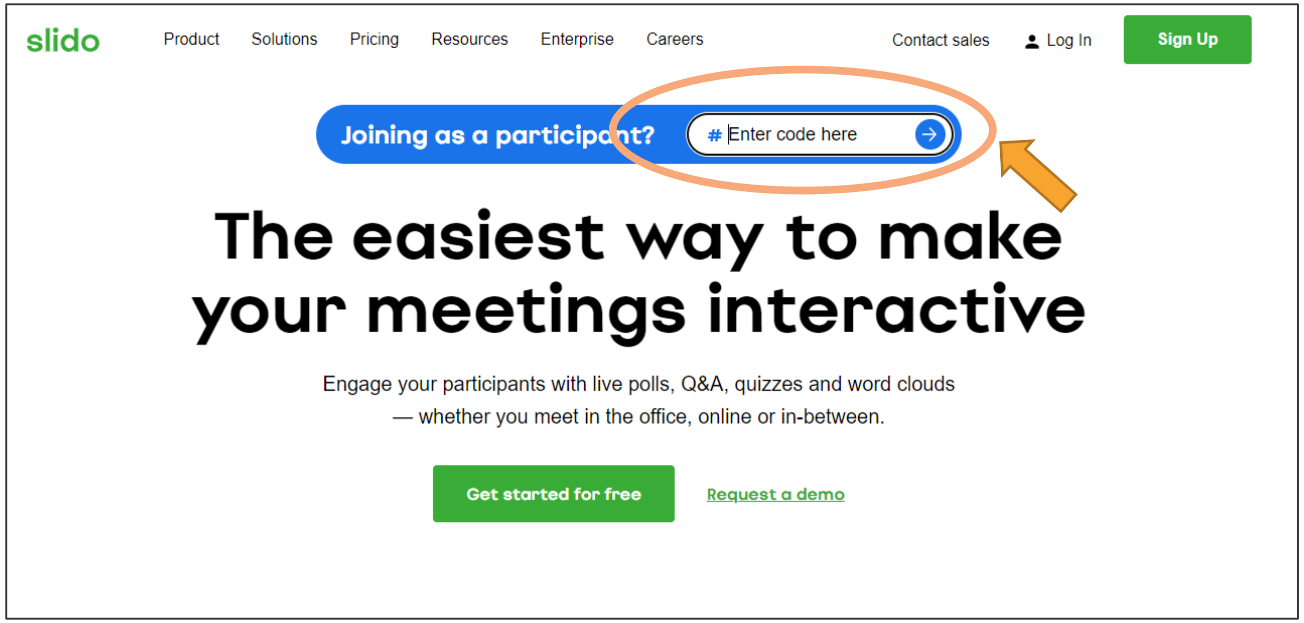
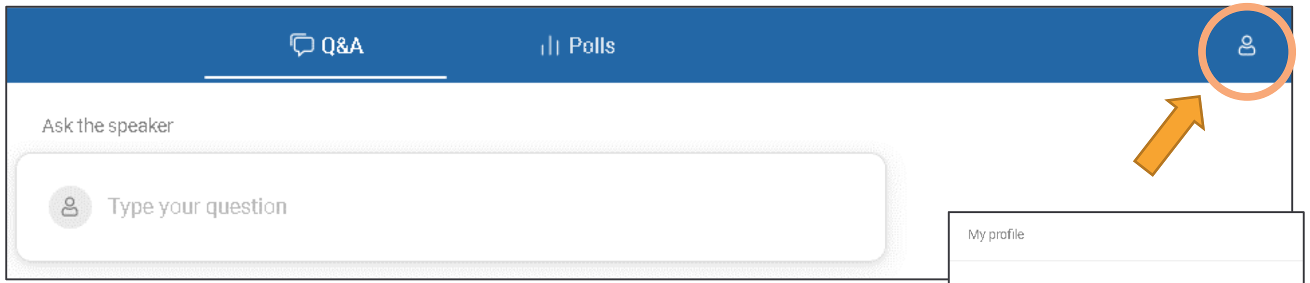
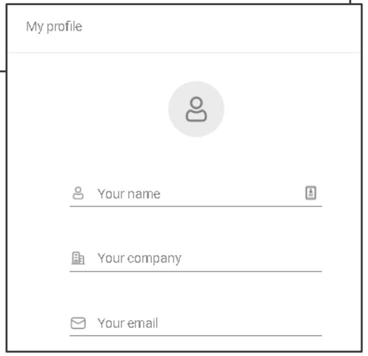
Housekeeping Rules

- The Webinar will be recorded
- Ask questions directly through sli.do
  - Log-in method in next slide
- Enter your name & company details
- Vote for the most relevant questions
- The moderator will select most relevant questions and ask the speakers to comment
- The teams "chat" and "hand raising" features will not be used.

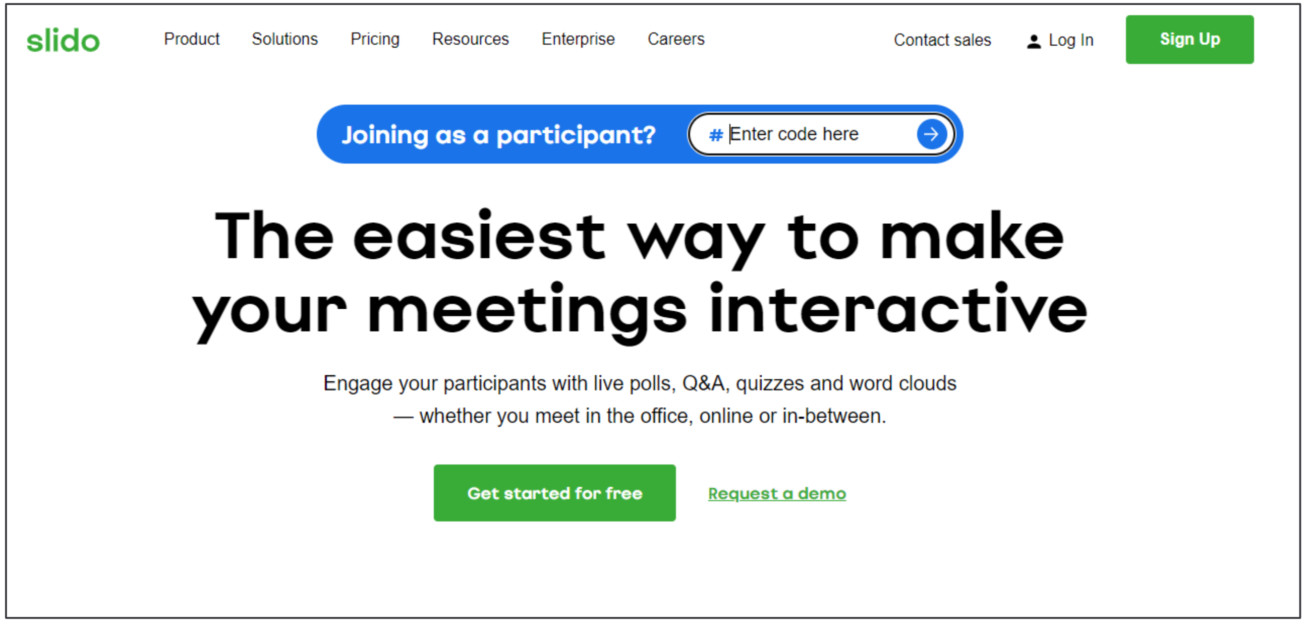






Submit your questions and answers on Slido

Go to www.sli.do and enter **#3236285** **OR** Scan the QR code with your phone



The recording will start now ☺

Today's Agenda

Part 1

Introduction

1. Introduction, timeline and recap from workshop Part 1
2. ACER's focus on ERAA 2023

Methodologies #1

3. EVA topics
4. Energy islands

Break (5 minutes)

Part 2

Methodologies #2

5. Network representation
6. Flow factor competition & curtailment sharing

Q&A

Closing remarks

Introduction

Marlene Petz,
ERAA Steering Group Convener, APG

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Background

- ERAA is an ENTSO-E legal mandate (Article 23 of Electricity Regulation), which aims to identify resource adequacy concerns by assessing adequacy of the electricity system to supply current and projected demands.
- It is a full pan-European monitoring assessment of power system resource adequacy, unique on its kind, based on a state-of-the-art probabilistic analysis, looking up to a decade ahead.
- Stepwise implementation of the methodology already began with ERAA 2021, with new improvements in the methodology in each edition (2022, 2021).
- ERAA 2023 aims to be an effective tool to identify adequacy risks, and includes an **enhanced Economic Viability Assessment** and advanced **Flow-Based market coupling** incorporated in the central reference scenarios.
- By proactively and factually identifying any system adequacy challenges, ERAA supports decision-makers in ensuring secure, affordable and sustainable energy to citizens and industries.

Progress on process and methodology

Fit-for-55 target

Public consultation and more intense communication

Input data as best available and aligned between MS, Regulators & TSOs

Meets the purpose of a risk assessment with robust input data

Interconnections (70% rule and evolution across the period)

70% rule issue integrated in the flow-based.

Accounting for network expansion

- Proxy expansion of 2025 domains based on TSO NTCs

Consistency between EVA and adequacy modelling

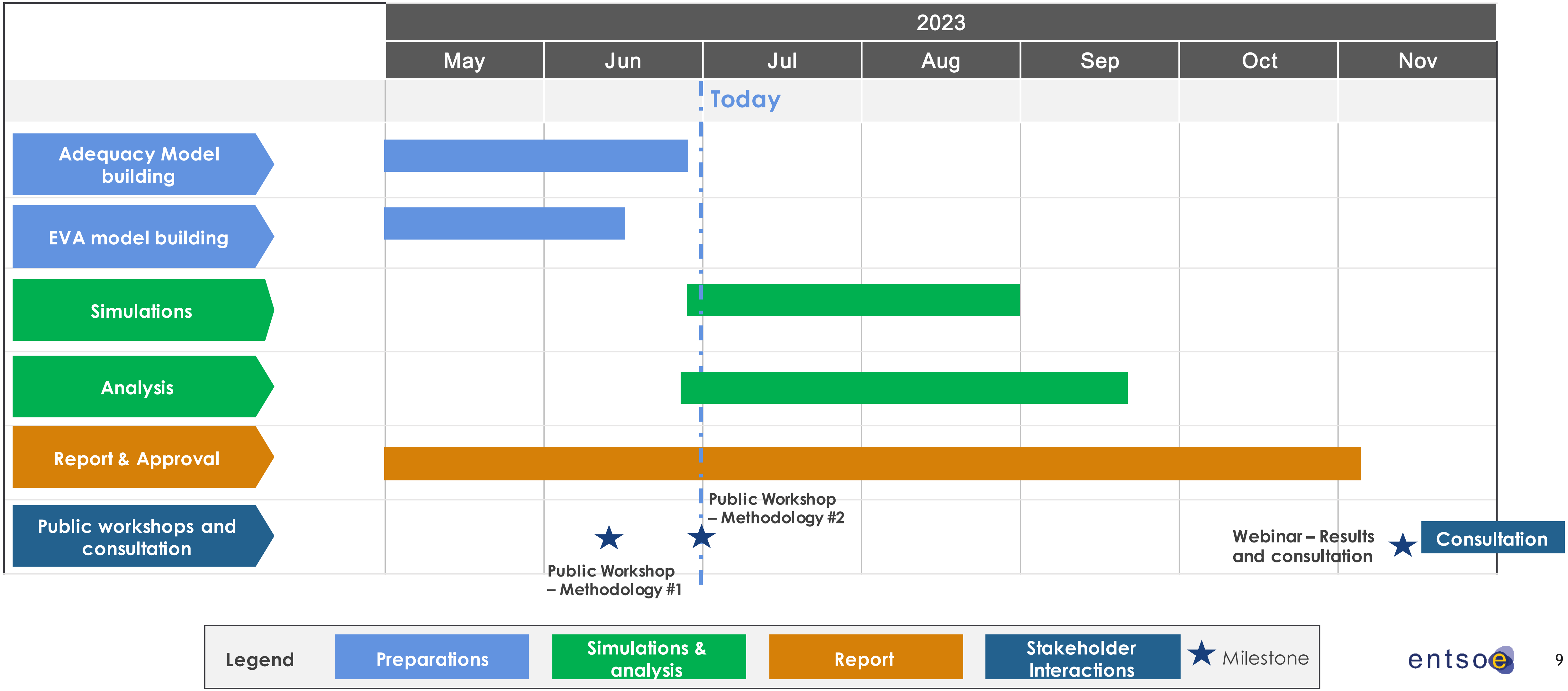
Recalibration of climate year weighting factors in EVA based on LOLE

Cross-border representation in EVA & ED steps

Curtailment Sharing

Acronyms: Member State (MS), Transmission System Operator (TSO), Net Transfer Capacity (NTC), Economic Viability Assessment (EVA), Loss of Load Expectation (LOLE), Economic Dispatch (ED)

Entering simulations phase



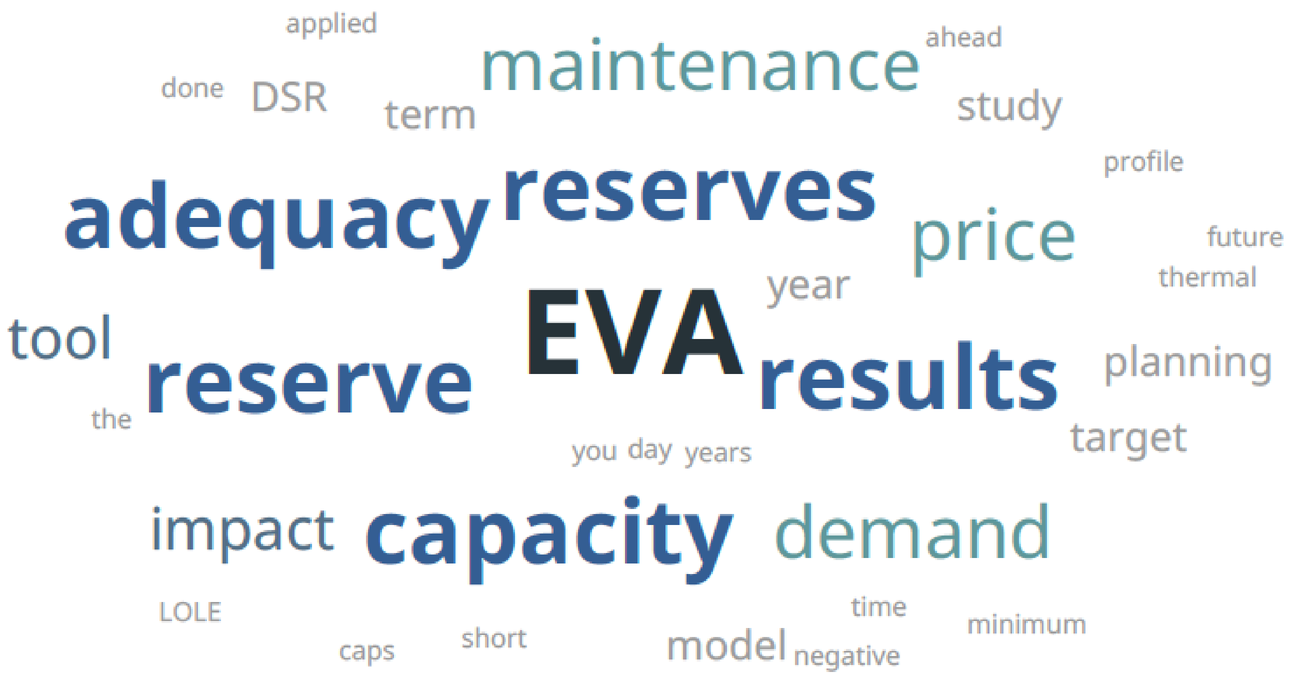
Recap of Workshop Part I

Slides and recording are available [here]

Topics covered

- Feedback from data call for evidence and workshop
- Price cap evolution
- Explicit DSR modelling and expansion potentials
- Maintenance Optimization in ERAA
- Reserve modelling

Word cloud from public's interaction



Recap of Workshop Part I

Sli.do statistics

26 Questions

36 Active users

37 Poll Votes

Remaining questions for Part 2:

- “Can you elaborate on the horizon applied in the EVA study? You mentioned that it wouldn't be accurate to consider one year at a time, and you're right. So what's the approach, each target year is solved on a 10-year ahead?”
- “Does the EVA take several/all target years (or even more) into account simultaneously? Or does it assess every target year independently of the other years?”
- “Can you estimate how much the flow-based coupling method changes the adequacy results compared to the NTC method (eg. from previous results)?”

Most important methodology element of ERAA:

Stochastic EVA

Why is ERAA important for the active users:

Interested on mid-term scenarios

Workshop Part I & II

Part I

- Feedback from data call for evidence and workshop
- Price cap evolution
- Explicit DSR modelling and expansion potentials
- Maintenance Optimization in ERAA
- Reserve modelling

Part II

- EVA topics
- Energy islands
- Network representations
- Flow factor competition & curtailment sharing

ACER

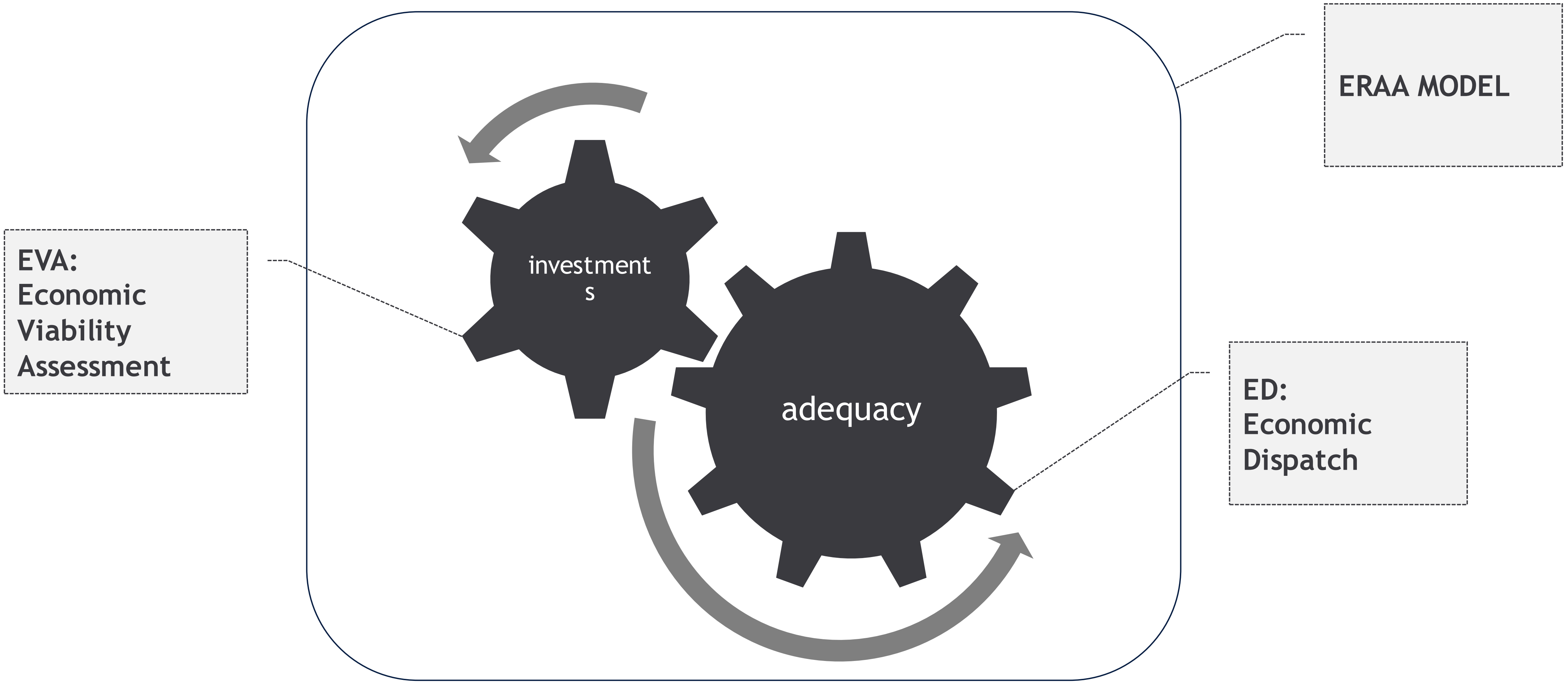
European Union Agency for the Cooperation of Energy Regulators

Consistency is key for robust output

ENTSO-E`s ERAA webinar

29 June 2023

Daniel Ihász-Tóth


ERAA MODEL
EVA:
Economic
Viability
Assessment
investment
s
adequacy
ED:
Economic
Dispatch

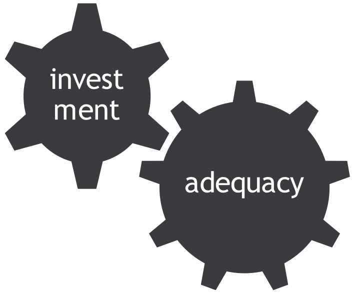
ERAA modules need to work together smoothly

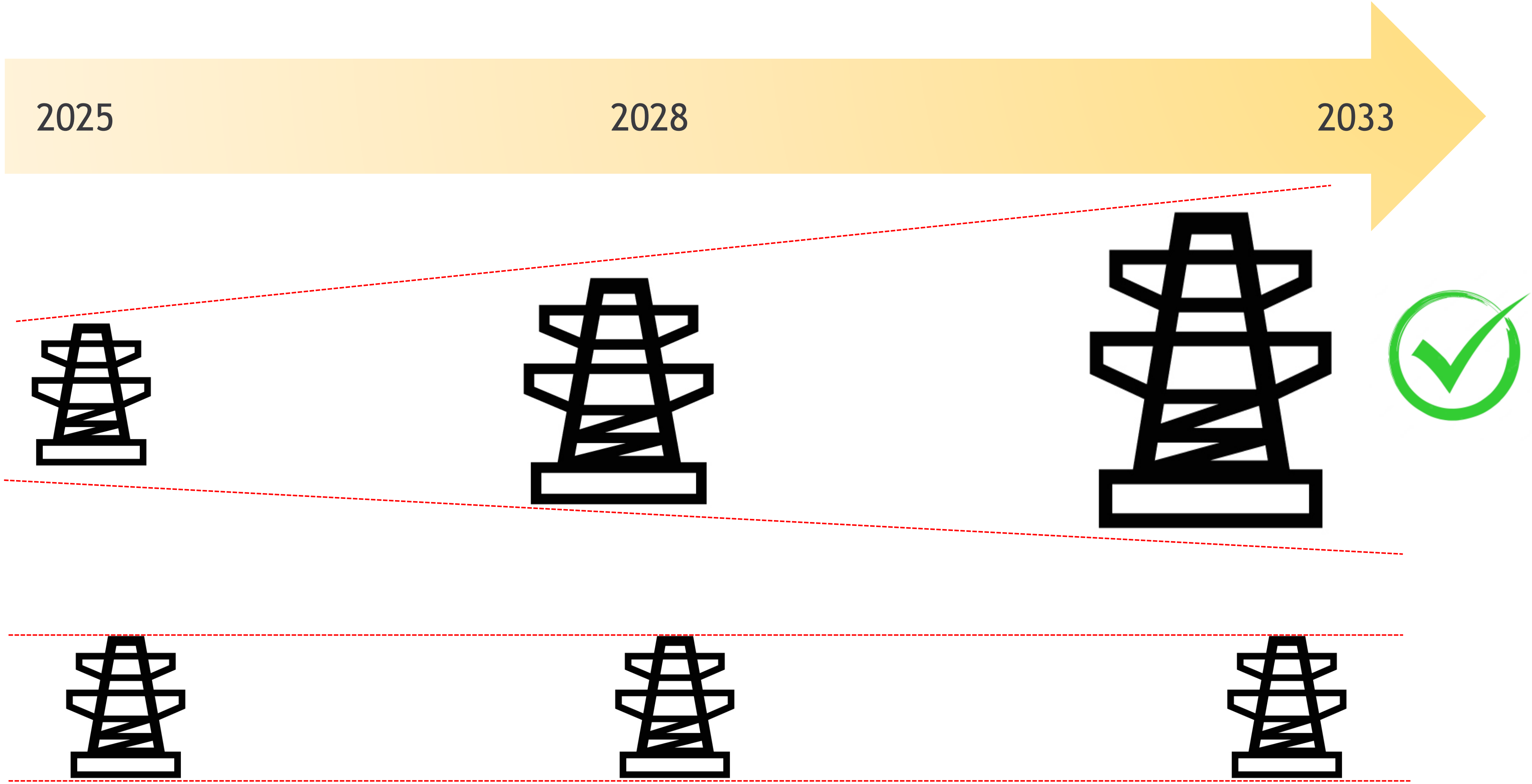
Consistent assumptions and implementation choices

Diverging assumptions and implementation choices

Diverging implementation choices and inconsistent assumptions can undermine the robustness of the results.

Improve consistency
Example 1: interconnector development



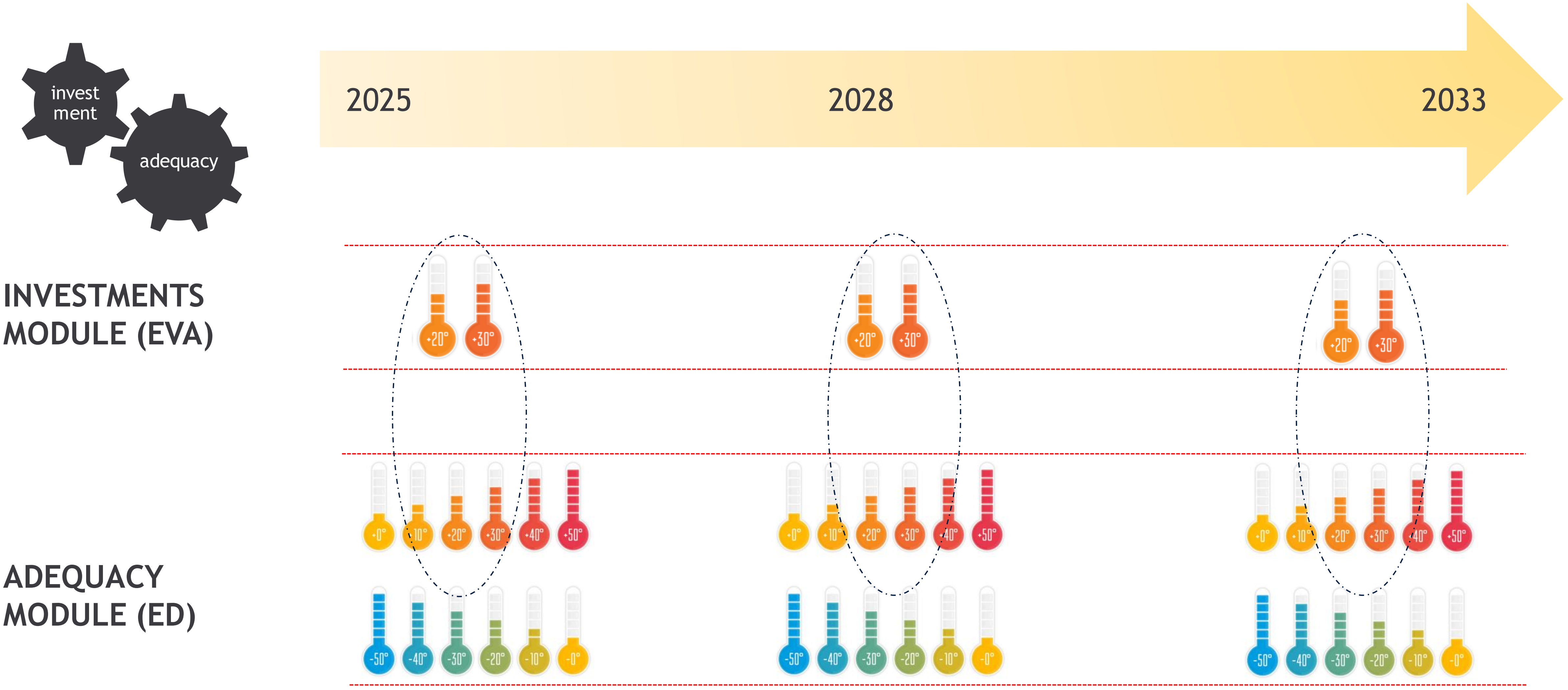


INVESTMENTS MODULE (EVA)

ADEQUACY MODULE (ED)

Note: within the `CORE` flow-based region

Improve consistency
Example 2: climatic variables



Questions?

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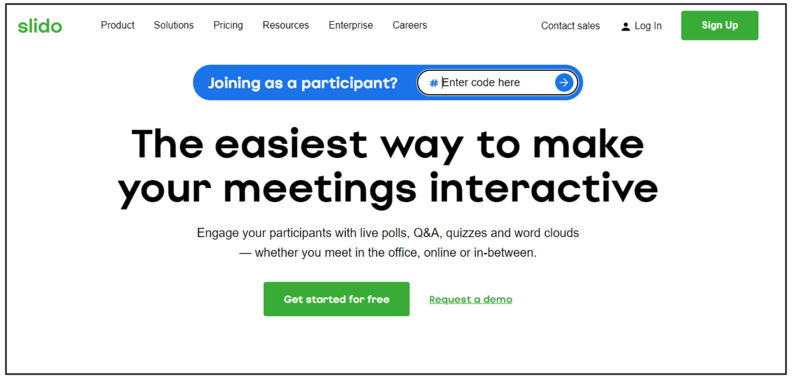

EVA topics

Felix Böing
ERAA Market Study Team, 50Hertz Transmission

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EVA Methodology in a nutshell

Pan-European generation and storage portfolio optimization over the horizon based on a total system costs minimization approach

Foresight for subsequent years is considered for (dis)investment decisions

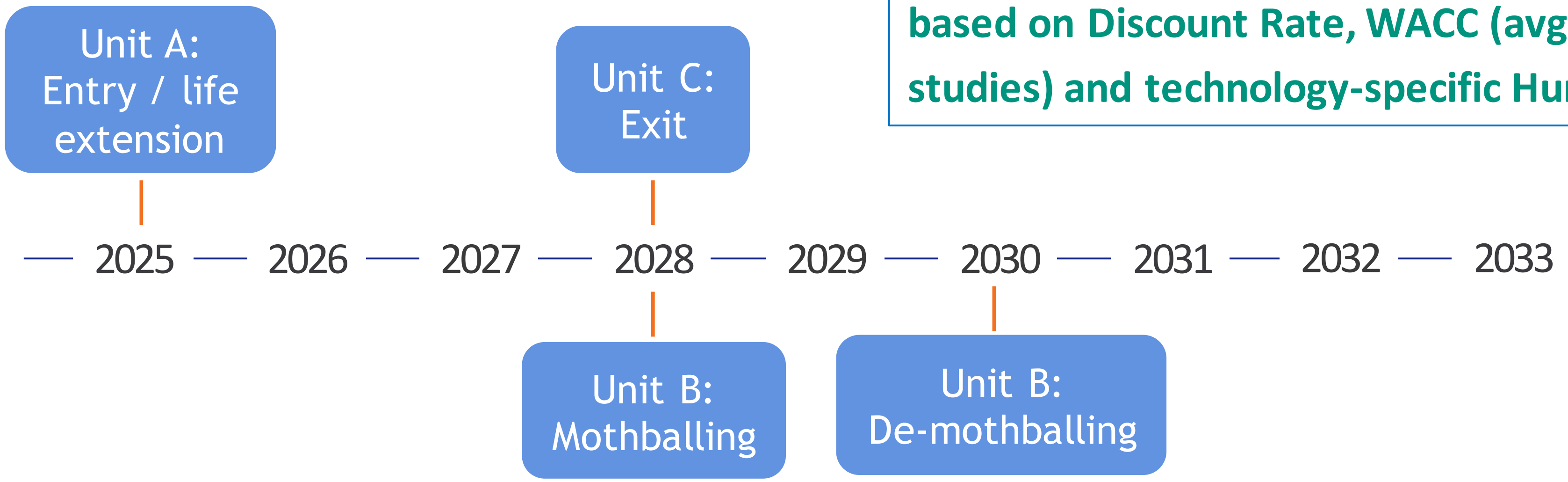
Modelled decisions:
Decommissioning, lifetime extension, (de-)mothballing of all thermal power plant types, commissioning of gas plants, DSR and battery storages

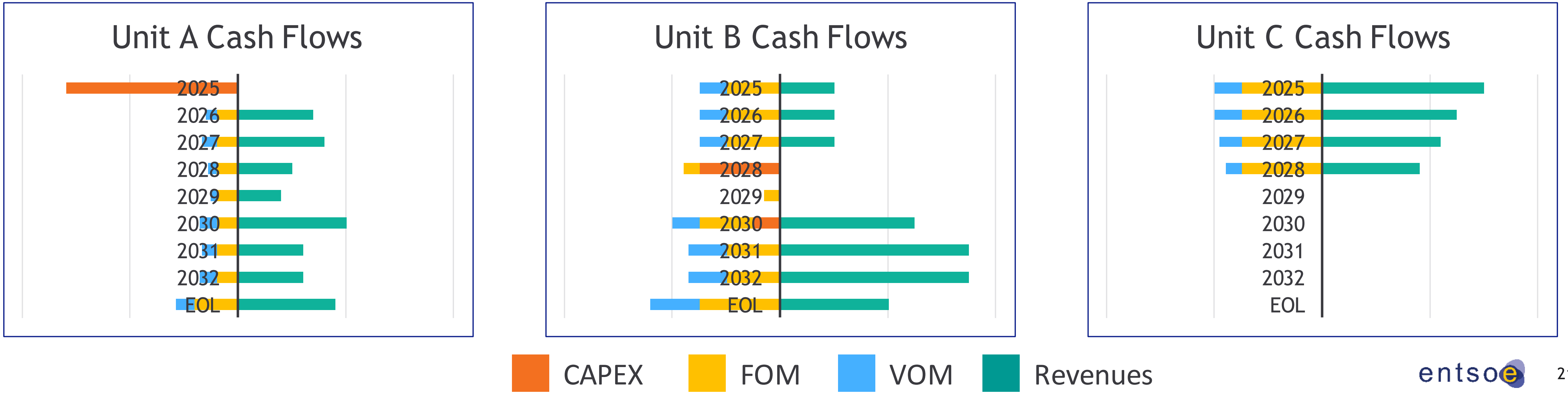
Price-Cap evolution based on ERAA22 methodology,
recalculated based on regulation update and ERAA22 price timeseries
4500 €/MWh (2025), and 8500 €/MWh (2033)

"Stochastic" Multi-Year: Three Climatic Years (CYs) modelled simultaneously in one optimization run

Example: Cashflows of 3 units

Model-endogenous representation of cash-flows based on Discount Rate, WACC (avg. from CONE studies) and technology-specific Hurdle Premium





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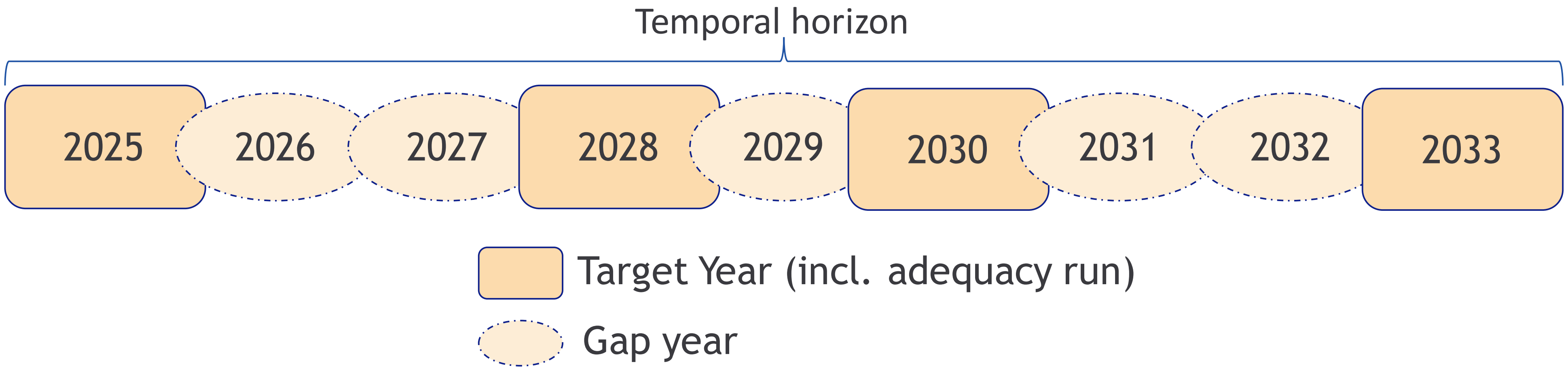
Temporal horizon, Target Years and Gap Years



Gap years are not modelled in the EVA or ED step

Temporal distance between target years is considered in terms of cost/revenue scaling and discounting of cash flows

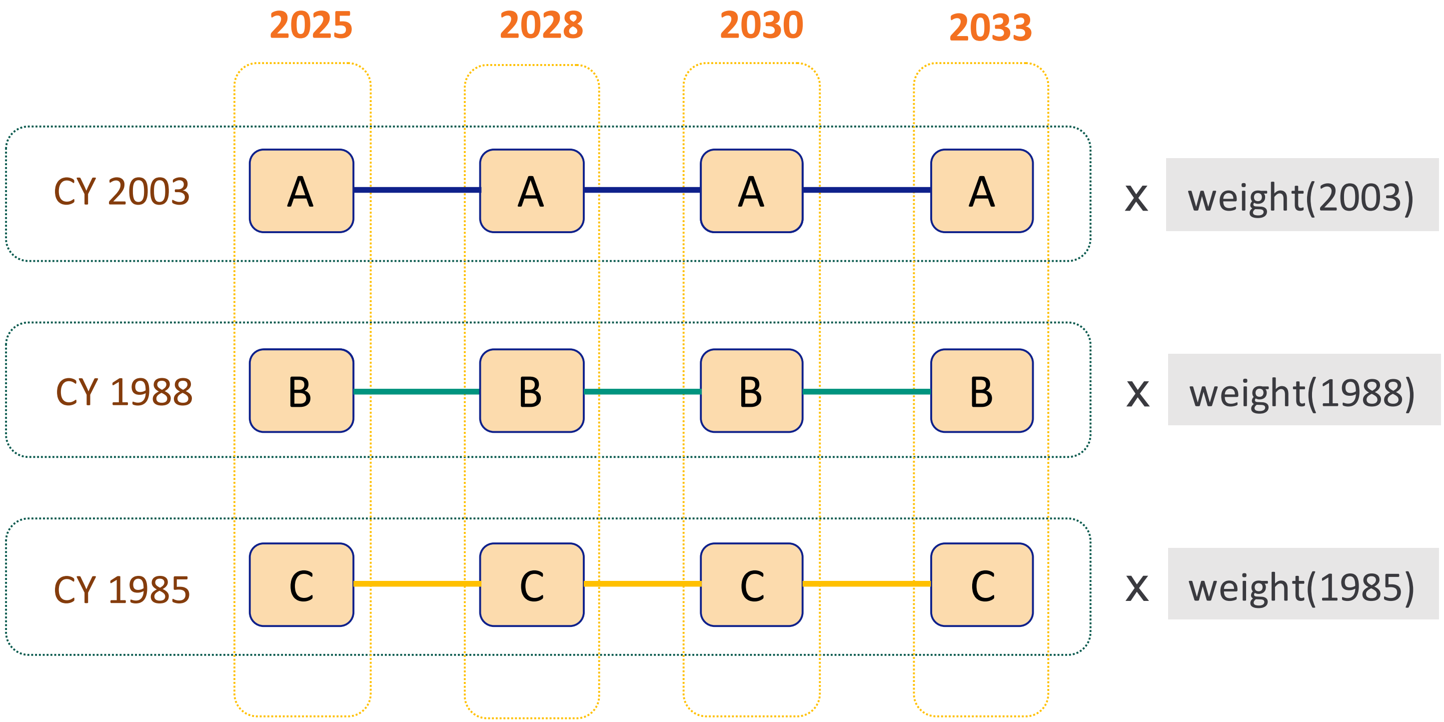
Stochastic EVA – Adding more climatic situations for representative investment decisions

ERAA 2022

- 3 representative Climate Years (out of 35) have been selected based on a clustering approach[1]
- Selected Climate Years: 2003, 1988, 1985

ERAA 2023

- Based on last year's results, the cost-weighting of the three climate years is adjusted in order to reach improved consistency between the EVA and ED steps.

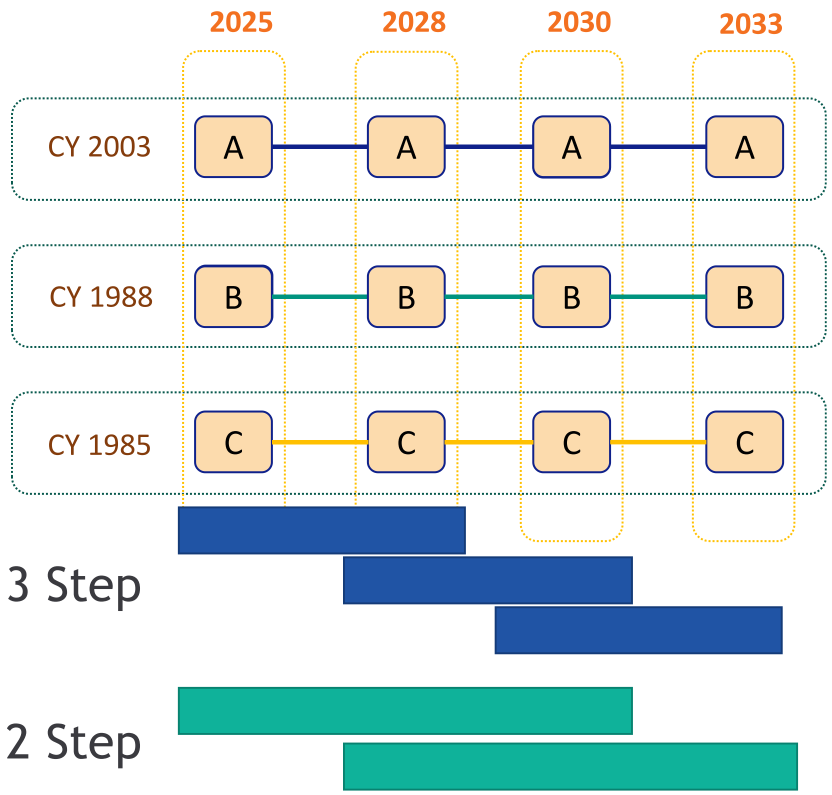


[1] **CY Clustering**
- EVA results for one target year are calculated with all CY
- The EVA (dis)investment decisions of each CY are evaluated in economic dispatch simulations for all other 34 CY
  → total system costs for non-optimal expansion plans
- Minimum distance clustering to find three representative CYs

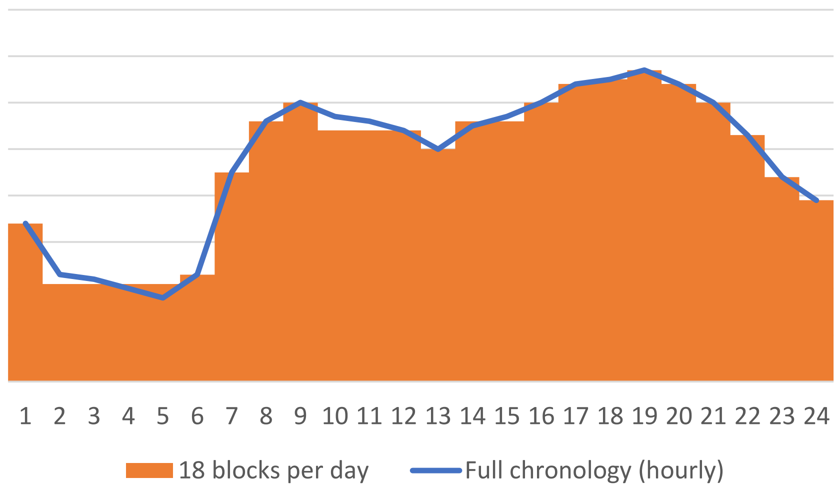
EVA insights – Solving an integrated 12-year expansion model in hourly resolution

Approaches to reduce memory usage (and runtime):

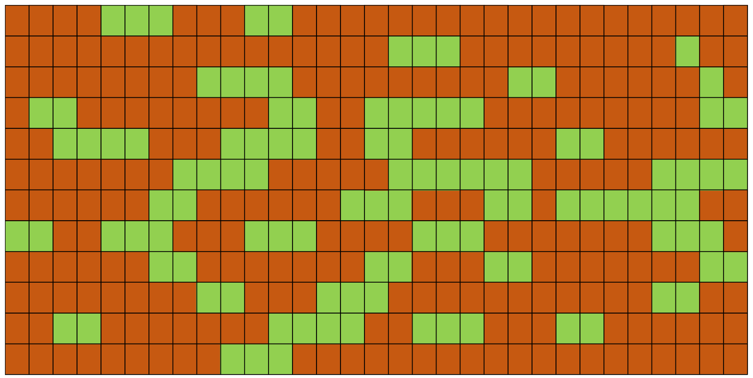
Rolling horizon (3-step or 2-step)



Hourly Sampling (18 blocks/day)



Daily Sampling (200 days/year)



Key take-aways

Methodology

- Overall system cost minimization approach continues to be the central modelling principle.
- All adequacy relevant (dis-)investment decisions are modelled endogenously in the EVA step
- Skipping Gap Years allows to include a larger temporal horizon in an optimization run.

Work in progress

- Reducing model size without losing accuracy (Rolling vs. sampling approach).
- Harmonization of scarcity situation representation within the EVA model (~100 000 h) and the ED/Adequacy model (>24 mio h).

Questions?

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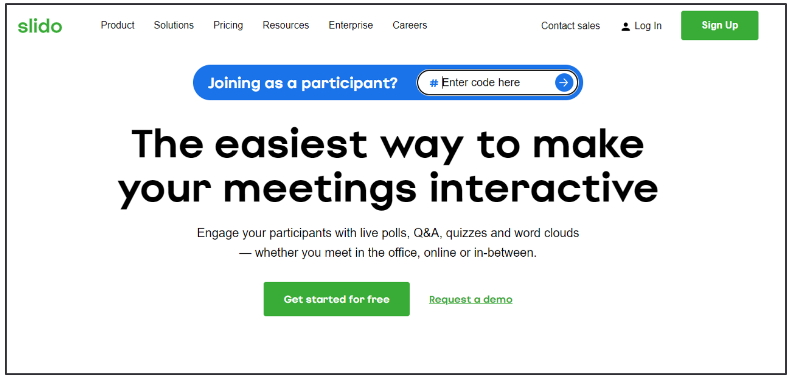

Agenda
EVA topics
Energy islands
Network representation
Flow factor competition & curtailment sharing

Energy islands

Antonio Hernandez,
ENTSO-E

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Energy Islands

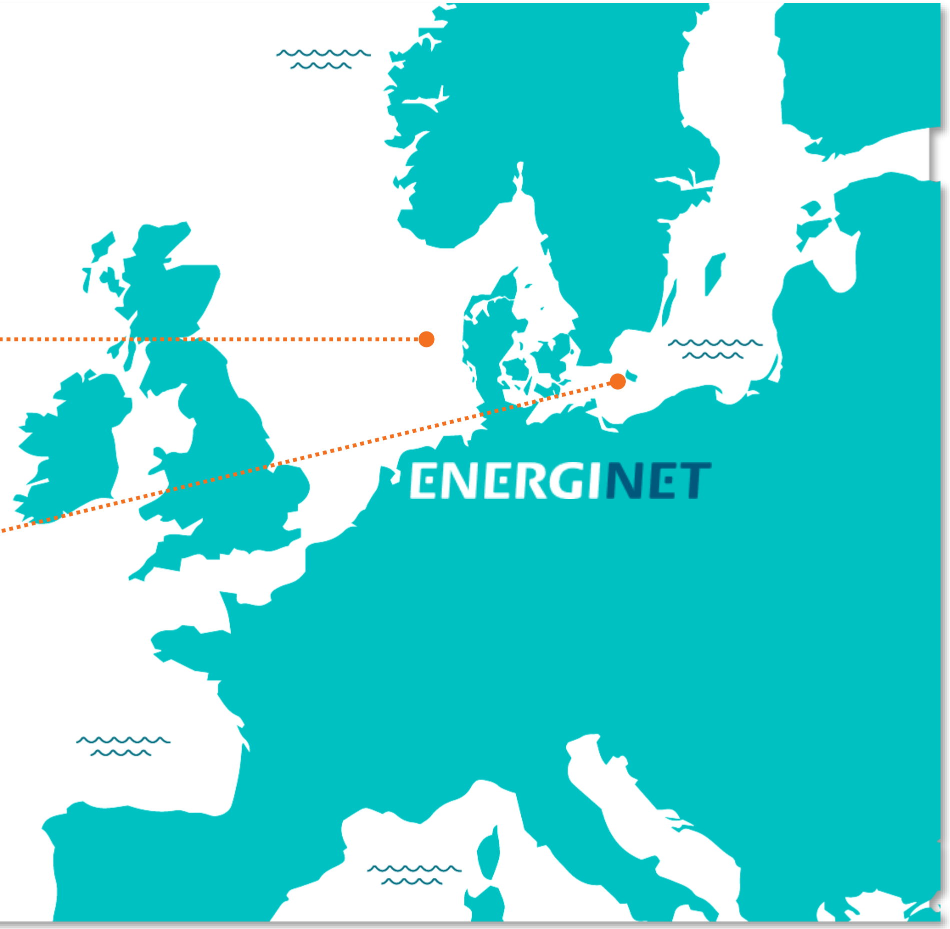
More info on Danish Energy Islands

The Danish case

The North Sea
3 GW offshore wind, later 10 GW

The Baltic Sea

3 GW offshore wind



ENERGINET

50hertz
Elia Group

elia
Elia Group

Other projects ongoing/planned and also modelled as offshore areas in BE, NL, DE.

Energy Islands

Modelling

ERAA 2022

- Offshore areas radially connected to shore
- Dedicated wind generation profiles for offshore power plants

*

ERAA 2023

- Offshore areas connected among them
- Dedicated wind generation profiles for offshore power plants

*Interconnections in map are not accurate geographical representations of energy islands and serve visualization purposes only

Energy Islands

More info on ONDP

Synergies with ONDP

ONDP: Offshore Network Development Plan

To be published in 2024

High-level outlook on the development of offshore systems

Close interactions to align on input data and assumptions

Questions?

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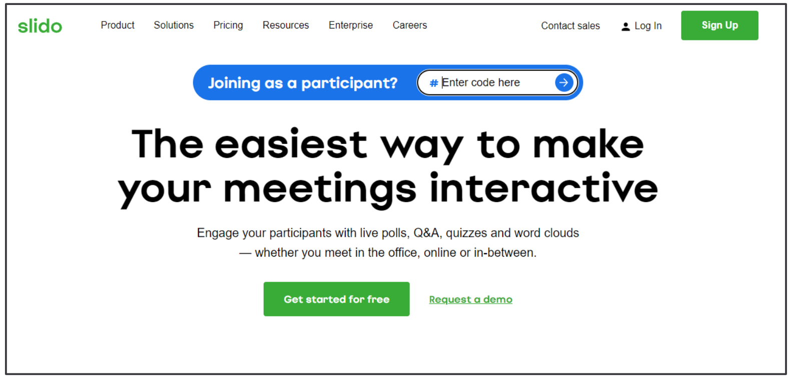
Short Break
Back at 11:00 CET



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Network representation

Lukas Galdikas

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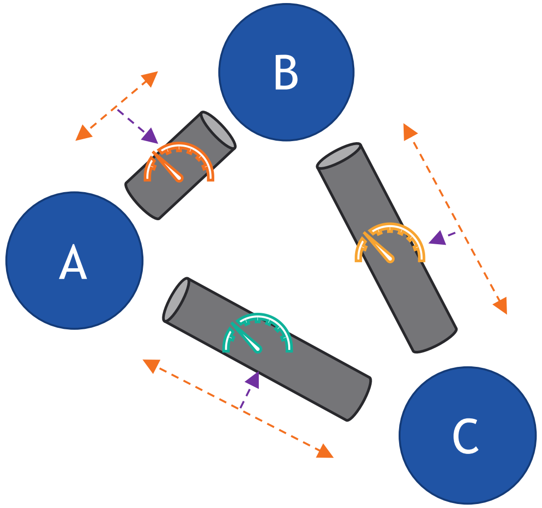
Network representation options

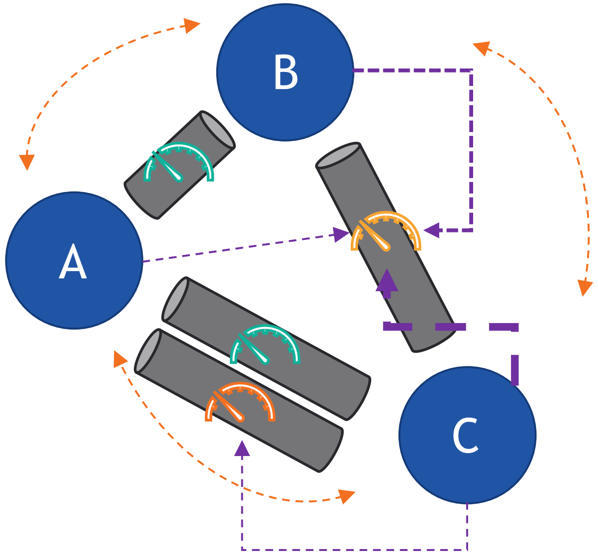
Net Transfer Capacities based Market Coupling [NTC MC]

Assessing only confident capability of network to accommodate flows.



Flow Based Domain based Market Coupling [FBMC]

Reflecting impact of situation in every Study Zone on loading of the network.



CNECs		PTDF matrix				RAM
Critical network element	Contingency	Influence of the balance on each element (PTDF)				RAM (MW)
		A	B	C	...	
Line 1	No contingency	-10%	13%	20%		150
	Contingency 1	-15%	10%	-10%		120
	Contingency 2	-15%	5%	-12%		100
Line 2	No contingency	5%	5%	-8%	...	150
	Contingency 3	1%	20%	2%		50
Line 3	No contingency	2%	6%	17%		400
	Contingency 4	5%	8%	20%		230
...	...	...				...

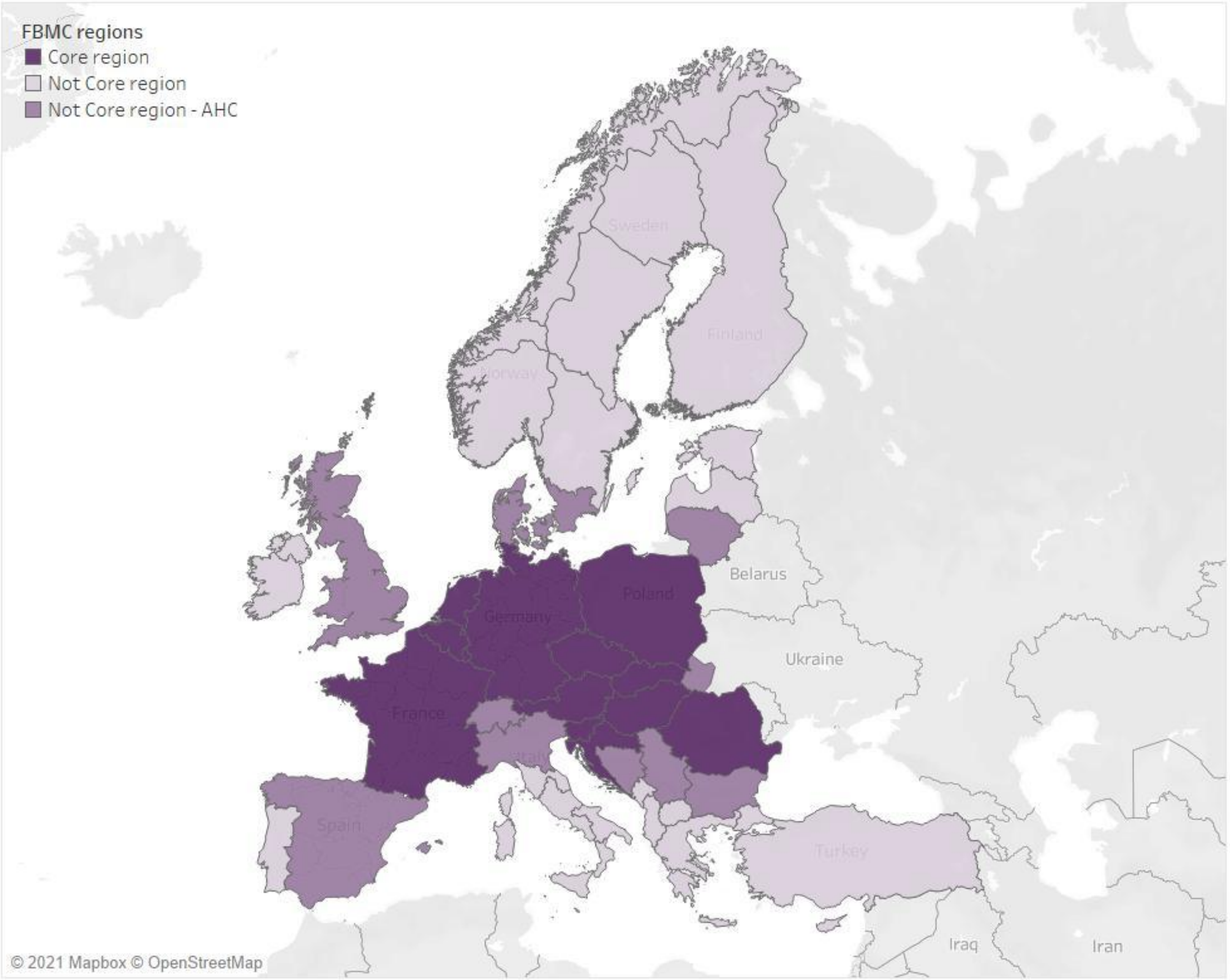
$$A \cdot (-0.1) + B \cdot 0.13 + C \cdot 0.2 + \cdots \leq 150 \text{ MW}$$

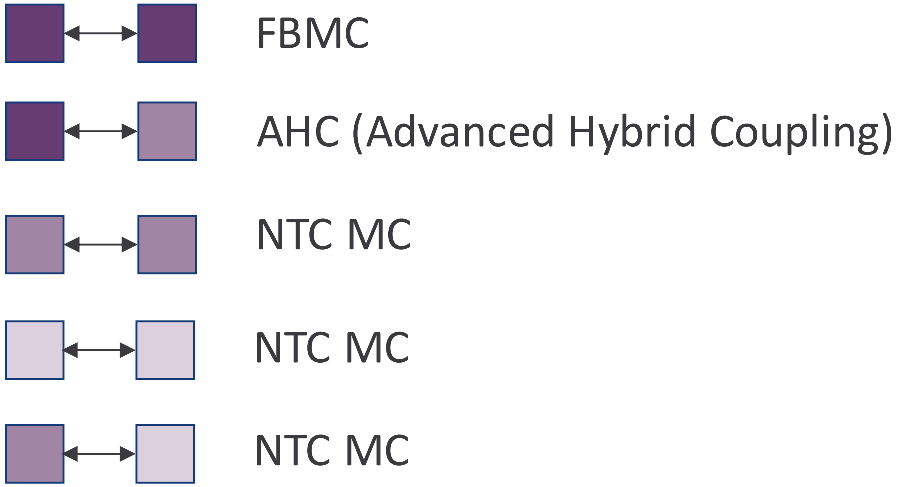
Cross-border link or CNECs

Electricity flow

Influence presentation (might have burdening and relieving impact)

A mix of Market Couplings applied in ERAA 2023





Methodology – Deriving FB domains from network

Core FB calculation

0 CNEC selection

0 ERAA Y-1 market simulation

1 Projection on TYNDP future grid

2 Clustering and representative hours

3 Remedial Actions optimization

4 Flow-Based domain computation and post-processing

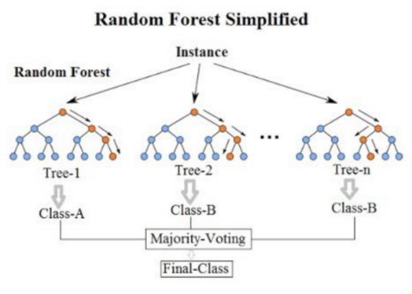
6 Probabilistic capacity allocation

5 Classification

Allocation to hours based on climatic variables scenario

Date	Day type
Climate Year 33, 10-27 (4h)	Winter
Climate Year 33, 11-09 (13h)	Winter
Climate Year 7, 09-14 (23h)	Winter
Climate Year 33, 06-14 (19h)	Summer

Typical day selection



Source : wikipedia

Random forest

Changes since ERAA 2022

Improvements: ERAA 2023 and beyond

Fit-for-55 target

Public consultation and more intense communication

Input data as best available and aligned between MS, Regulators & TSOs

Meets the purpose of a risk assessment with robust input data

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Consistency between EVA and adequacy modelling

Recalibration of climate year weighting factors in EVA based on LOLE

Cross-border representation in EVA & ED steps

Curtailment Sharing

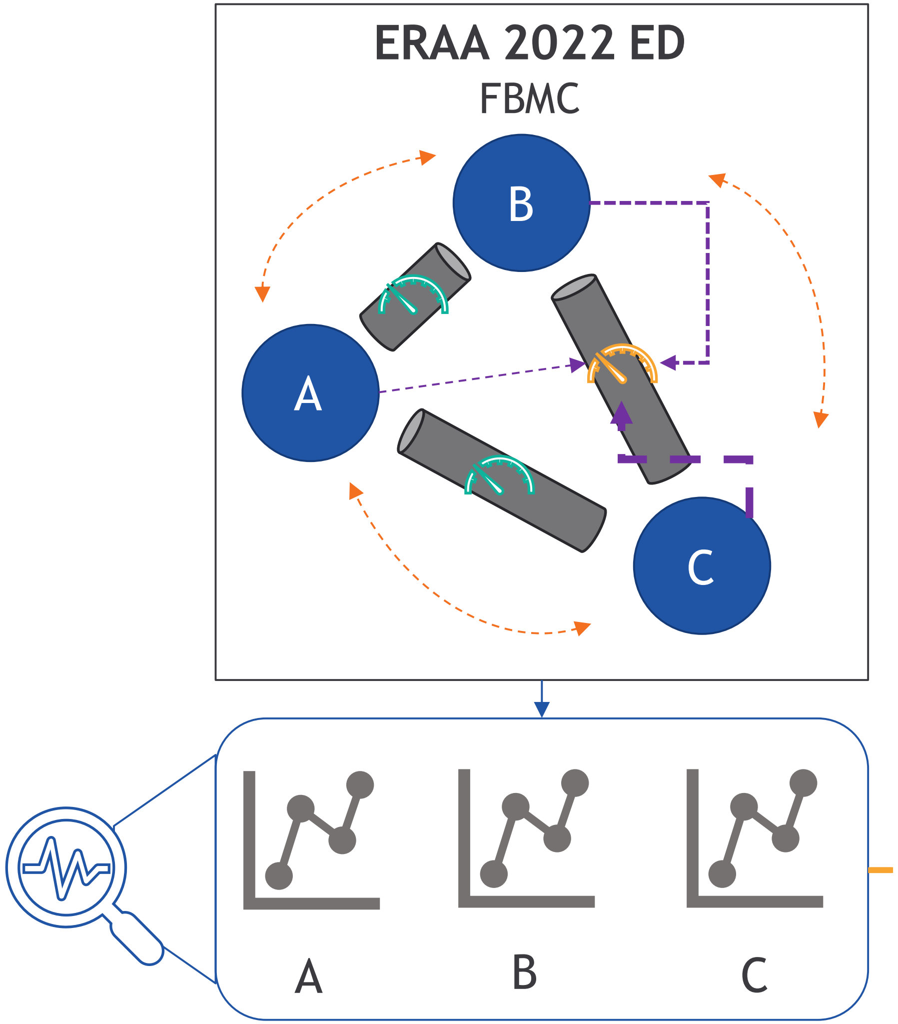
Improvements: ERAA 2023 and beyond

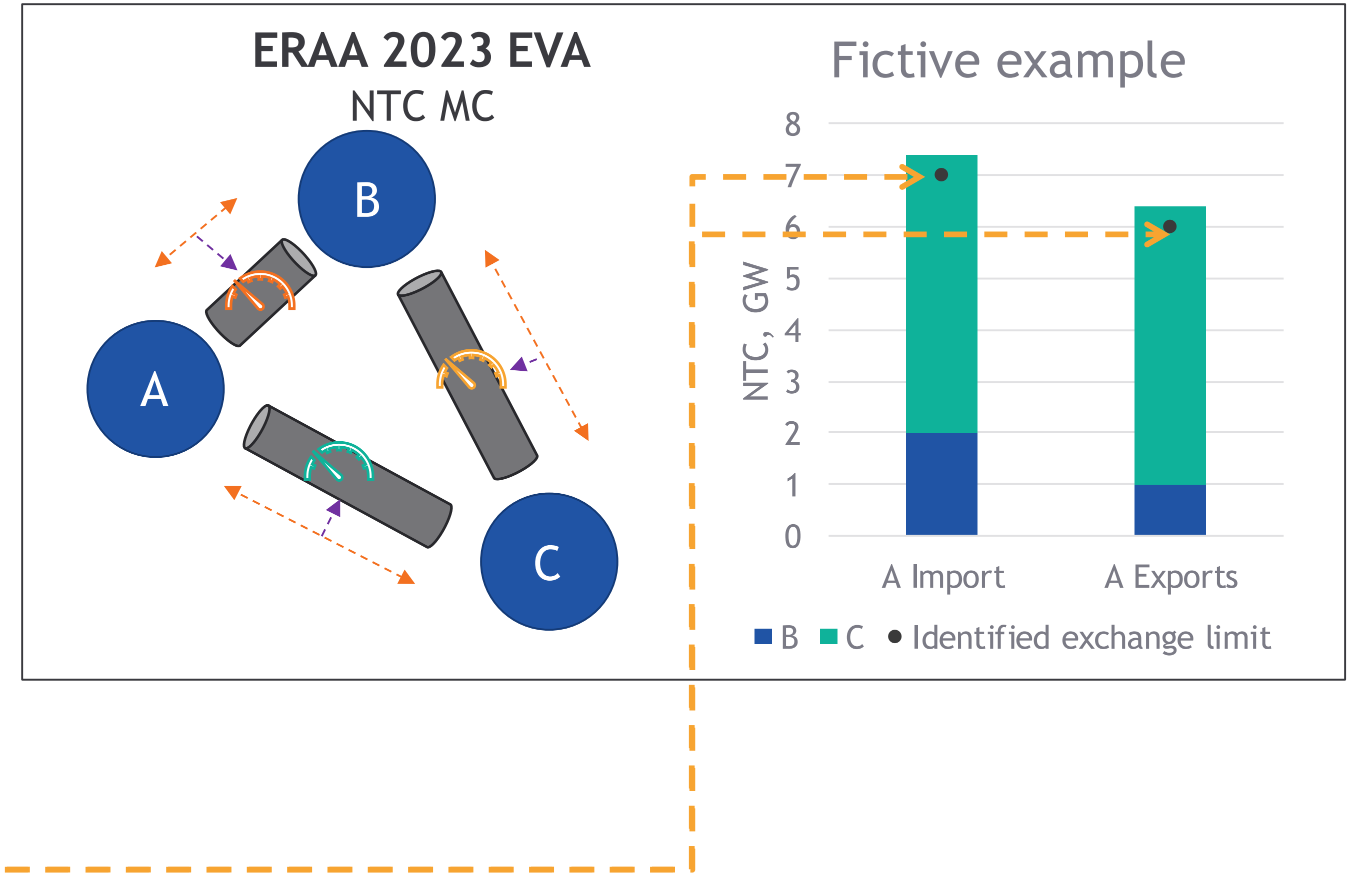
Area	From ERAA 2022	To ERAA 2023 approach	Best solution
Consistency enhancement between Economic Viability Assessment and Adequacy simulations	NTCs and FB domains computed from network models. No further link between models.	**Identified typical market positions in FBMC (ED) model** and used this information as additional input data in models with NTC MC (EVA)	**Use FBMC in all models consistently**
Network development representation	**No estimation of network development impact**	**Expanded FB domains** according to the trends identified in NTCs	**FB domains for every target year** with substantial network developments

Improvement 1 (EVA): increasing consistency between FBMC and NTC MC models

Improvements: ERAA 2023

Consistency between EVA and ED 1/2





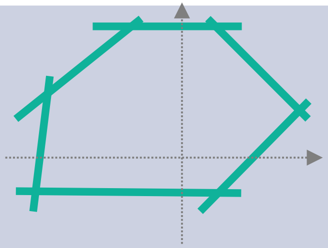
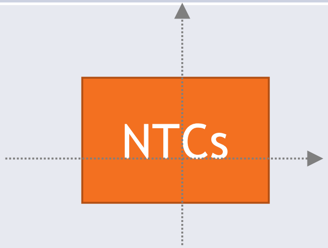
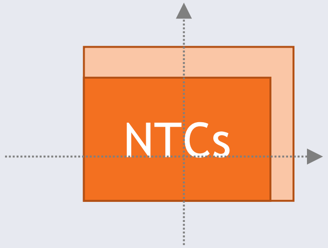
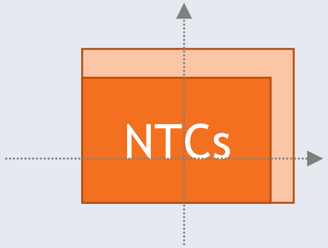
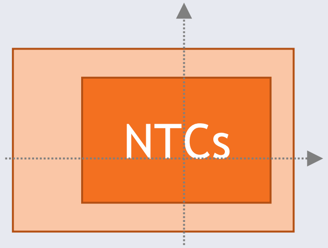
Improvements: ERAA 2023

Consistency between EVA and ED 2/2

1. Analyse Net Positions (NPs) in 2025 (ED simulations with FBMC)
2. Take P99 (export) and P01 (import) of NPs for each Study Zone
3. Use “2” in EVA model with TSOs NTCs complementary for 2025
4. Scale “2” according NTC development trends for future years
5. Raise up extreme low values

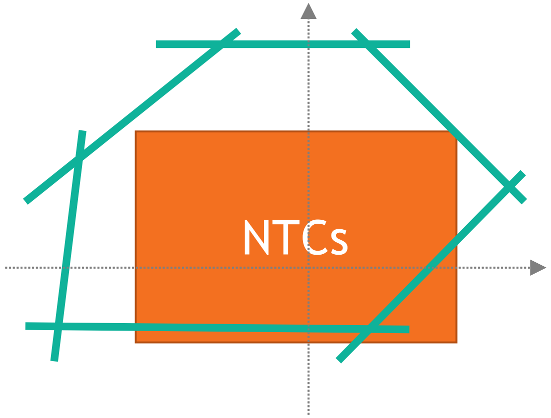
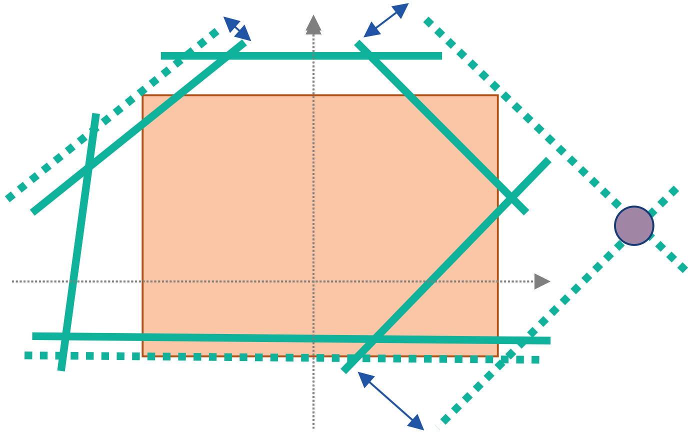
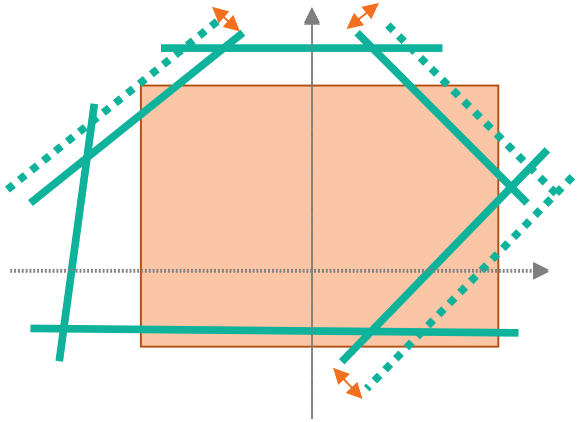
Improvement 2: Network development representation

Improvements: ERAA 2023
FB domain expansion for future target years 1/2

2025	2028	2030	2033
	??	??	??
			

Improvements: ERAA 2023

FB domain expansion for future target years 2/2

	Step 1: gathering input data	**Step 2:** Analysing FB expansion needs	**Step 3:** Reasonable FB expansion
Projection 1 E.g. A<->B	 2025	 2030	 2030
P …			
P 500 000+			

Reason why reasonable FB expansion has to be applied.

↕ RAM margin – additional RAM needed to accommodate NTCs (per CNEC and per Projection)

↕ Effective RAM margin – applied RAM margin for FB domain expansion (mimicking NTC developments)

500000+ projections are a result of all possible combinations of 19 borders within CORE region.

FBMC in ERAA for closer representation of actual network and market arrangements

Conclusions

FBMC enables better representation of network in market simulations and therefore enhances quality of adequacy simulation result.

NTC MC representation instead of FBMC is sometimes required to maintain reasonable performance of models. Ensuring reasonable coherence is important by:

- Deriving NTCs and FB domains from coherent network models
- Enhancing derived NTCs by additional limits from ED simulations using FB domains

Network evolution has impact on FB domains, which representation is intensive task.

Deriving FB domains from network and using it for any prospective studies looking few years ahead is a preferable approach.

Questions?

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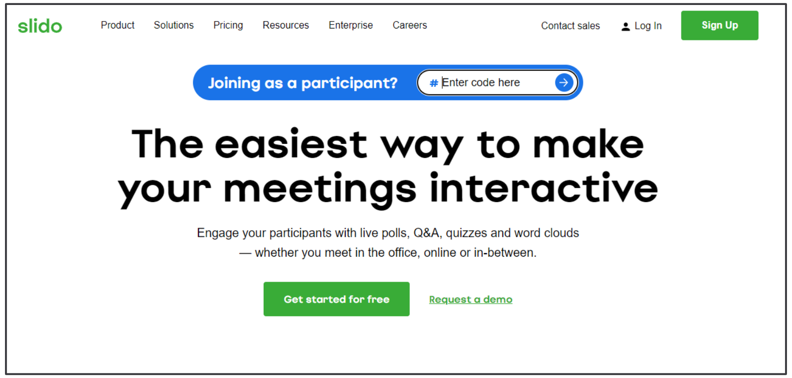

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Flow factor competition & curtailment sharing

Flow factor competition & curtailment sharing

Zakaria EL Khelloufi
ERAA Market Study Team, TenneT

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Flow Factor Competition

Key Driver

The resulting flow-based network constraints in the market coupling all have the form:

$$\sum_{z} \mathrm{PTDF}_{z,j,t} . NP_{z,t} \leq \mathrm{RAM}_{j,t}, \forall_{j,t}$$

From this equation we can derive that all bidding zones are competing for the same capacity (RAM), but their competitive position is determined by the zonal PTDFs. If there is an impact on RAM, this creates more or less capacity to compete for.

Two situations tend to occur due to the implementation of the FBMC constraints:

ENS can be created for net exporting countries in order to find the lowest ENS for the FB area as a whole.

Countries with low ‘flow-factors’ are penalized with ENS to the benefit of countries with high ‘flow factors’, even if all these countries are at the same time at the maximum market price cap.

Euphemia

Mitigation of Flow-Factor competition

Local matching & Curtailment sharing

Local matching

- Is an additional constraint setting a lower bound on the price-taking quantity*.
- Aims to enforce local matching of price-taking hourly orders with hourly orders from the opposite sense in the same bidding zone as a counterpart.

Curtailment sharing

- Aims to equalize as much as possible the curtailment ratios** between those bidding areas that are simultaneously in a curtailment situation, and that are configured to share curtailment. In other words, curtailment sharing aims to 'fairly' distribute the curtailments across the involved markets by equalizing this curtailment ratio.

*Price taking orders are orders defined at the maximum price of a bidding zone.

$$\text{**curtailment ratio} = \frac{\text{rejected price-taking orders in a bidding zone}}{\text{Submitted price-taking orders in bidding zone}}$$

Local Matching & Curtailment sharing

Implementation rules

Local matching constraint

- Each bidding zone is allowed to export only the share of generation capacity exceeding its internal demand; hence, preventing net exporters bidding zones to have ENS.
- Net importing countries should primarily use internal resources to cover internal demand, avoiding exports to countries driven by a better flow factor competition.

Curtailment sharing

- Curtailment ratio is defined as ENS/*DENS
- Curtailment ratios are equalized for net importer countries. LM will prevent net exporters from sharing ENS.

*DENS = Demand – Available capacity

Local matching & Curtailment sharing

ERAA2023

Base model

- FBMC run with LM constraint active.
- LM constraint modelled through conditional constraints.

Output/input Data

- FBMC constraints.
- Load from base run.
- Generation from base run.
- LM computed from base run (DENS).

Post-processing model

- Post-processing model is designed to take the solution of the base model with “frozen” Generation and Demand, in addition to LM constraints.
- A full quadratic function will be used to distribute ENS
- DENS weight factors.

Base Case

Conditional constraints

LM constraint

IF: Region.NetPosition – ENS => 0
OR **SUM(Line_Flows)** – ENS => 0

Region.NetPosition + Region.Load - Region.Generation <= 0
OR **SUM(Line_Flows)** + Region.Load - Region.Generation <= 0

If a BZ has no DENS, then it should not have a Net Export that exceeds Generation – Load. Thus, this is the LM constraint been enforced.

When the Conditional Variables are not active, then the constraints are relaxed, with an M value, M large. The M value is used such that it does not limit the BZs Net position prior to a condition activation.

FFC constraint

IF: Region.NetPosition – ENS < 0
OR SUM(Line_Flows) – ENS < 0

Region.NetPosition <= 0
OR SUM(Line_Flows) <= 0

If a BZ has ENS, then the BZ can be a Net Importer only. Thus, FFC minimization been enforced.

Post-process model

Model building

The post processing model is designed to take the solution of the base model with “frozen” Generation and Demand, in addition to LM constraints. The optimization of the post-processing model is purely on CS distribution.

Input data from base model

1. All FBMC related inputs of the base model as is:
   - PDTFs
   - RAM
   - Timeslices (domains)
   - Net Position Export limit (e.g. Net Position limit BG)
   - Flow limit (e.g. Gross Export BG)
   - Any other related FBMC / Transmission related inputs/constraints used in FBMC

2. Load from base run (total Load of the Region which includes ENS, Pump Load, Battery Load, Purchasers etc.)
   - This is the Load reported from base run under Region.

3. Generation from base run (total Generation of the Region which includes Batteries, DSR etc.)
   - This is the Generation reported from base run under Region.

4. LM from base run
   - Calculated from the results of base run, based on DENS.

Goals for ERAA2023

ENS & LOLE

ENS	ENS distribution	ENS does not move from hour to hour
	Total system ENS	Less than 0.1% relative difference
	ENS peak	Reduced when possible
LOLE	Total system LOLE	Stays the same
	LOLE at BZ level	Changes
DENS	DENS	Stable between base/post-process model

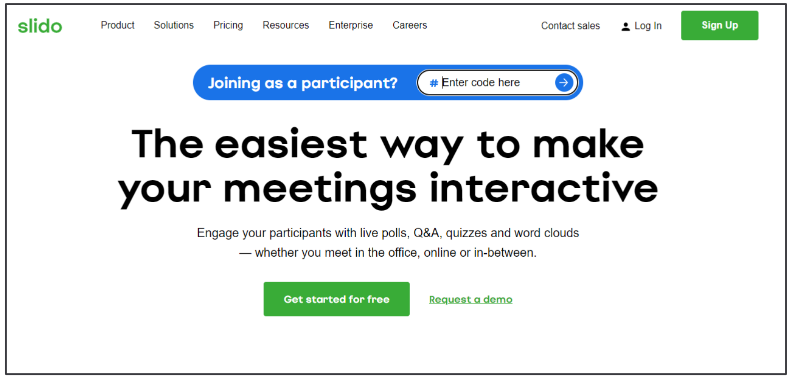
Comparison

ERAA2022 vs ERAA2023

	ERAA 2022	ERAA 2023
N° runs	Two: pre-/post-CS	Two: Base/post-pro run
First run	FFC effect present	FFC effect tackled
Second run: ENS distribution	Linearized quadratic	Full quadratic
Second run: RunTime	Higher than pre-CS run	Relatively quick
Second run: Model building	Less complex	More complex
LM constraint	Normal constraint	Conditional constraint

Questions?

Go to www.sli.do and enter **# 3236285** **OR** Scan the QR code with your phone



Agenda
EVA topics
Energy islands
Network representation
Flow factor competition & curtailment sharing

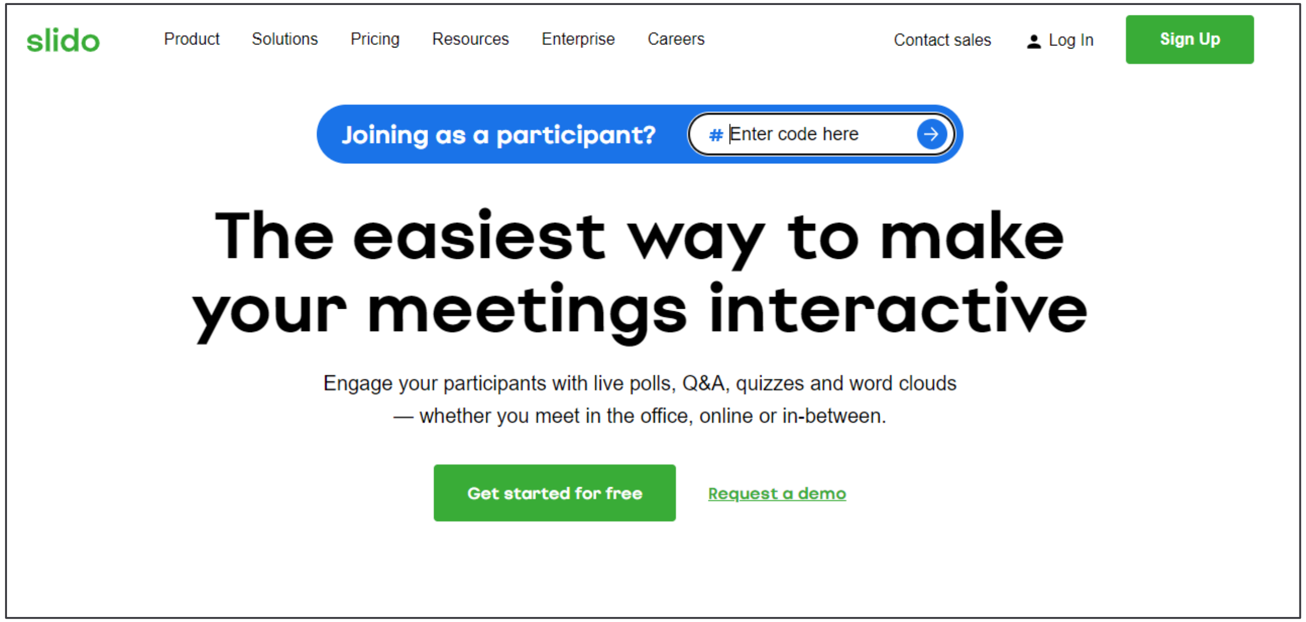
entsoe

Q&A

Lazaros Exizidis,
ERAA Project Management, ENTSO-E

Submit your questions and answers on Slido

Go to www.sli.do and enter **#3236285** **OR** Scan the QR code with your phone



Conclusions & next steps

Lazaros Exizidis,
ERAA Project Management, ENTSO-E

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Reliable Sustainable Connected

Don’t forget to join us for the next public webinars & workshops

15 March
- Webinar **“Preliminary input data”**
- Call for Evidence window opening

5 April

Call-for-Evidence window closure

13 June

Webinar **“ERAA 2023 Methodological Insights - Part 1”**

Today

Webinar **“ERAA 2023 Methodological Insights - Part 2”**

November

Publication

- Webinar on **“ERAA 2023 results”**
- Launching ERAA 2023 consultation

Key enhancements for ERAA 2023

Stakeholder interaction

- Multiple consultations and webinars on input data, methodologies and results
- Integrating views into ERAA 2023 and next ERAAs

Expanded methodology

- Scenarios heading towards Fit for 55
- Enhanced EVA with multi-year approach
- Flow-based in central reference scenarios, expanded to reflect additional project
- EVA network modelling brought closer to the adequacy model
- DSR, storage and electrolysers considered

Thank you for your attention

Cooperation

Planning, cooperation and targeted measures are key for a secure electricity system.

Coordination

Adequacy issues deeply interlinked; regional coordination is crucial.

Backup