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High-level approach to identify alternative bidding zone configurations for the bidding zone review

24 June 2021

9.30 – 11 CET

Online webinar

Public information

ACER
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Opening

9.30 – 9.35

Christophe GENCE-CREUX, Head of the Electricity Department, ACER

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Agenda

9.30 – 9.35	**Opening**	Christophe GENCE-CREUX, Head of the Electricity Department, ACER
9.35 – 10.00	**The high-level approach for the definition of alternative bidding zone configurations**	• Rafael MURUAIS GARCIA, Team Leader – Market Monitoring, Electricity Department, ACER • Marco PAVESI, Policy Officer – Market Monitoring, Electricity Department, ACER
10.00 – 10.30	**The application of clustering algorithms on nodal simulation results to support the identification of alternative bidding zone configurations**	Gianfranco CHICCO, Full Professor – Politecnico di Torino
10.30 – 10.55	**Q&A (online submissions via chatbox)**	**Moderator:** Christophe GENCE-CREUX, Head of the Electricity Department, ACER
10.55 – 11.00	**Closing**	Christophe GENCE-CREUX, Head of the Electricity Department, ACER

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Housekeeping rules

- Please be kindly reminded that **your microphone is muted** throughout the webinar
- You may pose questions via **chat during the presentation**; all attendees can see all questions (and the eventual replies given in the chat)
- The **slide deck** will be shared with you after the webinar via email and on the ACER website (including a **recording** of this webinar)

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Introduction

Rafael MURUAIS GARCIA, Team Leader – Market Monitoring, Electricity Department, ACER

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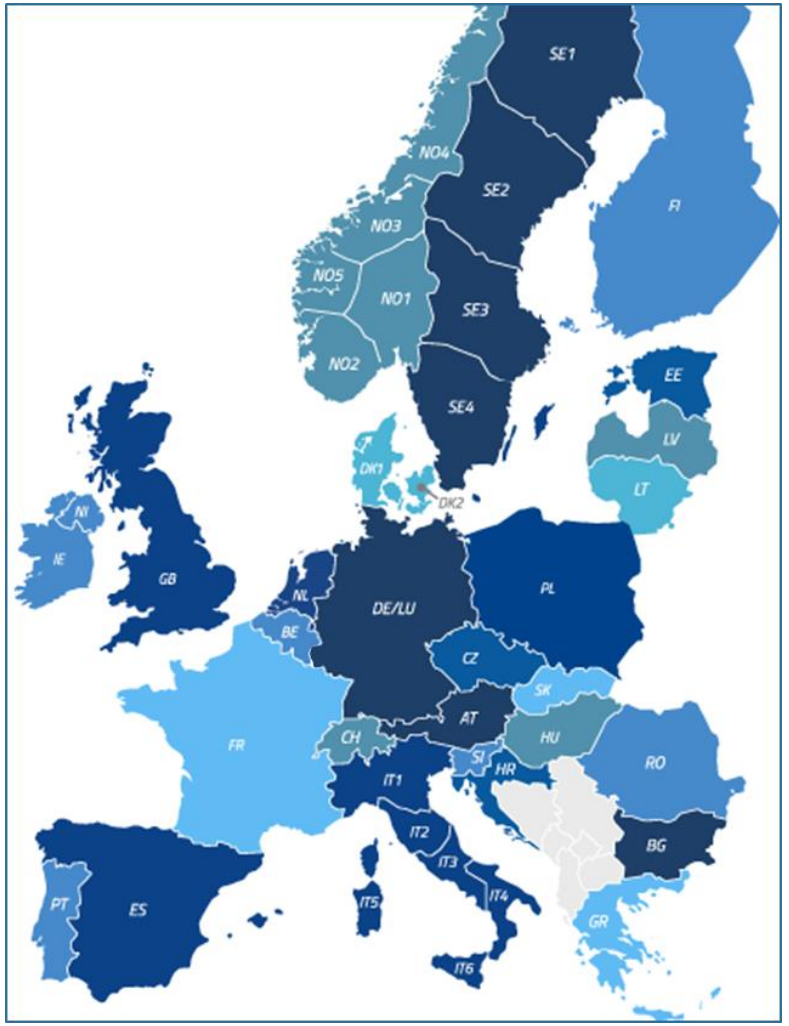
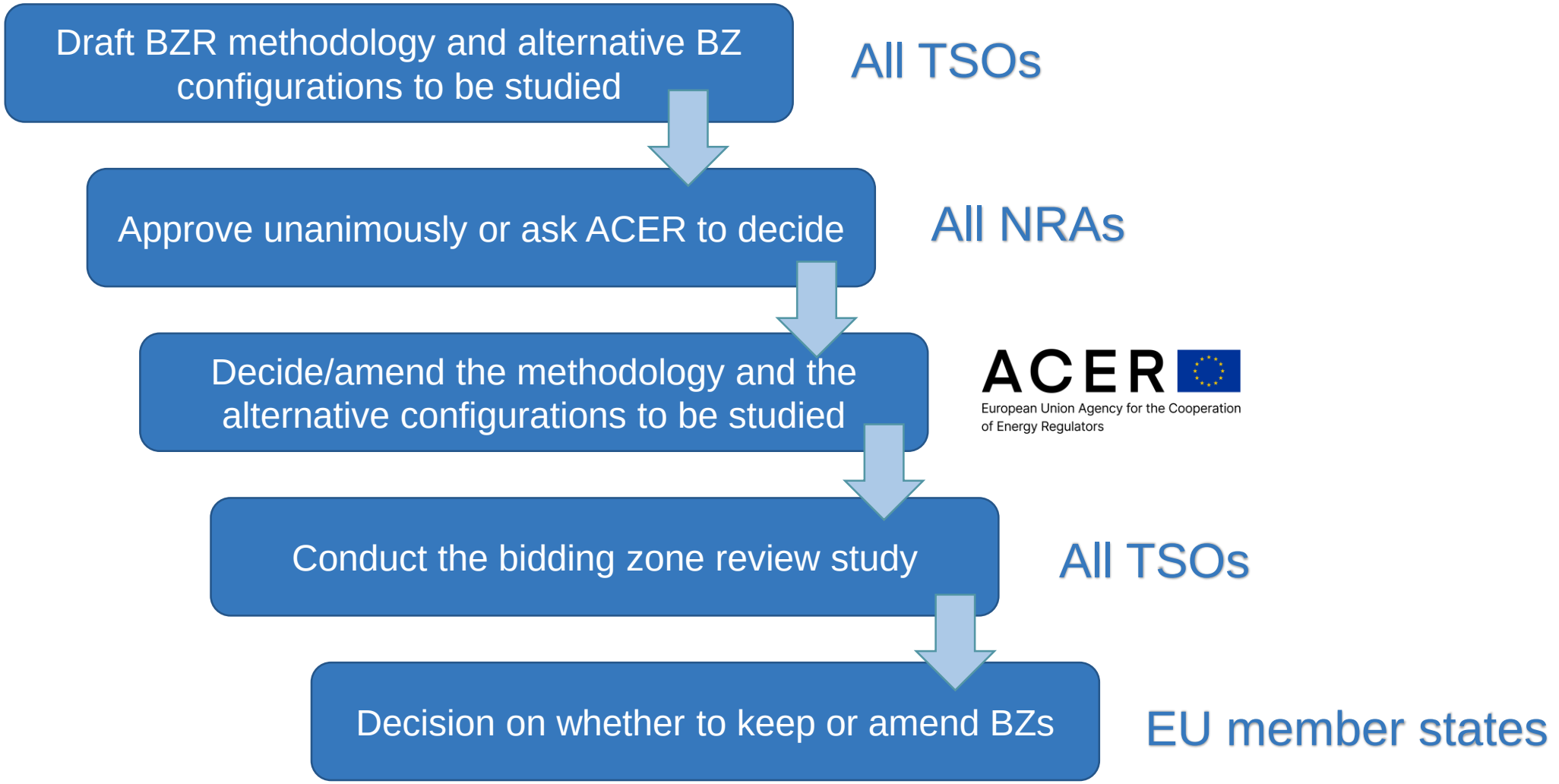
What are bidding zones? And why the need to review them?

- "A **bidding zone** is the largest geographical area within which market participants are able to exchange energy **without capacity allocation**"
- Bidding zones in Europe are currently mostly defined according to **national borders**. Few exceptions apply (DE/LU, DK, IT, NO, SE)
- The European electricity target model poses a challenge to Europe's status quo as it envisages coupled European Markets and bidding zones defined by **network congestion** rather than, for example, national borders
- Pursuant to **Article 14 of the Electricity Regulation**, in order to ensure an optimal configuration of BZs, a **bidding zone review** shall be carried out to ensure that **bidding zone borders are based on long-term, structural congestions** in the transmission network



Overview: The BZR process



The BZR process – ACER's role

- In the **absence of proposed alternative bidding zone configurations**, and the need for ACER to take an informed decision, a **two-step approach** was envisaged

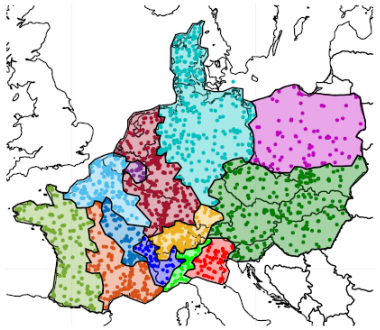
First ACER's decision → Second ACER's decision

24 November 2020

Content of this decision:

a) EU Methodology
b) A data request to TSOs: *Locational marginal pricing (LMP), i.e. nodal pricing, simulations for all Europe*

ACER to identify relevant alternative BZ configurations (clustering of LMP results)



Q1 2022

Content of this decision:
Alternative BZ configurations to be studied *in view of the LMP simulations performed by TSOs*

Model-based vs expert-based delineation of BZs

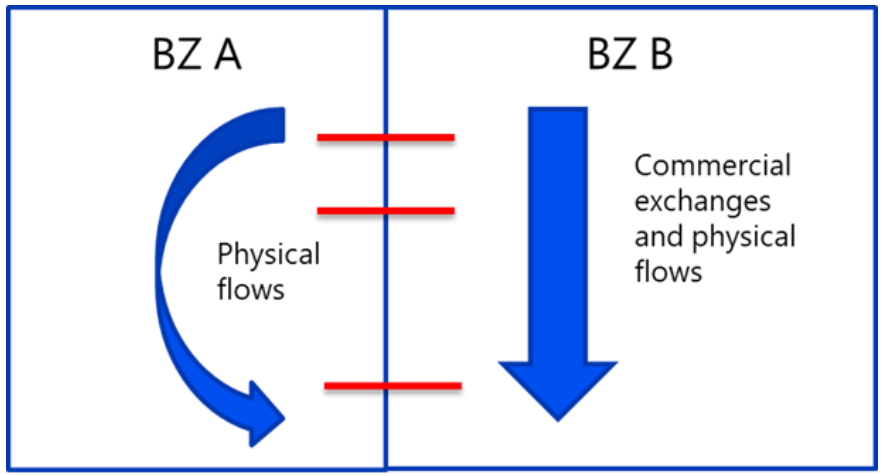
Expert-based delineation of BZs

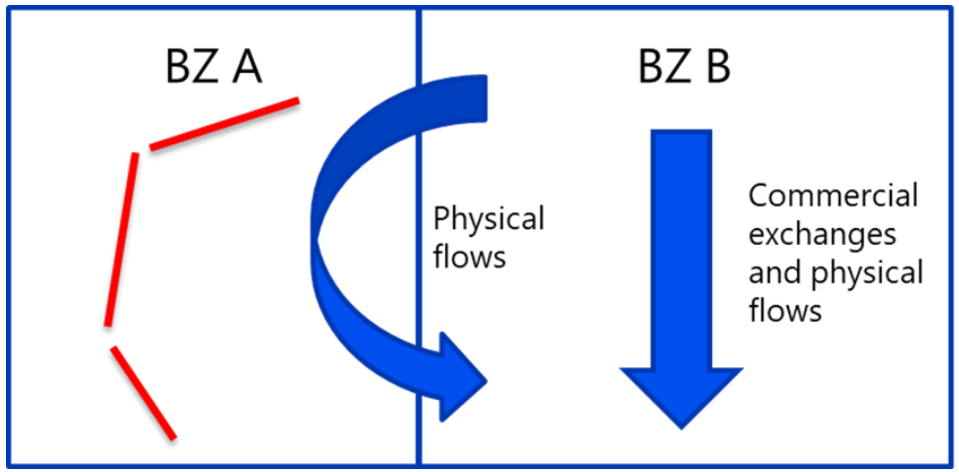
Model-based delineation of BZs

Expert-based refined with elements of modelling	*Model-based based on predefined boundaries*
i. **Start from expert-based configurations** ii. Use available data or perform certain simulations to confirm, prioritise or refine some expert-based configurations	i. **Start by performing market/network simulations** (e.g. locational marginal pricing simulations in combination with nodes clustering techniques) ii. Prioritise and/or refine configurations subject to certain delineation constraints

The need to investigate both physical and commercial dimensions of congestion

- **Why identifying physical congestions only is not enough?**





- One might conclude that there is no need to study alternative BZ configurations as physical congestions lay on BZ borders
- However, (structural) **physical congestions are caused (partly or mainly) by exchanges between network areas within B**

- In this example, BZ B would claim that there are no physical congestions within its network
- However, **exchanges between intra-zonal areas of BZ B significantly affect physical congestions in BZ A**

Both examples clearly indicate the need for establishing a cause-effect relationship between physical congestions and network areas contributing to them

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The high-level approach

Rafael MURUAIS GARCIA, Team Leader – Market Monitoring, Electricity Department, ACER

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The regulatory framework

- While the BZR study has to consider all the criteria listed in the CACM Regulation, **the following three elements** are explicitly mentioned in the Electricity Regulation (Article 14(1)) as objectives to be pursued when delineating BZs:
  1) Minimisation of **structural congestions** within BZs
  2) Maximisation of **economic efficiency**
  3) Maximisation of **cross-zonal trading opportunities**
- Moreover, the **70% target** is regarded as a binding requirement, which could lead to a BZ change if not met (Article 15(5) of the ER)
- Finally, pursuant to Article 14(5) of the ER, the **target year of the analysis** is set to be three years after the approval of the BZR package (i.e. methodology & alternative BZ configurations), hence **2025**

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Available input data and tools

- The following **input data** are available to ACER to pursue the regulatory objectives:
  - A set of **historical network models** covering the most recent three years (i.e. 2018, 2019 and 2020)
  - The results of the **LMP analysis** conducted by TSOs **for the target year 2025**
- With the available input data, the following **tools** will be used by ACER:
  - **Flow decomposition**, to assess how different BZ configurations contribute to non-allocated flows (loop flows and internal flows) that “consume” cross-zonal capacity on critical network elements.
  - **Clustering techniques**, applied to the results of the LMP analysis, to cluster individual nodes into BZs
- The combination of the two tools allows establishing a **cause-effect** relationship between physical congestions and the network areas that, by exchanging energy, significantly contribute to such congestions, in line with the definition of congestions in the Regulation

Treatment of MS borders when identifying BZs

MSs borders are completely ignored ⟵ ⟶ **BZs are fully aligned with MSs borders**

Greenfield configurations	*Consider MS borders as partial boundary conditions*
MSs borders are completely disregarded: The algorithm may suggest completely new BZs all across the EU. ✓ Advantage: The clustering algorithm is not constrained ✗ Challenges • A number of arbitrary choices are to be made (e.g. the target number of BZs) • Implementation challenges (e.g. with LFC blocks across MSs) • No experience in Europe with BZs combining parts of MSs (except the Single Energy Market of Ireland)	MSs are considered as a partial boundary condition: • Splits of BZs within MSs are possible • Mergers of BZs within MSs are possible • Mergers of MSs or part of MSs are not considered. • Once the main issue (structural congestions) is resolved, future BZRs could identify potential MSs mergers (or mergers of part of MSs) ✓ Advantages: • In line with the main objective of the Electricity Regulation for the BZR: addressing congestions efficiently and increasing CZ capacity. • Easier to prioritise configurations to be studied, less arbitrary choices • Experience in Europe with BZs within MSs ✗ Challenges ✗ Some choices still to be made, but the Electricity Regulation provides some guidance ✗ Prioritising alternative configurations and combinations of them, to be studied

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The high-level approach

Input data

- Historical network models
- LMP simulation results (2025)

- BZ identified in step 1
- LMP results (2025)

- Nodes allocated to alternative BZs

Process

Ranking BZs based on:

a) **Maximisation of CZ capacity:** Low amount of LFs+IFs

b) **Economic efficiency** (e.g. minimisation of LMP differentials within a BZ)

Poorest performing BZ*

Running the clustering algorithm.

a) **Clustering technique**

b) **Boundary conditions** (n+1 BZs within a MS)

*n=number of iterations for the MS

The objectives are met:

a) **The 70% target on CNECs**

b) **Proxy for economic efficiency** (e.g. low LMP differentials within all BZs)

Selection of target BZ/MS

Clustering

Stop criterion**

* If a Member State is already split into 2 or more BZs, the whole Member State will be considered when identifying alternative configurations
** An additional fourth step that is not part of the iterations is also required to combine the identified individual alternative BZ configurations to study their joint impact

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The application of clustering algorithms

Gianfranco CHICCO – Full professor, Politecnico di Torino

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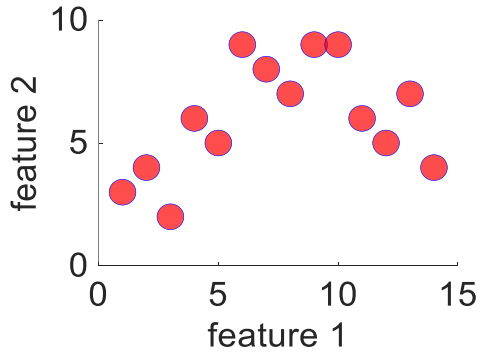
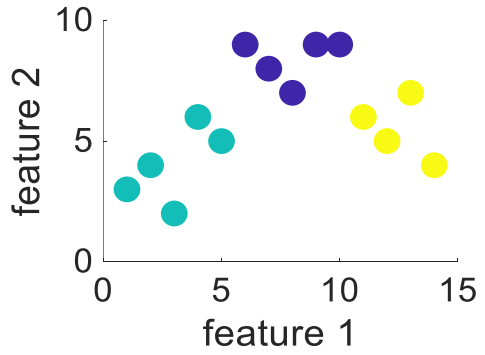
Clustering scope

Clustering is a procedure that starts from a population of entities and partitions of these entities into *groups* by analysing a set of relevant variables (called *features*)

- In the specific case, the entities are the *nodes* of the transmission system
- The *features* represent meaningful quantities for the study



Input features



Number of clusters = 3

In the activity in progress, *indications* have been taken from:

- Literature *review*
- Previous *experiences*

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Features of interest

Features available for a number of *time intervals* during the period of observation

Nodal prices	• mostly used in the literature • technical and economic relevance
Shadow prices	• less common in the literature • provide further economics-based insights
Power Transfer Distribution Factors (PTDFs)	• used to some extent in the literature • purely technical

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From the literature review
Main approaches

The main approaches found have been *partitioned* into three *classes*

Scenario-based clustering

- data are available as time series for *groups* of time periods (e.g., for different climatic areas, different seasons, or different years)

Single-case clustering

- a *single snapshot* or time series is provided in the data

Other approaches

- applications of *non-clustering* methods, for example *optimisation* problems or *graph search* procedures

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From the literature review
Distinction between *two types of methods*

Deterministic methods

- ✓ The solution depends on the user's choices on the *parameters*
- ✓ The solution *remains the same* if the parameters do not change
- ✓ Example: *hierarchical* clustering

Probability-based methods

- ✓ The solution depends on the user's choices on the parameters and on the extraction of *random numbers* during the execution
- ✓ The solution *changes* also if the parameters do not change
- ✓ The algorithm has to be run *multiple times*, to make a *statistical analysis* of the results
- ✓ *Examples*: k-means, k-medoids, fuzzy c-means, meta-heuristic algorithms, and the last stage of the spectral clustering

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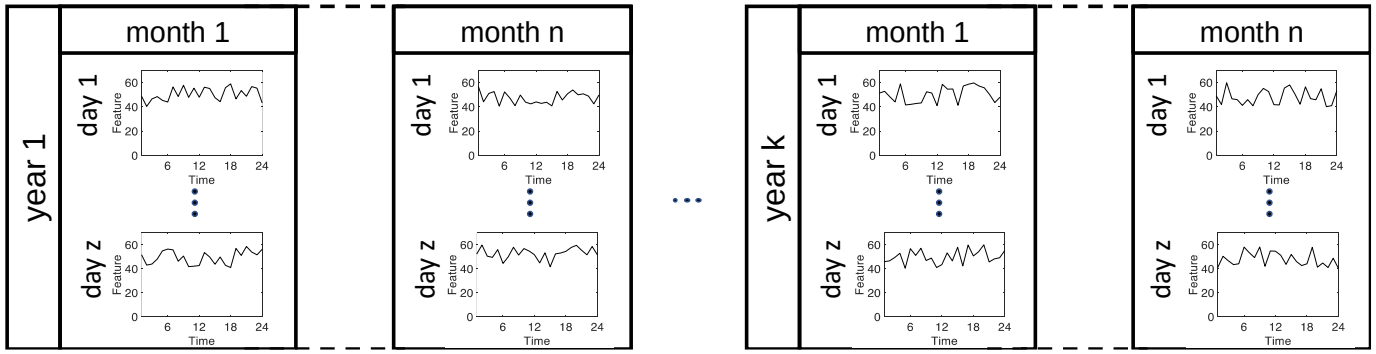
Scenario-based analysis

In the activity in progress, nodal price data refer to *multi-period scenarios*

- The main *criterion* for selecting the scenarios is the *climate year* (different years of reference)
- For each climate year, a number of *months* are considered, also to represent *seasonality effects*
- Within each month, the features are available as *hourly data* for given days



The scenarios are handled on the basis of the *relevance* of the information

- The scenarios provide a *variety* of information on different operating conditions
- Possible hours with *equal* features for all the nodes will be excluded

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Differences between the problem at stake and classical clustering approaches

The chosen 'solution' cannot rely on a *conventional* clustering algorithm, because:

- ✓ At each step of the iterative process, a given geographical area is divided into a *limited number* of clusters, while typically clustering algorithms are used to form *many* clusters
- ✓ As the target number of clusters is provided as an input for each step, there is *no need* to assess the *best number of clusters* by using suitable indicators
- ✓ Data refer to *multi-period scenarios* to be handled together
- ✓ Information on *network topology* and *operation* are *additional constraints*, while the links among the nodes are not usually considered in classical clustering algorithms
- ✓As, at each iteration, a given geographical area is split into a limited number of clusters, there are the conditions for testing clustering *variants* less commonly adopted in the literature, e.g., *divisive* (*top-down*) rather than *agglomerative* (*bottom-up*) algorithms

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Example from previous activity

Probabilistic multi-scenario methodology

Features considered: *nodal prices* (calculated from Optimal Power Flow with security constraints) and *PTDFs*

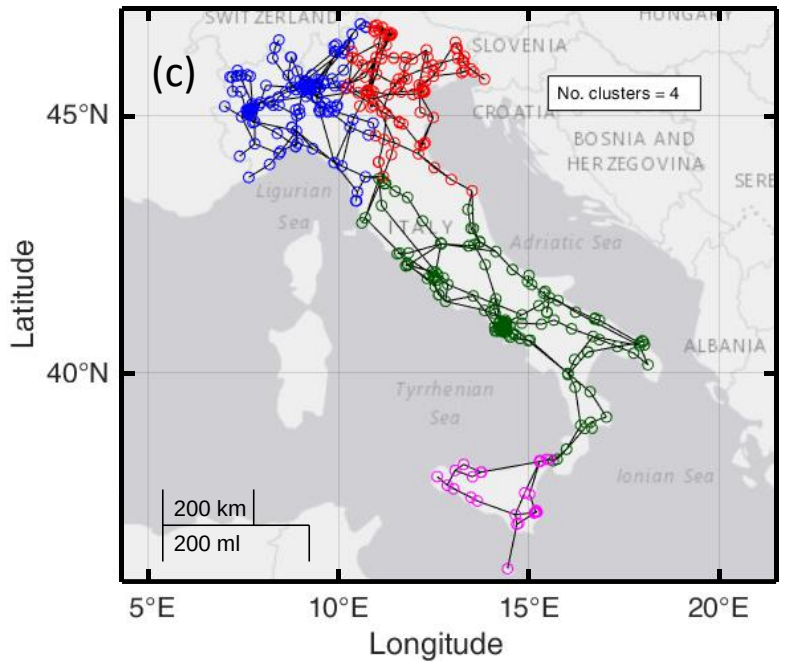
Scenarios defined from solutions in *normal* operation and *planned maintenance* cases, *weighted* by the expected frequency of occurrence

Clustering algorithm executed for each scenario, obtaining in each case the node partitioning into clusters

Similarity matrix constructed by considering the network data, how many times the nodes belong to the same cluster, and the scenario weights

Spectral clustering executed to form the final number of zones

Recent application in Italy(*)



Example: nodal price scenarios handled with hierarchical clustering and topological constraints (4 clusters)

(*) Colella, P.; Mazza, A.; Bompard, E.; Chicco, G.; Russo, A.; Carlini, E.M.; Caprabianca, M.; Quaglia, F.; Luzi, L.; Nuzzo, G. "Model-Based Identification of Alternative Bidding Zones: Applications of Clustering Algorithms with Topology Constraints", *Energies*, **2021**, 14, 2763.

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Clustering approaches under test

Graph-based clustering

- Constructs a data *similarity graph* based on the data relationship, then
- Creates the *groups* by performing graph-theoretic optimisation

Constrained clustering

- Incorporates in the clustering procedure information on the *node connection* to the network
- Avoids solutions in which the groups of nodes created are *not connected*

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Conclusions on clustering

- Because of the specific aspects recalled in previous slides, the *definition* of the clustering algorithm is not just a choice among the existing algorithms
- The appropriate selection of the *algorithm* depends on data and has always to be carefully assessed with the *data* at hand
- *The decision on the most suitable clustering algorithm will be possible only after detailed testing on the system based on the full data available*
- *Deterministic* clustering procedures are mostly of interest, because their results do *not* depend on random variables, so that a full statistical analysis of the results is not needed
- *Customised* clustering procedures are included in the testing

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Q&A

10.30 – 10.55

Provide your questions on the subject in the chatbox.
We will group them and try to provide an answer

Moderator: Christophe GENCE-CREUX, Head of the Electricity Department, ACER

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Closing

10.55 – 11.00

Christophe GENCE-CREUX, Head of the Electricity Department, ACER

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Next steps

- A public consultation on the approach presented today will be launched in early July for a duration of 4 weeks
- TSOs will deliver the final results of the LMP simulations by 31 October 2021
- ACER's decision on the alternative BZ configurations is foreseen for Q1 2022
- If you have any further questions, please send an email to ACER-ELE-2020-001@acer.europa.eu

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Annexes

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Relevant articles of the Electricity Regulation

- **Article 14(1):** *"Member States shall take all appropriate measures to address congestions.* ***Bidding zone borders shall be based on long-term, structural congestions in the transmission network.*** *Bidding zones shall not contain such structural congestions unless they have no impact on neighbouring bidding zones, or, as a temporary exemption, their impact on neighbouring bidding zones is mitigated through the use of remedial actions and those structural congestions do not lead to reductions of cross-zonal trading capacity in accordance with the requirements of Article 16.* ***The configuration of bidding zones in the Union shall be designed in such a way as to maximise economic efficiency and to maximise cross-zonal trading opportunities*** *in accordance with Article 16, while maintaining security of supply."*
- **Article 14(5):** *"[…] The methodology shall be based on* ***structural congestions which are not expected to be overcome within the following three years****, taking due account of tangible progress on* ***infrastructure development projects*** *that are expected to be realised* ***within the following three years."***
- **Article 15(5):** *"For those Member States for which the assessments referred to in paragraph 4 demonstrate that a transmission system operator has not complied with the linear trajectory,* ***the relevant Member States shall, within six months of receipt of the assessment report referred to in paragraph 4, decide unanimously whether to amend or maintain the bidding zone configuration within and between those Member States****. […]"*

Thank you for your attention!

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