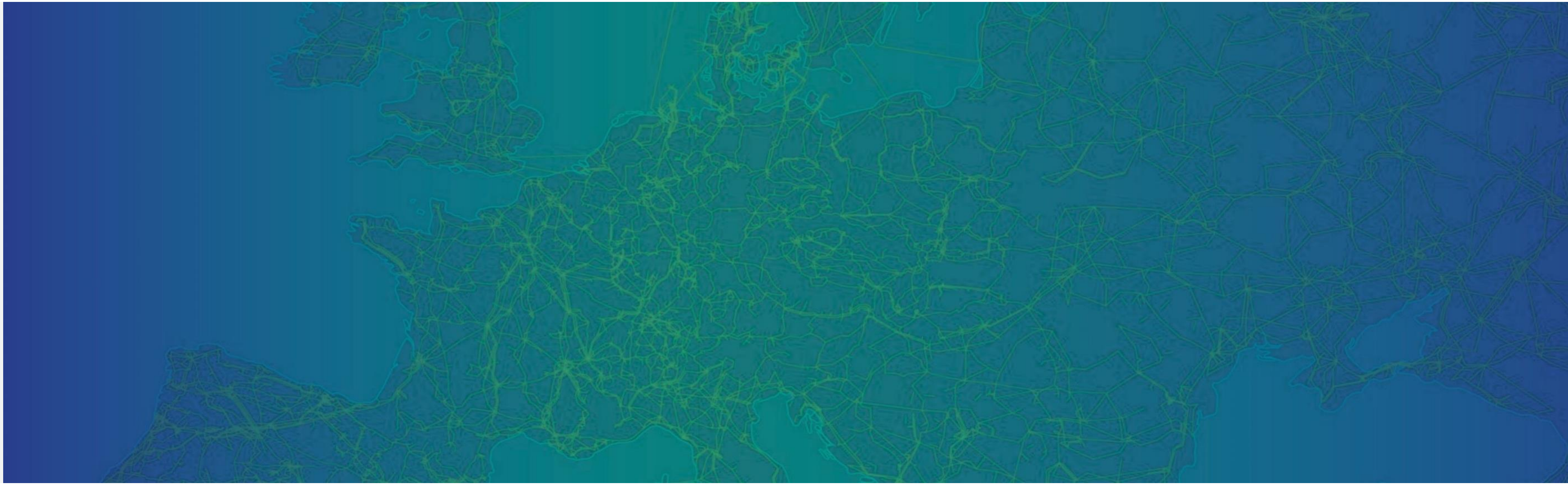
Explanatory document for the public consultation

07 November 2024



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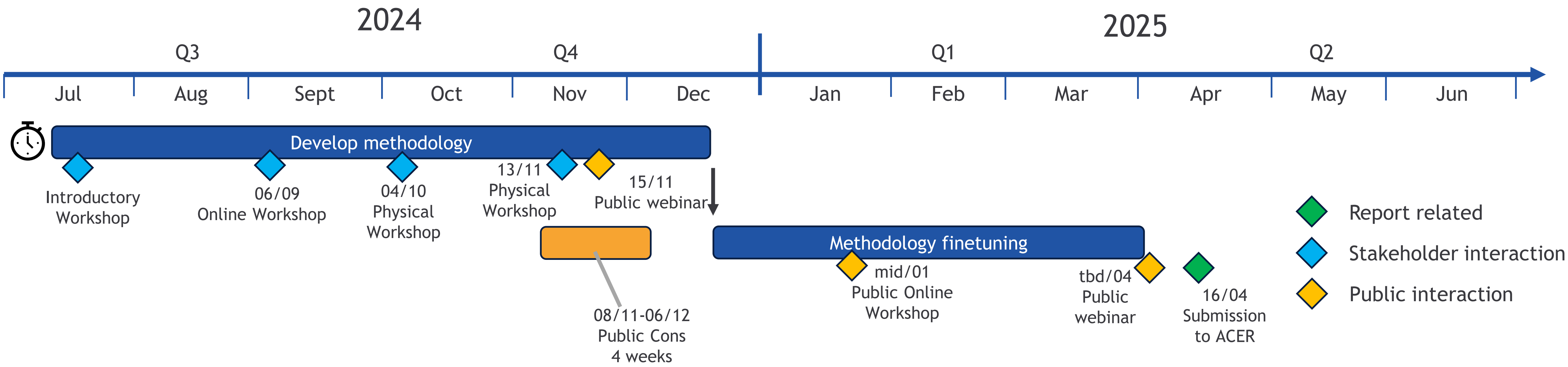
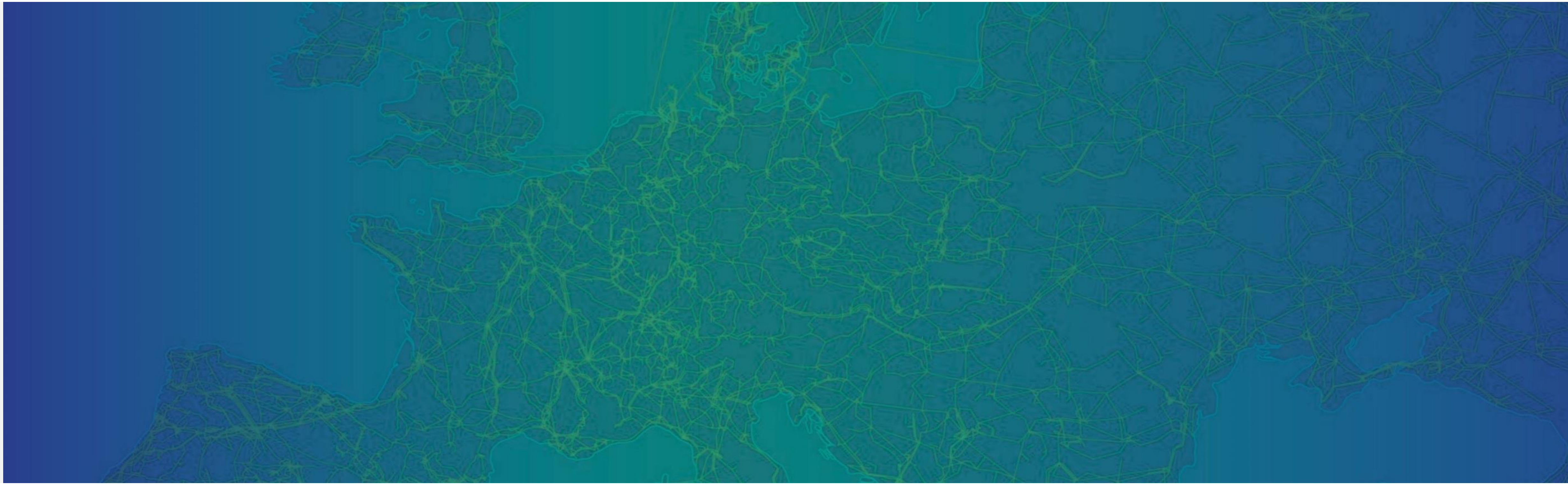
Timeline


2024
2025
Q3
Q4
Q1
Q2
Jul
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Develop methodology
Introductory Workshop
06/09 Online Workshop
04/10 Physical Workshop
13/11 Physical Workshop
15/11 Public webinar
08/11-06/12 Public Cons 4 weeks
Methodology finetuning
mid/01 Public Online Workshop
tbd/04 Public webinar
16/04 Submission to ACER
Report related
Stakeholder interaction
Public interaction

Boundaries of the methodology and general approach

Relevant information for Articles 1, 5-12, 14 of the draft methodology



Definition of flexibility needs

From the EMDR…

EMDR Def.

"**Flexibility**" means the ability of an electricity system to adjust to the variability of generation and consumption patterns and to grid availability, across relevant market timeframes

Art 19e

…The report referred to in paragraph 1 shall at least:

(a) evaluate the different types of **flexibility needs**, at least on a seasonal, daily and hourly basis, **to integrate electricity generated from renewable sources in the electricity system**, inter alia, different assumptions in respect to electricity market prices, generation and demand;

…develop a methodology for the analysis by transmission system operators and distribution system operators of the **flexibility needs**, taking into account at least:

(i) all available sources of flexibility in a cost-efficient manner in the different timeframes, including in other Member States;

(ii) planned investment in interconnection and flexibility at transmission and distribution level; and

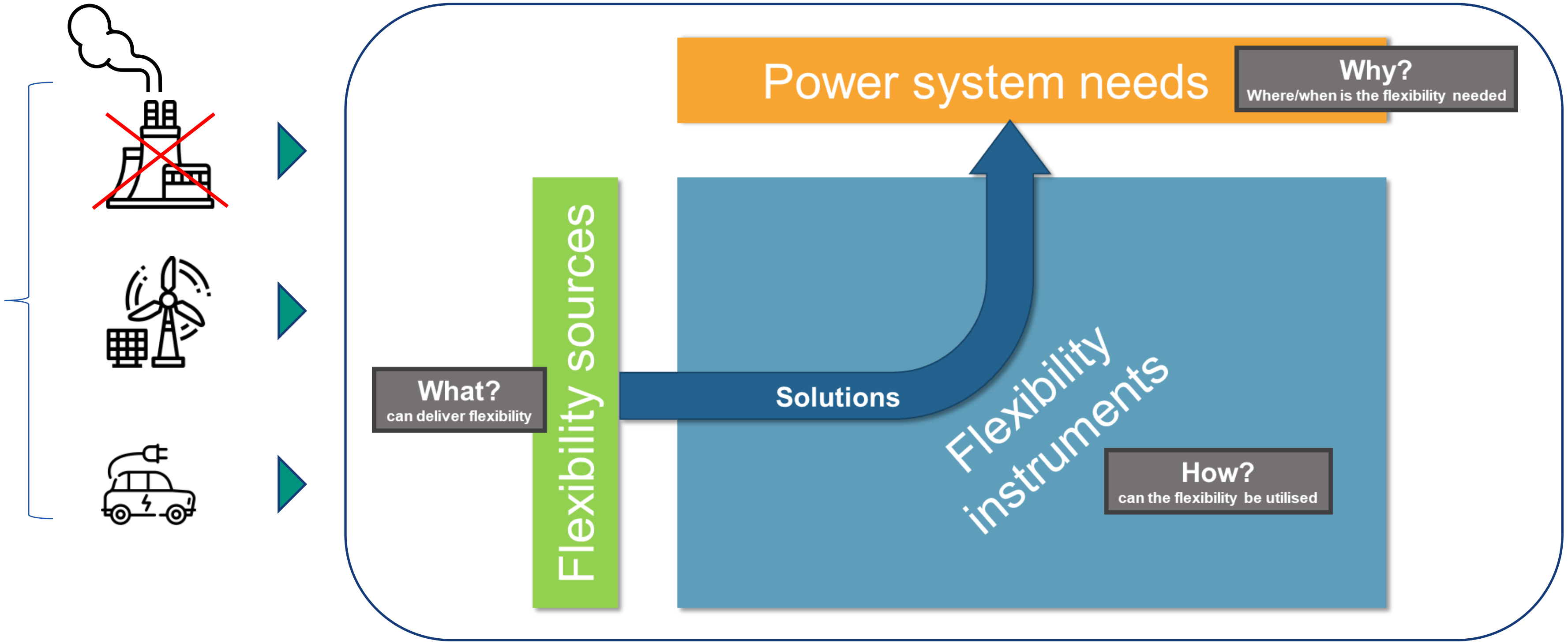
(iii) **the need to decarbonize the electricity system** in order to meet the Union's 2030 targets for energy and climate, as defined in Article 2, point (11), of Regulation (EU) 2018/1999, and its 2050 climate neutrality objective laid down in Article 2 of Regulation (EU) 2021/1119, in compliance with the Paris Agreement adopted under the United Nations Framework Convention on Climate Change.

Definition of flexibility needs

What is a flexibility need? When does it occur?

In a fully carbon neutral system, based on electrified consumption and variable renewable energy sources, flexibility will be essential to complement the variability of both generation, demand and grid availability and to address the increase of system complexity

EU targets

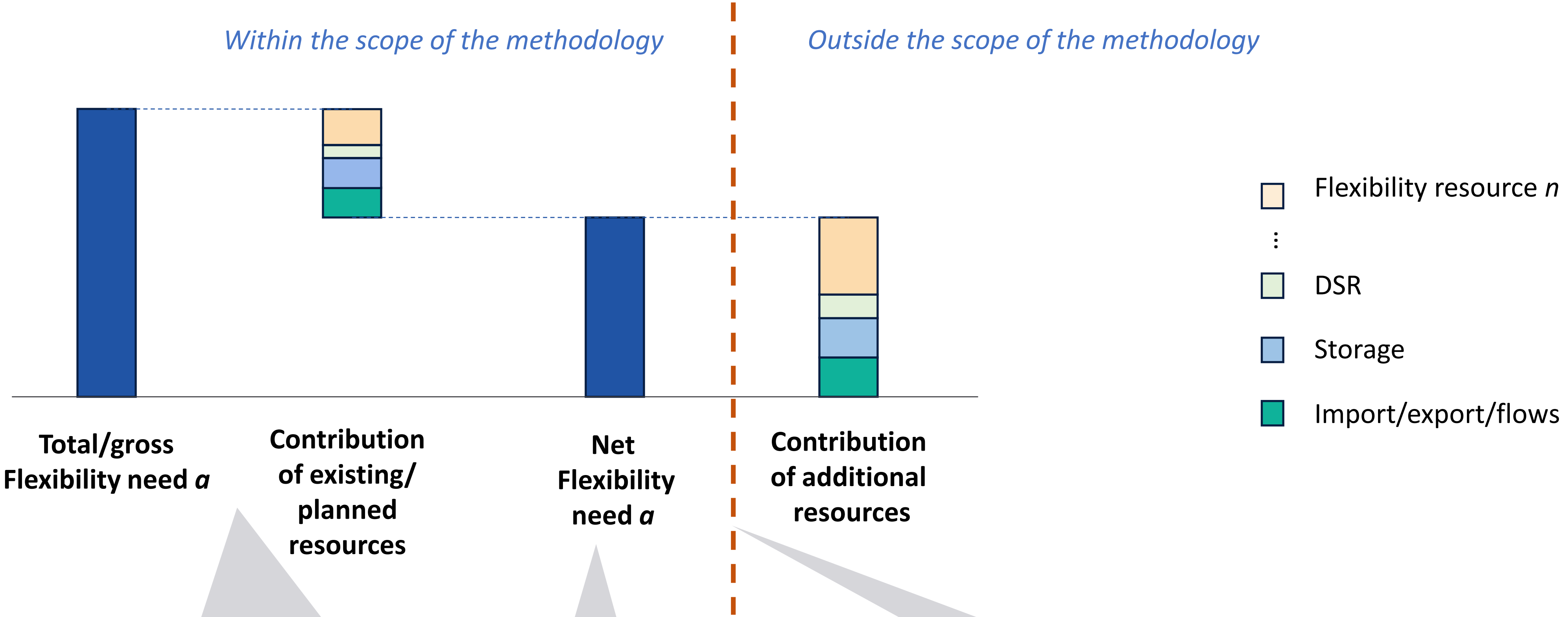


"Flexibility" means the ability of an electricity system to adjust to the variability of generation and consumption patterns and to grid availability, across relevant market timeframes

A flexibility need occurs when the power system is not able to cover this variability and availability

Definition of flexibility needs

Boundaries of the methodology



The methodology will consider appropriate **reference conditions** to account for:

- Planned investments in grid/flexibility
- Cost-efficient contribution of existing/planned flexibility resources
- Different assumptions in respect to electricity market prices, generation and demand

Flexibility needs are to be provided **through capability types**, i.e. actionable metrics (capacity, energy) **useful to policymakers** that keep technological neutrality

The methodology will also provide for **guiding criteria** to best interpret flexibility needs and orient policymakers to the identification of most suitable flex resources to cover them

General approach

INPUTs

ERAA/Adequacy output
- Relevant market simulation results time series

ERAA/Adequacy input
- Installed capacity of generation, flexible resources
- Net transfer capacity between BZs
- Standard Ramping limits

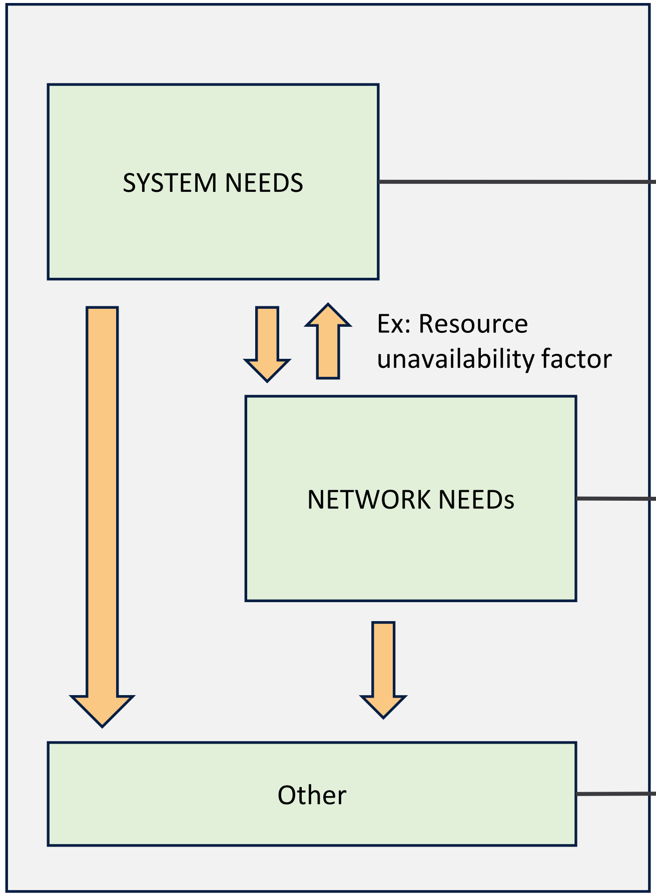
Additional input - TSO
- National ramping limits
- Historical forecast errors of generation and demand

DNDP input/output
- Flexibility needs (grid limitations)

Additional input - DSO
- Flexibility needs from other relevant studies

Additional input
- Additional data needed for guiding criteria

JOINT METHODOLOGY (Post processing of input)



OUTPUTs (Capability types and other indicators)

- RES integration needs: surplus generation (GW, TWh)
- Ramping needs: residual load variations (GW)
- Short-term flexibility needs : prediction errors (GW)

- Congestion needs

- Indicators for guiding criteria

Guiding principles to quantify system needs and support policy decision

- Define achievable, necessary and sufficient requirements for each Member State taking into account availability of information/tools and time constraints
  - Manage complexity in view of additional information it brings (avoid complex ‘to be developed’ methods)
  - Take into account existing constraints on availability of data/tools and effective implementation within the Regulation timeframe
  - Provide a base case assessment + additional options for Member States to conduct additional analysis, sensitivities, indicators whenever deemed possible/relevant
- Ensure consistency with ERAA/NRAA (in line with Article 19e of the EMDR)
  - Assessment mostly based on output data of ERAA/NRAA
  - Align with ERAA/NRAA scenarios and assumptions on sector coupling, non-fossil fuel resources, interconnections, ….
  - Base case assessment based on post-processing of ERAA/NRAA output. (Alternative option – still under discussion in slide 47-48)
  - Revisions of ERAA/NRAA input data, methodologies or outputs are out of scope of the FNA methodology
- Reference condition should reflect ERAA/NRAA evolutions and national needs
  - Assessment based on at least one reference scenario of ERAA/NRAA and associated market dispatch availability
  - Possibility for national TSO to run assessments based on additional reference conditions, including after adequacy step
- Ensure complementarity with ERAA/NRAA studies
  - Indicators for RES integration needs, ramping needs and short-term flexibility needs not accounted in ERAA/NRAA
- Enrich system needs results with insights on the TSO-DSO networks only when/where information is available and relevant
  - Limitations of generation output due to congestion (when/where available and not already accounted in ERAA/NRAA input data)
  - Availability of existing flexible assets on T/DS-level (when/where available and not already accounted in ERAA/NRAA input data)

ERAA/NRAA: European/National Resource Adequacy Assessment

Guiding principles to quantify network needs and support policy decision

- Define achievable, necessary, and sufficient requirements in each Member State taking into account availability of information / tools and time constraints
  - Manage complexity in view of the additional information it brings (avoid complex ‘to be developed’ methods)
  - Take into account existing limits on availability of data / tools and effective implementation within the Regulation timeframe
  - Provide a base case assessment + additional options for Member States to conduct additional analysis, sensitivities, indicators whenever deemed possible / relevant

- Ensure consistency with national studies
  - Network needs assessment mostly based on output of Network Development Plans and needs for local services
  - Consistency requirements of NDP include consistency between themselves, with National Energy and Climate Plans …

- Ensure complementarity with existing studies
  - DNDP focus on local services, while other studies can provide further assessments

- Enable to enrich system needs results with insights on the DSO networks only when / where information is available and useful
  - Limitations of generation output due to congestion (when/where available and not already accounted in ERAA/NRAA input data)
  - Availability of existing flexible assets on T/DS-level (when/where available and not already accounted in ERAA/NRAA input data)

Flexibility needs covered

Relevant information for Articles 5-12 of the draft methodology

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Type of flexibility needs covered

System Needs

- Inertia
- Restoration

Out of scope following very TSO specific nature

- Short-term: prediction errors
- Ramping: residual load variations
- RES integration: surplus generation

Covering both TSO balancing and market portfolio balancing

- Adequacy & RES shortage

Already covered in ERAA/NRAA

Network needs

- Congestion management
- Voltage control*

*Included in DSOs studies

Choice of needs to be included in the assessment follows principles of compliance with the EMDR, relevance, complementarity with respect to other assessments and practical implementation

System needs – Overview

Seasonal → Daily → Hourly → Real time

System needs

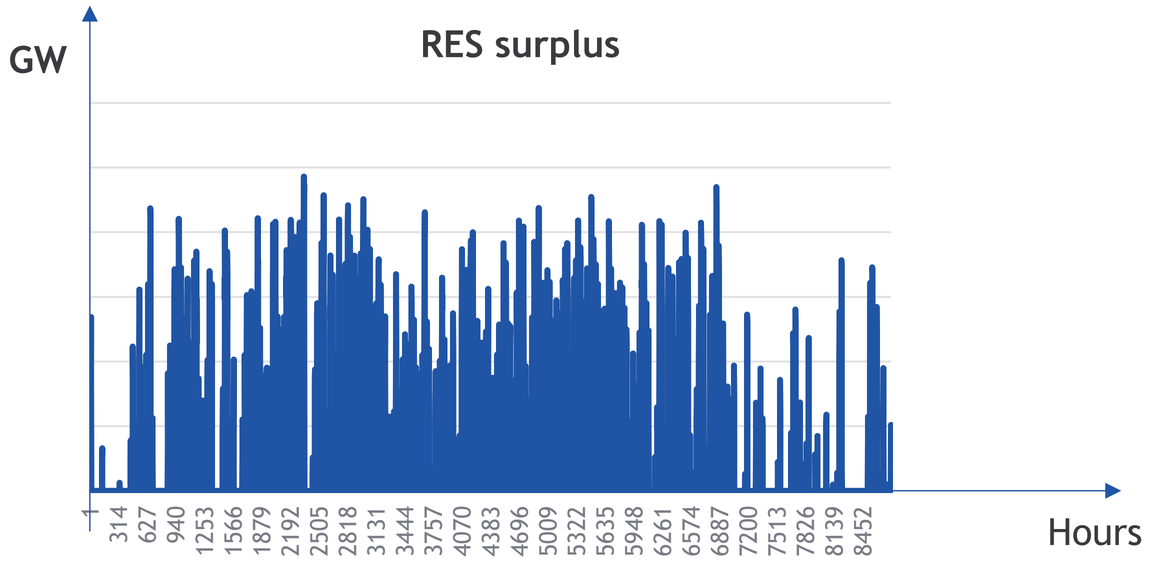
RES integration needs : surplus generation	Ramping needs: residual load variations	Short-term flexibility needs : prediction errors
• Study downward flexibility needs based on behavior of the ERAA/NRAA RES generation curtailment indicator in terms of energy, duration and intervals and periods and conditions at risk. • Characterize flexibility needs into different timeframes (daily, weekly, annual) through the optimization of a dummy flex variable	• Quantify flexibility shortages associated to the management of up- and downward residual load ramps over a period of 60 minutes or lower based on the technical constraints (e.g. ramping constraints) of dispatched units	• Quantify flexibility shortages associated to the management of up- and downward residual load / generation prediction errors based on the margins of dispatched units

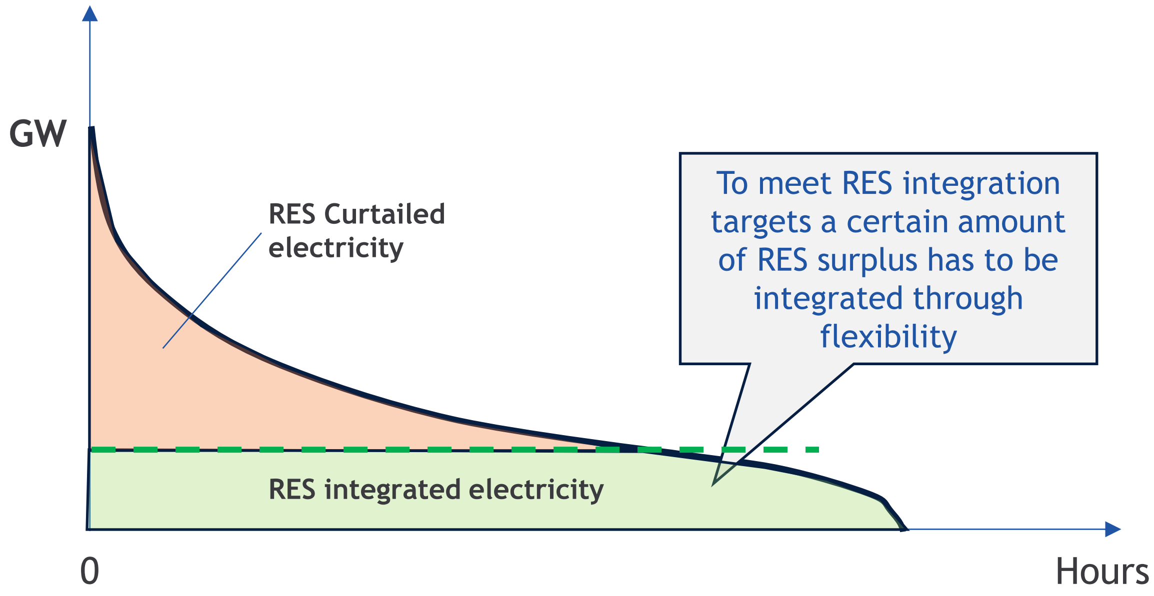
Pending relevance and availability of data

Network needs

- Injection constraints on T/DS-level (where not already accounted in ERAA/NRAA)
- Availability of existing flexible assets on T/DS-level (where not already accounted in ERAA/NRAA)

System needs – RES integration needs





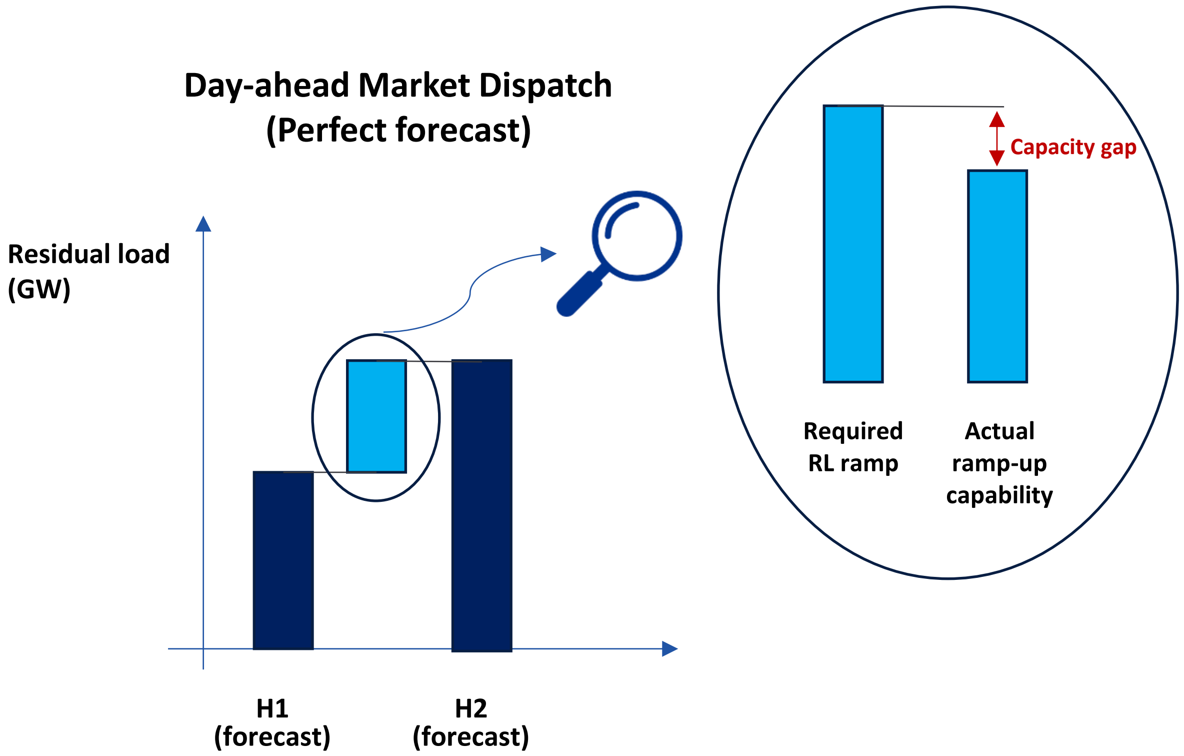
When it occurs? Why is important?

- As a result of the increasing RES installed capacity, **RES surplus conditions will become structural**
- When RES surplus cannot be integrated in the system (technically and economically) it results in **curtailed electricity**
- Member States are requested to meet their individual **RES integration targets** defined in National Energy & Climate Plans or other national policies
- In this context **a flexibility need occur when the RES curtailed electricity does not allow the Member State to meet its RES integration targets**

Expected metrics/Capability type

- Max, min, mean percentile values of RES surplus (TWh, GW) across relevant timeframes (hourly, daily, weekly, monthly/seasonal)
- Probabilistic distribution of RES surplus (TWh, GW) across relevant timeframes (hourly, daily, weekly, monthly/seasonal)
- Other relevant representations (heat maps, correlation)
- Capacity of dummy & technology neutral flexibility variable (GW) to reduce daily, weekly and monthly needs while meeting RES integration targets

System needs – Residual Load variation



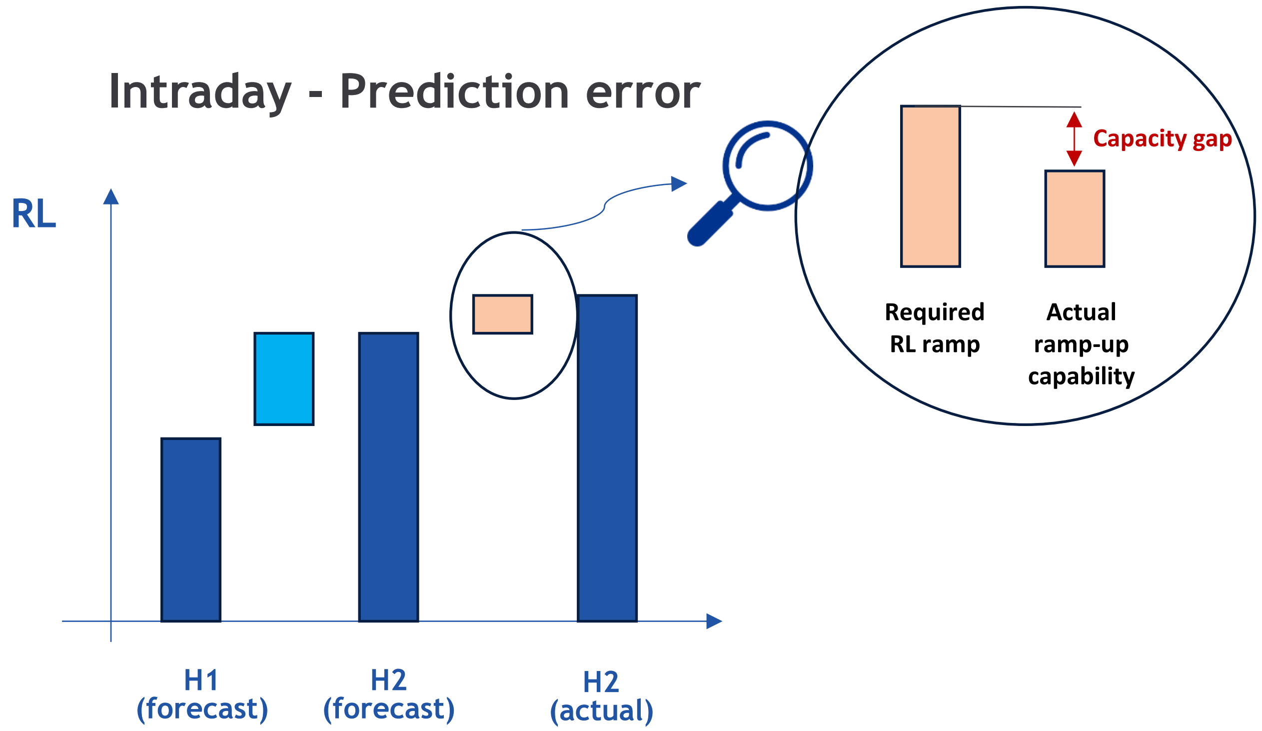
When it occurs? Why is important?

- Flexible units are normally needed and used to **manage forecasted variations of Residual Load (RL)**, broadly defined as the difference between demand, RES generation and Must Run generation
- **Actual ramping capability** of existing/planned flexible generation units **can be constrained** by their **technical limits** and **availability factors**
- In this context **a flexibility need occurs when actual ramping capability is not enough to meet the required RL ramp**

Expected metrics/Capability type

- Technology-neutral capacity gap (GW) to meet ramp-up/down requirements
- Max, min, mean, percentile and other characterization across different Climate Years

System needs – Prediction errors



When it occurs? Why is important?

- Flexible units are also needed to **manage unexpected variations of Residual Load** due to **errors in the prediction** of electricity generation and demand and due to outages
- **Actual ramping capability** of existing/planned flexible generation units **can be constrained** by their **technical limits** and **availability factors**
- In this context **a flexibility need occurs when actual ramping capability is not enough to meet the required RL ramp**

Expected metrics/Capability type

- Technology-neutral capacity gap (GW) to meet ramp-up/down requirements
- Max, min, mean, percentile and other characterization across different Climate Years

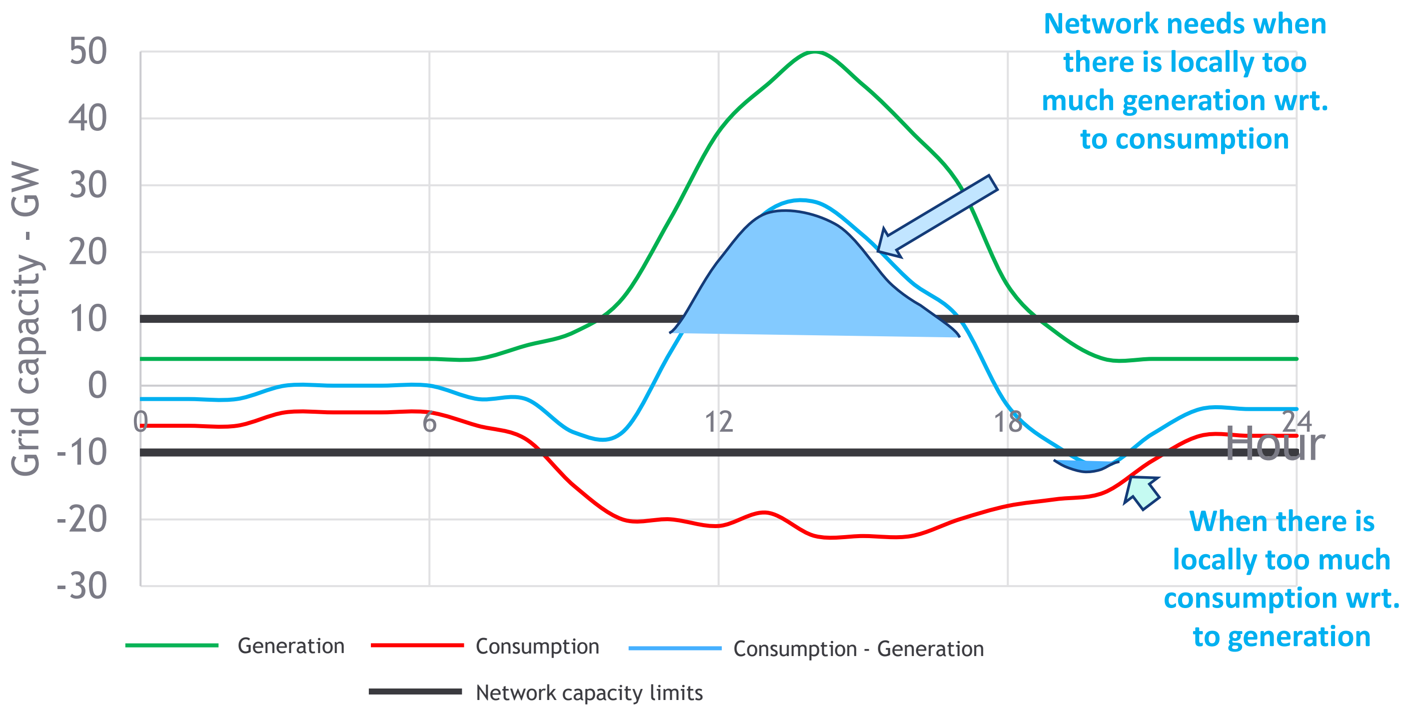
Network needs – Congestion & Operational Limits

Graph illustrates network needs
in a high PV area

when the grid is operated
in **normal "N" scheme**

/!\ Network needs **during outage have a completely different shape**

(unpredictable start time and duration, quantity depending on the load on "recovery" assets)



Network needs – Congestion & Operational Limits

When and where it occurs? Why is important?

- A ‘**congestion issue**’ means a situation when the electric current flow through a physical asset exceeds operational limits
- SO **must maintain power flows within operational** limits, which induces flexibility needs to prevent or solve congestion
- Congestion can occur during sunny days (high PV areas), day or night during windy periods (wind farms areas), a combination of both in areas with lots of PV and wind farms.
- Congestion can also occur at any time for durations depending on the unavailable asset and the local and temporal network situation.
- Congestion reduces the amount of generation available to, or demand needed from, the system even if there would be no need from a system « copper plate » point of view.

Network needs – Congestion & Operational Limits

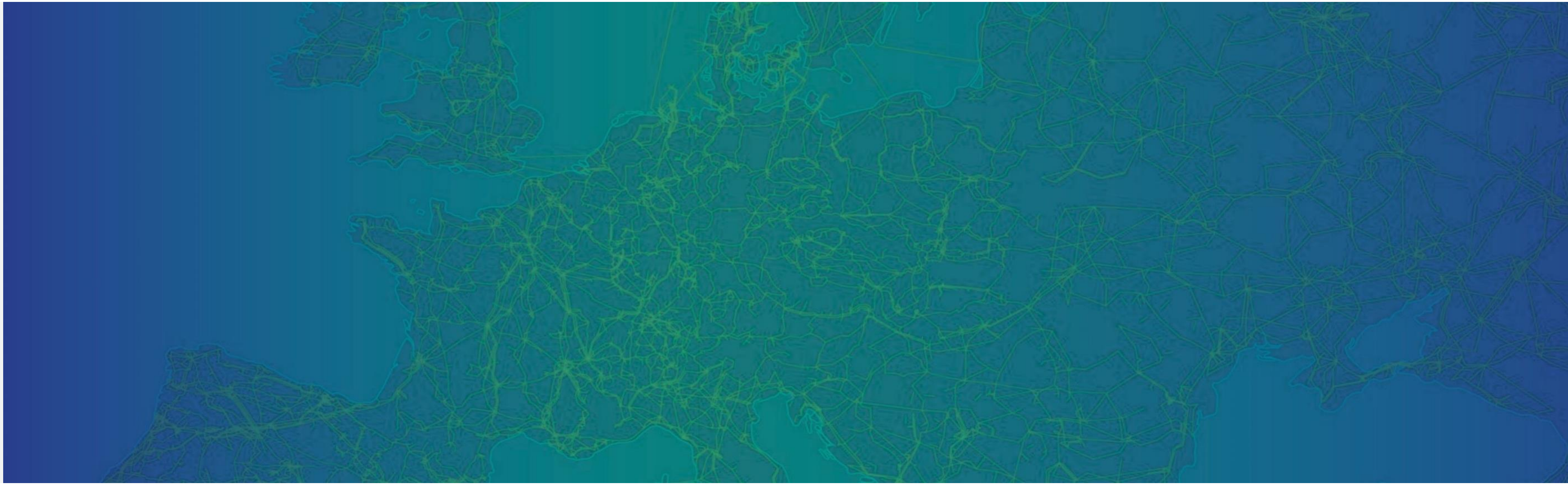
Expected metrics / Capability type

Upwards and downwards data:

- Max GW of RES curtailment or demand outage expected in critical events over the planning time
- If possible : on the critical events, over the planning horizon : Expected TWh/year (split by season if possible) and/or TWh/day (typical days if possible)
- Hourly GW for specific days (if possible / available)
- /!\ The above metrics may be relevant for normal « N » scheme » ; metrics for N-1 (planned/unplanned outage) schemes would be different

Input scenarios and sets of data

Relevant information for Articles 6-7, 11 of the draft methodology



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ERAA/NRAA methodology vs FNA

A grid is adequate when sufficient generation and import capacity allow demand to be met, guaranteeing security of supply

Storage

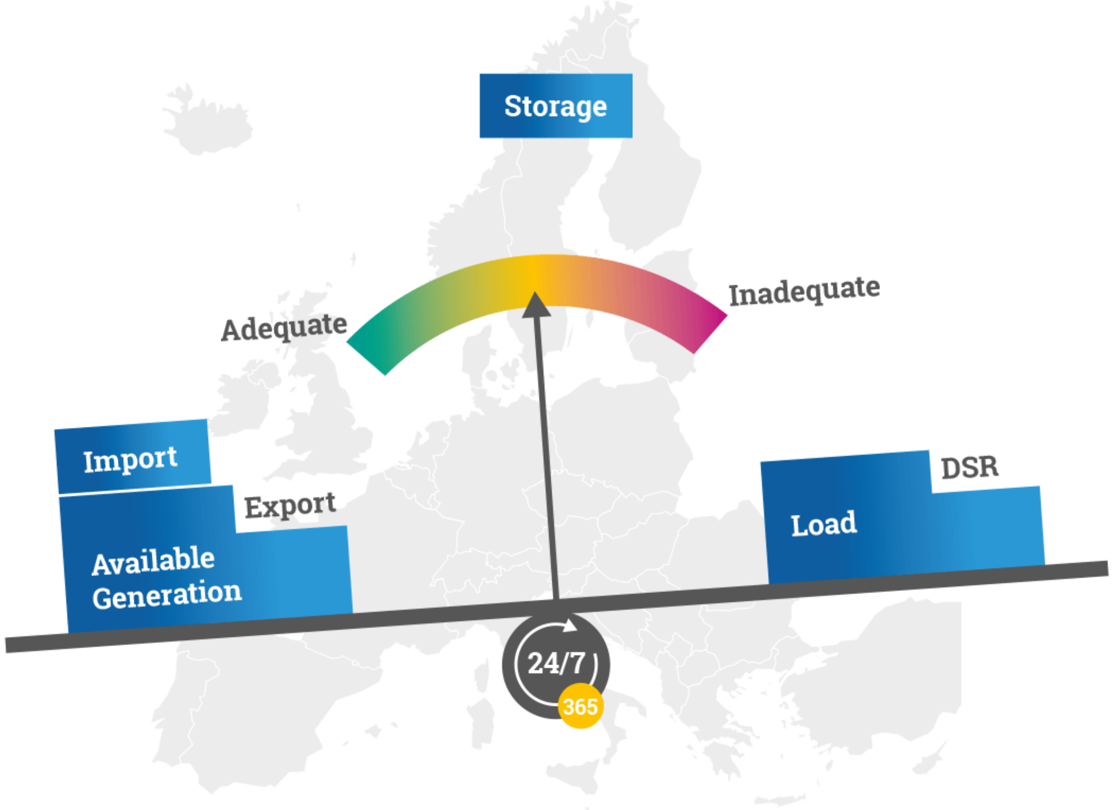
Available Generation | Network Infrastructure | Demand

=

Deterministic Forecast
- ENTSOs' Scenarios
- Planned Outages

+

Uncertainty in supply:
- Wind generation
- Solar generation
- Hydro generation
- Forced outages



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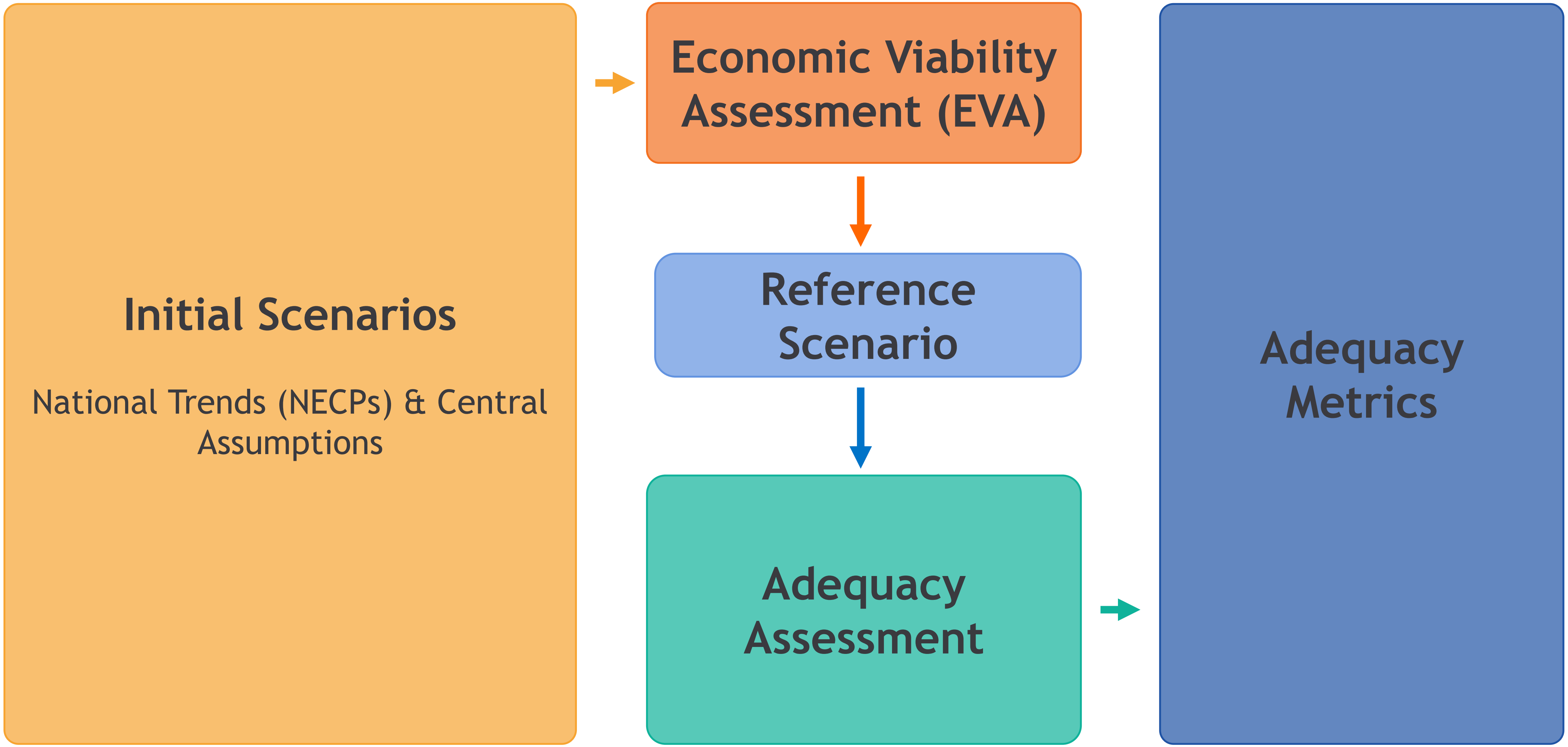
Deterministic Forecast
ENTSOs' Scenarios

+

Uncertainty in demand:
- Temperature/climate

The ERAA – A multi-step process



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The Framework of the ERAA

PEMMDB

Net Generation Capacities

Market Coupling

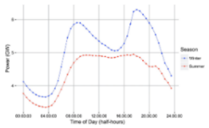
Net Transfer Capacities
Flow-Based

PECD

Capacity Factors


Hydro Database

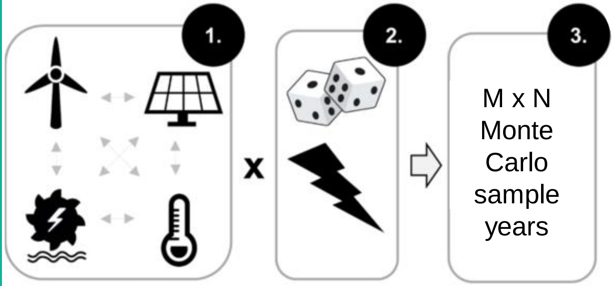

Temperature profiles

DEMAND

Native demand forecasts

National Trends (NECPs) & Central Assumptions

Economic Viability Assessment (EVA)
- Stochastic overall costs minimization
- Iterative revenue-based approach

Reference Scenario
- Include EVA entry/exit of market capacity

Economic Dispatch* Model: Monte Carlo Simulation


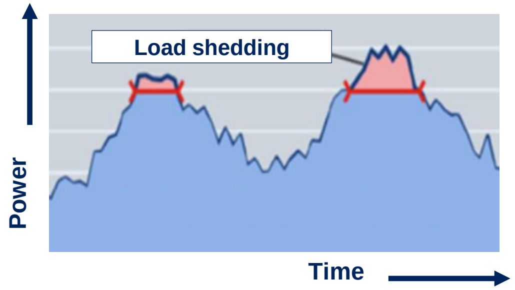
N years of independent climate data

M random draws for unplanned outages

adequacy Metrics

$$EENS = \frac{1}{M \times N} \sum_j ENS_j$$

$$LOLE = \frac{1}{M \times N} \sum_j LLD_j$$



LOLE = Loss Of Load Expectation [h/yr]:

average number of hours in which the demand exceeds the generation and import capacity in a market area.

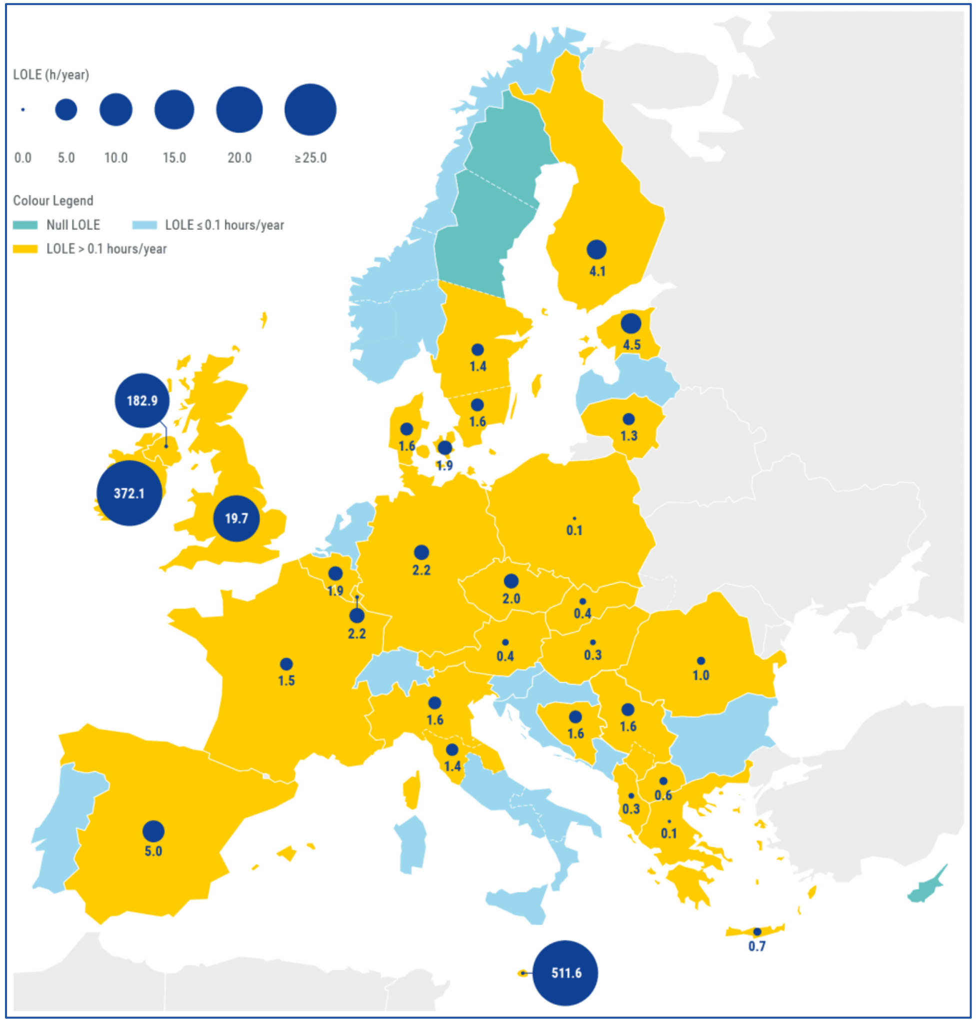
EENS = Expected Energy Not Served [GWh/yr]:

average energy not supplied when the demand exceeds the generation and import capacity in a market area.

* The ERAA Economic Dispatch model dispatches resources in the system to meet demand for every hour of the simulation and every study zone, while minimizing costs and respecting a set of constraints (Interconnector capacity for example)

ERAA adequacy results published – 2023 edition

Adequacy



ERAA/NRAA as an input to FNA (1 of 2)

The use of ERAA/NRAA market dispatch output as a starting point for the Flexibility Needs Assessment allows a reliable quantification of needs while complying with the requirements of the EMDR

"…estimated flexibility needs for a period of at least the next 5 to 10 years" → ERAA/NRAA already cover the + 10 years horizon

"…achieve security and reliability of supply" → Adequacy is part of the security and reliability of supply. FNA complements ERAA/NRAA

"The report shall be consistent with the European resource adequacy assessment and national resource adequacy assessments" → Consistency is ensured via use of ERAA/NRAA reference scenario data

"…taking into account the integration of variable renewable energy sources and the different sectors…,… interconnected nature of the electricity market"

"potential availability of cross-border flexibility/ take into account sources of flexibility that are expected to be available in other Member States"

"consider planned investment in interconnection and flexibility at transmission and distribution level; and

the need to decarbonise the electricity system in order to meet the Union's 2030 targets for energy and climate"

ERAA/NRAA are already based on policy scenarios accounting for:

- Sector coupling (e.g. hydrogen, P2G)
- Planned interconnections
- Modelling of all EU and relevant non-EU countries and associated RES, demand, generation and flexibility

ERAA/NRAA as an input to FNA (2 of 2)

The use of ERAA/NRAA market dispatch output as a starting point for the Flexibility Needs Assessment allows a reliable quantification of needs while complying with the requirements of the EMDR

"…consider the potential of non-fossil flexibility resources such as demand response and energy storage, including aggregation and interconnection, to fulfil the flexibility needs"

"…consider all available sources of flexibility in a cost-efficient manner in the different timeframes, including in other Member States;"

"…Consider different assumptions in respect to electricity market prices, generation and demand"

The key input to the FNA is represented by economic dispatch simulations, that already provide as a result the cost-efficient and optima use of existing available sources of flexibility, including those in other Member States

By considering a wide variety of climate conditions, economic dispatch simulations also intrinsically consider different conditions in respect to resulting electricity market prices, generation and demand, while ensuring compliance with policy targets

Distribution Network Development Plans

Background – legal basis for DNDP in Network Code Demand Response

- Framework Guidelines NCDR (95) The new rules shall establish principles for the DSO's NDP described in Article 32 of the Electricity Directive

2019/944 Article 32

3. The development of a distribution system shall be based on a transparent NDP that the DSOs **shall publish at least every two years** and shall submit to the regulatory authority. The NDP shall provide transparency on the **medium and long-term flexibility services needed**, and shall set out the **planned investments for the next five-to-ten years**, with particular emphasis on **the main distribution infrastructure** which is required in order to connect new generation capacity and new loads, including recharging points for electric vehicles. The NDP shall also include the use of demand response, energy efficiency, energy storage facilities or other resources that the DSO is to use as an alternative to system expansion.

4. The DSO **shall consult** all relevant system users and the relevant TSOs on the NDP. The DSO shall **publish the results** of the consultation process along with the NDP, and submit the results of the consultation and the NDP to the regulatory authority. The regulatory authority may request amendments to the plan.

Background – content of the DNDP

- **General principles on the planning criteria**, allowing for taking into account particular characteristics at national and DSO level. On national level, the DSOs shall apply planning criteria that are **consistent between them** and with the planning methodology of the **national TSOs for the TYNDP** where relevant.
- **Scenario data and/or assumptions** shall be sufficiently consistent among all DSOs on national level, taking into account the scenarios used by the national TSO in its planning.
  - Reflect the most plausible futures of the electricity distribution system **for the next five to ten years**, including anticipatory needs defined in accordance with relevant national processes;
  - Be coordinated between the concerned distribution and transmission system operators;
  - Encompass, at least, **current and forecasted electricity demand, generation and storage capacities and consider national energy and climate plans**, local energy strategies and other relevant development factors
- Information on **planned and ongoing investments and on local flexibility services**

General principles on the DNDP

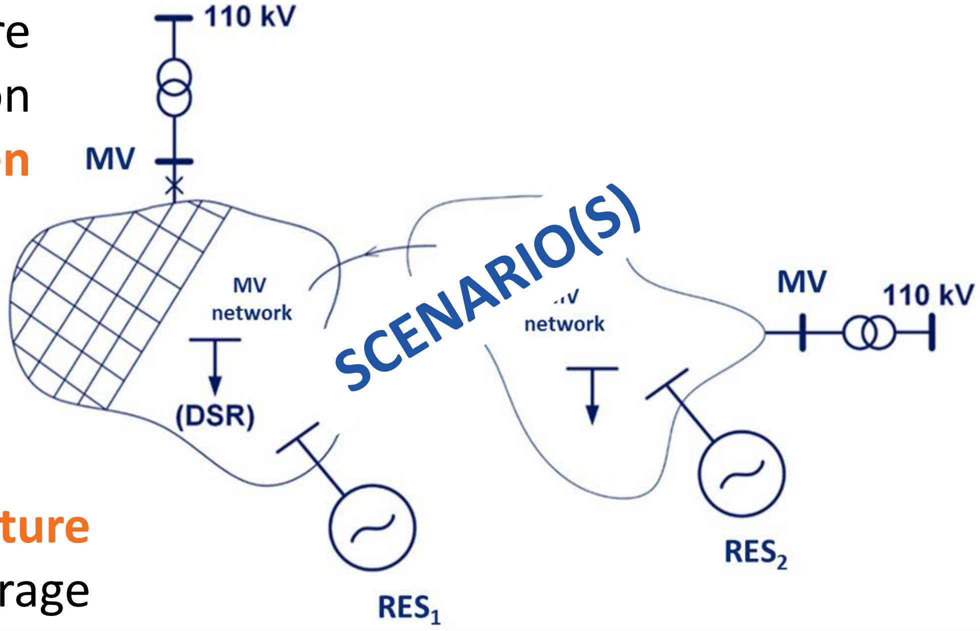
The methodology for planning and identifying needs for local services is described in each DNDP and complies with the following criteria

- abide national regulation and comply with national requirements for operators
- allow for taking into account particular characteristics at national and DSO level (voltage levels, regions)
- identify and establish DSOs observability areas
- be coordinated with the planning methodology and the scenario building process of the national TSOs
- consider development scenario(s)
- consider congestion local services
- consider generation or demand limitations
- consider flexible connection agreements (non-firm connection agreement),
- consider other relevant criteria

Requirements on development scenario(s)

Allow to identify the **future needs** of distribution **network development and local services**

Describe the **most probable prospective(s)** of the future electricity distribution system, in the **five-to-ten** years window



Be coordinated between concerned DSOs and TSOs and national bodies

Encompass existing and future demand, generation, storage capacities, consider national energy and climate plans, local energy strategies and relevant development factors

Scenario(s) **assumptions** be described comprehensively for stakeholders

DNDP as an input to FNA for DSO network needs 1/2

The use of DNDP output as a starting point for the Flexibility Needs Assessment allows a reliable quantification of needs while complying with the requirements of the EMDR

Article 19e

"…estimated flexibility needs for a period of at least the next 5 to 10 years"

"…consider the potential of non-fossil flexibility resources such as demand response and energy storage, including aggregation and interconnection, to fulfil the flexibility needs"

"…consider all available sources of flexibility in a cost-efficient manner in the different timeframes, including in other Member States;"

"potential availability of cross-border flexibility/ take into account sources of flexibility that are expected to be available in other Member States"

DNDP shares a vision of needs for local services on a technology neutral basis

- "provide transparency on the medium and long-term flexibility services needed"
- "include the use of demand response, energy efficiency, energy storage facilities or other resources that the DSO is to use as an alternative to system expansion"
- "take into account demand response and other relevant resources and assess future needs for local SO services, in particular as an alternative for grid reinforcement"

What DNDP contains

- Information to market participants as to future local services needs in the medium and long-term have been taken
- Needs in DNDP may be aggregated, especially at lower voltage levels where the cinematics of the network can depend on a single actual connection application, or the behavior of a single system user

/!\ Actual local services needs being procured may differ from DNDP → in market info

/!\ Network needs may extend beyond local services, in particular considering flexibility relative to connection agreements

/!\ cross border issues are of little relevance for DSO local services

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DNDP as an input to FNA for DSO network needs 2/2

The use of DNDP output as a starting point for the Flexibility Needs Assessment allows a reliable quantification of needs while complying with the requirements of the EMDR

Article 19e

"consider planned investment in interconnection and flexibility at transmission and distribution level;

"…achieve security and reliability of supply"

"…taking into account the integration of variable renewable energy sources and the different sectors…,… interconnected nature of the electricity market"

DNDP "set out the planned investments for the next 5 to 10 years, required to connect new generation capacity and new loads, including recharging points for electric vehicles"

"…Consider different assumptions in respect to electricity market prices, generation and demand"

"be consistent with the European resource adequacy assessment and national resource adequacy assessments"

the need to decarbonise the electricity system in order to meet the Union's 2030 targets for energy and climate"

DNDP assumptions and scenarios are consistent with other national existing scenarios, and in particular NECP, and scenario used by TSO in its planning

Scenario data and/or assumptions shall be sufficiently consistent among all DSOs on national level, taking into account the scenarios used by the national TSO in its planning.

/!\ consistent does not mean and cannot be identical

Elements of methodology for system needs

Relevant information for Articles 5-10, 12 of the draft methodology

Reminder of guiding principles and system needs indicators

Guiding principles

FEASIBILITY
Minimum requirements build on existing tools and post-processing accessible (i.e. ERAA/NRAA) allowing for additional specifications where nationally relevant

CONSISTENCY
Use of scenarios, assumptions and methodologies of existing studies to the extend possible (i.e. ERAA/NRAA)

COMPLEMENTARITY
Complement shortage indicators studied in existing methodologies and studies (i.e. ERAA/NRAA)

APPLICABILITY
Technology-neutral metrics (e.g. MW and MWh of surplus energy) enabling the assessment of policy targets and need for measures

POLICY RELEVANCE
Focus on system needs (variations of generation and demand) and network needs (grid availability) in line with EMDR definition

System needs indicators

RES integration needs : surplus generation

- Study downward flexibility needs based on behavior of the ERAA/NRAA RES generation curtailment indicator in terms of energy, duration and intervals and periods and conditions at risk.
- Characterize flexibility needs into different timeframes (daily, weekly, annual) through the optimization of a dummy flex variable

Ramping needs: residual load variations

- Quantify flexibility shortages associated to the management of up- and downward residual load ramps over a period of 60 minutes or lower based on the technical constraints (e.g. ramping constraints) of dispatched units

Short-term flexibility needs : prediction errors

- Quantify flexibility shortages associated to the management of up- and downward residual load / generation prediction errors based on the margins of dispatched units (ERAA / NRAA)

Network needs

NETWOK NEEDS

RES Injection constraints due to local congestions

General approach – Base case assessment

Out of scope of the FNA

ERAA/NRAA

Economic dispatch simulation

Ensure CONSISTENCY by re-using inputs for ERAA / NRAA :

- Residual load (hourly)
- Residual load variations (hourly)
- Load & Renewable generation (hourly)
- Installed capacities of assets

Ensure CONSISTENCY by re-using results of ERAA / NRAA

- Surplus energy per hour
- Economic dispatch

(per unit / technology, per hour)

Identification or revision of targets for installed non-fossil flexibility resources, to be eventually supported by dedicate mechanisms

In scope of the FNA

System needs assessment

Network needs Assessment

Where applicable

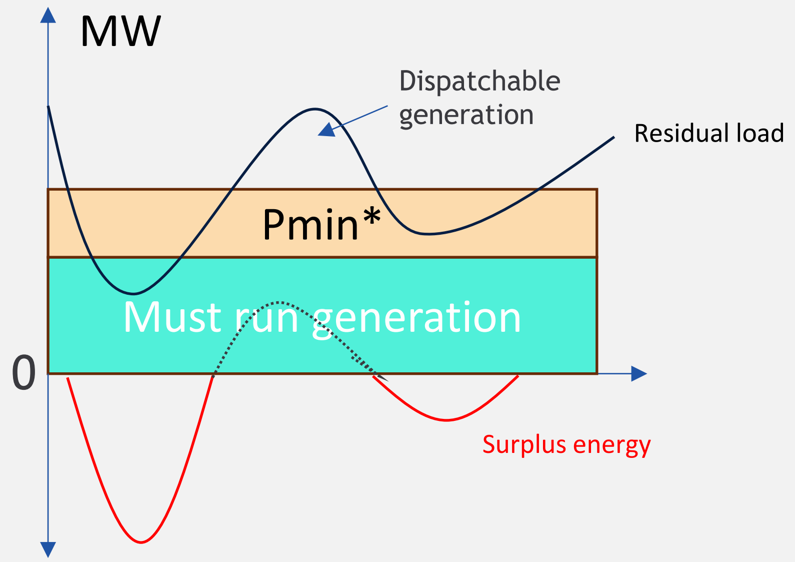
- RES integration
- Ramping
- Short-term flex

Assessment against existing RES integration targets

1. RES integration needs

The RES integration needs is calculated to cover surplus renewable energy that needs to be curtailed, typically during low demand and high renewable generation conditions. It follows system constraints and cannot be stored, shifted or exported by available storage, demand response, other non-fossil flexibililty resources or transmission capacity

Illustration of surplus energy



*minimum generation levels of dispatched units

Retrieve the RES generation curtailment indicator from ERAA / NRAA per hour, per simulation (e.g. climate year) for a certain target year(s)

Network needs

RES Injection constraints due to local congestions

Only when relevant/available

Statistical analysis of the surplus generation :

- Key indicators (average, maximum, percentiles)
- Probability distribution (e.g. box plots)
- Periods at risk (e.g. heat map)
- Conditions at risk (e.g. correlation)

When and under which conditions does a member state faces the risk of surplus/curtailment ?

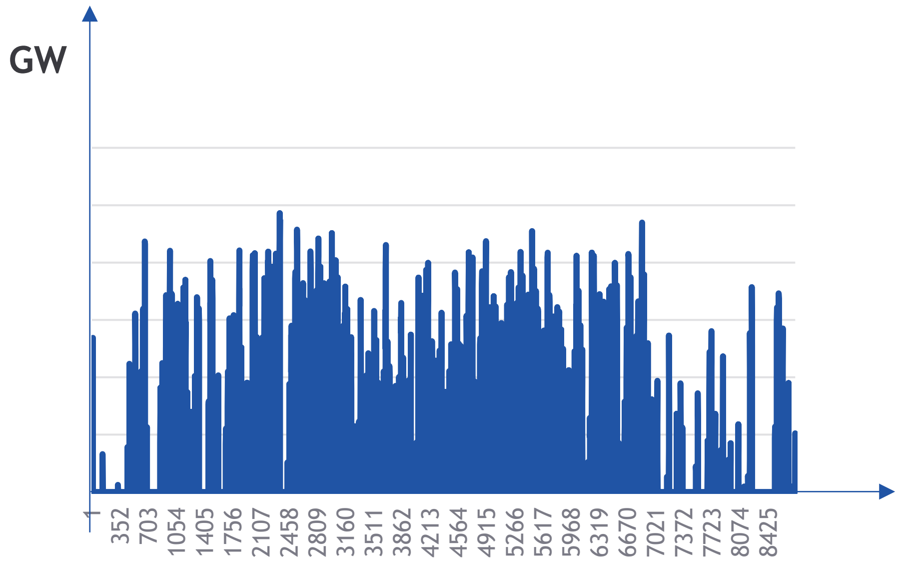
Operational challenge?

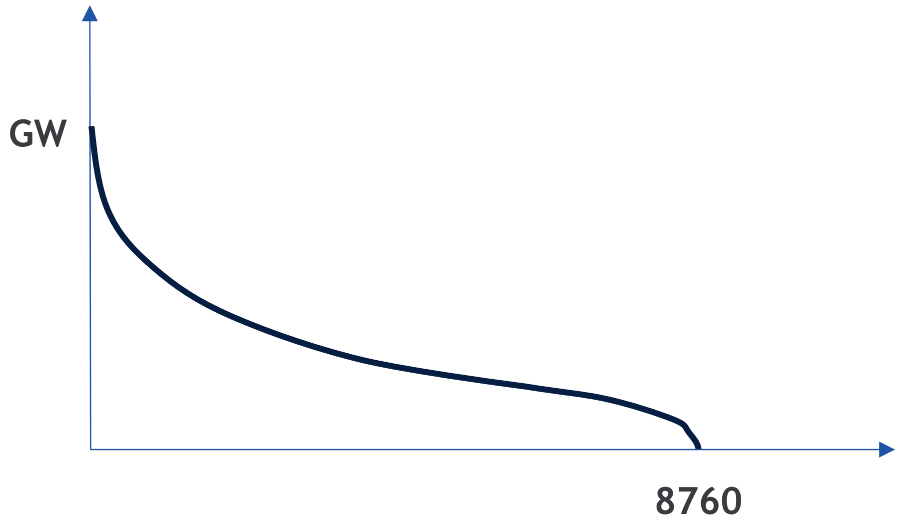
Assessment of total surplus energy in terms of seasonal, daily and hourly basis and in view of national RES integration targets

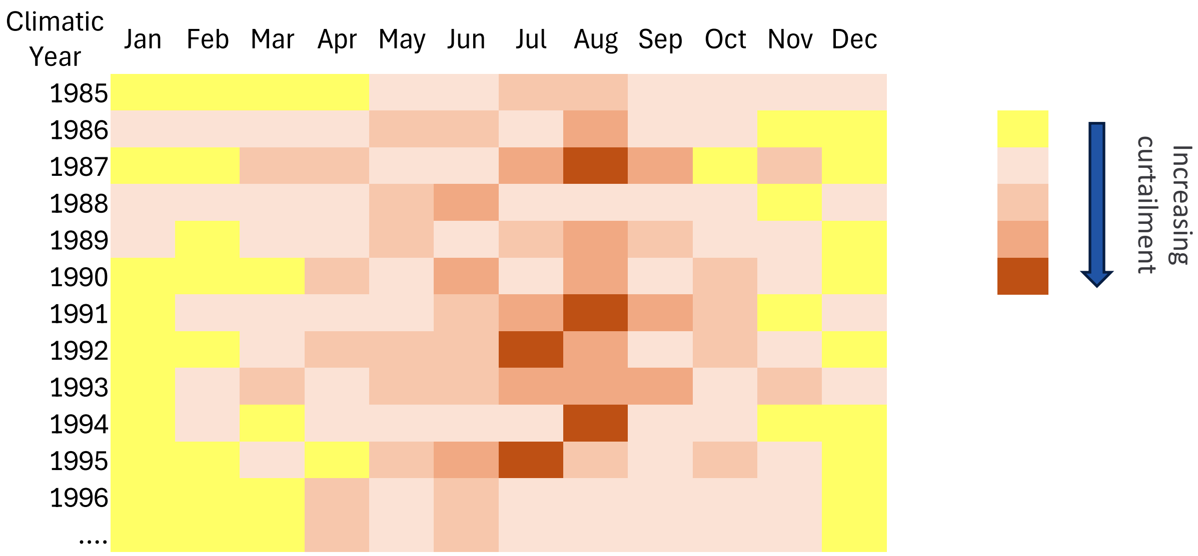
Determination of RES integration needs in terms of an optimization of a 'dummy' flex variable (GW) (representing non-fossil fuel technology) on seasonal, weekly and daily basis

National Targets

1. RES integration needs – Samples of Statistical analysis







The first step involves the characterization of the RES generation curtailment indicator through a wide set of statistical distributions and analysis, including, for example:

a) the average, maximum and minimum amount of RES generation curtailment

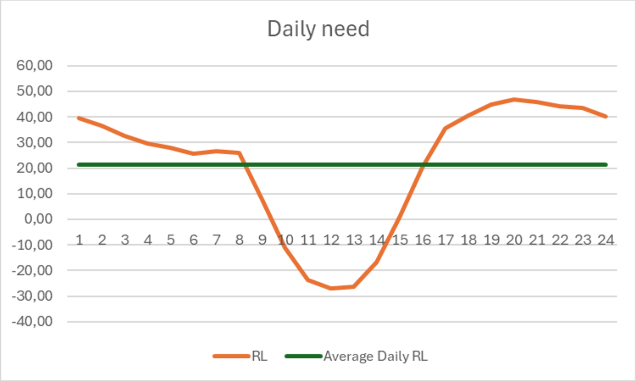
b) a probability distribution of the RES generation curtailment and relevant percentiles (e.g. 99.9%)

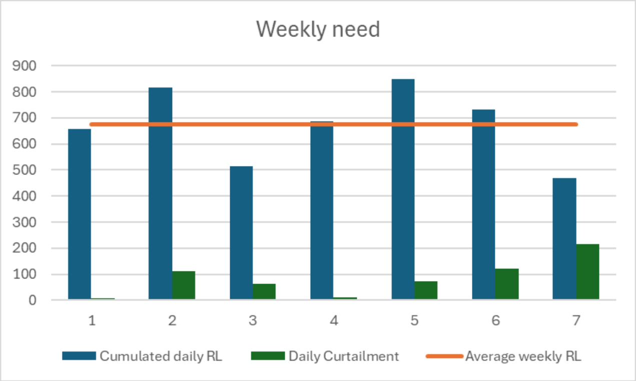
c) a heat map of the curtailment in function of time and day

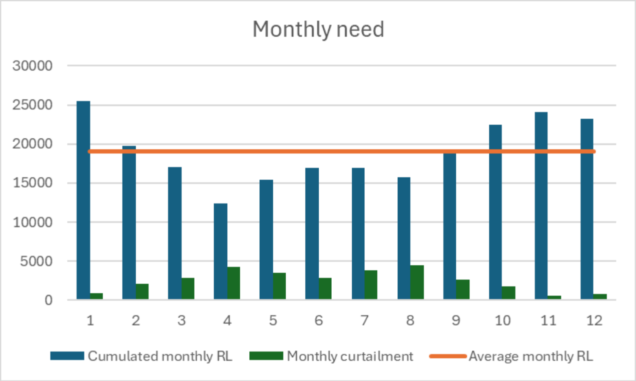
d) the correlation between curtailment and system conditions such as at least the wind generation, solar generation, demand, spot price

e) Other, to be provided by TSOs

RES integration needs – Dummy flex variable







The second step involves the introduction of dummy flex variables representing additional capacity of technology-neutral flexibility resources needed to achieve RES integration targets for each of the analysed timeframes. This can be done through the following actions*:*

1. Derive Dispatched **Residual Load time series** from market dispatch results, considering contribution of existing storage, DSR, other carbon-free flexible resources and interconnections. This can be derived as follows:
    - Negative RL equals RES generation curtailment
    - Positive RL equals generation from dispatchable units other than Must Run
2. Runs 3 different post-processing optimizations introducing a **dummy flex variable** to quantify :
    - Daily dummy flex capacity (GW)
    - Weekly dummy flex capacity (GW)
    - Annual dummy flex capacity (GW)

Each optimization aims at finding the optimal capacity of the dummy flex variable to:

- Achieve the RES curtailment target (Constraint)
- Minimize either daily, weekly or annual needs calculated using Artelys[1] or similar time – decomposition or other approaches (Objective function for each respective optimization)

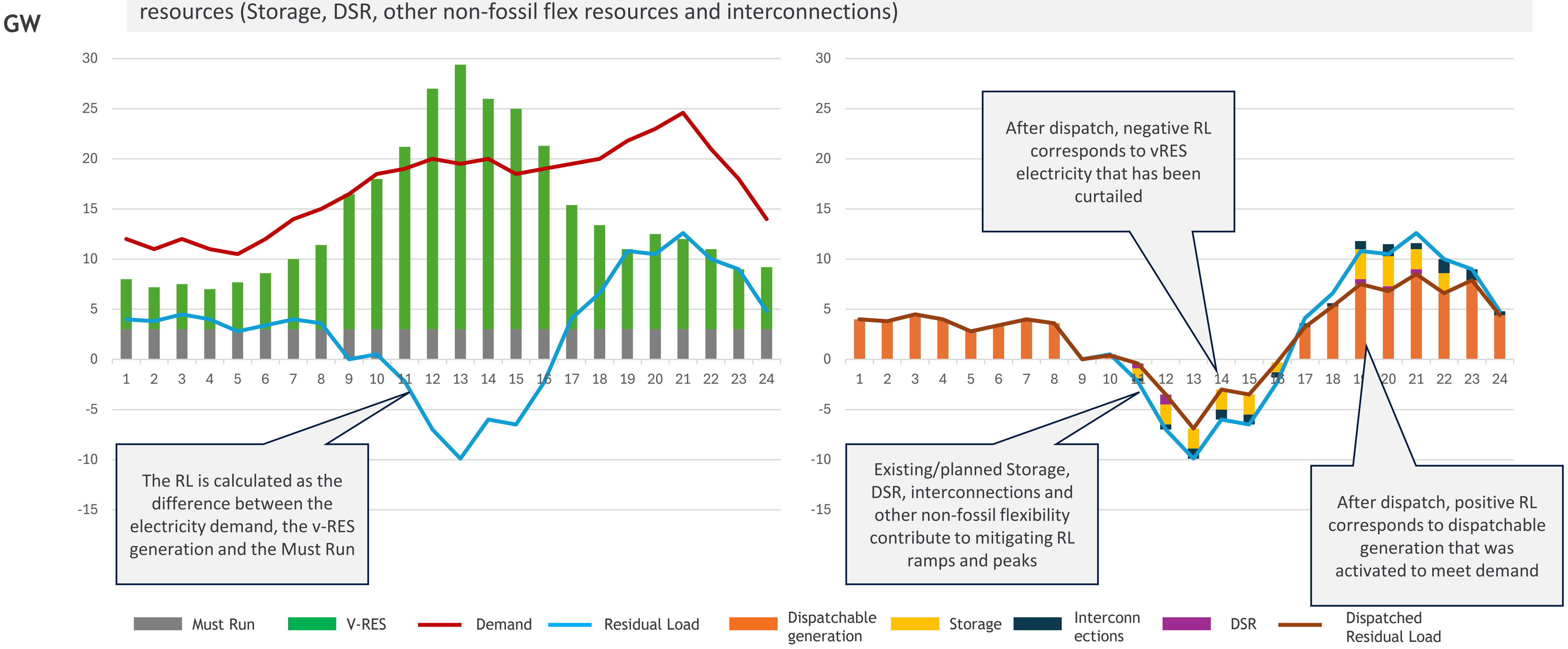
Daily, weekly and annual dummy flex technologies have different equivalent charging/shifting capacity (expressed in equivalent hours) and behaves differently in each corresponding optimization:

- Daily dummy flex charges/shifts during hours of RES excess and discharges/shifts as soon as hourly RL is higher than the daily average
- Weekly dummy flex charges/shifts during hours of RES excess and discharges/shifts proportionally during days having cumulative RL lower than the weekly average
- Annual dummy flex charges/shifts during hours of RES excess and discharges/shifts proportionally during the months having cumulative RL lower than the annual average

1. Based on Metis Study 2018

1. RES integration needs –Dummy flex variable (2 of 4)

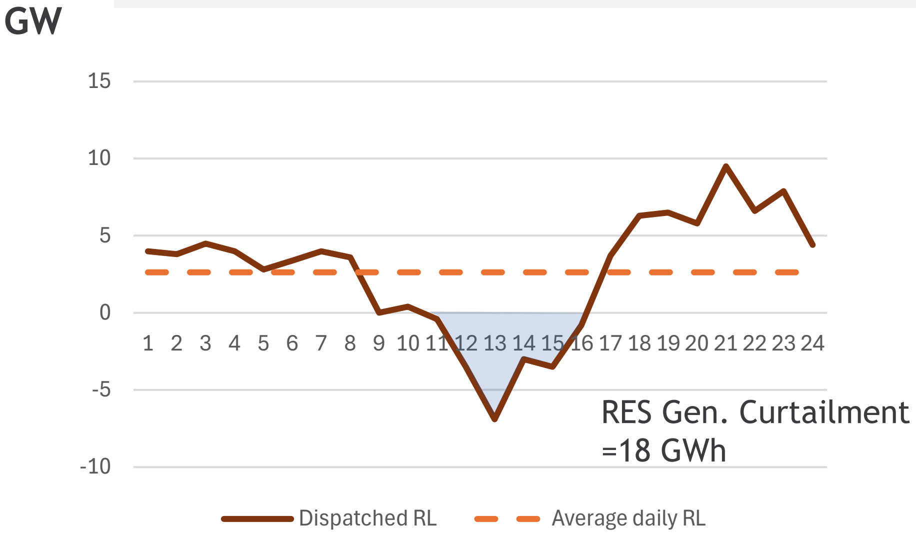
Dispatched Residual Load is obtained from Residual Load by taking into account the dispatched contribution of existing/planned flexibile resources (Storage, DSR, other non-fossil flex resources and interconnections)



1. RES integration needs – Dummy flex variable (3 of 4)

Samples

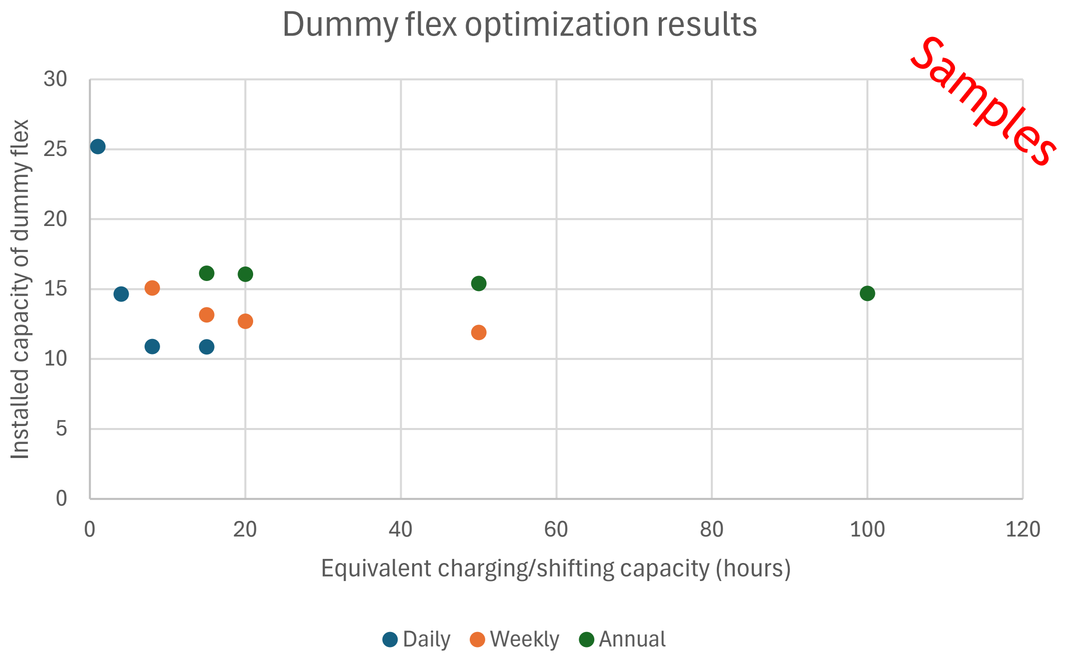
Once dispatched Residual Load is derived, the dummy flex variable can be model as follows *(sample for single day)*

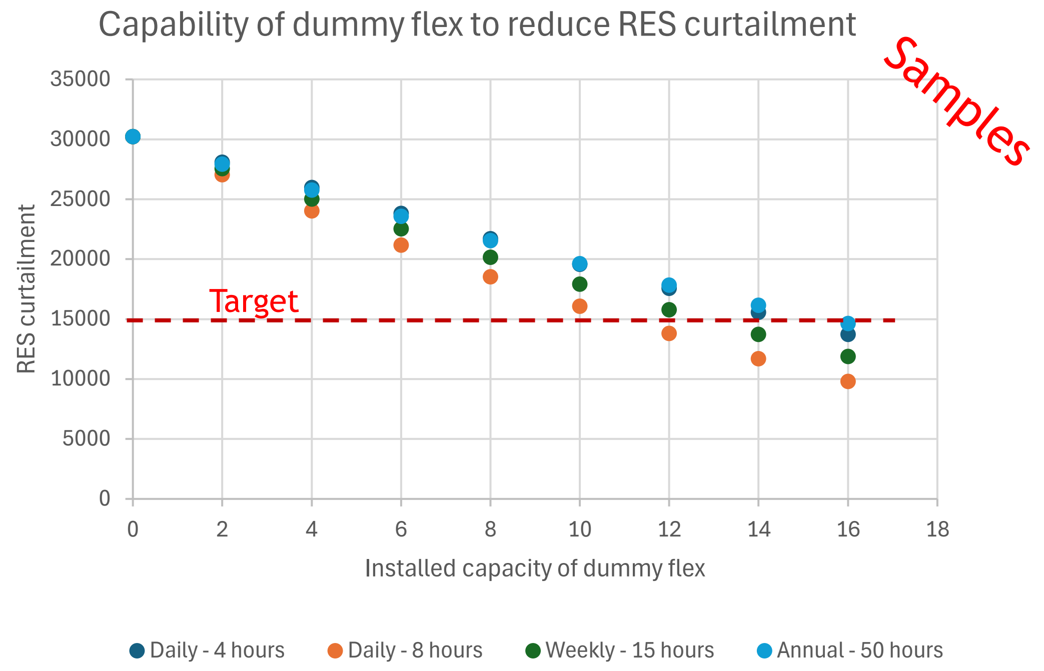


1. RES generation curtailment is derived from negative dispatched Residual Load
2. If total RES generation curtailment (18 GWh in the sample) is higher than the target (e.g. 10 GWh) a daily dummy flex variable is introduced
3. The variable is modeled to minimize daily needs, i.e. get the dispatched RL closer to the daily average while reducing total RES generation curtailment
4. By progressively increasing the dummy flex variable it is possible to identify the minimum additional capacity that allows to meet the RES curtailment target (+ 2GW in the sample)

1. RES integration needs – Dummy flex variable (4 of 4)

What reported as a sample for a single day in the previous slide is extended to a whole year and applied to daily, weekly and annual needs





What reported as a sample for a single day in the previous slide is to be extended to a whole year and applied to daily, weekly and annual needs.

2. Ramping needs

The Ramping needs is calculated to cover expected hourly residual load variations taking into consideration the technical constraints of flexible generation units.

This analysis complements the simplification of some technical constraints in ERAA / NRAA with lower relevance for adequacy (e.g. simplification of minimum power or start-up / shut-down constraints to manage computation power). Member states already accounting such technical constraints in their NRAA can study the behaviour of surplus generation and shortage indicators during non-scarcity related periods

Retrieve the residual load from ERAA / NRAA per hour, per simulation (e.g. climate year) for a certain target year

Retrieve the economic dispatch from ERAA / NRAA per unit / technology, per hour, per simulation (e.g. climate year) for a certain target year

Network needs

Only when relevant/available

Determine the residual load variation per 60 minutes per hour

Identify aggregated up- and downward ramping capabilities per hour, per simulation based on technical constraints per dispatched unit / technology, per hour

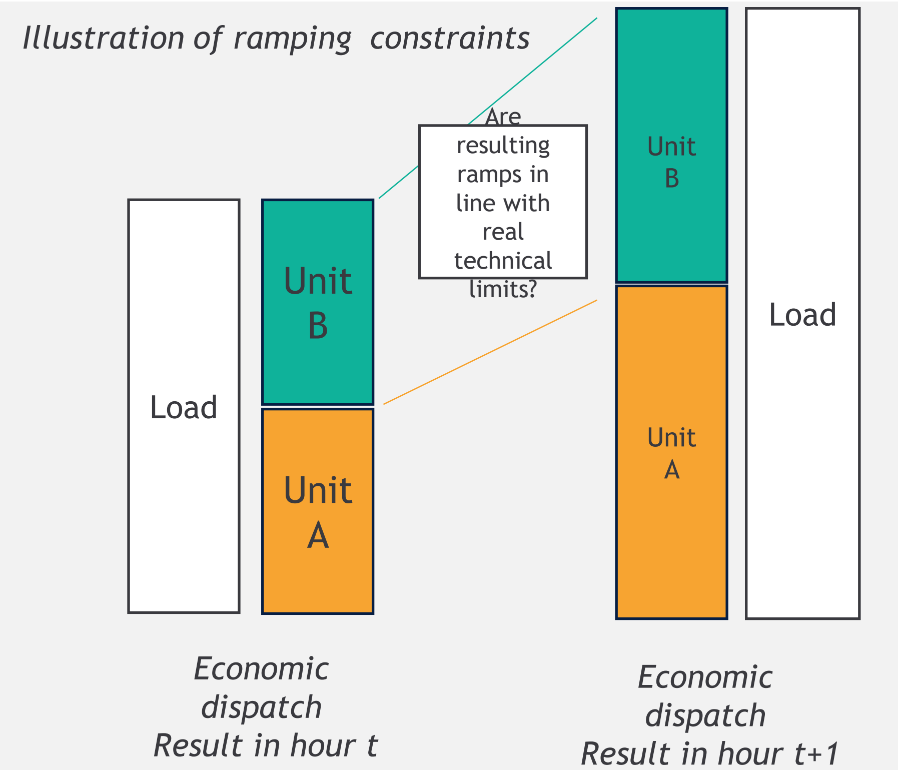
Accounting cross-border flexibility (remaining capacity)

Technical characteristics of technologies

Identifying **additional ramping needs** by means of the difference between the residual load variation and available ramping capability of dispatchable units (GW)

Statistical analysis of the ramping needs

Capacity gap (GW)

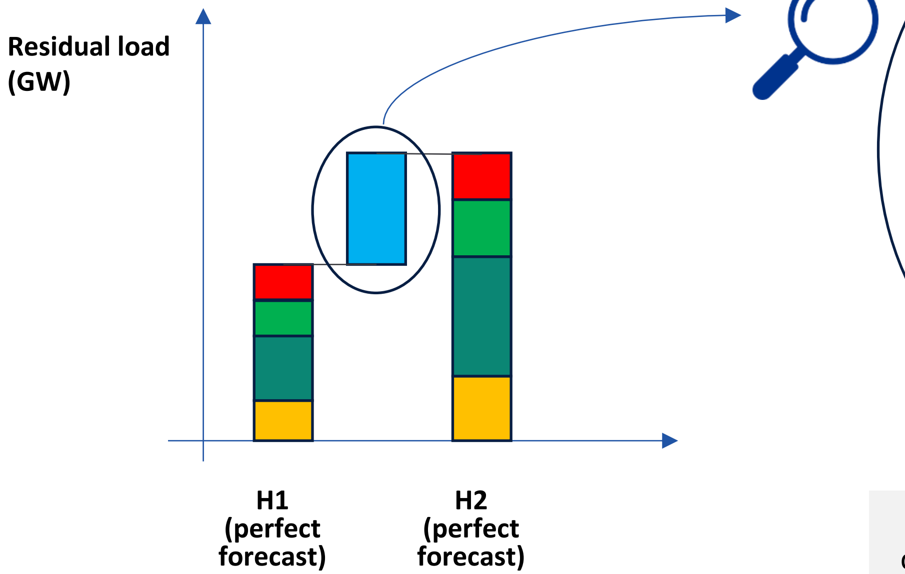


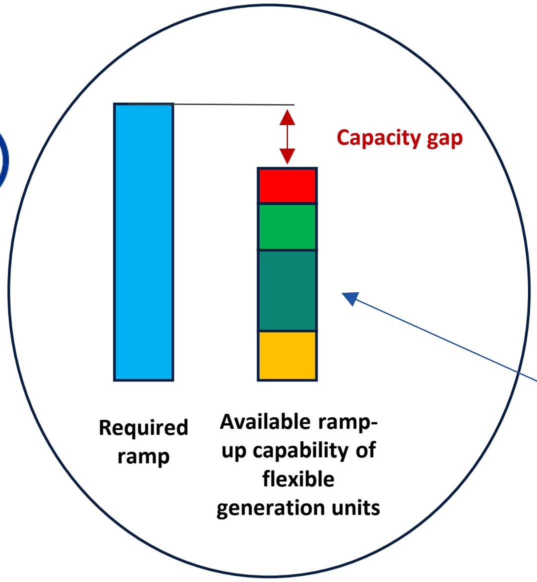
2. Ramping needs - Sample

Legend

- DSR
- Storage
- Thermal
- Import/Export

Day-ahead Economic dispatch (Perfect forecast)





ERAA/NRAA market dispatch does not typically model technical constraints of flexible generation units.

When applying actual technical constraints of flexible generation units and interconnections (i.e. their ramp-up limits in the sample) the available ramp-up capability is obtained.

If this available ramp-up capability is lower than

Category #	Fuel	Type	Unavailability				Minimum stable generation	Ramp up rate	Ramp down rate
			Forced outage		Planned outage				
			annual rate	Mean time to repair	annual rate	winter			
			%	Days	number of days	% of annual number of days	(% of max power)	% of max output power / min	% of max output power / min
1	Nuclear	-	5%	7	54	15%	40%	5%	5%
2	Hard coal	old 1	10%	1	27	15%	40%	2%	5%
3	Hard coal	old 2	10%	1	27	15%	40%	2%	5%
4	Hard coal	new	7,50%	1	27	15%	25%	4%	5%
5	Hard coal	CCS	7,50%	1	27	15%	25%	4%	5%
6	Lignite	old 1	10%	1	27	15%	50%	2%	5%
7	Lignite	old 2	10%	1	27	15%	50%	2%	5%

Ramp-up limits of thermal generation units

3. Short-term flexibility needs

The short-term flexibility needs is calculated to cover unexpected variations of the demand, renewable generation or forced outage of assets taking into consideration technical constraints of flexible generation units.

- To give a complete view on flexibility needs during the intra-day and balancing time frame, the method covers flexibility required by the market (to balance portfolios) as well as transmission system operators (to balance residual imbalances)
- This analysis complements the assumptions of 'hourly resolution' and 'perfect forecasts' in the ERAA/NRAA assessments

Retrieve the residual load prediction errors from national databases

Retrieve the economic dispatch from ERAA / NRAA per unit / technology, per hour, per simulation (e.g. climate year) for a certain target year

Network needs

Only when relevant/available

Determine the probability distribution and the flexibility needs to cover e.g. 99.9% of all forecast errors (where possible associated with system conditions)

Identify aggregated up- and downward margins between 5 minutes and 5 hours, per simulation based on technical constraints per dispatched unit / technology

Accounting cross-border flexibility (remaining capacity)

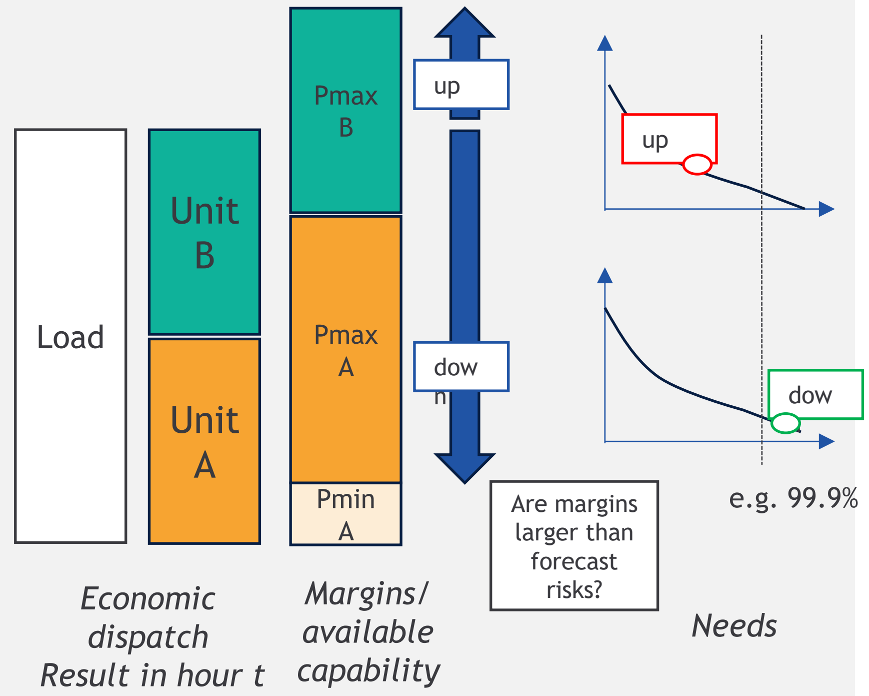
Technical characteristics of technologies

Identifying **additional short-term flexibility needs** by means of the difference between the forecast error and flexibility needs and available residual ramping capability of dispatchable units (GW)

Statistical analysis of the short-term flexibility needs

Capacity gap (GW)

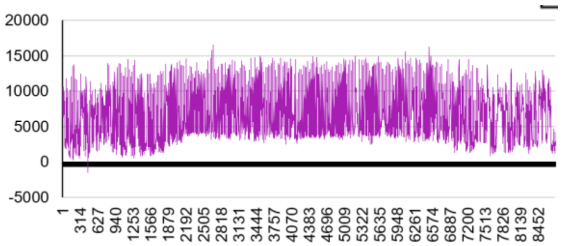
Illustration of short-term flexibility



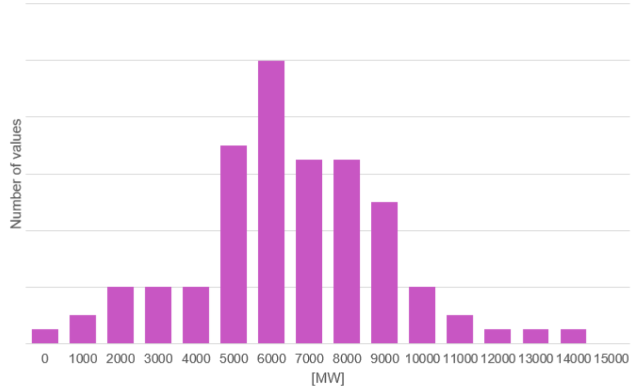
3. Short-term flexibility needs

Upward and downward needs (forecast errors), available residual ramping capability and shortage (capacity gap) is calculated for every hour => 8760 values per year creates time series

1) Time series

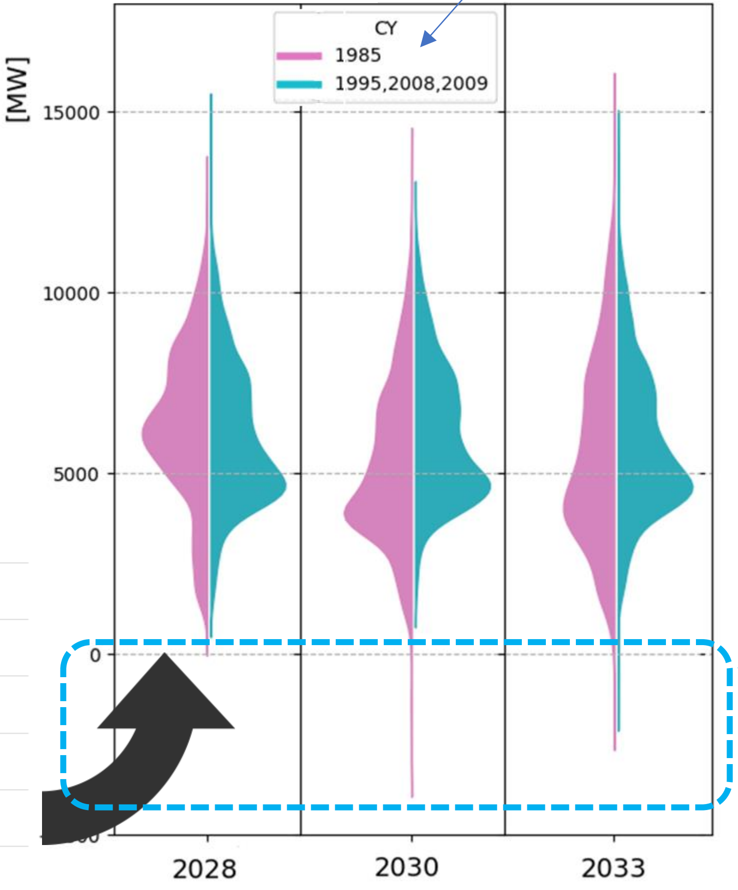


2) Histogram / probab. distribution

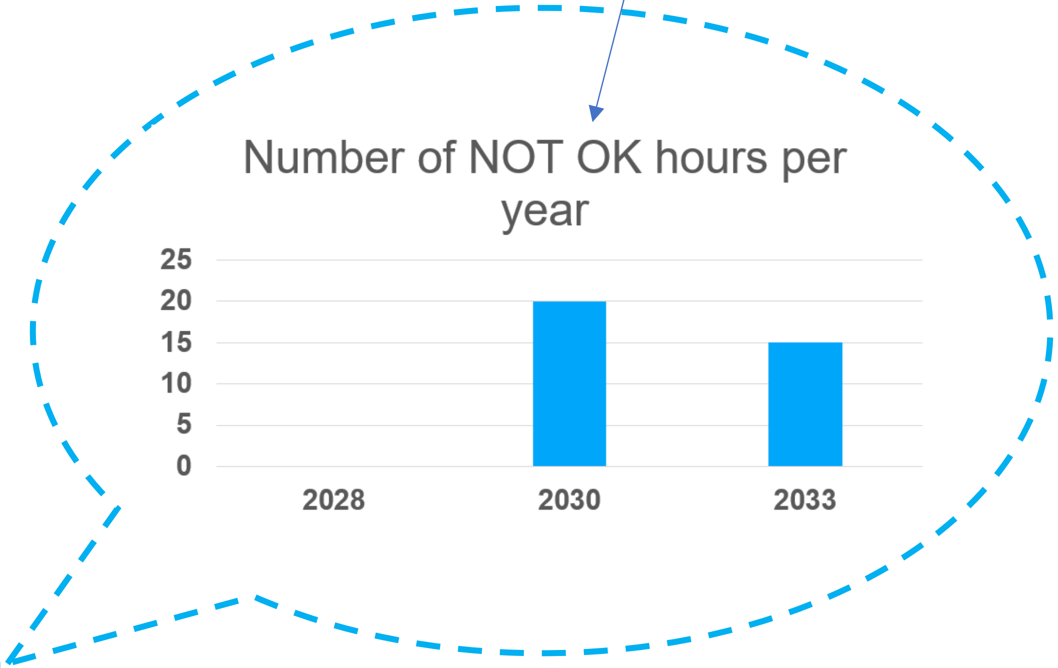


Different probability distribution for various climate years shows sensitivity towards weather

3) Violinplot



Shortage values below 0

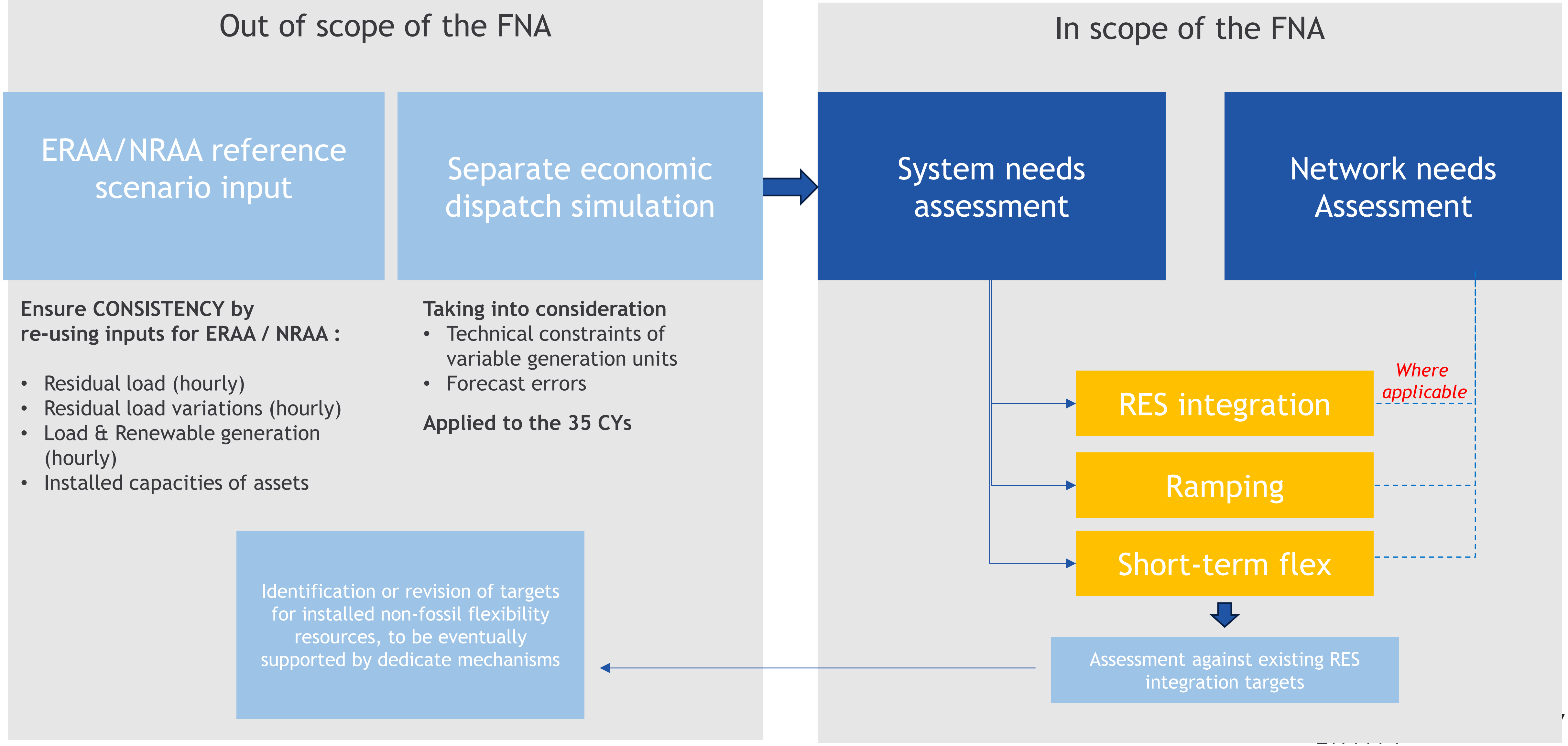


TODO: Add more detailed view on shortage capacity [MW] during NOT OK hours

Note: The presented data visualization approach is applicable needs (forecast errors), available residual ramping capability and shortage (capacity gap), and for upward and downward direction. Only the blue bubble is related solely to shortage.

General approach – Additional option for TSOs

(still under discussion - currently not included in the draft methodology)



General approach – Additional option for TSOs
(still under discussion - currently not included in the draft methodology)

As an alternative to using the economic dispatch results extracted from the ERAA or NRAA, TSOs may decide to run separate economic dispatch simulations, based on the same ERAA/NRAA input, which take into account technical constraints of flexible generation units to manage residual load ramps forecast errors if possible.

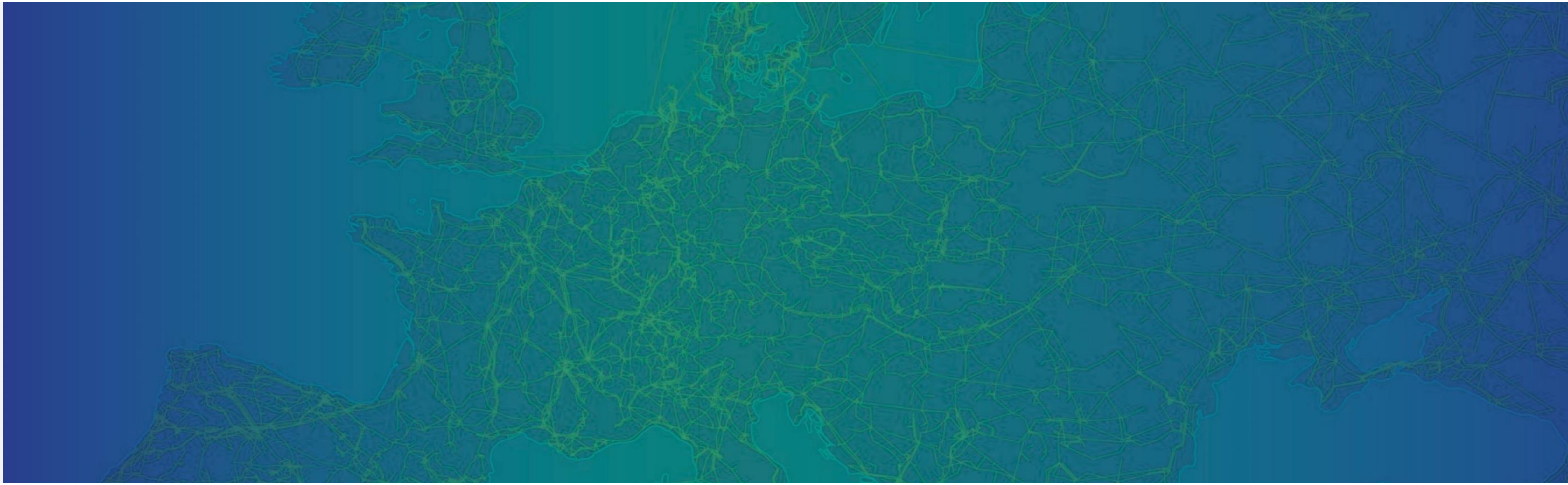
Separate economic dispatch can then be used to derive RES integration needs through the same approach presented in slide 37 (or reported in article 10 of the draft methodology) or by modelling dummy flex variables in the dispatch model

Ramping needs and short-term needs would instead be derived by analysing the behaviour of shortage and excess indicators (such as the energy not served and the RES generation curtailment) and verifying if the occurrence of shortage or excess condition was associated to technical constraints of generation units (e.g. ramping constraints)

The FNA team will further assess the opportunity to include this option in the final version of the methodology

Elements of methodology for network needs

Relevant information for Article 11 of the draft methodology



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Key ideas for the methodology for DSO flexibility network needs

3 concerns

Availability and relevance of input data and methods

Efficiency to perform the task and make use of data

Relevance of output data: to provide **meaningful and usesul** data for the purpose of the FNA

Context affecting these concerns

DNDP is intended to be a core DSO outlook over the 5 to 10 years, but not all DSOs publish DNDP, or DNDP information is not sufficient or available

=> **Method** needed to provide data **where DNDP information is not sufficient or available**

Detailed locational or temporal data might be meaningless or even impossible to compute (as it depends on the action of a single customer)

=> **Need to aggregate data** to provide meaningful and useful figures

There could be hundreds of very different DSOs nationally, with many DSOs covering a small geographic area or sharing similar issues

=> May be **more efficient to aggregate the needs of several DSO**, that is to provide the need of several DSOs all together

Network need - Process overview

Network needs (prevent or solve congestion) : BOTTOM-UP approach

STEP 1: DSO provide data and analysis to National Entity

- **Each DSO provide flexibility needs** from **DNDP** + flexibility needs from additional assessments if relevant
  → input for the flexibility assessment from each DSO to national entity

STEP 2: National Entity synthetises data from STEP 1

- **Overall National needs** to prevent or solve congestion

STEP 3: DSO and TSO fine tune forecast of system needs if / where / when needed and relevant

- **If or where network needs** might have a **relevant impact** on system needs, **fine tune data**
- DSO provides data with better time or locational granularity to TSO and **TSO takes into account for system needs**

STEP 4: -> Guiding criteria -> policy recommendations

STEP 1 – Flexibility needs to solve or prevent congestion from each SO

1

For the next five to ten years, each SO is responsible to provide data:

- Annual activated flexibility volumes to solve or prevent congestion
- Ranges of daily and hourly flexibility to solve or prevent congestion
- /!\ data will be aggregated, as local data is highly dependent of local dynamics of system users connection application, change of individual injection/consumption patterns, …

2

As default DSO (respectively TSO) shall use annual volumes of local services identified in DNDP used to prevent or solve grid limitations. When these volumes do not encompass all future flexibility needs in their grid, additional assessments shall be performed by the corresponding DSO (resp. TSO). These assessments shall consider:

- Each DSO (resp. TSO) shall perform a forecast based on its available data and NECP scenarios
- Each DSO (resp. TSO) shall consider the grid reinforcements described in DNDP and TYNDP

3

Volumes of grid limitations and corresponding flexibility needs from DSO shall be provided to the National Entity based on the template and units defined in this methodology.

STEP 1 and 2 : Data from each DSO for the methodology

- Data on flexibility needs for DSO (based on injection and data for consumption scenario over the planning horizon) - data upwards and downwards
  - Potential metrics (to be confirmed if / where and to which extent possible to compute/provide)
    - Max GW of RES curtailment or demand outage expected in critical events over the planning time
    - If possible : on the critical events, over the planning horizon : Expected TWh/year (split by season if possible) and/or TWh/day (typical days / typical network conditions if possible)
    - Hourly GW for specific days (if possible / available)
    - Qualitative data where quantitative data is not available
  - /!\ The above metrics may be relevant for normal « N » scheme » ; metrics for N-1 (planned/unplanned outage) schemes would be different

- /!\ Data only for DSO network needs – does not concern resources activated for TSO (network or system needs) purposes
- Where relevant, data from some DSO can be extrapolated based on the data provided by other DSO.

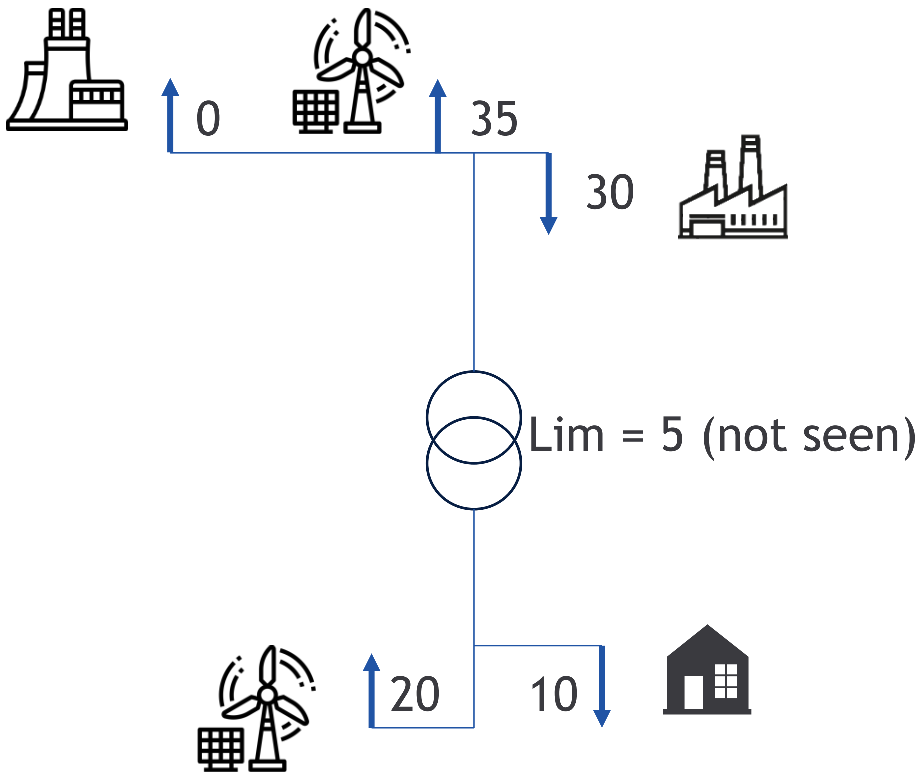
STEP 3 – Fine tuning
if /where / when needed and where data is available or relevant

- TSO and DSO can **fine tune the estimation of system or network needs** by exchanging data that feeds associated quantification approaches, depending **on the relevance to fine-tune and to yield more accurate data**
  - **when comparing orders of magnitude** of DSO network needs, TSO network needs, system needs and the impact of uncertainty and assumptions on DSO / TSO / system needs
  - **when considering the relevance of providing granular / local data with assumptions and uncertainty with respect to aggregated data with more certainty,** or the capability to provide such additional data
- This additional information allows to revise the system needs upwards or downwards in function of:
  - Additional RES integration / ramping / short-term needs following moments with local congestions while **avoiding double counting** during simultaneous local congestions and surplus RES energy in the system
  - Additional or reduced RES integration / ramping / short-term needs following moments with reduced or additional availability of local flexibility resources
  - Scheduled generation and consumption by affected area to increase the accuracy of the assessment
- TSO and DSOs shall agree on
  - Identification of the DSO grid areas affected by congestions, where fine-tuning would be useful
  - approaches for annualization of results if additional data is provided for specific conditions (e.g. representative days of the year, renewable generation and load conditions
  - on coverage approaches in case factors are representative for only a sub-set of DSOs at national level,

STEP 3 – Fine tuning: situation where it is not necessary

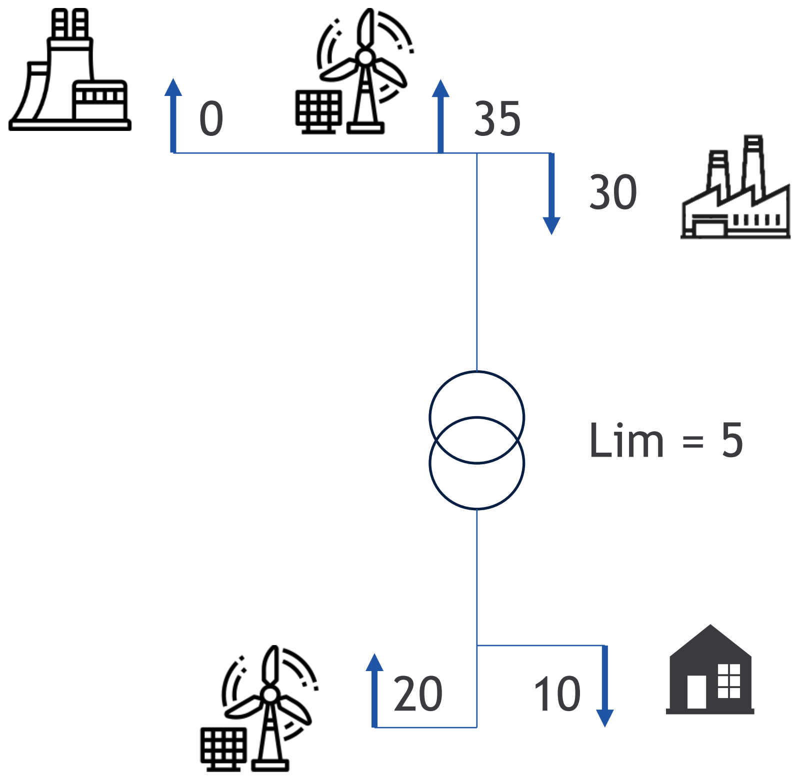
When the whole system is in RES excess condition, system need assessment already address RES curtailment due to local congestions

Copper plate (MW)



=

Non-Copper plate (MW)



Total RES curtailed = 15

Total RES curtailed = 15

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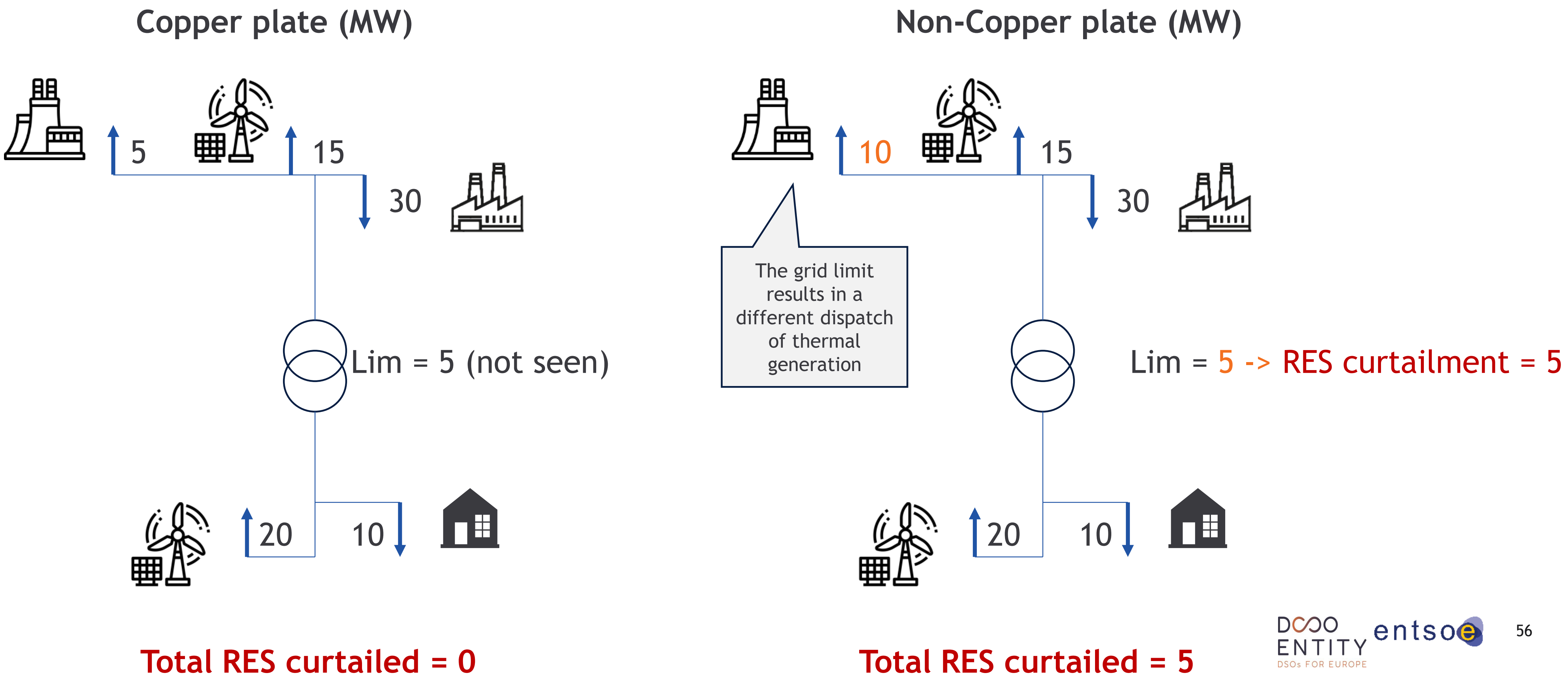
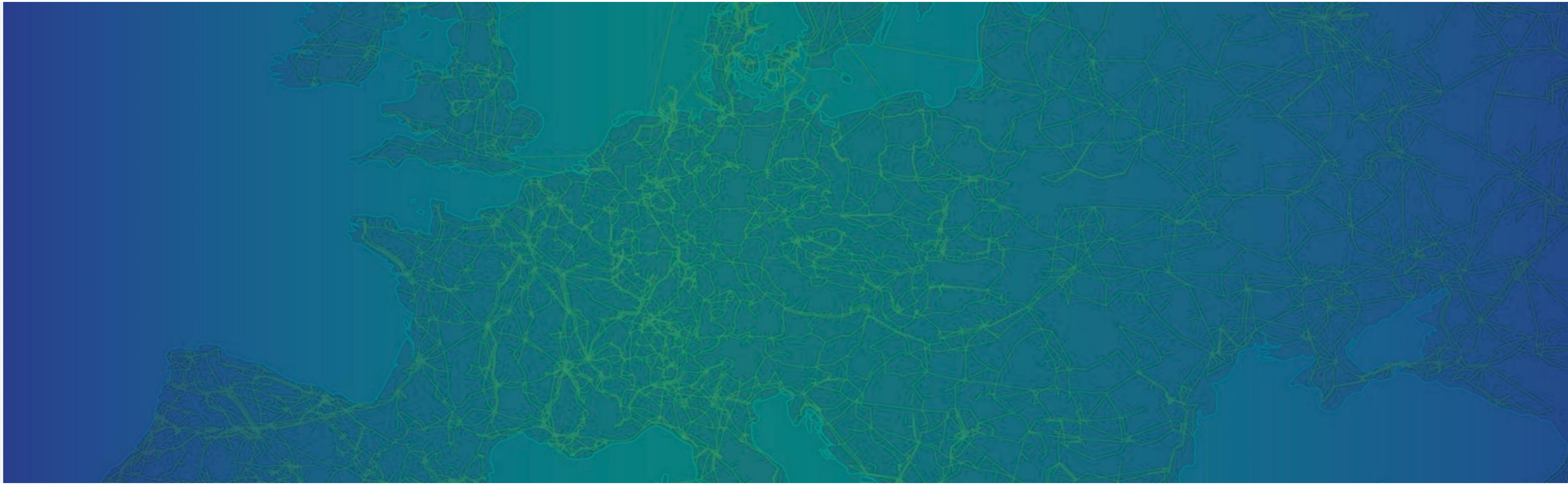
STEP 3 – Fine tuning : situation where it is useful

When the whole system is not in RES excess condition, system need assessment does not assess RES curtailment due to local congestions, thus underestimating overall RES curtailment



Elements of guiding criteria
(still under development - currently not included in the draft methodology)

Relevant information for Article 14 of the draft methodology



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Guiding criteria - General approach

Context/Whereas

As defined in Art. 19e (4) of the Regulation, the methodology for the analysis of the flexibility needs shall contain guiding criteria on how to assess the capability of the different sources of flexibility to cover the flexibility needs.

The purpose of the guiding criteria is therefore to characterize flexibility needs through an assessment of the capabilities of flexible resources to cover them, while a neutral technological approach is respected.

Guiding criteria shall provide relevant information on such required capabilities to interpret the results of the needs assessment analyses and drive policymakers in the identification of the most suitable technologies to cover needs.

It is out of the scope of this methodology to specify means to access flexibility in each Member State (such as market based, rules based, flexible connection agreements and tariff signals etc.)

Preliminary text of article 14 (currently under discussion)

1. At national level, TSOs and DSOs shall assess the capability of flexible resources to cover the flexibility needs identified in Articles 8 to 11 by:

   a. identifying the most relevant technical requirements, also taking into account the ones reported in paragraph 2 of this article for distribution network needs and paragraph 3 of this article for system needs; and
   b. characterising the technical requirements through relevant metrics, indicators and ranges of values based on the results of the quantified flexibility needs and other quantitative or qualitative considerations.

Guiding criteria – Technical requirements for distribution network needs

Distribution network needs resulting from the application of the methodology can be further characterized through specific requirements, such as:

- **availability window**: when the resource shall be available (morning, night…)
- **full activation time;**
- **validity period;** in which periods or from when on the resource is available (next year, summer, workdays, Sundays../ immediately, next month, next year etc.)
- **location**; in which voltage level (vertical dimension) and geographical area (horizontal dimension)
- **quantity;** ranges of the quantities of flexibility needed
- **duration**;
- **recovery time** or minimum duration between the end of deactivation period and the following activation;
- **direction of activation**; and
- If available and relevant, economic criteria

Guiding criteria – Technical requirements for system needs

Possible sub-indicators

The system needs resulting from the application of the methodology can be further characterized through specific sub-indicators
For example, for RES integration needs

- Number of days when the need occur (e.g. RES generation curtailment)
- Steepness of the Residual Load morning and evening ramps
- Max hourly /Avg daily RES generation curtailment
- Number of Hours with consecutive RES generation curtailment
- Others (*currently under development*)

For each of them statistical analysis can be introduced to facilitate the identification of sets of technical requirements to cover RES integration needs

For the other needs similar sub-indicators can be derived

Guiding criteria – Technical requirements for system needs

Ramping needs

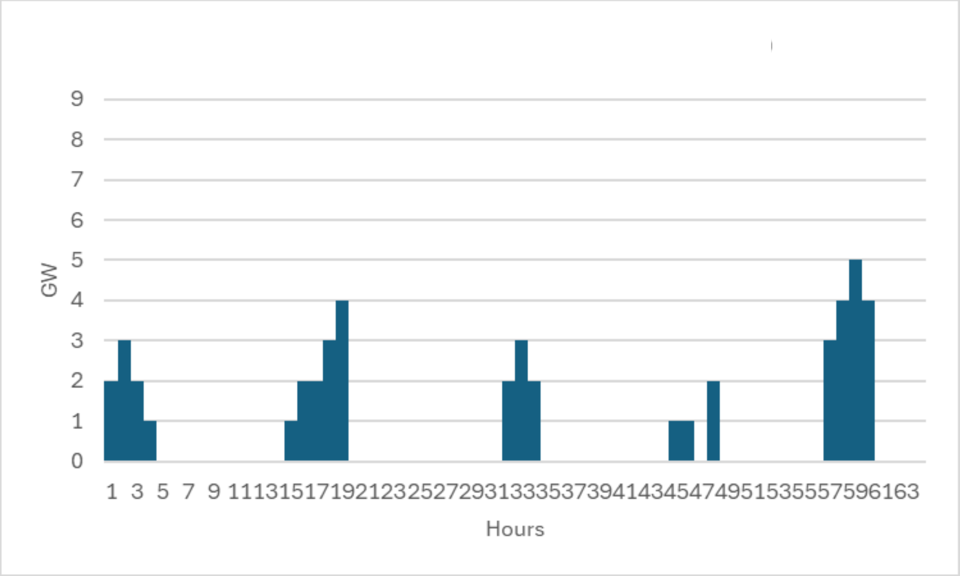
Ramping needs resulting from the application of the methodology can be further characterized through specific sub-indicators, such as:

- Number of capacity gap events during the year
- Average duration of capacity gap events
- Average time between capacity gap events
- Max capacity gap observed
- Average capacity gap per event
- Others (*currently under development*)

For each of them statistical analysis can be introduced to facilitate the identification of sets of technical requirements to cover RES integration needs

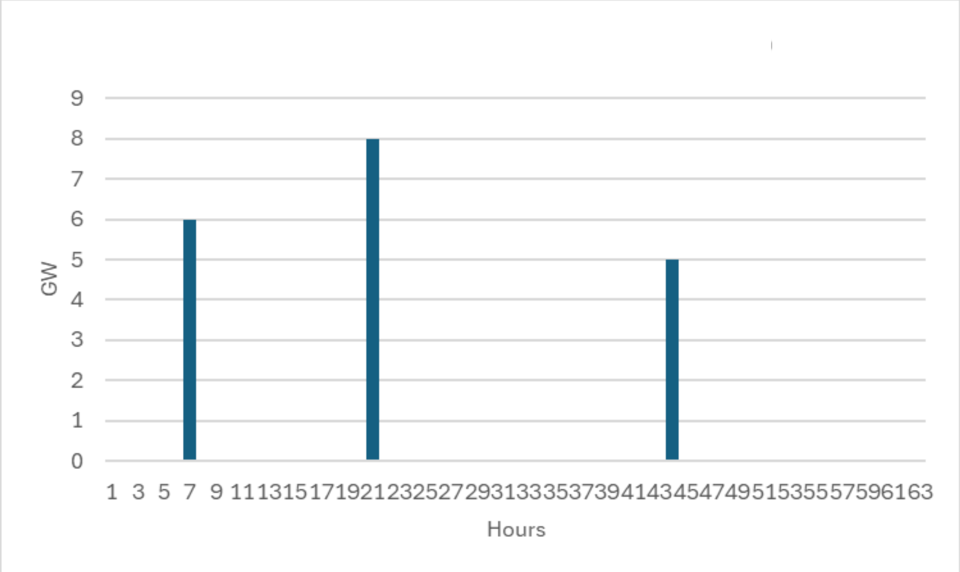
Guiding criteria – Technical requirements for system needs

Sample application of guiding criteria



Occurrence of the RES generation curtailment event	#	5
Average duration of events	hours	3,8
Average time between events	hours	8
Max RES Generation curtailment	GW	5

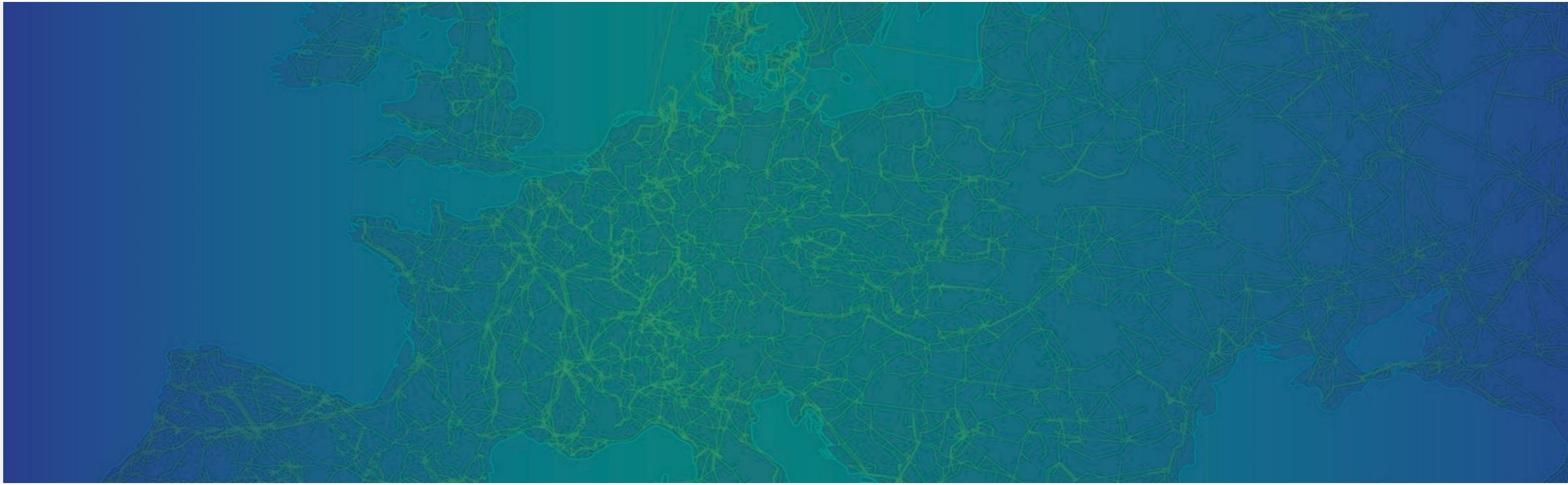
Need for more energy-type resources



Occurrence of the RES generation curtailment event	#	3
Average duration of events	hours	1
Average time between events	hours	15
Max RES Generation curtailment	GW	8

Need for more capacity-type resources

Explanation on flexibility DSO network needs
1st draft of recitals



DSO ENTITY
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Reliable Sustainable Connected

General context of DNDP, a DSO outlook over the next 5-10 years

- Congestion or voltage issues are defined in such a way to account for operational limits that the systems operators may apply in line with accepted national practices, which may not be covered by the definition of ‘physical congestion’ in Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (the “Regulation (EU) 2019/943”) , nor by the definition of ‘congestion’ in Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (the “Commission Regulation (EU) 2015/1222”). Operational limits may include thresholds set at connection point between systems operators’ network e.g., through contractual agreements between systems operators on the use of the network capacity, or through defined ranges for importing or exporting active or reactive power, etc or others limits or operational criteria like e.g., aging of equipment.
- According to Article 32 of Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (the “Directive (EU) 2019/944”), distribution system operators have to cost-efficiently integrate new electricity generation, especially installations generating electricity from renewable sources, storages and new loads including charging points for electric vehicles or heat pumps. For that purpose, distribution system operators, at national level, shall introduce transparent distribution network development plan (‘DNDP’), including methodology and scenarios and/or assumptions to identify network development projects making sure that the provided description is comprehensible for stakeholders.
- TSOs and DSOs within Member State should ensure that their development plans are consistent and coordinated. In addition, they should ensure that the necessary information is exchanged during the planning processes to determine the network investment needs. Coordination should ensure that necessary data used during the planning process is exchanged between TSOs and DSOs and reconciled when relevant to the process.

Where DNDP information is not sufficient or available

- Where DNDP information is not sufficient or available, DSOs should provide the data based on their internal assessments from other sources, which shall be based on the same principles as or DNDP. Such assessments should reflect the most plausible futures of the electricity distribution system for the next five to ten years, including anticipatory needs defined in accordance with relevant national processes. Such assessments should also be coordinated between the concerned TSOs and DSOs. Such assessments should also be encompass, at least, current and forecasted electricity demand, generation and energy storage capacities and consider national energy and climate plans, local energy strategies and other relevant development factors.

- As defined in Article 32(5) of the Directive (EU) 2019/944, Member States may decide not to apply the obligation set out in Article 32(3) of Directive (EU) 2019/944 to integrated electricity undertakings which serve less than 100 000 connected customers or which serve small isolated systems. In these cases, DSOs shall assess flexibility network needs based on internal studies or extrapolating data from other DSOs.

How DSOs provide data and analysis

- Planning methods aim at designing the network to be operated. Planning methods are consistent with the operations capabilities of each DSO, the national requirements for quality of supply and other criteria, thus planning methods may differ from one DSO to the other even within the same country. Times horizons of DNDPs vary between 5 to 10 years, because of different national regulations, in particular the effect of regulatory periods, the voltage levels operated by each DSO, availability of data, and other factors. Methods to evaluate flexibility needs include planning methods and other methods.
- The flexibility network needs assessment may contain aggregated data, because the local kinematics of LV or even MV networks can depend on the behaviour of a single customer (connection application, change of consumption or production pattern) which may occur without advanced notice . Such needs could be defined on a statistical and aggregated manner, whereas assessing in a locally and temporally precise manner would be meaningless (possibly obsolete in great extent within a matter of days) or impossible to achieve.
- At national level, DSOs shall coordinate between themselves on the granularity(ies) of data, the types and extent of data, and the corresponding time horizon(s) within the 5 to 10 years, taking into account the availability of data or relevance of assumptions over the time horizons, the availability of relevant methods, applicable national framework pursuant to DNDP, network tariffs periods, relevant legal or regulatory frameworks, or other relevant criteria.
- At national level, DSOs can decide to perform the analysis and provide the data and analysis as defined in the methodology for the analysis of the flexibility needs referred to Article 19e(4) of Regulation (EU) 2019/943 alone or organized in a team of several DSOs. In many Member States, DSOs are organized through associations that represent them. In these cases, these associations shall be entitled to act on behalf of DSO in the processes related to this methodology for the analysis of the flexibility needs referred to Article 19e(4) of Regulation (EU) 2019/943