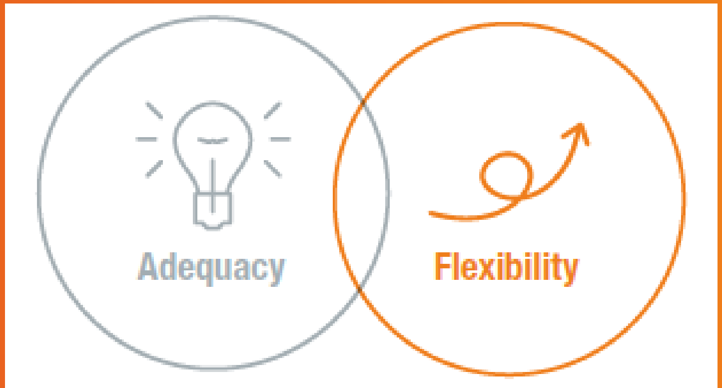
Adequacy and Flexibility study 2019



Ad-Hoc Task Force implementation Strategic Reserve

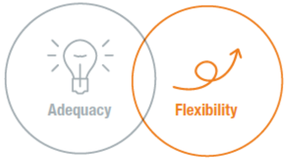
January 22, 2019

Context

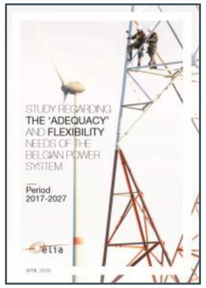
Regulatory & Legal framework

APR 2016

Adequacy & Flexibility
2017 - 2027



At the request of the Minister for Energy, an ad-hoc study covering the adequacy and flexibility of Belgium was published in April 2016. An Addendum (September 2016) requested by the authorities was also performed based on a large stakeholder consultation following the initial study.



JUL 2018

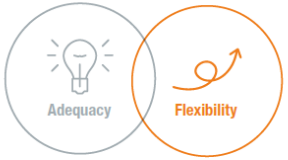
New legal requirement in the federal electricity law:

Art. 7bis, §4bis: "*Uiterlijk op 30 juni van iedere tweejaarlijkse periode voert de netbeheerder* ***een analyse uit met betrekking tot de noden van het Belgische elektriciteitssysteem inzake de toereikendheid en de flexibiliteit van het land voor de komende tien jaar****. De basishypotheses en -scenario's alsook de methodologie die gebruikt worden voor deze analyse worden bepaald door de netbeheerder in samenwerking met de Algemene Directie Energie en het Federaal Planbureau en in overleg met de commissie.*"

Memorie van toelichting: *"De eerste versie van deze studie dient opgeleverd te worden voor 30 juni 2019."*

JUN 2019

Adequacy & Flexibility
2020 - 2030



This study will thus be published before 30 June 2019 and will cover the timeframe of 2020 up to 2030.

Stakeholder interaction

Phase 1: Preparation of the methodology

- Preparation methodology improvements adequacy study
- Development new methodology flexibility study
- Discussions with CREG / FOD / PLANBUREAU

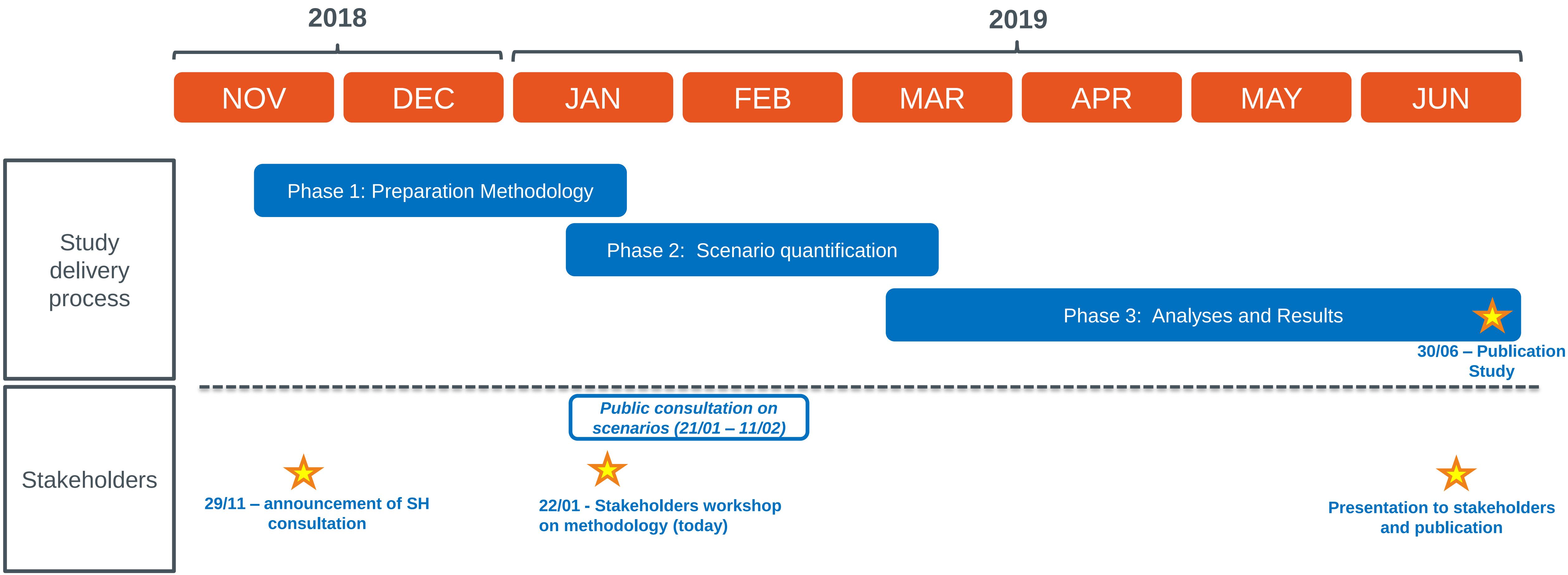
Phase 2: Scenario quantification

- Development of reference scenario
- Public consultation on the reference scenario
- Definition of sensitivities (after public consultation)

Phase 3: Analyses and presentation of results

- Presentation stakeholders
- Report

Timeline



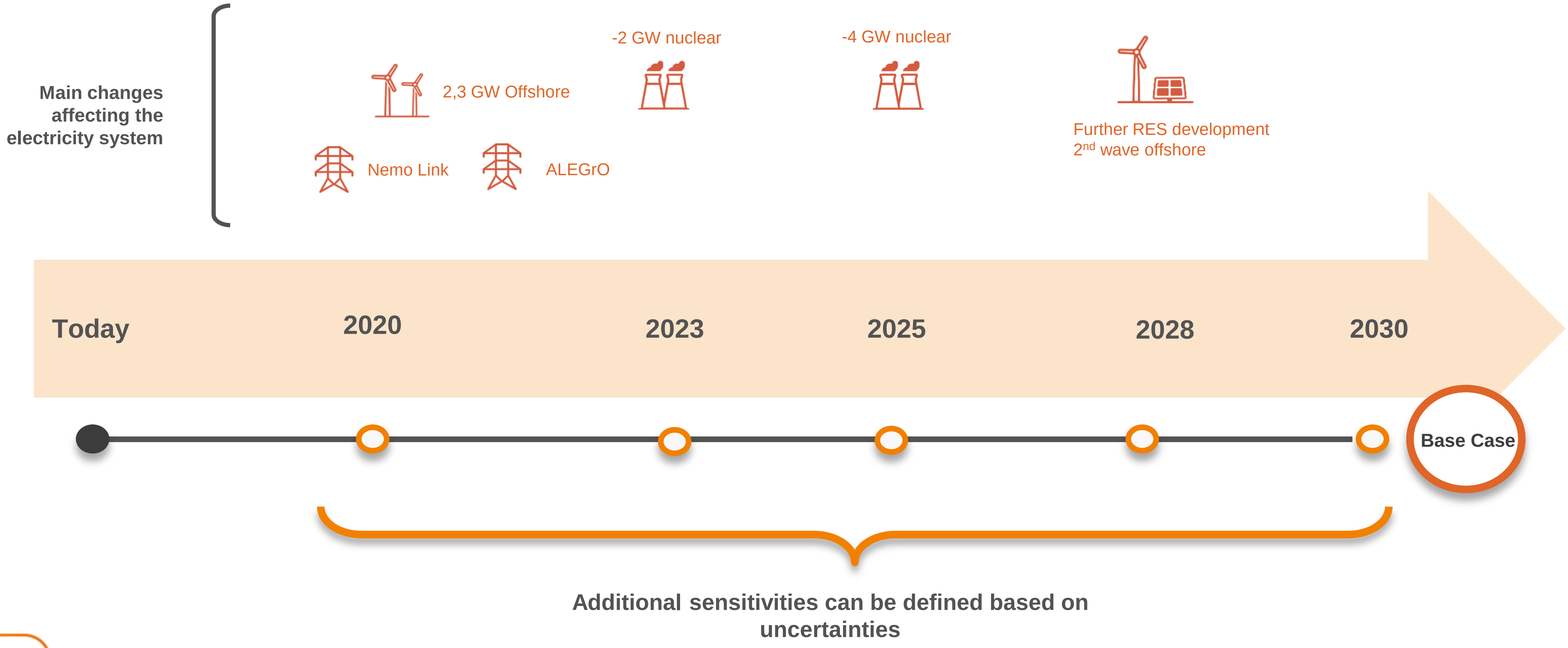
2018
2019
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
Study delivery process
Phase 1: Preparation Methodology
Phase 2: Scenario quantification
Phase 3: Analyses and Results
30/06 – Publication Study
Stakeholders
Public consultation on scenarios (21/01 – 11/02)
29/11 – announcement of SH consultation
22/01 - Stakeholders workshop on methodology (today)
Presentation to stakeholders and publication

Agenda of the meeting

- **Adequacy methodology & general scenario set-up**
  - Focus on methodology improvements
- **Flexibility methodology**
  - Presentation of new methodology to assess flexibility needs
- **Public consultation**
  - Practicalities

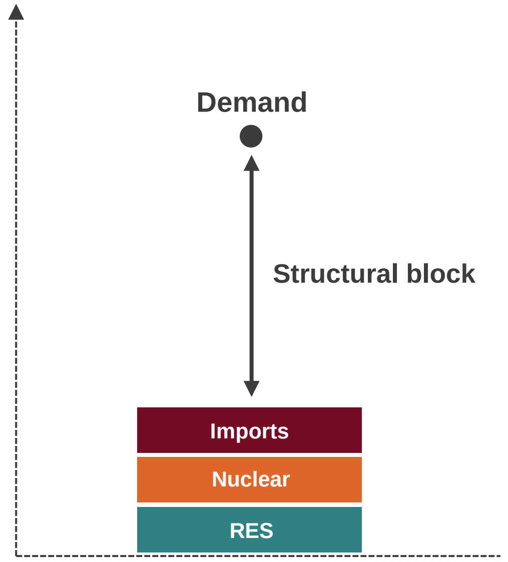
General scenario set-up

5 time horizons will be quantified following a base case scenario with additional possible sensitivities



The study consists in identifying the structural block capacity and characteristics to satisfy the adequacy criteria and flexibility requirements of the Belgian system

What is the structural block ?



Structural block is a capacity considered as 100 % available and flexible.

When filling this block with different technologies, the effective availability & characteristics will be taken into account.

Structural block =
Volume of adjustable national power (on top of the nuclear, RES capacity and imports) needed to satisfy the adequacy and flexibility of the system.

“Assumed available capacity” is defined as:

- Imports (if the energy is available abroad – tackled by modelling more than 20 other countries)
- Nuclear
- RES (biomass, wind, solar, hydro « run of river »)

The structural block could be filled with:

- Market response
- Storage facilities (pumped storage, batteries, etc)
- CHP
- Thermal units (CCGT, OCGT,…) (existing or new)

Market response, storage facilities and CHP: **Assumptions**

Thermal units: **Enough to meet** adequacy criteria and flexibility requirements

	Type	Base Case	Sensitivity 1	Sensitivity 2	...
		Scenarios			
Structural block	Market Response	Assumptions			
	Storage	Assumptions			
	CHP	Assumptions			
	CCGT/OCGT	Enough to meet adequacy criteria & flexibility requirements			

1 base scenario will be constructed for all proposed time horizons

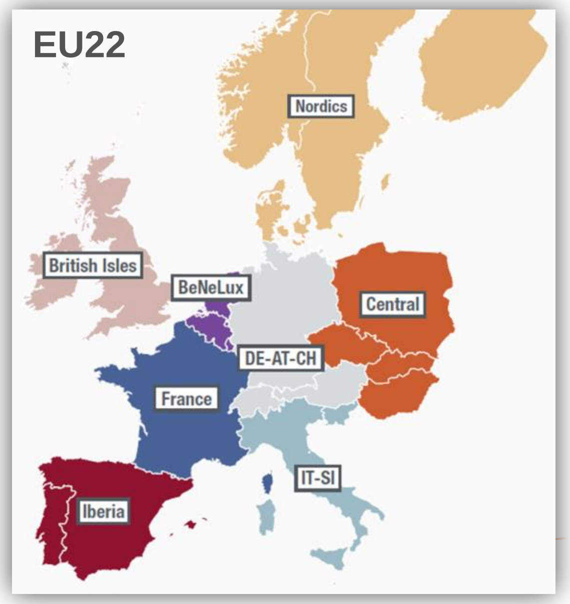
- The base case scenario is aligned with the “Energy Pact”
- The base scenario can be seen as a ‘new policies’ based on Belgian ambitions
- This scenario is submitted for public consultation

Additional sensivities will be defined to cover key uncertainties

- Sensitivities will be performed in order to capture the range of uncertainties on key assumptions

22 countries will be modelled in detail

- Hypotheses of neighbouring countries are discussed bilaterally, with as base, the European studies (MAF, PLEF and TYNDP2018) and updated with the most recent market information



Adequacy methodology

The adequacy methodology builds upon the expertise of Elia. Since the last study publication (Apr. 2016), several methodological improvements are planned to be introduced

Adequacy and flexibility study **2016**

- Steps of **100 MW** vs. **500 MW** will be used to determine the needed capacity *(this implies a larger set of 'Monte Carlo' years to be simulated)*
- Explicit modelling of **decentralized storage** will be introduced (batteries,…)
- **HVDC outages** to be modelled and taken into account
- **Flow Based modelling** to be implemented *(new and not yet used in studies covering timeframes higher than 3 years ahead)*

Adequacy and flexibility study **2019**

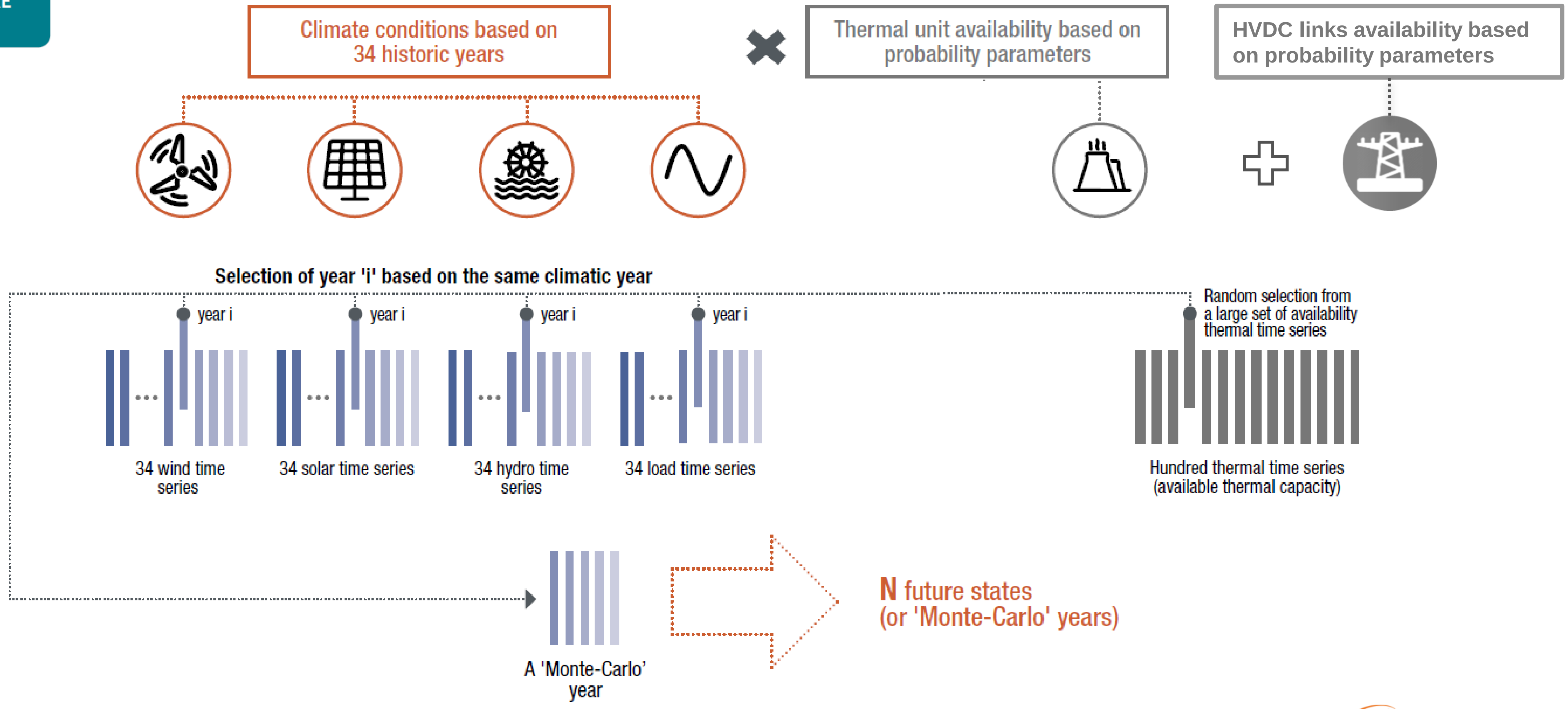
The methodology used in the scope of this study is "state of the art" and aligned with the one used in the "Mid-term Adequacy Forecast" from ENTSO-E and the yearly assessment of the Elia "Strategic Reserve Volume Evaluation".

The methodology consists of 3 main steps

1. DEFINITION OF FUTURE STATES
2. IDENTIFICATION OF MOMENTS OF STRUCTURAL SHORTAGE
3. ADDING VOLUME TO MEET THE ADEQUACY CRITERIA

A large amount of Monte-Carlo years will be simulated (based on 34 climatic years) at each iteration

1 DEFINITION OF FUTURE STATES



ANTARES will be used to perform the market simulations

2 IDENTIFICATION OF MOMENTS OF STRUCTURAL SHORTAGE

antaressimulator

INPUT DATA

- **Consumption**
- **Centralised thermal production facilities**
- **Decentralised thermal production facilities**
- **Renewable production**
- **Interconnection capacity between countries**
- **Storage**
- **Demand flexibility**

For 22 countries

SIMULATIONS

Hourly dispatch optimisation to minimise costs

MODEL OUTPUT

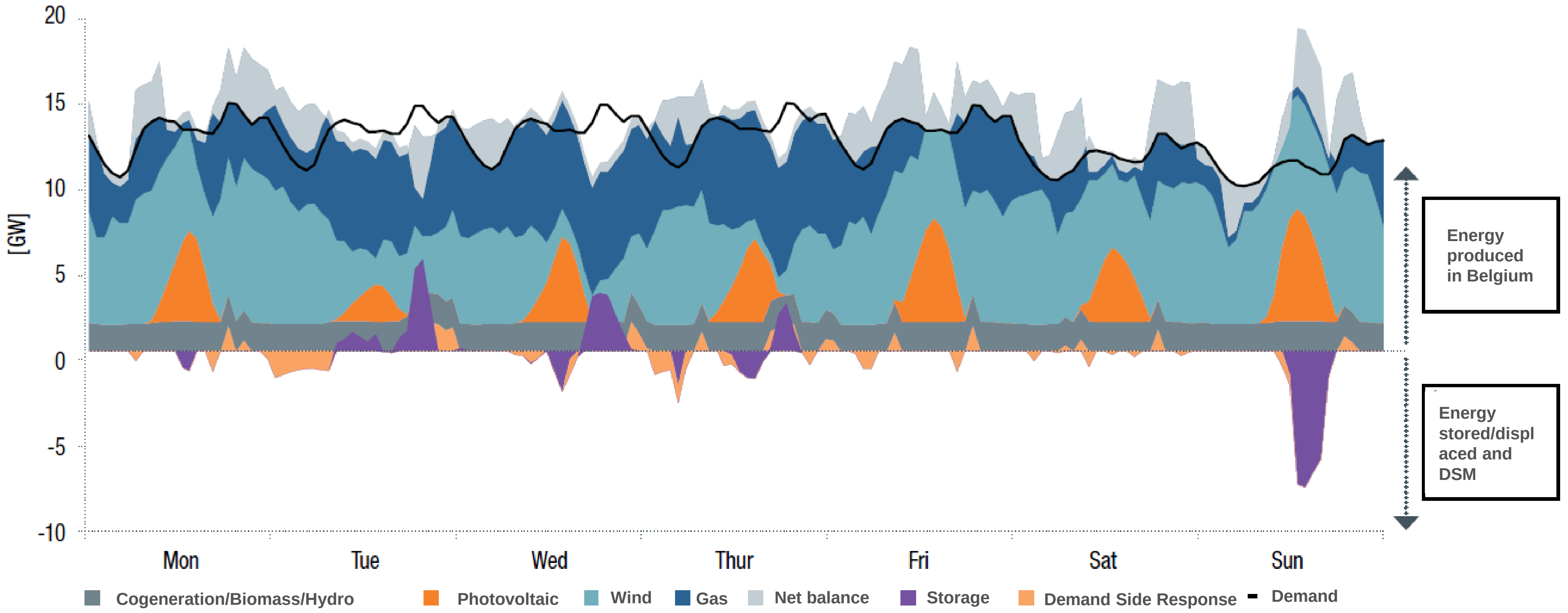
- **Hourly dispatch** for all units in each country
- **Commercial exchanges** between countries
- **Hourly marginal prices**

▼

- **Adequacy** indicators
  - LOLE, ENS
- **Economic** indicators
  - Market welfare, total costs, unit revenues, running hours
- **Sustainability** indicators
  - Emissions, RES share
- **Dispatch** indicators
  - Imports/exports, generation per type

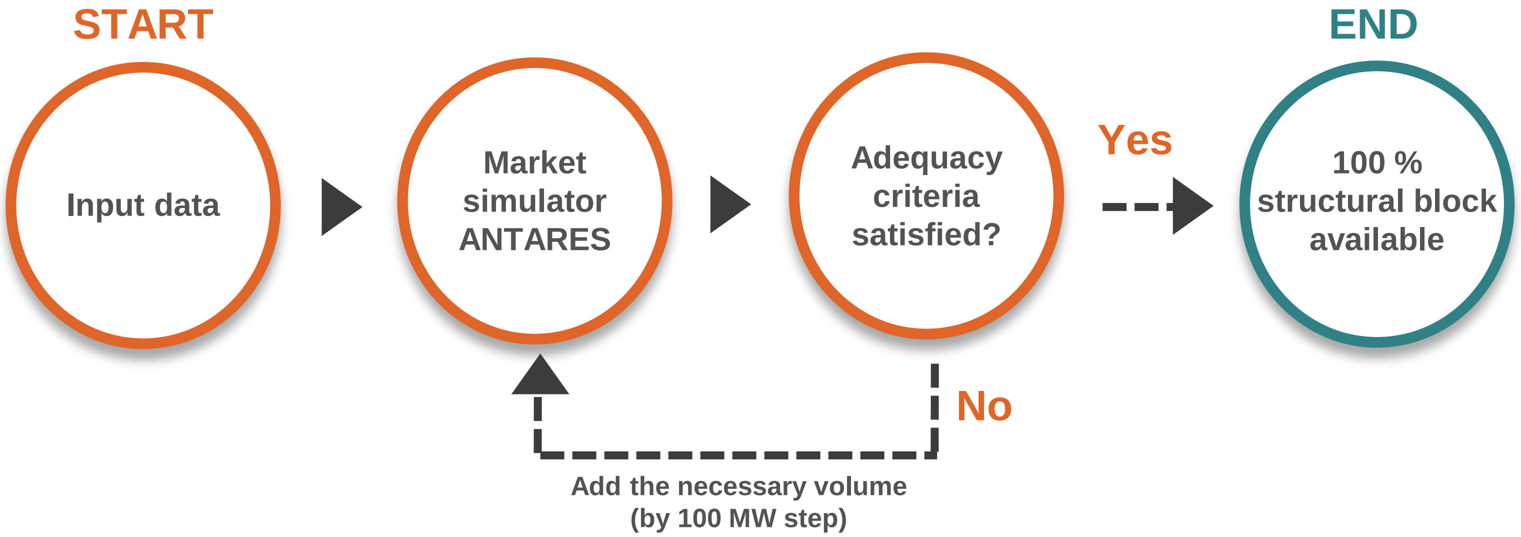
Every hour of the year is simulated (and for each "Monte-Carlo year")

2 IDENTIFICATION OF MOMENTS OF STRUCTURAL SHORTAGE



Volume will be added iteratively (per steps of 100 MW) to meet the adequacy criteria of Belgium volume

3 ADDING VOLUME TO MEET THE ADEQUACY CRITERIA



Legal adequacy criteria of Belgium

- Average LOLE < 3 hours
- LOLE95 < 20 hours

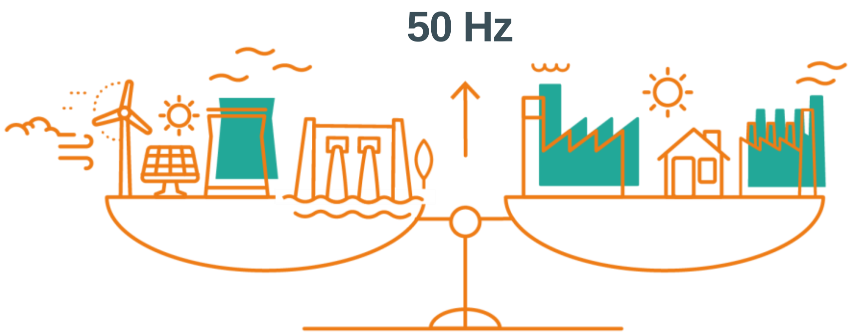
Flexibility methodology

Flexibility of a Power System

"The extent to which a power system can modify electricity production or consumption in response to variability, expected or otherwise" - International Energy Agency 2011

Flexibility drivers

- Variability and uncertainty of consumption
- Variability and uncertainty of production, especially renewable sources
- Production or transmission incidents

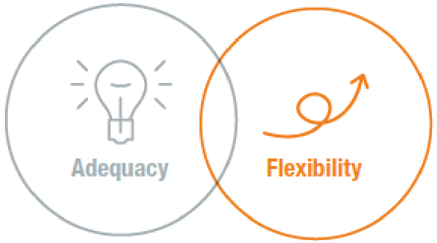


Flexibility Means

- Flexible set up of production units, i.e. conventional units but also biomass, CHP, RES, etc.
- Flexible demand (demand response)
- Interconnections
- Storage

Adequacy study

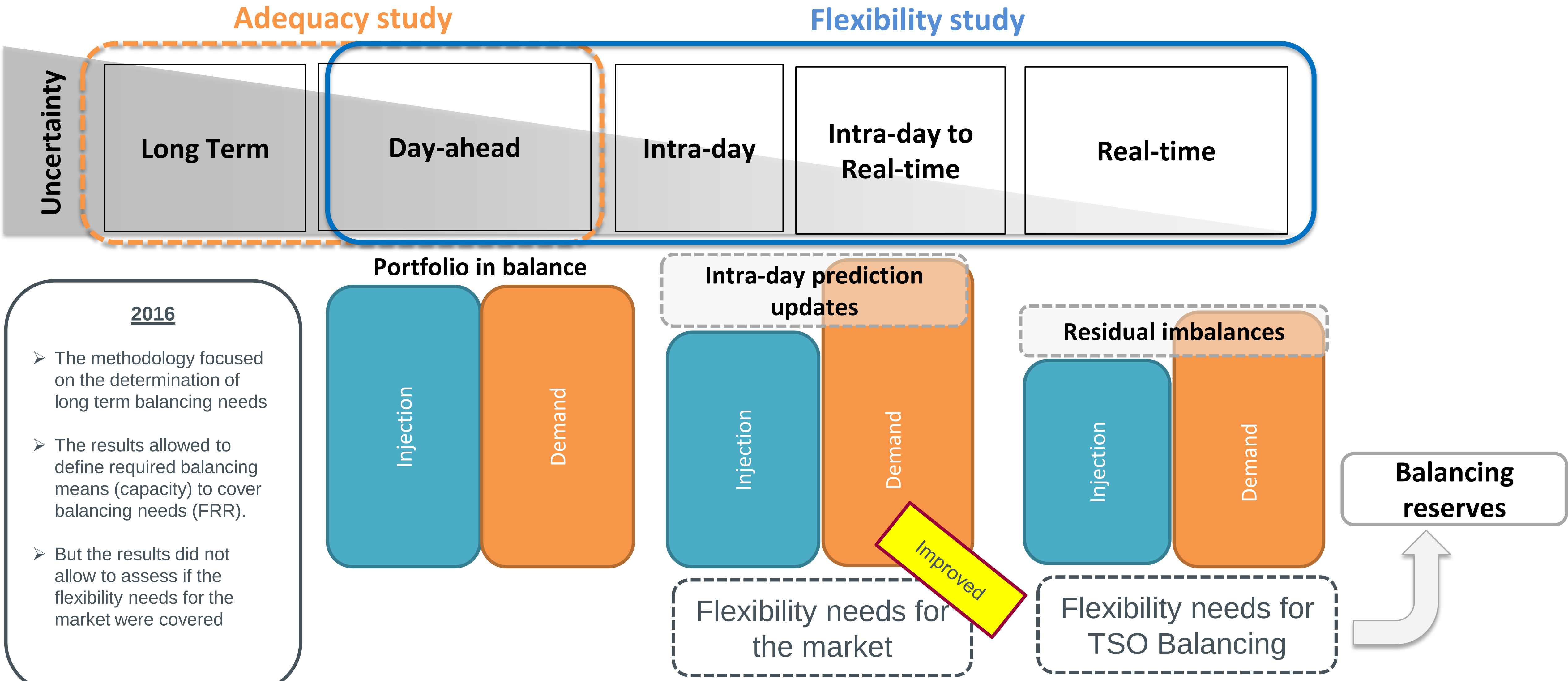
The adequacy study investigates the required generation capacity to cover peak demand periods.



Flexibility Study

The flexibility study investigates the required technical characteristics to deal with demand and supply variations.

Adequacy and Flexibility



2016

- The methodology focused on the determination of long term balancing needs
- The results allowed to define required balancing means (capacity) to cover balancing needs (FRR).
- But the results did not allow to assess if the flexibility needs for the market were covered

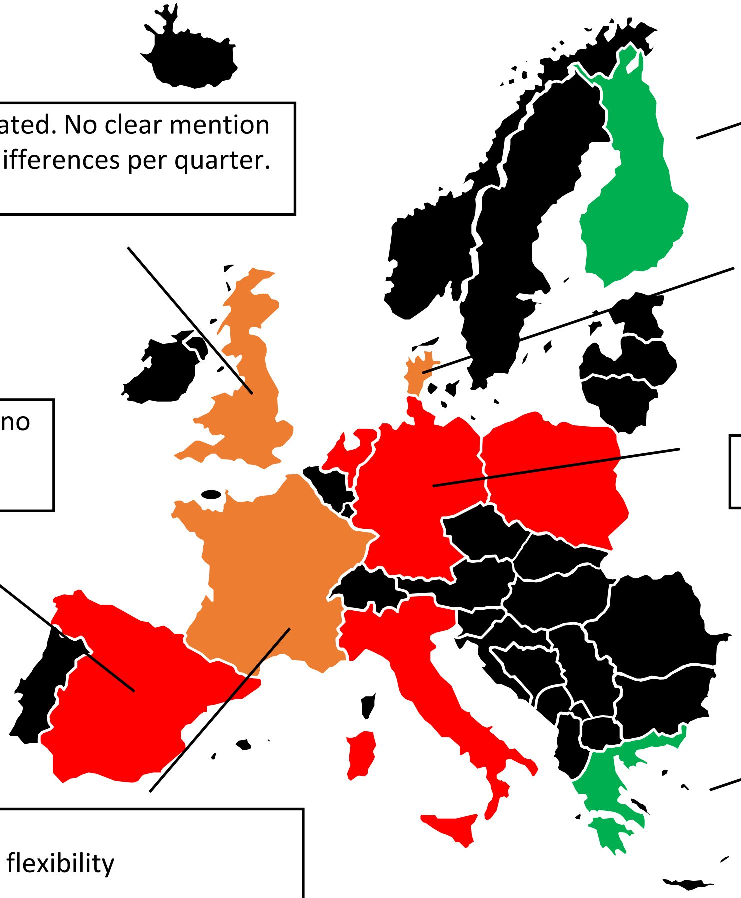
Enlarging the scope of the flexibility study

In order to have a full view on the ability of the future system to cover flexibility needs, it is insufficient to focus on TSO Balancing Reserves, but it is to be verified whether the system is capable of covering all flexibility needs, including those covered by the market. If this is not the case, it cannot be guaranteed that all flexibility needs are covered

1	A new method is developed to determine the total flexibility needs
2	A new method is developed to assess the availability of flexibility

- **Results will verify if identified adequacy needs will at the same time be sufficient to deal with flexibility needs**
  - And if not at least provide insight in the type of capacity (technology) which is needed
- **Results allow to anticipate the operational challenges ahead for ensuring the availability of the flexibility resources**
  - And anticipate necessary measures to facilitate flexibility

Overview of flexibility studies conducted by other TSOs



Study on the demand and supply of flexibility

Y+5 balancing needs are calculated. No clear mention of method. Interesting to see differences per quarter. Q2 highest needs in volume.

Flexibility from a total energy perspective.
Hourly residual demand analysis

No study. “If PV can also be curtailed, no issue in the future as ramping issues might occur with large amount of PV”

“Flex is not an issue” as there will be enough thermal units to cope with ramping constraints

Flexibility assessment method in the electricity generation adequacy study

Hourly ramping distributions in BP.
R&D will start working on intra-hourly flexibility requirements.

Available | Ongoing | No | No Info

A very limited number of TSOs are performing long term flexibility studies or do it on a hourly basis. There is a will to perform such studies in the future with the increase of RES.

Methodology overview

1	**Determining the needs for flexibility**
	Extrapolation of historical load and renewable (un)expected variations and forced outages of power plants.

→

2	**Assessing the availability of flexibility**
	Assessment of flexibility that can be provided by available capacity in the system

1. Determine the flexibility needs based on an extrapolation of historic load and renewable prediction errors
   - ➢ Moving beyond balancing needs which was only based on historical system imbalances assessments

2. Defining three types of flexibility needs*
   - Slow flexibility : day-ahead forecast errors
   - Fast flexibility: intra-day forecast errors
   - Ramping flexibility: forecast error variations

**Except from FCR, balancing capacity is not determined anymore (as FRR is being covered by the total flexibility needs)*

Modeling the flexibility needs : illustrative example

Market players schedule and dispatch generation capacity based on the residual demand : total demand – wind power – photovoltaics power – must run power

Market players schedule available power plants (or other capacity) to cover the predicted residual demand

36 -12h ahead

Almost all capacity can be scheduled (if not in maintenance)

Market players re-schedule available power plants (or other capacity) to cover predicted residual demand variation.

36 h – few hours ahead

Capacity with fast start-up times can be re-scheduled (e.g. gas fired units)

Market and TSO dispatch available capacity of scheduled power plants to meet the residual demand observed

Few hours ahead until real-time

The output of spinning capacity can be adapted (subject to technical constraints)

time

D-1

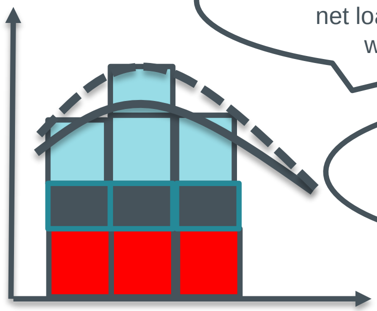
Market schedules 1 gas unit on top of maximum nuclear and import

Is there sufficient capacity to deal with hourly load and variations?

ID

Market schedules 2nd gas unit in period 2 to cover increased net load prediction following wind forecast error

Market covers increased load expectation in period 1 & 3 with available upward capacity of 1st gas unit.

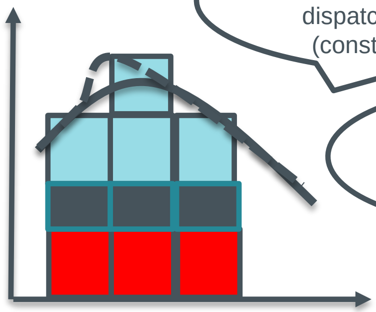


Is there sufficient **slow flexibility** with adequate start-up times available to deal with intra-day forecast updates ?

RT

Market/TSO uses available upward capacity on dispatched power plants (constrained by Pmax)

No time left to start new power units



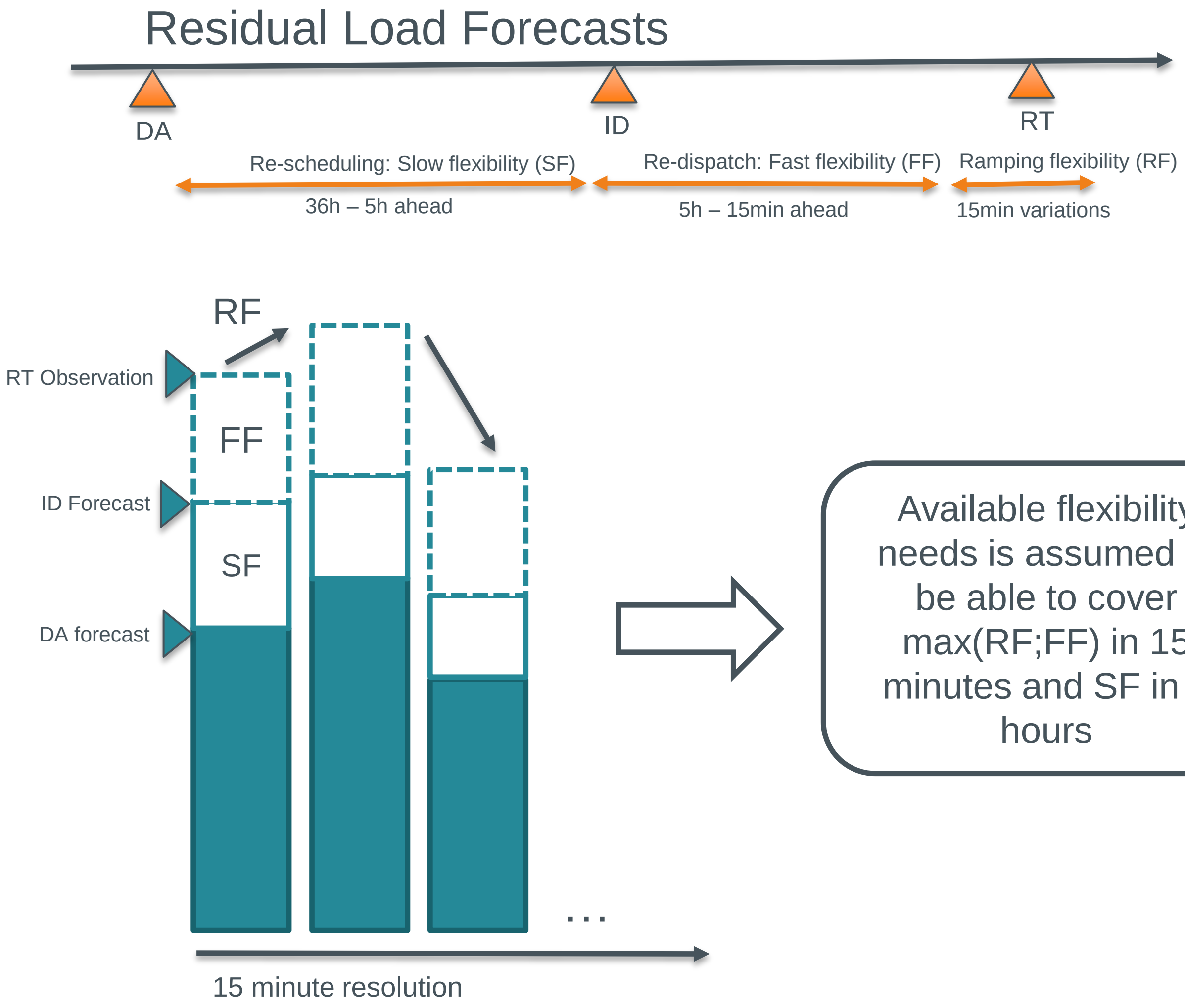
Is there sufficient **fast flexibility** with sufficient **ramping flexibility** to adapt dispatch to unexpected real-time variations?

adequacy study

flexibility study

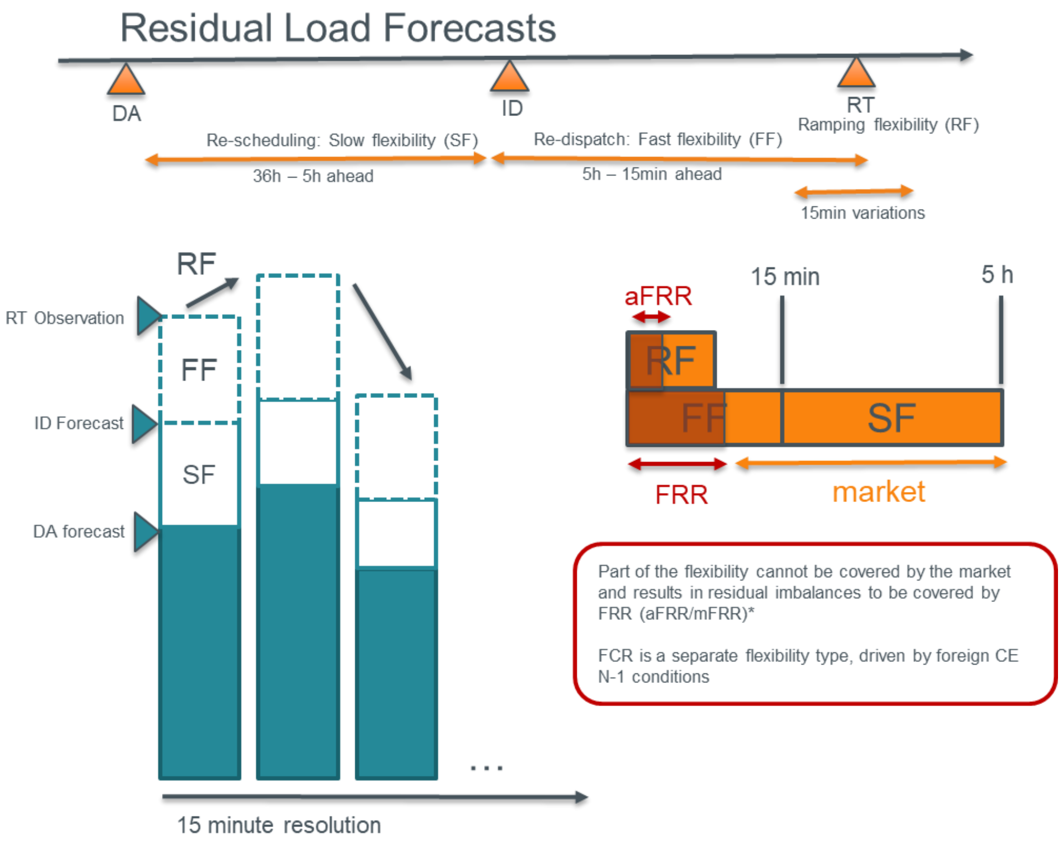
Different types of flexibility

Type of Flexibility	Slow flexibility (SF)	Fast Flexibility (FF)	Ramping flexibility (RF)
Definition	Capacity which can be regulated up- or downward in more than 5 hours	Capacity which can be regulated up- or downward in 15 minutes	Capacity which can be regulated continuously up- or downward in a timeframe of 1 to 15 minutes (cfr. MW/min)
Objective	Deal with intra-day prediction updates of residual demand Deal with forced outages (5 hour to 36 hours)	Deal with unexpected variations of residual demand Deal with forced outages (up to 5 hour duration) Deal with N-1	Deal with minute variations of the residual load
Indicator	Residual demand forecast errors between day-ahead and intra-day	Residual demand forecast error between intra-day and real-time	Residual demand forecast error variations
Link with balancing	None (assumed to be market flexibility)	Includes total FRR (FRR covering SI)	Includes aFRR (FRR covering 15 min SI variations)



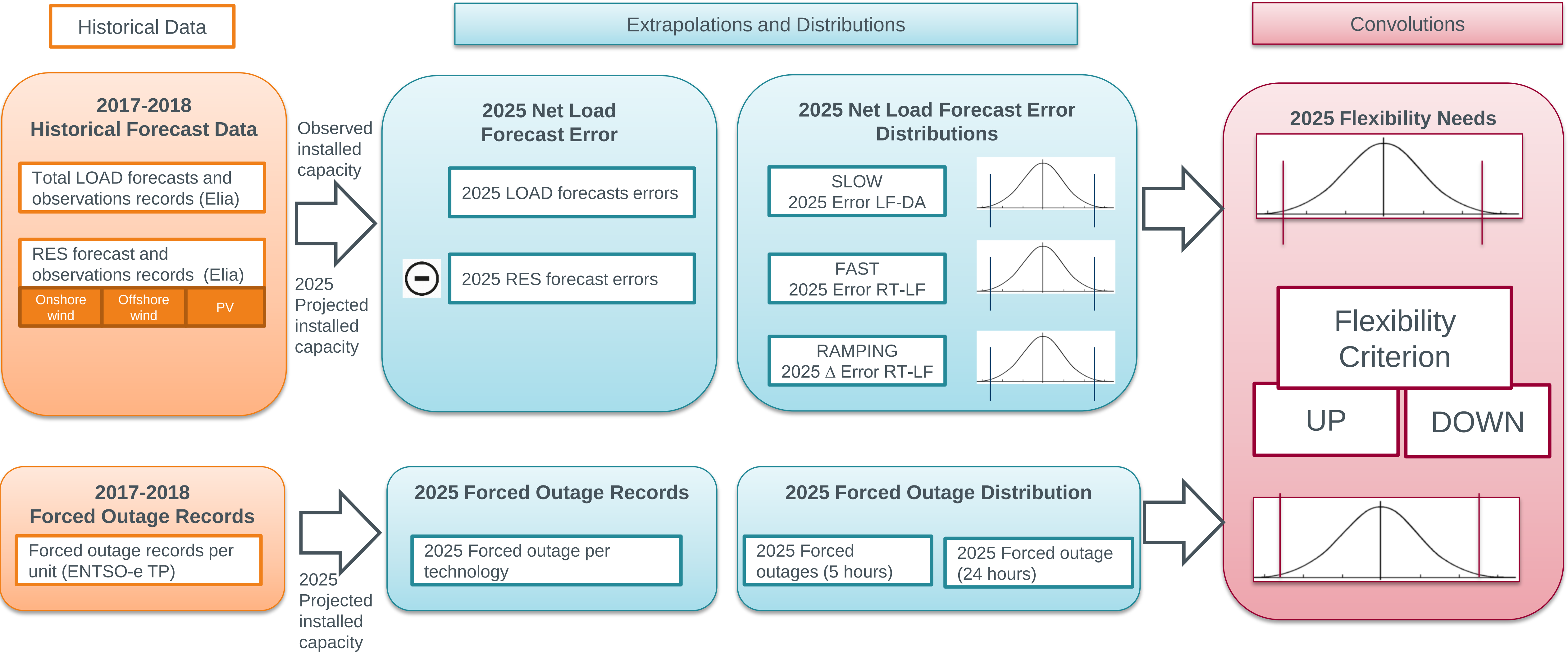
Available flexibility needs is assumed to be able to cover max(RF;FF) in 15 minutes and SF in 5 hours

Relation with the dimensioning of balancing capacity



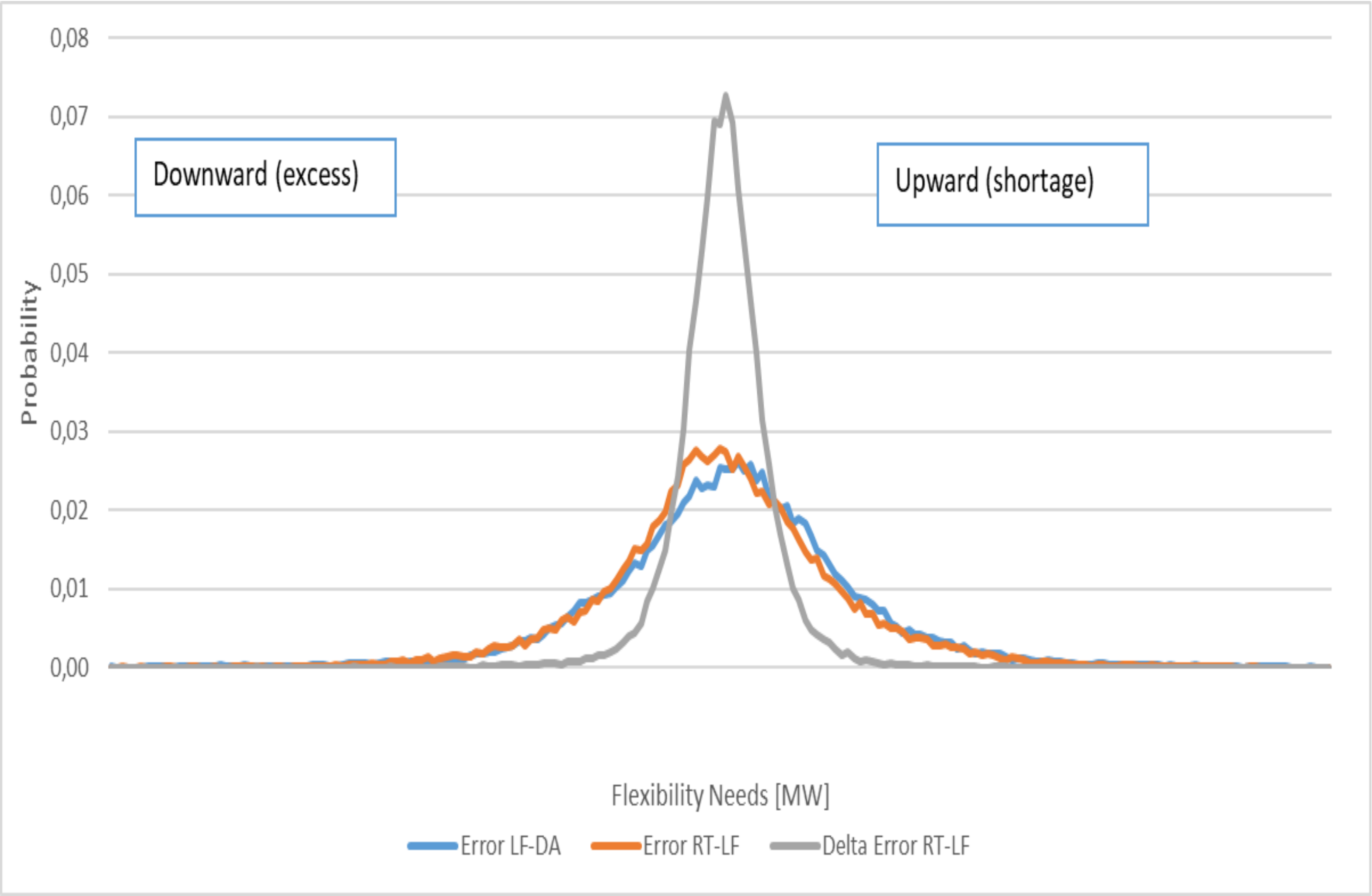
- The scope of the study is enlarged to flexibility instead of balancing capacity
- Part of the residual load variations and forecast errors may not be covered by the market, this will translate into residual system imbalances which will drive the reserve needs based on a dynamic dimensioning methodology (not in scope of the study)
  - **RF: variations of residual load (MW/min or MW;15min)**
    - aFRR: variations of system imbalance (MW; 7,5 min)
  - **FF: close-to real time residual load forecast errors (MW;15min)**
    - FRR (aFRR+mFRR): system imbalance (MW; 15 min)
  - **SF: intra-day residual load forecast errors (MW;5 h)**

Calculating the flexibility needs



Typical results

Probability Distribution Curve



Percentiles

	2025	**[MW]**		
	Percentile	Slow flex	Fast	Ramping
UP	…			
UP	**0,10%**			
UP	1,00%			
DOWN	99,0%			
DOWN	**99,90%**			
DOWN	….			

Overview Methodology (1)

STEP 1: Ex Ante
Flexibility Needs Analysis

Statistical analysis of historical load and renewable forecast errors and forced outages

Day-ahead forecast errors

Intra-day forecast errors

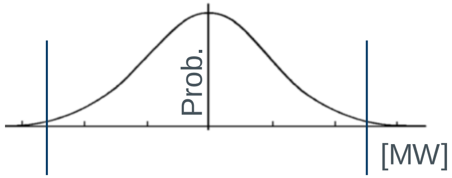
Forecast error variations

Slow flexibility

Fast flexibility

Ramping flexibility

Forced Outages of Generation and Transmission Assets



Determine the flexibility needs expressed in MW to cover all forecast errors or variations.

Methodology overview

1 — Determining the needs for flexibility

Extrapolation of historical load and renewable (un)expected variations and forced outages of power plants.

→

2 — Assessing the availability of flexibility

Assessment of flexibility that can be provided by available capacity in the system

1. Determine hourly available flexibility from thermal and non-thermal capacity*
   - ➢ Compare with flexibility needs and identify potential flexibility issues during typical periods

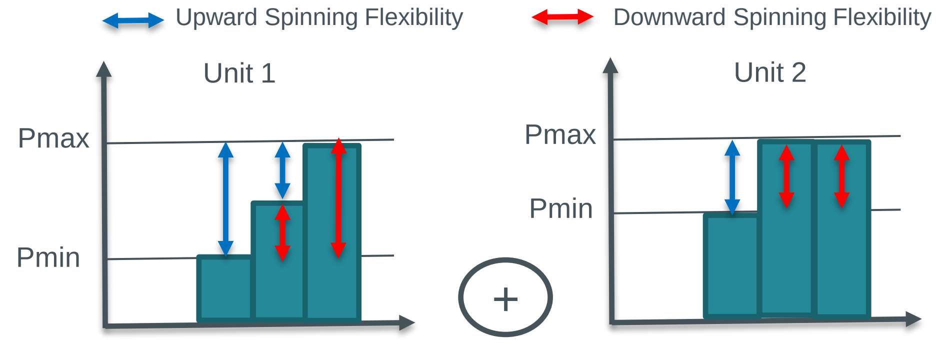
2. Implement flexibility needs in adequacy simulations
   - ➢ Identify the impact on adequacy indicators and identify technical requirements towards flexibility

**Using results of adequacy calculations*

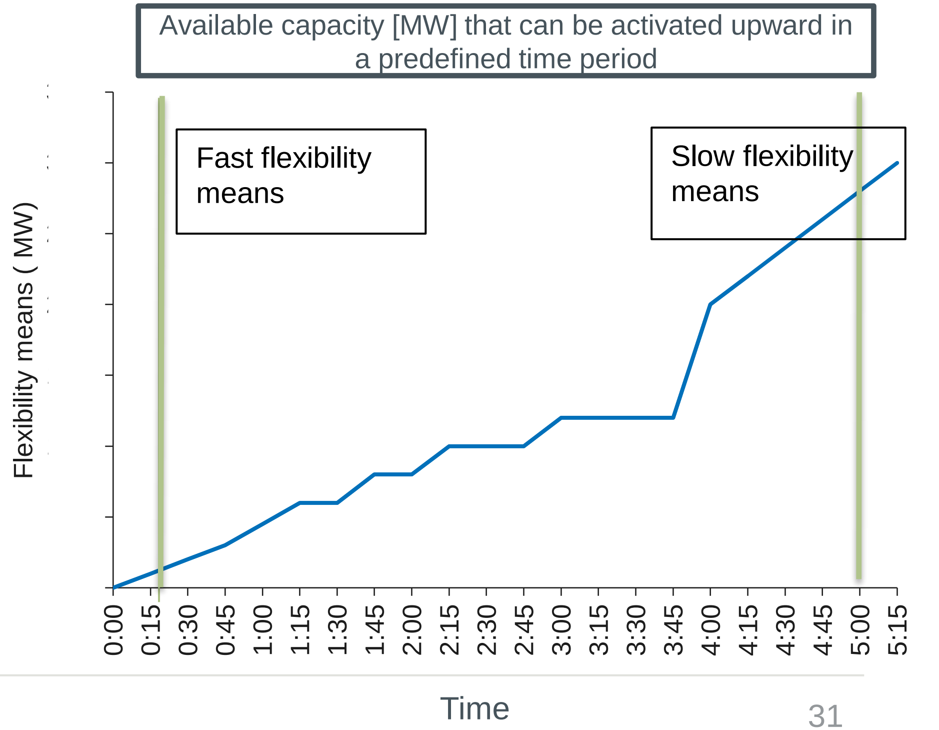
Assessing the available flexibility

- **ANTARES** provides the day-ahead schedule of all power plants (and other capacity) given a certain residual demand :
  - For every hour for an entire year (for different Monte Carlo years)
  - Also demand response, batteries and pumped storage (energy constrained technologies)

- **This allows to determine available flexibility for each time frame:**
  - How much capacity can be ramped in 15 minutes (RR_i)?
  - How much spinning capacity is available ($Pmax_i$, $Pmin_i$)?
  - How much additional non-spinning capacity is available ($Pmax_i$)?



Illustrative example



Flexibility parameters

Elia will need to make assumptions on flexibility capabilities of each technology taken into account. This will be based on literature studies or Elia's expert view. As these assumptions will have an important impact on the results of the study, and bound to future uncertainty, **Elia consults the sector on the assumptions taken for the reference scenario.**

	Min up	Min down	Start up time	Ramp Rate	Min Stable power	Ramp Rate	MAX ramping flex	MAX Fast flex	MAX Slow flex	Max. Duration
	hours	hours	hours	MW/min	% Pmax	%Pmax/min	%Pmax	%Pmax	%Pmax	hours
Existing Nuclear										
RES										
CCGT new built										
CCGT existing/recent										
CCGT existing/old										
OCGT new built										
OCGT existing										
CHP										
Pumped Storage existing										
Home/small scale batteries										
Large scale batteries										
V2G										
DR shedding										
DR shifting										
Interconnection										

Illustrative - Public Consultation

Overview Different Approaches

Simulation adequacy model (including flexibility constraints)

Integrate flexibility constraints in ANTARES

- Integration of flexibility constraints in the adequacy model (replaces current balancing constraints)
    - Simulations take into account flexibility provided by :
        - Thermal capacity (conventional production units)
        - Non-thermal capacity (demand response and storage)
    - Results may impact on adequacy indicators (e.g. Loss of Load Indicators, Production Curtailment)
    - Assess additional requirements to ensure available flexibility (minimum technical requirements of installed capacity)

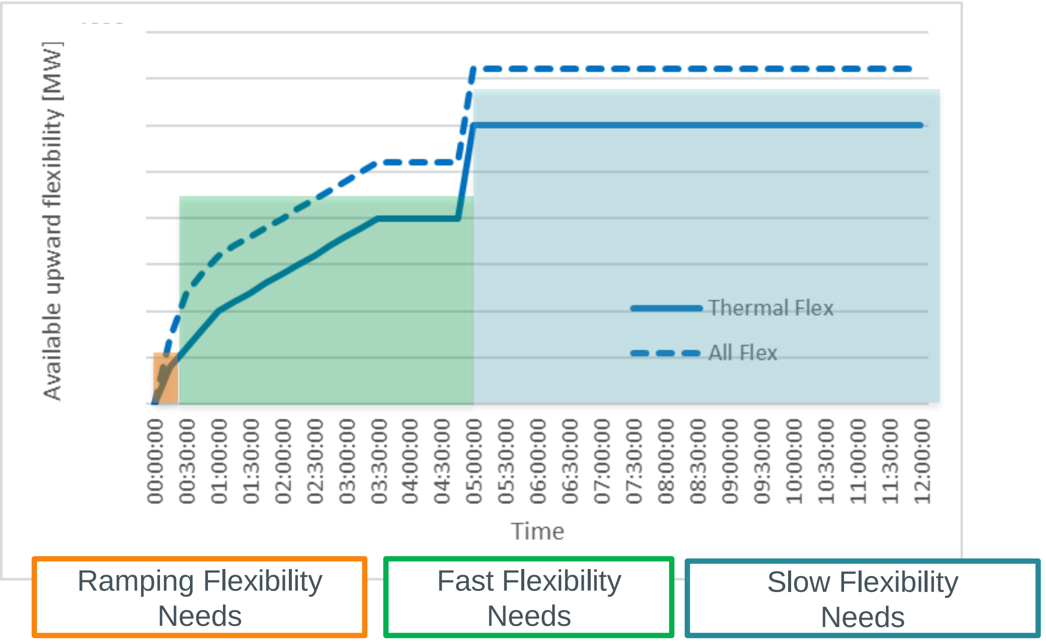
Assess available flexibility

- Assess available flexibility on an intra-hourly basis and cross-check with flexibility needs (based on the results of ANTARES)
    - Results will detect flexibility problems during certain situations (based on flexibility indicators and flexibility graphs)
    - Result allows to study the available flexibility during particular cases (e.g. storm event)
    - Results allow to assess additional requirements to ensure available flexibility

Typical results

	2025	[MW]		
	Percentile	Slow Flex	Fast Flex	Ramping Flex
UP	…			
UP	**0,10%**			
UP	1,00%			
DOWN	99,0%			
DOWN	**99,90%**			
DOWN	….			

Flexibility graphs



Overview Methodology (2)

STEP 1: Ex Ante
Flexibility Needs Analysis

Statistical analysis of historical load and renewable forecast errors and forced outages

ANTARES

STEP 2 : Ex Post
Flexibility Availability Analysis

Comparison with available flexibility resulting from generation schedules in adequacy assessments

Day-ahead forecast errors

Intra-day forecast errors

Forecast error variations

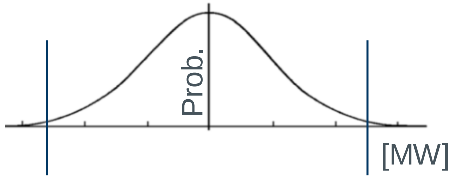
Slow flexibility

Fast flexibility

Ramping flexibility

Forced Outages of Generation and Transmission Assets

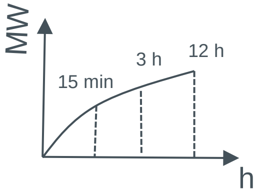
Determine the flexibility needs expressed in MW to cover all forecast errors or variations.



Integrate additional flexibility requirements in adequacy assessment

Observe available flexibility in results adequacy assessment

Assess challenging flexibility situations (e.g. storm events).



Determine the available up and downward flexibility of the scheduled power plants

Methodology: key take-aways

- **The methodology allows to determine the <u>total flexibility needs</u> of the system**
  - Together with adequacy study, all current relevant flexibility requirements are covered
  - The methodology is moreover adaptable to new flexible types
  - Assessing the share of total flexibility to be covered by TSO or market is out of scope
  - ➢ Dimensioning the balancing capacity is outside the focus of the study (covered by day-ahead dynamic dimensioning)

- **The methodology allows to <u>cross-check flexibility needs with available flexibility</u> observed in the adequacy simulations**
  - Allows to assess if installed capacity is able to meet the flexibility needs
  - Allows to assess if operational flexibility covers the flexibility needs
  - ➢ Allows to identify operational challenges and prepare measures to ensure adequate flexibility in real-time

Public Consultation

Objective and Scope

Objective is to receive feedback from stakeholders concerning the input parameters and assumptions of the base case scenario from 2020 to 2030

- The public consultation is not part of Elia's obligations in the framework of the Electricity Law;
- Elia feels it is important to consult the market parties on the input parameters and assumptions made with market actors

- The **Base Case scenario** was discussed with the FOD, CREG and Plan Bureau.
  - It is based on the "Energy Pact" values for RES (which includes a "second wave offshore" by 2030), storage and market response;
  - It follows the evolution of nuclear capacity as foreseen in the current law.

Practical Aspects

An Excel file containing the "base case" scenario is submitted for consultation

0. Scenario framework
1. Renewables
2. Nuclear
3. Interconnections
4. Structural block - 'Base case' scenario
   - 4.1 CHP
   - 4.2 Market Response
   - 4.3 Storage
   - 4.4 Needed capacity to ensure SoS and flexibility needs
5. Total electricity consumption
6. Economic and technical variables
   - 6.1. Fuel and CO2 prices
   - 6.2. Investment costs
   - 6.3. Forced outage rates
   - 6.4. Flexibility characteristics
7. Assumptions for other countries

Questions? Rafael.FeitoKiczak@elia.be

Period for public consultation

- **Start :** 21 January 2019
- **Deadline:** 11 February 2019, 18.00

Link and more information:
http://www.elia.be/en/about-elia/publications/Public-Consultation/20190121_Public-consultation-on-the-data-used-for-the-study