2024 - 2034

ADEQUACY AND FLEXIBILITY STUDY FOR BELGIUM

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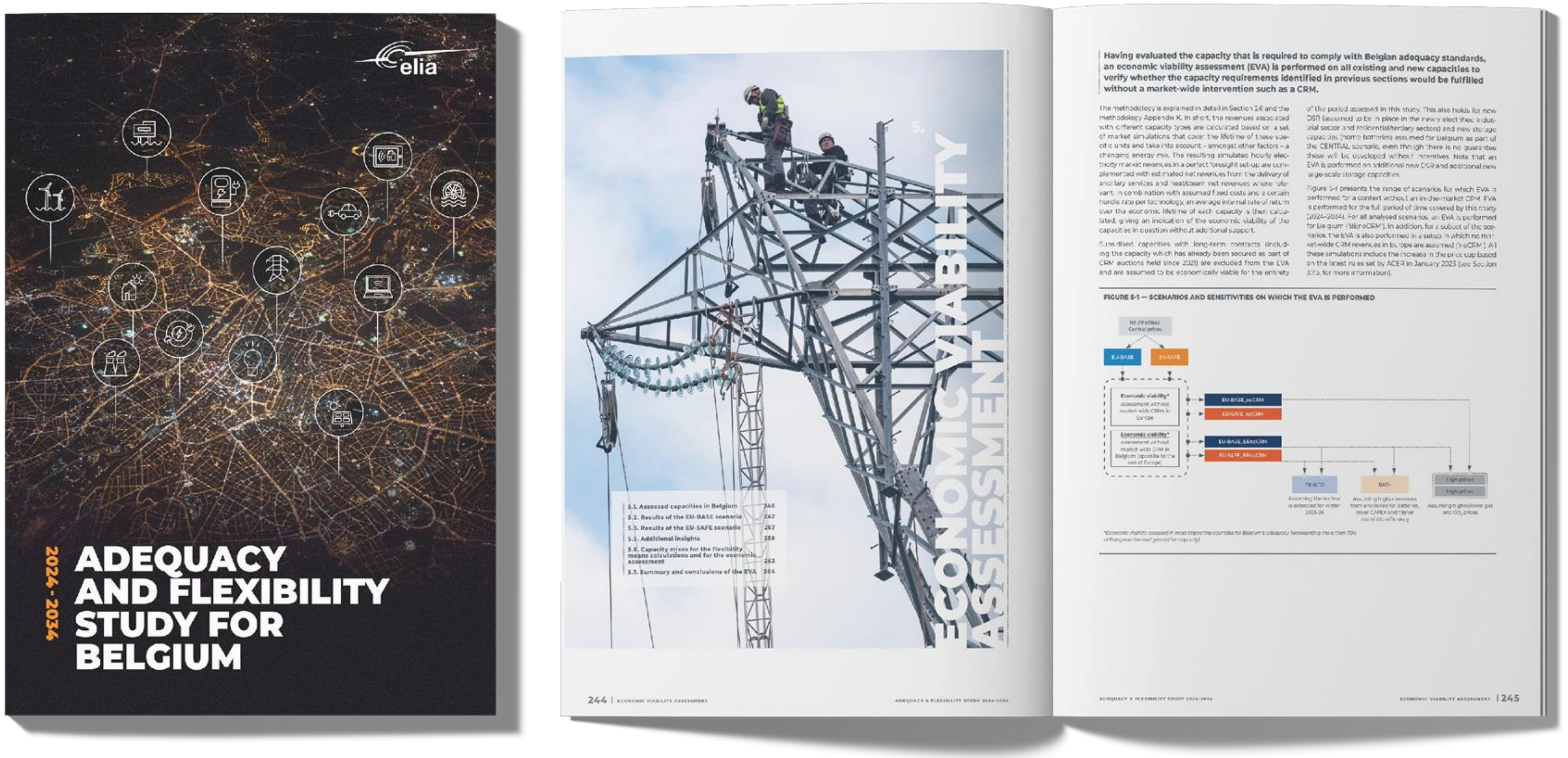
Generalities



- This presentation is given as a primeur to the Users Group
- A press conference will be held in the afternoon
- We therefore kindly ask you **to not share any information regarding the study before 4PM this afternoon.**
- A printed version of the report (version from a few days ago) will be provided to all of you at the end of this presentation
- The final report will be published this afternoon

AGENDA

(and indicative timings)

- **Regulatory** framework and **stakeholder** interaction **[9h00-9h15]**
- **Scenario** framework and assumptions **[9h15-10h00]**
- **Adequacy** results **[10h00-10h40]**
- Break 15min **[10h40-10h55]**
- **Economic viability** assessment **[10h55-11h15]**
- **Flexibility** needs and means **[11h15-11h45]**
- **Other** insights & **main messages** **[11h45-12h00]**

Regulatory framework and stakeholder interaction

This study is based on the requirements set in the electricity law and uses the expertise that Elia has developed in its past Adequacy and Flexibility studies

APR 2016

Adequacy & Flexibility 2017-2027

At the request of the Minister of Energy, an ad hoc study covering the adequacy and flexibility of Belgium's needs was published in April 2016. As requested by the authorities, an addendum was subsequently published in September 2016, based on a large stakeholder consultation which was undertaken following the publication of the initial study.

JUL 2018

Legal requirement in the Belgian Electricity Act

Art. 7bis, §4bis (Elia's translation into English): "*No later than 30 June of each biennial period, the system operator shall carry out an **analysis of the needs** of the Belgian electricity system in terms of the country's **adequacy** and **flexibility** for the next **ten years**.*
*The basic **assumptions** and **scenarios**, as well as the **methodology** used for this analysis, shall be determined by the system operator **in collaboration** with the **Directorate General for Energy** and the **Federal Planning Bureau** and in **concertation** with the **regulator**.*"

JUN 2019

Adequacy & Flexibility 2020-2030

The first study published in 2019 after the modified law.

JUN 2021

Adequacy & Flexibility 2022-2032

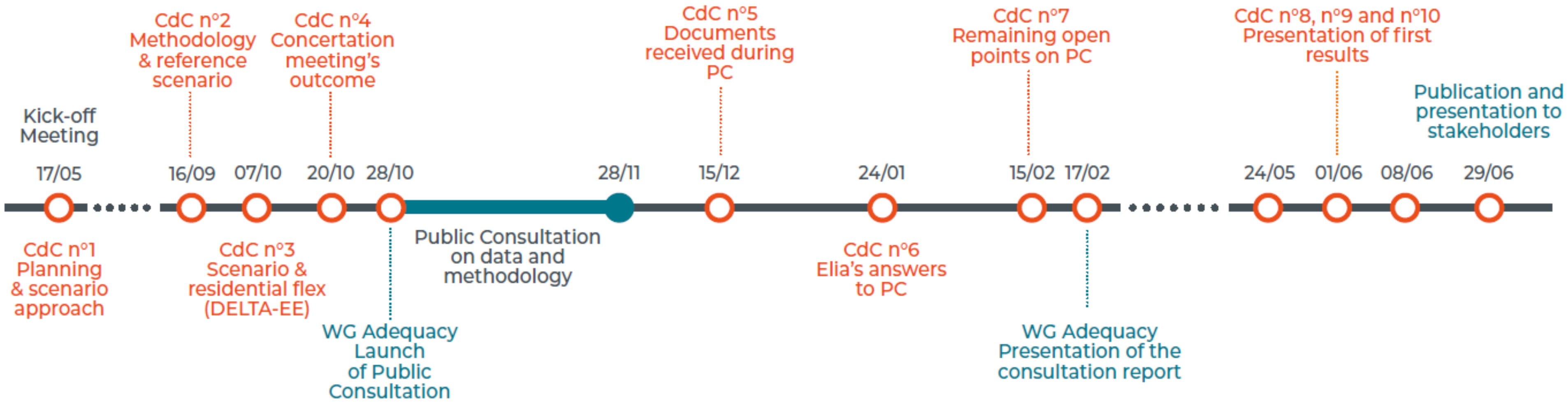
The study published 2 years ago.

JUN 2023

Adequacy & Flexibility 2024-2034

The present study.

The study followed a very extensive stakeholder involvement process (including a public consultation on methodology and data)



* **Comité de Collaboration (CdC)** - meeting with Elia, the FPS Economy and the Federal Planning Bureau and with CREG
* **Public Consultation (PC)** report - report containing answers to each comment received from stakeholders during the public consultation.
* **Adequacy Working Group (WG)** - meeting during which Elia and market parties can discuss the development and evolution of the different mechanisms related to the topic of adequacy.

Stakeholder feedback

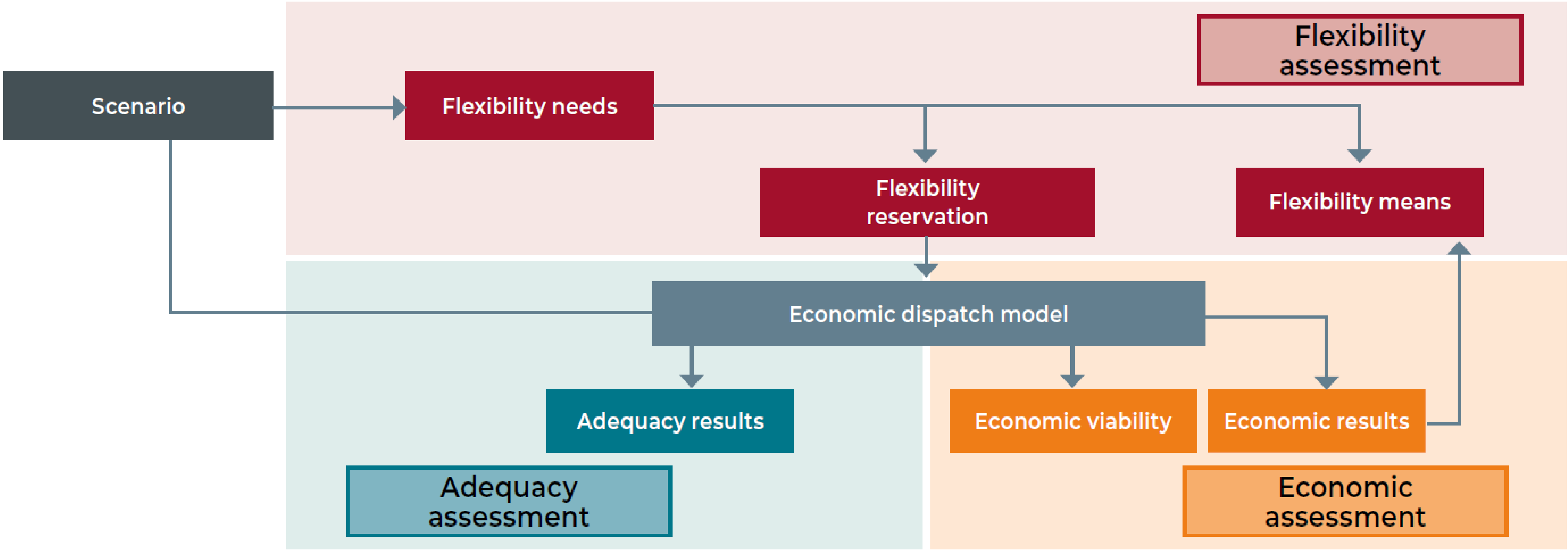
- **12 non confidential** replies received
- **3 confidential** replies received
- **>200 comments** received
- **>20** requests for sensitivities

Public consultation report & Annexes were already published

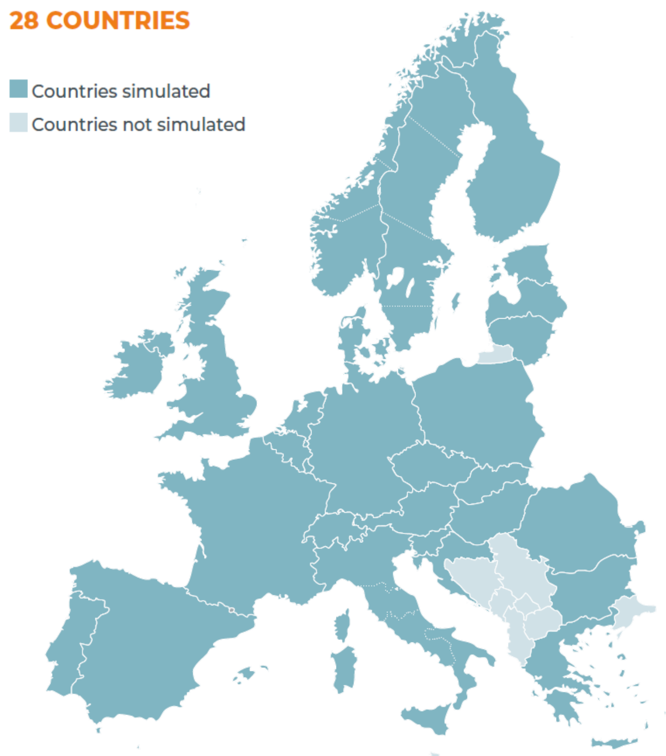
- Scenario data + complete methodology
- Study of residential and tertiary flexibility with DELTA-EE
- Study on forced outage rates with N-SIDE
- Study on updated Economic Viability metrics from Prof. Boudt
- Study on fixed costs of existing units with AFRY

Consultation report with answer (discussed within CdC) **to each feedback**

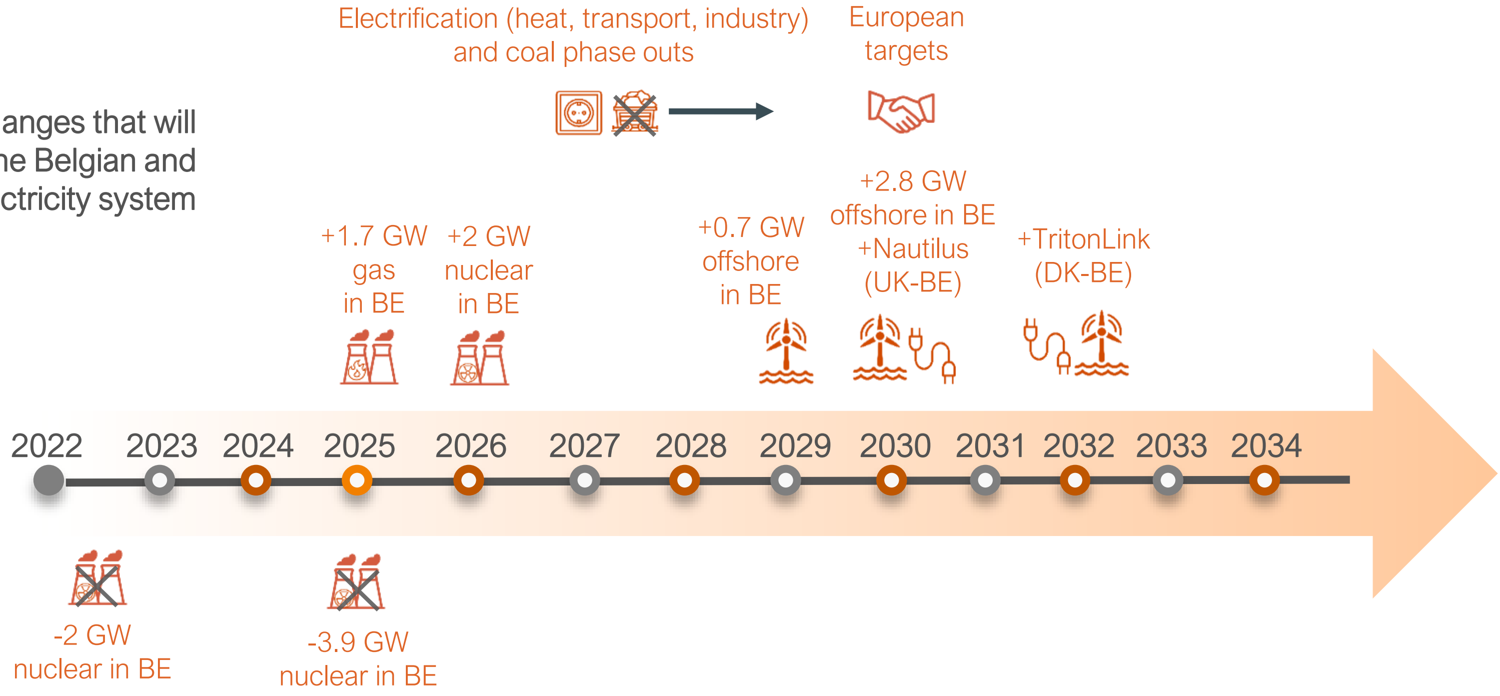
This study covers 3 main topics related to adequacy, flexibility and economics



We looked **10 years ahead**, covering the most important events that will affect the electricity system in the future, simulating **28 countries**



Main changes that will affect the Belgian and EU electricity system



- Main scenarios analysed for adequacy
- Detailed analysis and sensitivities for adequacy and economics
- Detailed analysis and sensitivities for adequacy, economics and short term flexibility

Years are simulated from 1 September Y to 31 August Y+1, hence 2025 corresponds to 1 September 2025 until 31 August 2026.

Scenario framework and assumptions

The scenarios used in this study are aligned with the most recent figures and ambitions of Belgium and other countries

- aligned with the recently published **draft Regional and Federal Energy and Climate Plan** for **Belgium,** those were anticipated thanks to exchanges with the Regions and DSOs;
- **data** for **other countries** based on the ERAA22 complemented with more recent information/ambitions, national studies and **REPowerEU**, **Fit for 55** plans, offshore ambitions;
- the approved **Federal Grid Development plan** for Belgian grid assumptions;
- the **TYNDP 2022** for other countries' **grid** assumptions;
- the **Clean Energy Package** for the capacity calculation rules and known action plans/derogations;
- the **IEA** – World Energy Outlook 2022 for fuel and carbon prices complemented with **forward prices**;
- a **large amount of sources** for CAPEX and fixed costs of technologies;
- an **academic study** for defining the **economic viability metric**;
- Several external studies for the **flexibility** assumptions and **outages**.

In addition, **a large amount of sensitivities** were investigated on European assumptions, Belgian assumptions, the grid, capacity calculation rules and economics.

Belgian scenario and sensitivities

1 CENTRAL scenario for Belgium was constructed
(a large number of sensitivities were applied on this scenario)

Belgian scenario and sensitivities

- **Demand & flexibility**
- Supply & storage

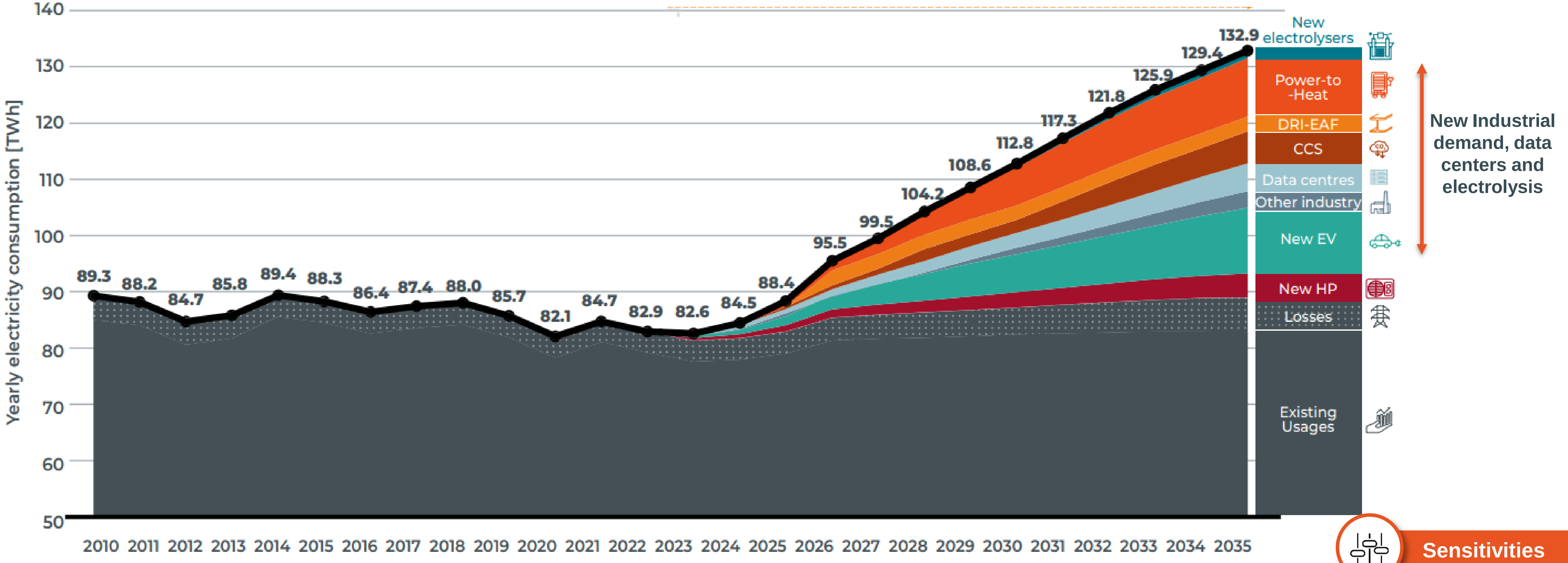
The future electricity load is decomposed in 7 components with associated assumptions on flexibility

Electricity load components	Associated flexibility assumed		Flexibility assumed in the CENTRAL scenario*
Historical usage of electricity	Market response (DSR from existing usages)	Existing DSR (or market response) in the system with potential new additional volumes that can be invested in if economically viable	Existing DSR (Market Response) and additional if viable in the EVA.
Transport electrification	Vehicle-to-X Smart charging	Different modes of (dis-)charging EV considered depending on the EV usage, infrastructure and market incentives	Shares of EV, HP are optimised *High/Low scenarios defined*
Buildings heat electrification	Smart consumption	Assumed flexibility for heat pumps while ensuring comfort of consumers	
Electrolysers	Power-to-H_2	Turned on when electricity prices below a certain threshold	<u>Foreseen evolution</u> • E-boilers 100%; • Electrolysis 100%; • HP 80%; • DRI-EAF 75%; • Data centers 50%; • CCS 0%. *High/Low scenarios defined*
Data centres	Data centres	Activating back-ups when very high prices	
Industry new usage and electrification	CCS / DRI-EAF	Flexibility from the process	
	Power-to-Heat	Turned on when electricity prices below a certain threshold	
Losses			

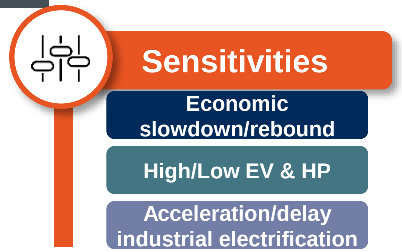
*flexibility taken into account in the economic dispatch model. Only part of this flexibility can be used in the short term flexibility assessment to balance fast and unexpected variations

Electricity demand is expected to increase significantly in the coming decade, mainly driven by new electrification in industry, transport and heating

NORMALISED HISTORICAL AND ASSUMED FUTURE YEARLY TOTAL ELECTRICITY CONSUMPTION IN THE CENTRAL SCENARIO FOR BELGIUM



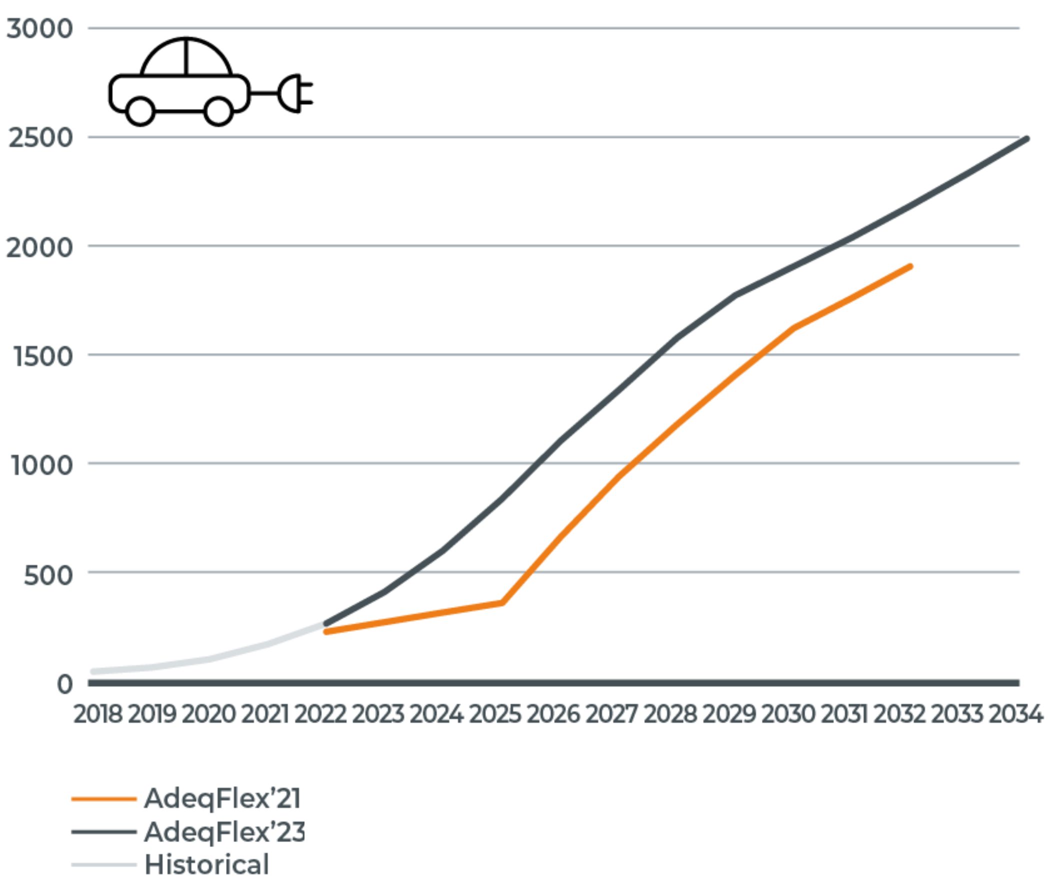
Electrolysers and power-to-heat are an output of the economic dispatch model



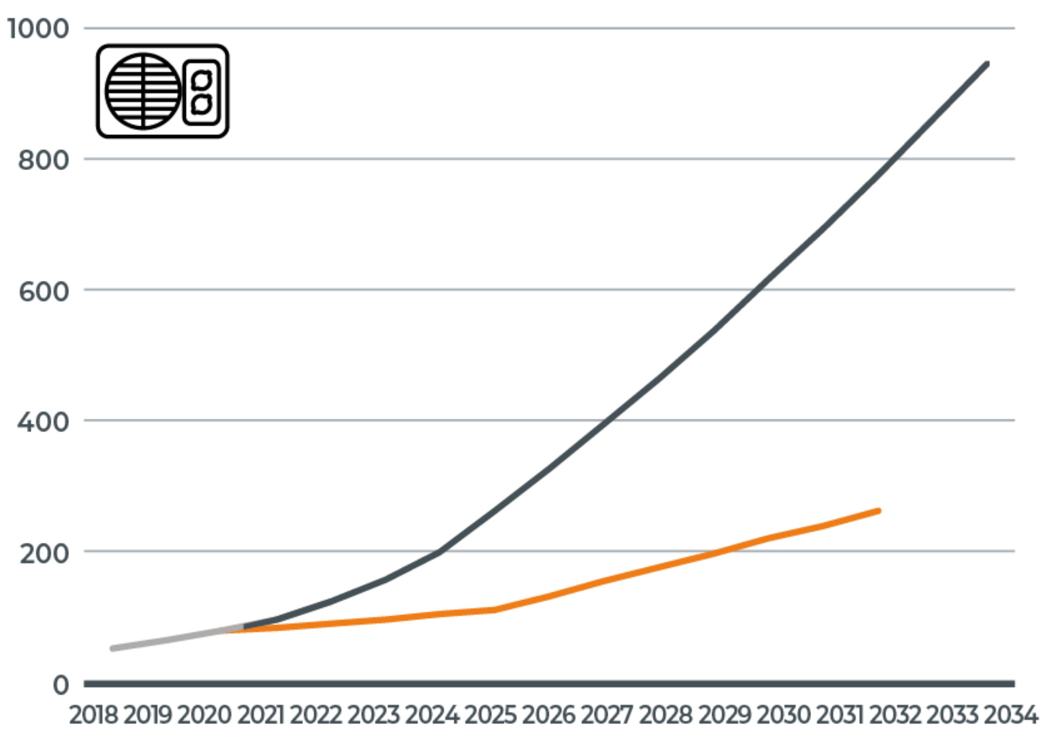
The total consumption presented here is the load including 'auto consumption' (it is therefore different from the Elia grid load).

The uptake of electric vehicles & heat pumps comes earlier and faster
- based on the most recent regional and federal ambitions
- taking the latest sale numbers into account

Amount of electric passenger cars (EV+PHEV thousands)



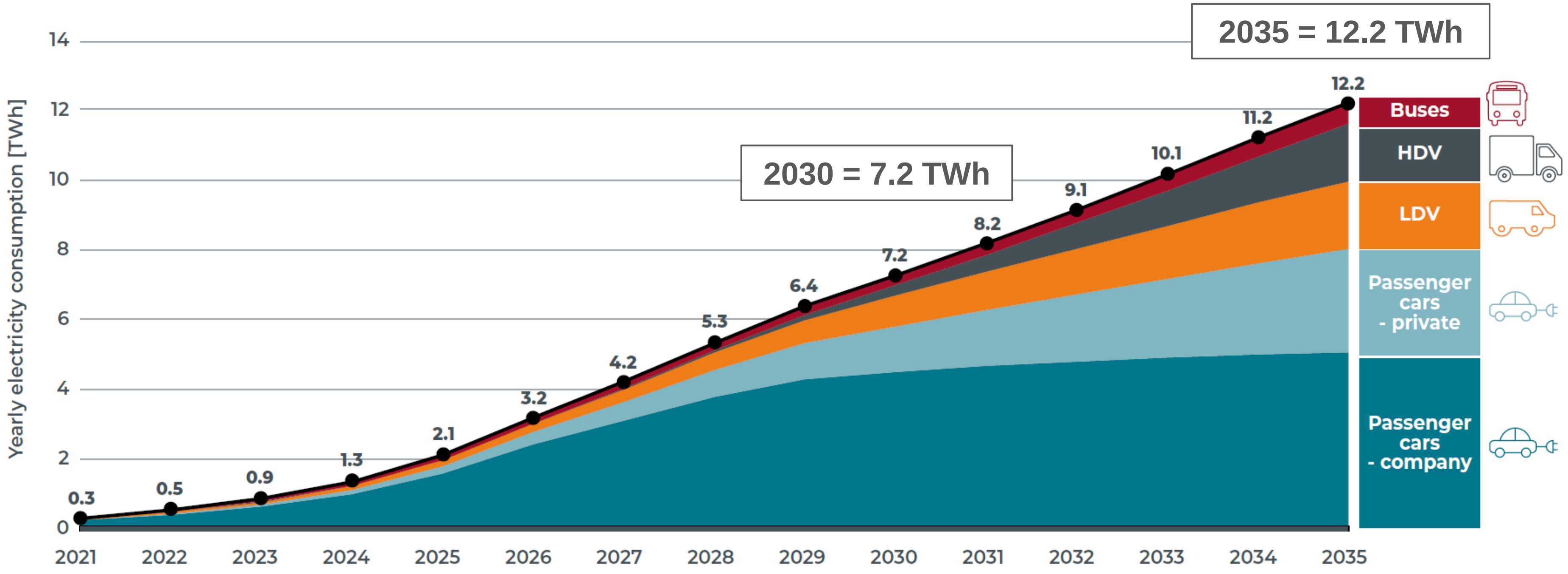
Equivalent amount of hydronic heat pumps (thousands)



- *AdeqFlex'21 was based on the final NECP 2019*
- *AdeqFlex'23 is based on the known policies in February 2023 (in-line with the draft regional and federal climate plans to be handed by Belgium to the EC)*

Passenger cars are expected to electrify already in the short term, vans, trucks and buses are also expected to electrify with a later timeframe

YEARLY ELECTRICITY DEMAND FOR ROAD TRANSPORT IN THE CENTRAL SCENARIO



Share in stock* in...	2030	2035
Buses	30%	70%
HDV	3%	18%
LDV	21%	42%
Passenger cars	34%	49%

Sensitivities (High/low) on the future penetration are performed

More details on the assumptions (amounts, energy consumed, profiles...) are available in the report

Sensitivities
High
Low

*stock of the corresponding category

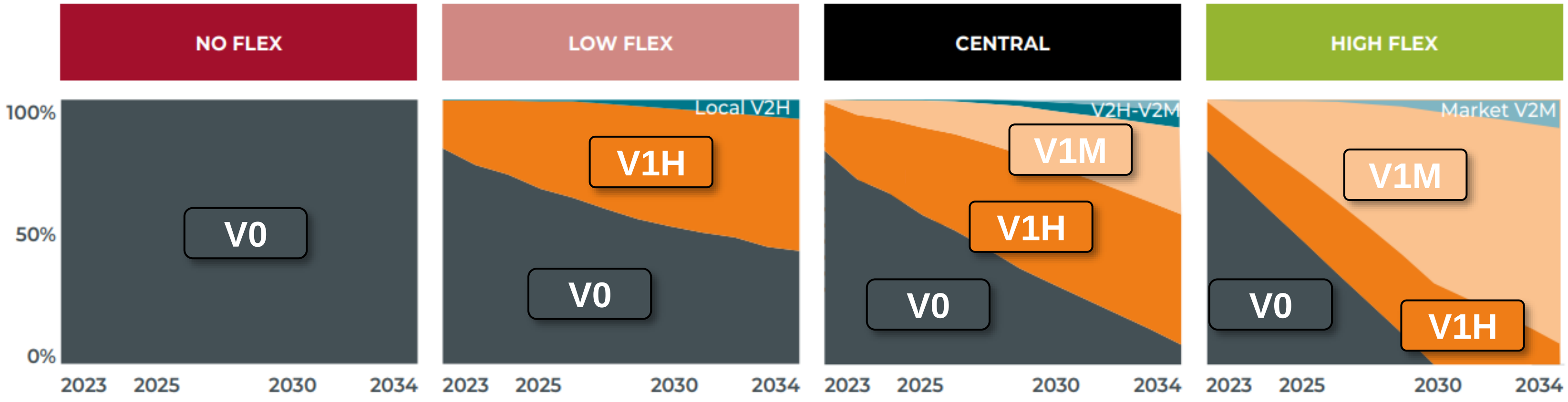
EVs are assumed to be charged in various ways. In the CENTRAL scenario:

- **2/3 of EVs are expected to be optimised by a local or market signal in 2030**
- **Almost 100% EVs in 2034 are assumed to follow some form of intelligent charging**

Operation modes

Technology	Profile name	Description	Rationale	
Electric Vehicles (EV)	V0	Natural charging	Charging as soon as plugged in	No flexibility
	V1H	Delayed charging	Evening peak charging is moved to the early morning	**Flex to home**
	V1M	Smart charging	Charging daily energy needs when it suits the market best	**Flex to market**
	V2H	Vehicle-to-home	Netting of house load in the evening, charging early in the morning	**Flex to home** *Fixed input times-series*
	V2M	Vehicle-to-market	Charging daily energy needs, and discharging taking round-trip efficiency into account, when it suits the market best	**Flex to market** *Dispatched by the model*

Scenarios



The average charging profile of EV is expected to evolve with the increasing share of optimized profiles and evolution of the residual load

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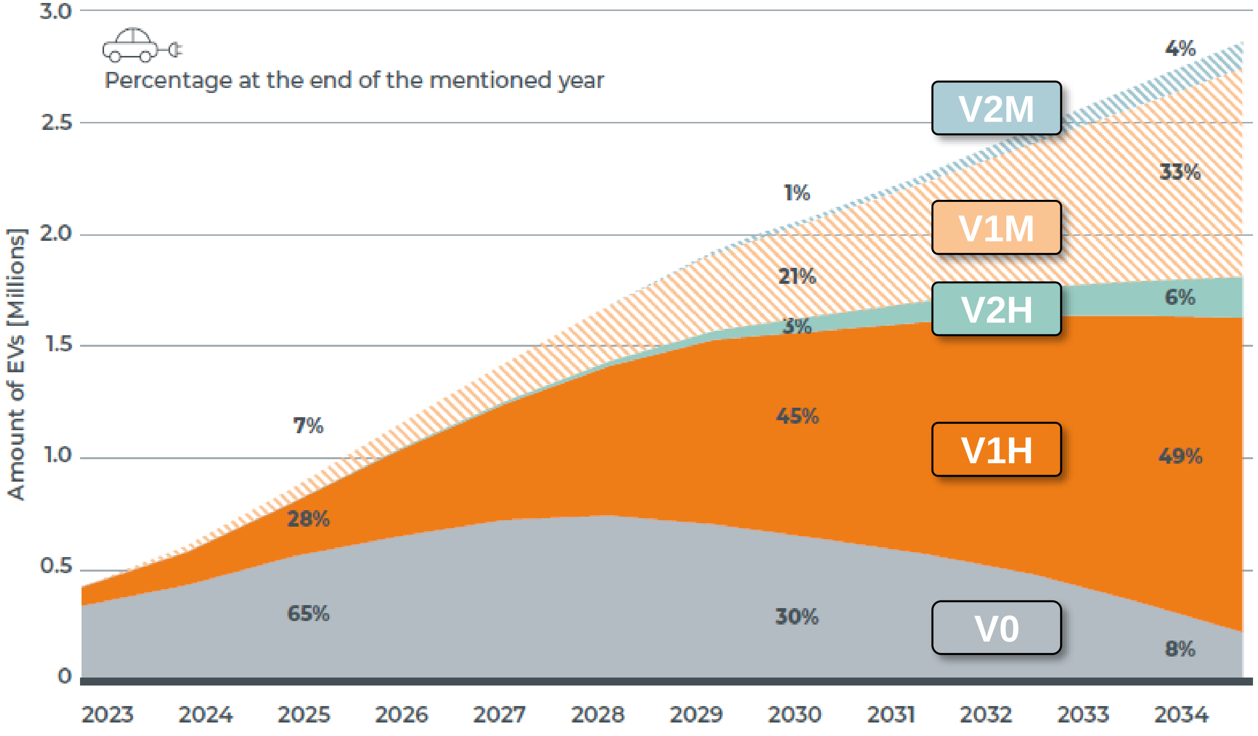
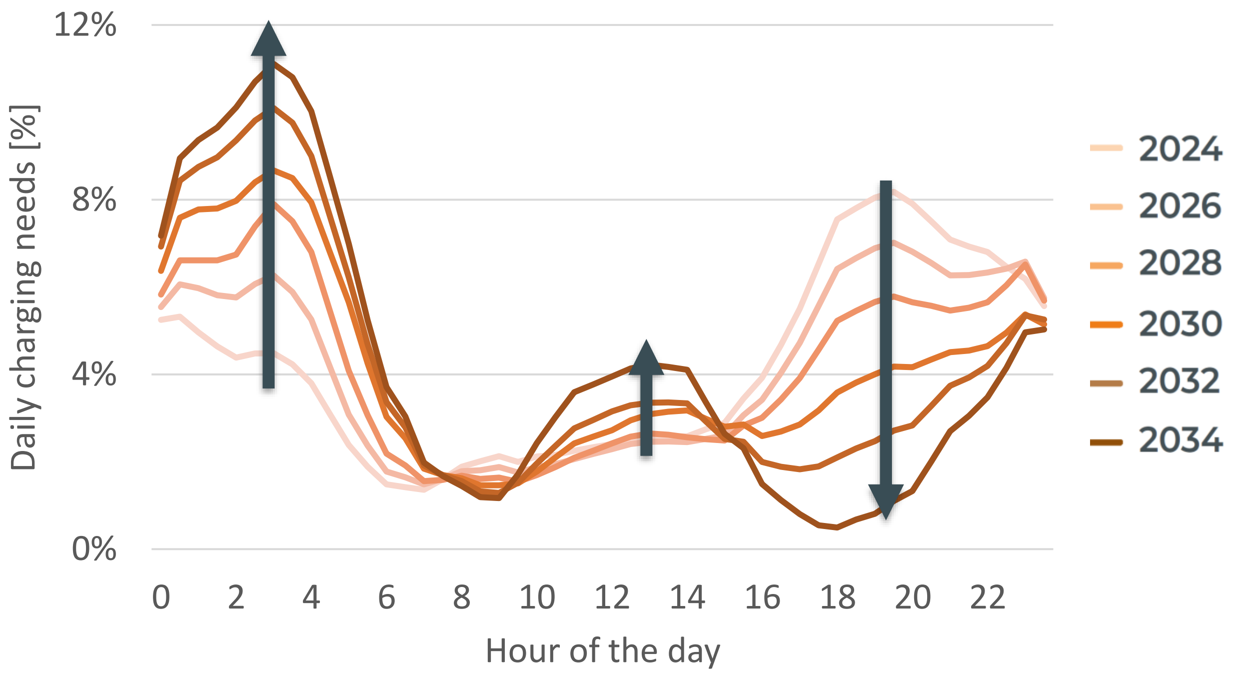
Amount and shares of each operation mode (CENTRAL)



EVs = passenger EV and electric LDV (BEV + PHEV)

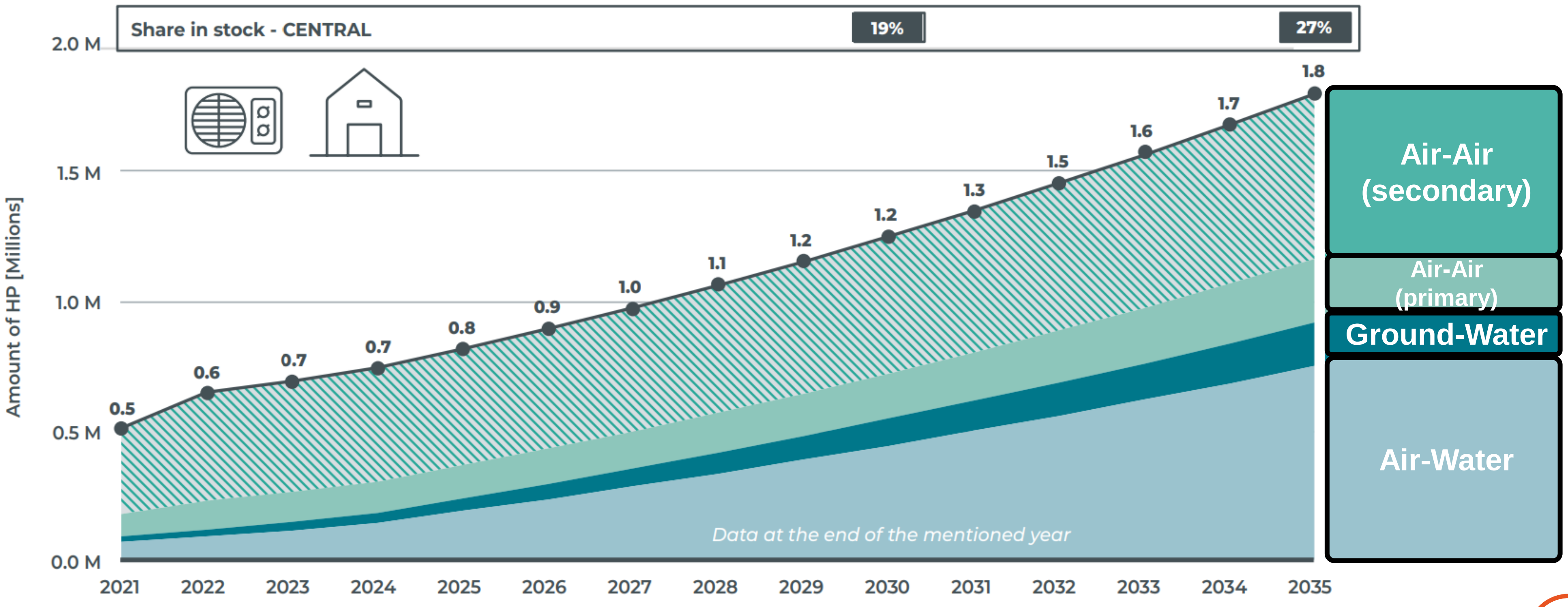
Aggregated average hourly winter profile evolution



V2M	Vehicle-to-market	**Flex-to-market:** *Dispatched by the model*
V1M	Smart charging	
V2H	Vehicle-to-home	**Local flex**: *Fixed input times-series*
V1H	Delayed charging	
V0	Natural charging	

The amount of installed heat pumps is expected to increase steadily in the buildings sector

ASSUMED AMOUNT OF HEAT PUMPS IN THE RESIDENTIAL SECTOR



Tertiary sector is also accounted for (around 150k in 2030 and 230k in 2035)

Sensitivities (High/low) on the future penetration are performed

More details on the assumptions (heating demand, COP curves...) are available in the **report**

Sensitivities

- High
- Low

HPs are assumed to be operated in various ways. In the CENTRAL scenario:
- **1/3 of HPs are expected to be optimised by a local or market signal in 2030**
- **2/3 of HPs are optimised by 2034**

Operation modes

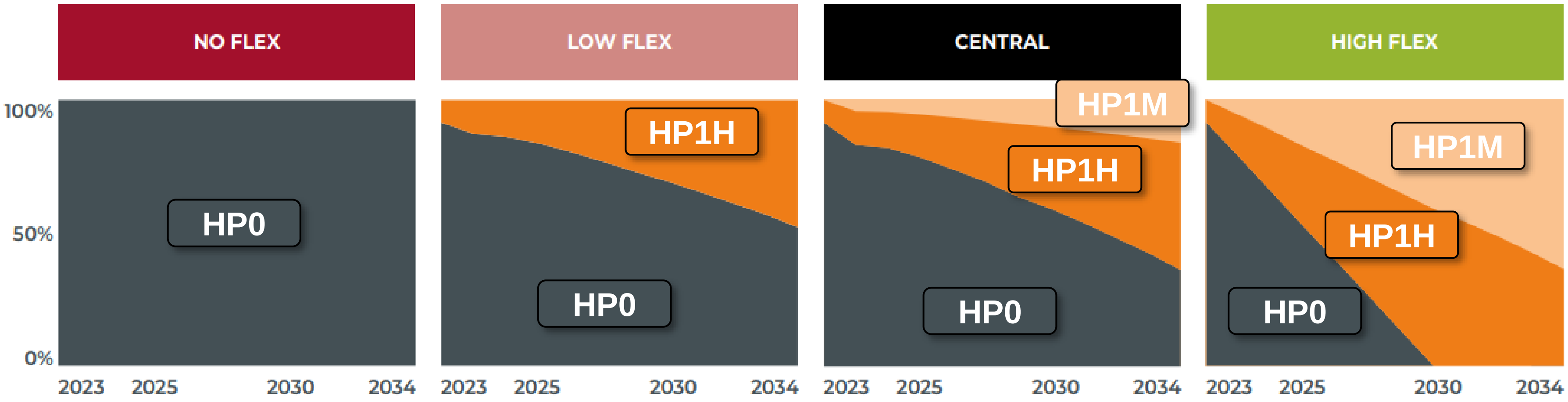
Technology	Profile name	Description	Rationale
Heat Pumps (HP) - Space Heating	HP0	Natural profile	Heat when homes are occupied to the setpoint (21°C). The profile demonstrates a morning and evening peak
	HP1H	Pre-heated profile	Reduce the morning and evening peak via pre-heating of homes, respecting a tolerance of +-2°C around the setpoint
	HP1M	Smart heating	Answer daily needs when it suits the market best, while respecting comfort constraint (+-2°C around the setpoint).

No flexibility

Flex to home:
Fixed input times-series

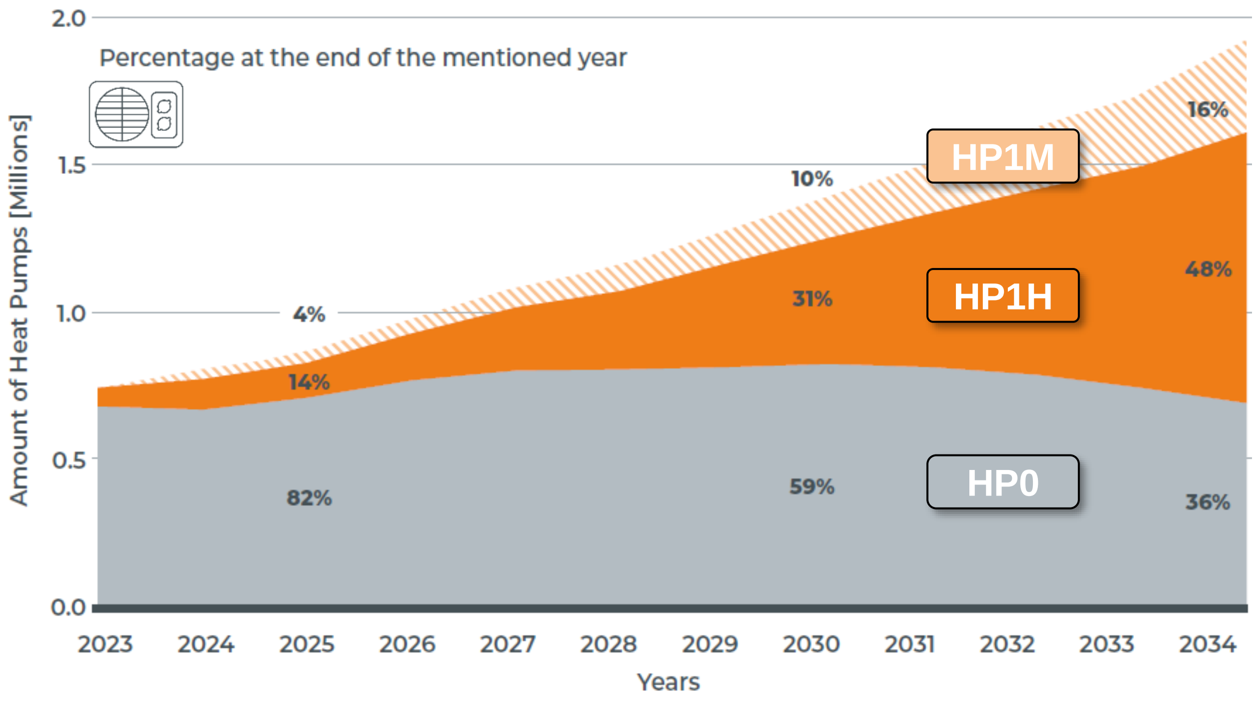
Flex to market:
Dispatched by the model

Scenarios

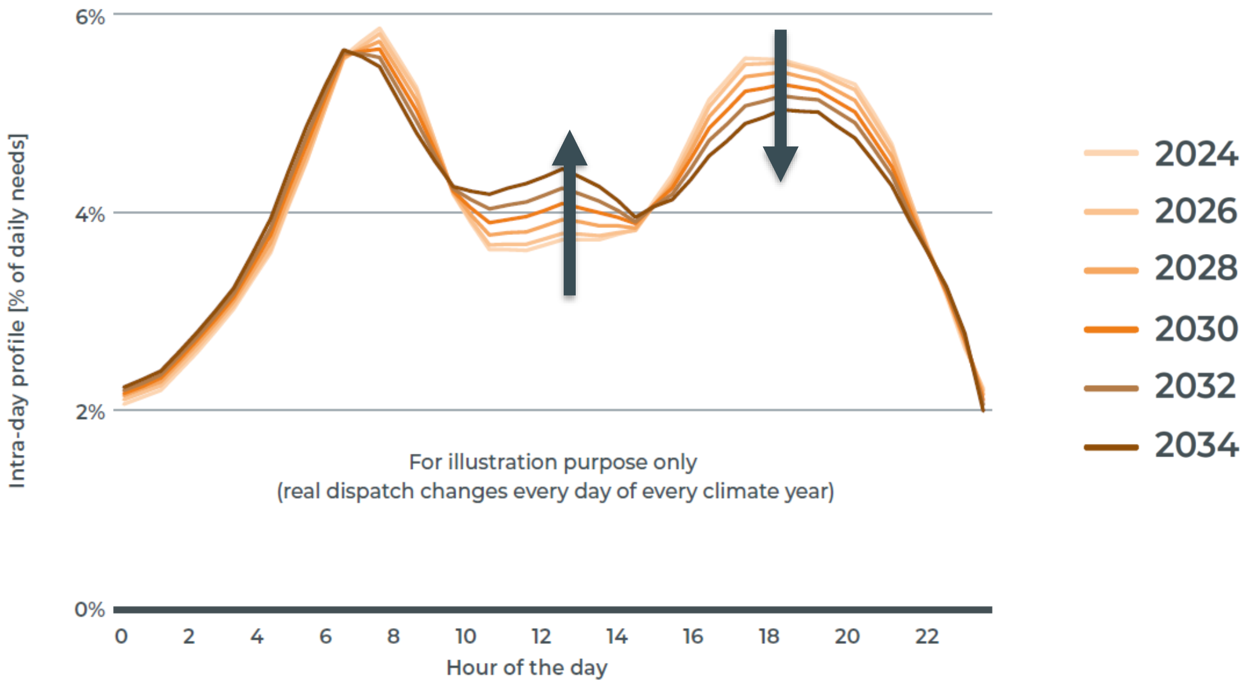


The average hourly consumption profile for HP is also expected to evolve

Amount and shares of each operation mode (CENTRAL)



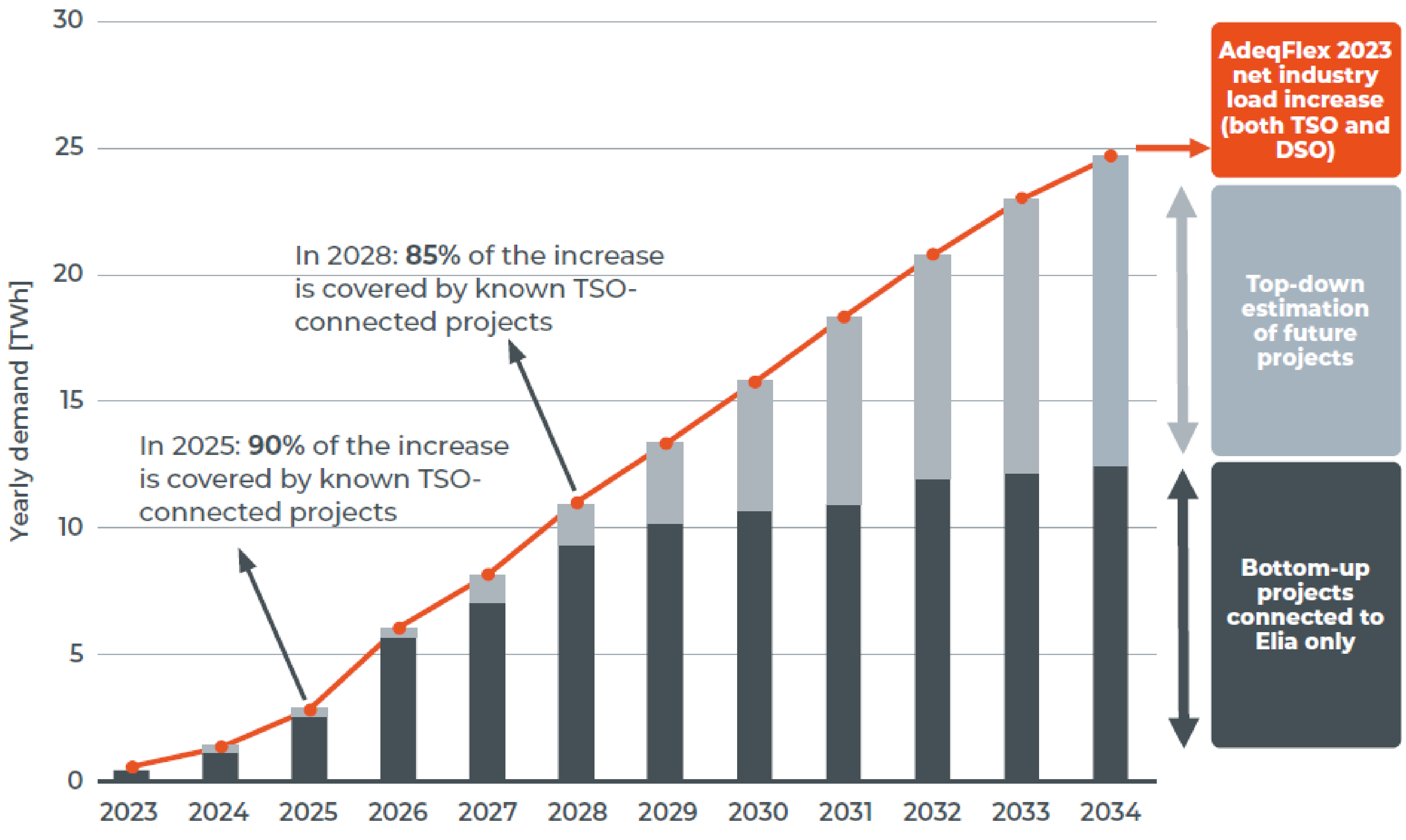
Aggregated average hourly winter profile evolution



HP1M	Smart heating	**Flex-to-market:** *Dispatched by the model*
HP1H	Pre-heated profile	**Local flex**: *Fixed input times-series*
HP0	Natural profile	

The uptake in industry and data centres is confirmed by the latest information that Elia has on connection requests and estimates regarding load evolution

Breakdown of the assumed industrial demand increase for Belgium in the CENTRAL scenario



- Industry viewpoint 2022
- Estimation of dates based on 'detailed grid connection studies' energizing dates and additional customer information complemented with an industrial cluster analysis

- Growth due to new projects to be connected @Elia (not yet known) or in later years
- Growth in smaller (DSO-connected) clients mainly focused in:
  - Food and drinks sector
  - (Smaller scale) data centres
  - SMEs and small industries

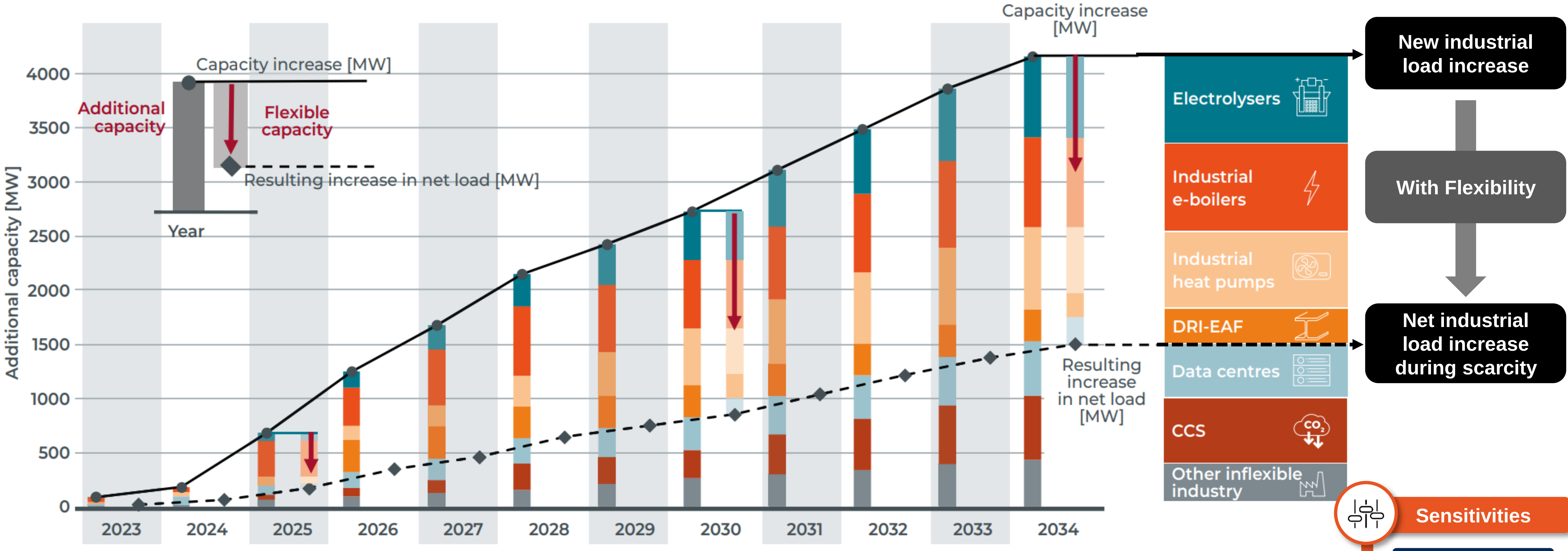
- Only TSO connected projects
- Based on known detailed grid connection studies' dates and additional customer information on expected capacities (MW) and energy demand (MWh)

Sensitivities

- 1Y-2Y acceleration
- 1Y-2Y-3Y-4Y delay

The industrial, data centres and electrolysers load increase is limited when accounting for the assumed flexibility of newly electrified processes

ASSUMED EVOLUTION – ADDITIONAL NOMINAL CAPACITY AND FLEXIBILITY FROM NEW INDUSTRIAL PROCESSES IN THE CENTRAL SCENARIO [MW]



Sensitivities

- High FLEX
- Low FLEX

The CENTRAL scenario assumes that around 70% of the additional industrial, data centres and electrolysers loads are not consuming during scarcity

- **The estimated impact of high electricity prices on the consumption is accounted for.**
- **Existing volumes of market response are taken into account.**
- **In addition, a potential additional volume is identified for each time horizon.**

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Impact of high prices

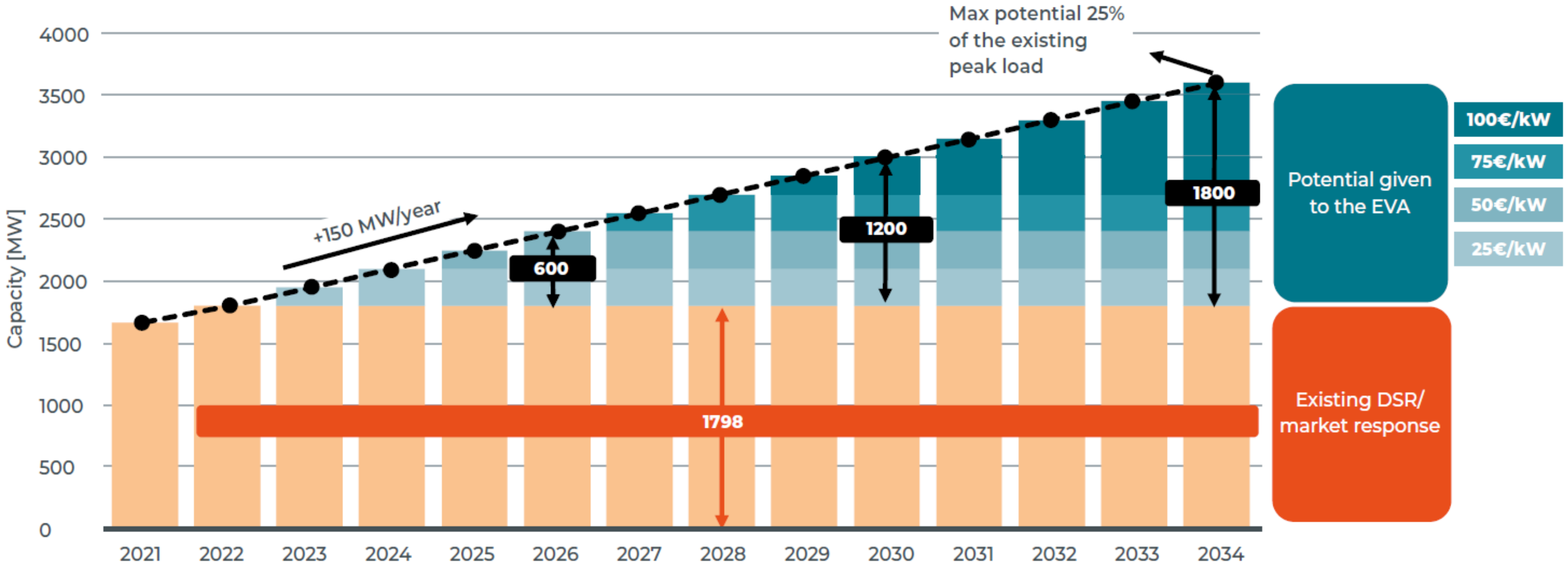
The **impact of high average electricity prices on the consumption** is estimated:

- The impact is estimated to be -4.5 TWh in 2024 and -1.2 TWh in 2026 in the CENTRAL scenario (based on the forward prices)
- Several sensitivities are performed to assess the impact of higher/lower prices on the consumption

Sensitivities
SlowDown/high prices
ReBound/low prices

Flexibility from existing usages

EXISTING MARKET RESPONSE AND CAPACITY POTENTIAL CONSIDERED IN THE CENTRAL SCENARIO



Sensitivities
DSR POT

2021 value is based on the latest E-CUBE study. The value of 2022 was obtained assuming a +8% growth (highest increase proposed by E-CUBE).
The potential additional volume in 2034 goes well beyond any study found in the literature for demand response.

A large number of sensitivities are performed on the expected consumption evolution and associated flexibility for Belgium

Electricity consumption and associated flexibility

	Electricity consumption – CENTRAL	Electricity consumption – SENSITIVITIES	Associated flexibility for adequacy – CENTRAL	Associated flexibility for adequacy – SENSITIVITIES
Existing usages	**Macro-economic** projections from June 2022 taking the impact of **high electricity prices**, into account.	REBOUND / SLOWDOWN High/lower demand due to low/high energy prices	**Existing DSR** (or Market Response) from E-CUBE study with **potential new additional** volumes if economically viable.	DSR POT All additional potential DSR capacity is assumed to be in the market already.
Transport electrification	**Electric vehicles growth** rate based on latest **trends** and **policies.**	HIGH EV / LOW EV **Faster** ('HIGH') and **slower** ('LOW') uptake of **electric vehicles.**	Shares of **out-of-market EV** (natural profile or locally optimised) and **in-the-market EV** (charging and/ or discharging based on market) [DELTA-EE study].	H. EV FLEX / L. EV FLEX **Higher ('HIGH') and lower ('LOW') share of in-the-market EV.(*)**
Buildings heat electrification	**Heat-pumps growth rate** based on latest **trends** and **policies.**	HIGH HP / LOW HP **Faster** ('HIGH') and **slower** ('LOW') uptake of **heat-pumps.**	Shares of **out-of-market HP** (natural profile or locally optimised) and **in-the-market HP** (optimised by the dispatch) [DELTA-EE study].	H. HP FLEX / L. HP FLEX **Higher ('HIGH') and lower ('LOW') share of in-the-market HP.(*)**
Industry new usage and electrification (incl. data centres)	**Fuel switching** and new **data centres** based on Elia Group **viewpoint on industry**.	ACCEL. / DELAY **Faster** electrification rate of the industry ('ACCELERATION') and **slower** ('DELAY') rate.	From Elia Group viewpoint and exchanges, flexibility assumed per process considered.	H. IND FLEX / L. IND FLEX **Higher and lower % of flexible capacity per process considered.**

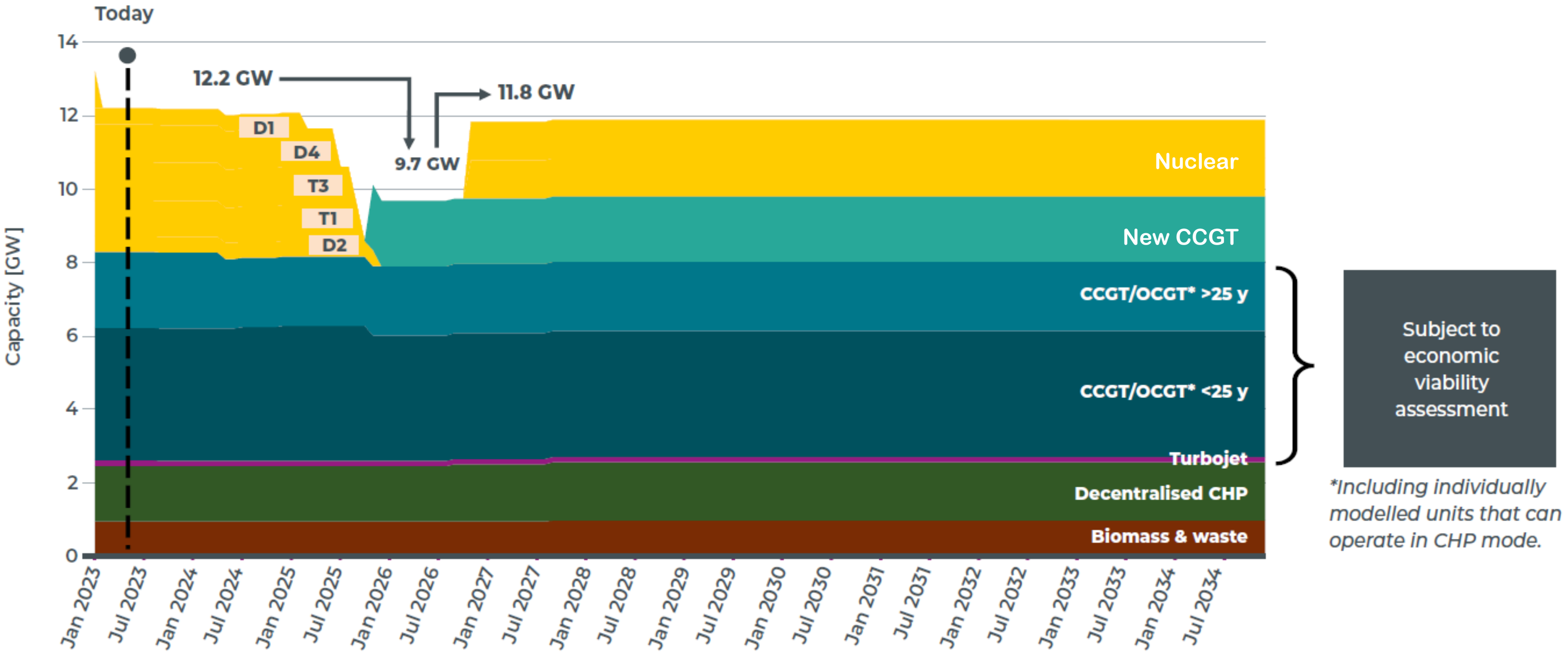
** Note that a theoretical 'No Flexibility' sensitivity is also performed for EV and HP (in addition to the 'High' and 'Low Flexibility'), where no flexibility is assumed.*

Belgian scenario and sensitivities

Demand & flexibility

Supply & storage

Thermal capacity is based on the official closures, extension and already CRM contracted new capacities



*Including individually modelled units that can operate in CHP mode.

EVA

EVA performed on **existing thermal capacities** and **new capacities**

Sensitivities

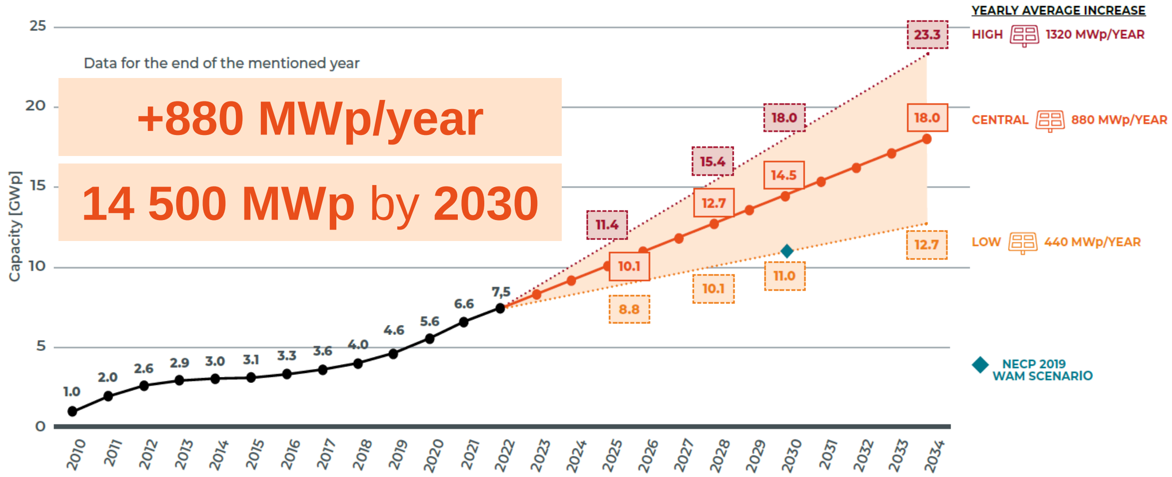
FLEX LTO		*Nuclear avail. in winter 25-26*
DELAYED LTO		*Nuclear extension later than 26-27*
HIGH NuFO	LOW NuFO	*+/- Nuclear Forced Outage*
HIGH CHP	LOW CHP	*+/- 1000 MW by 2030*
LOW TJ/OCGT		*Less avail. due to CO_2 restrictions in CRM*
Rodenhuize & Vilvoorde		*Avail. in the market*

CENTRAL scenario

- All existing units unless **official closures** announced
- **Nuclear closure** followed by **nuclear extension of D4/T3** as from **winter 2026-27** (no Flex LTO for winter 2025-26)
- **Two new CCGTs** contracted in the CRM framework as from **winter 2025-26**

Accelerated integration of renewable energy sources in Belgium, in-line with latest regional and federal ambitions

Evolution of installed solar capacity

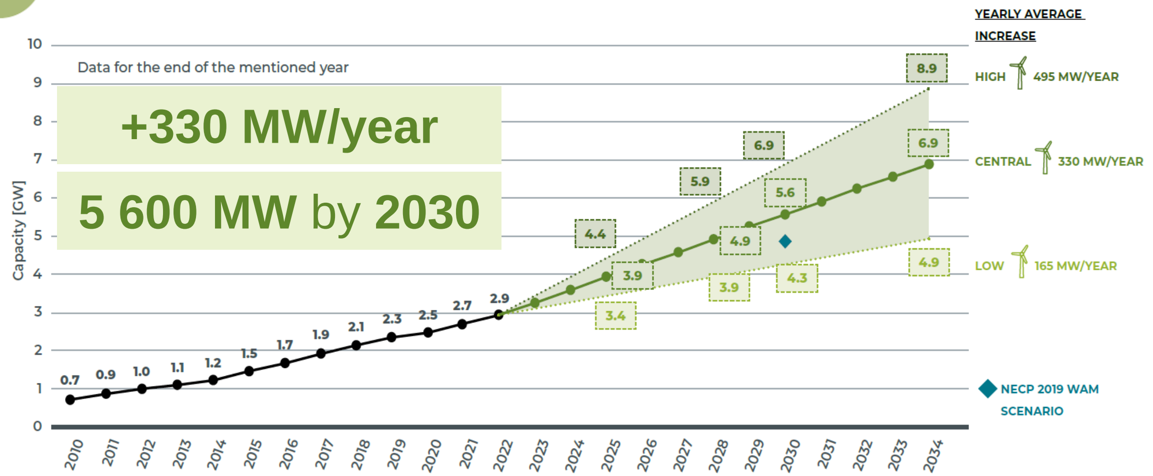


Sensitivities

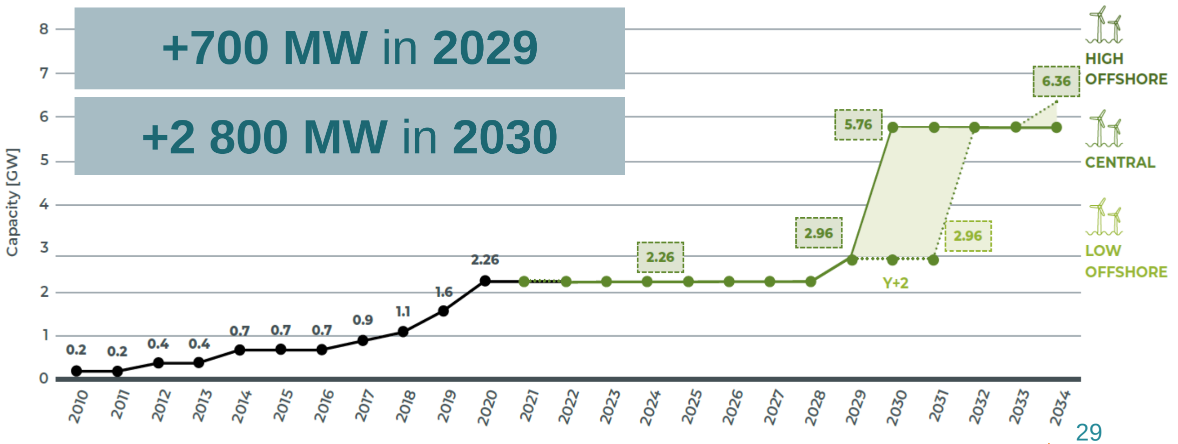
HIGH RES | LOW RES

HIGH OFFSH | LOW OFFSH

Evolution of installed onshore wind capacity



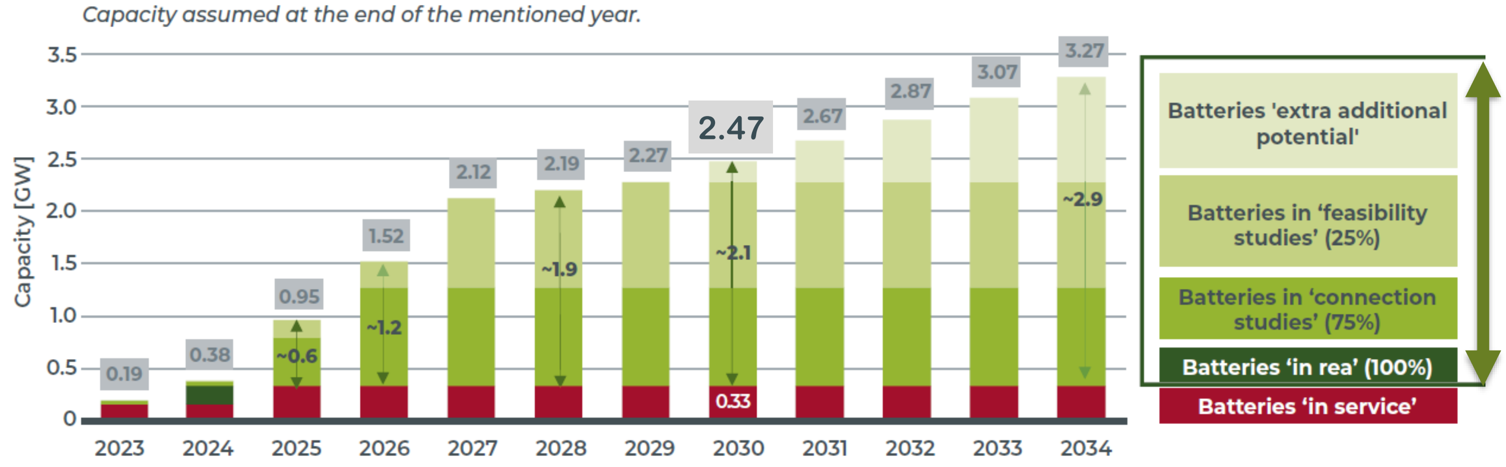
Evolution of offshore wind capacity



Large-scale batteries capacity is based on existing and already contracted capacity, complemented with additional capacity if economically viable. Small-scale batteries capacity follows solar PV evolution.

Large-scale batteries

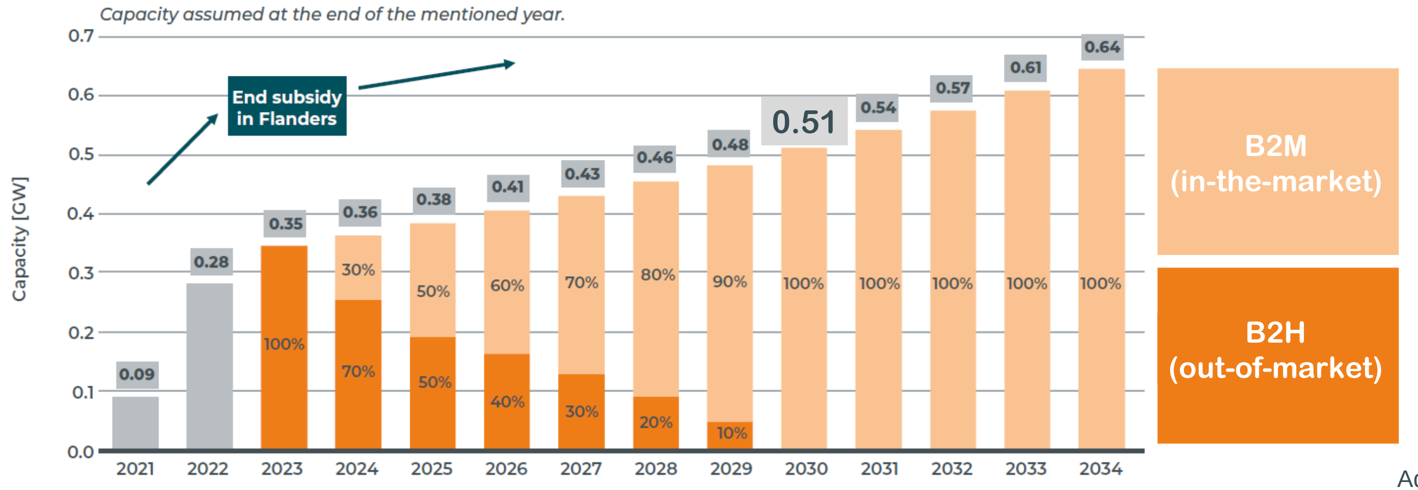
Up to ~2.5 GW by 2030
(depending on EVA)



Potential nominal new capacity

Small-scale batteries

~0.5 GW by 2030
(100% in-the-market)



Sensitivities

LARGE BATT POT

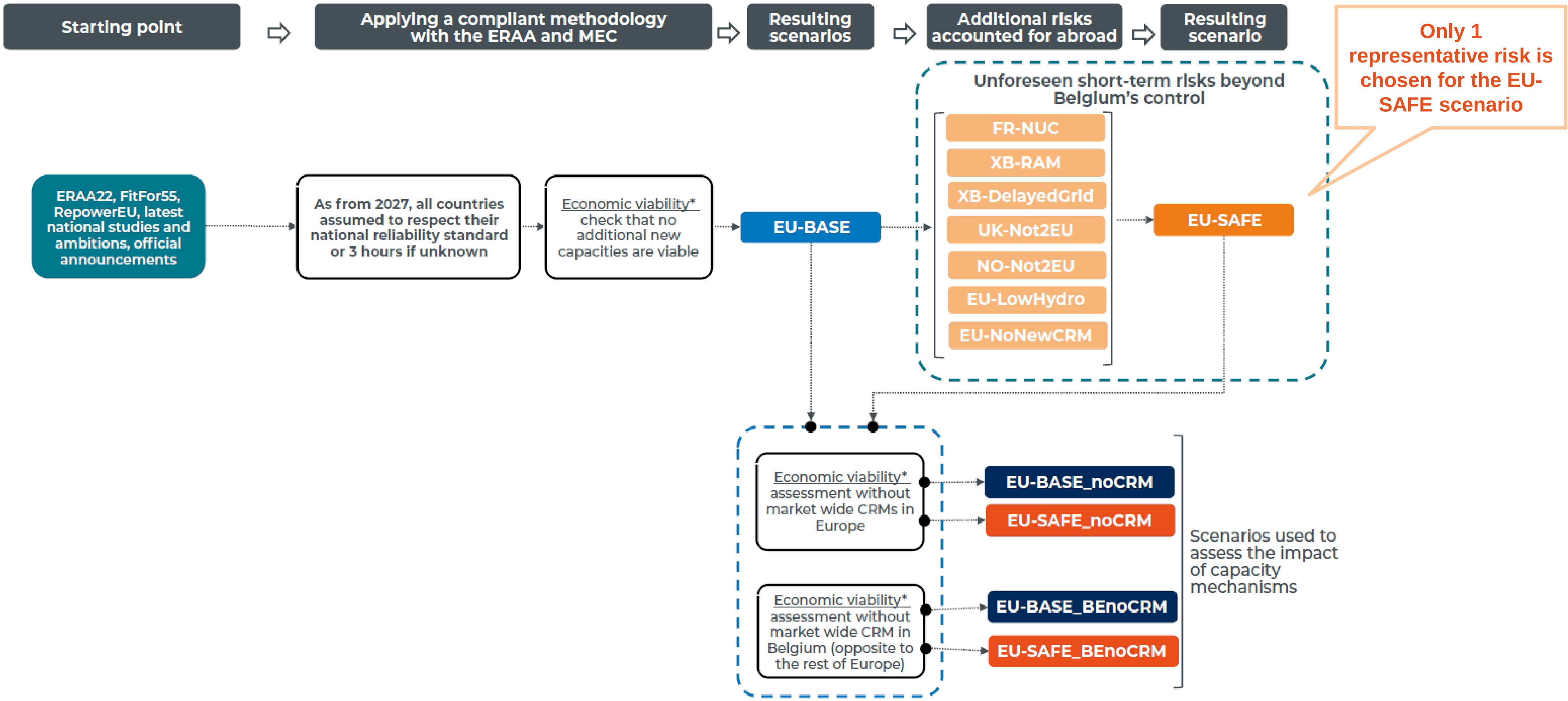
Additional large-scale batteries in-the-market

SMALL BATT FLEX

Within the high/low flex sensitivities, different share of in-the-market small-scale batteries

Assumptions for other European countries

The European scenario framework of this study is based on the ERAA22 dataset complemented with more recent data (if available) and follows the ERAA methodology



*Economic viability assessed in most impacting countries for Belgium's adequacy (representing more than 70% of European thermal generation capacity)

Accelerated integration of renewable energy sources in Europe
Coal phase out planned in Europe

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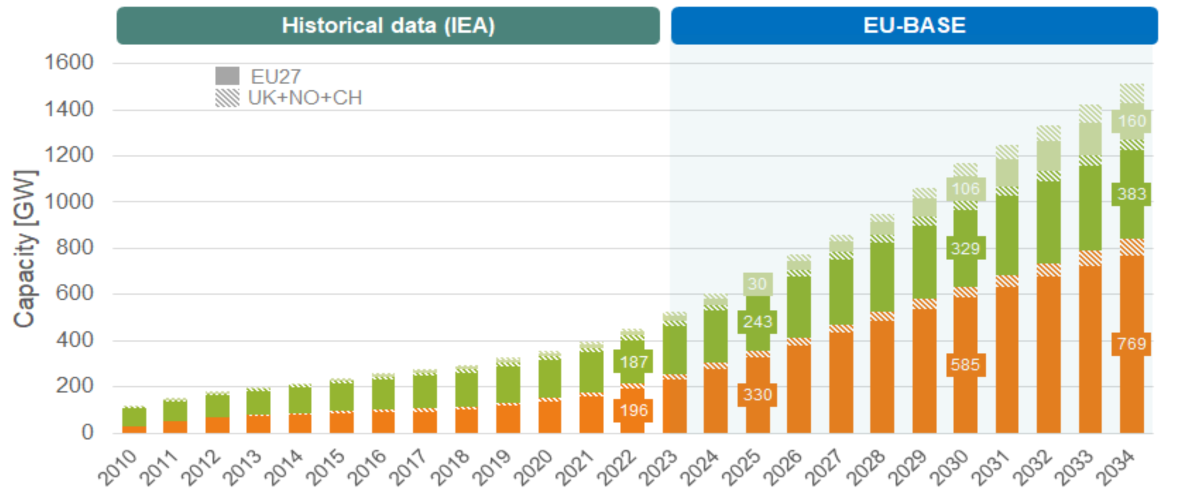
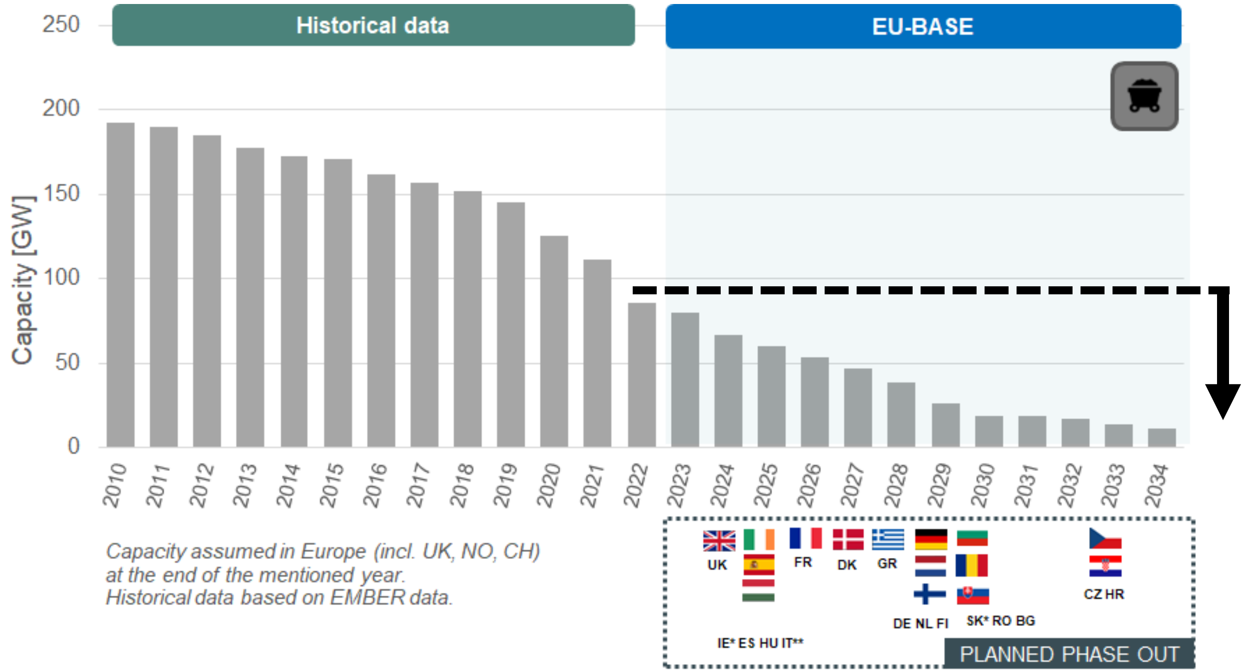


Capacity assumed at the end of the mentioned year

2022 - 2030

COAL



Capacity assumed in Europe (incl. UK, NO, CH) at the end of the mentioned year.
Historical data based on EMBER data.

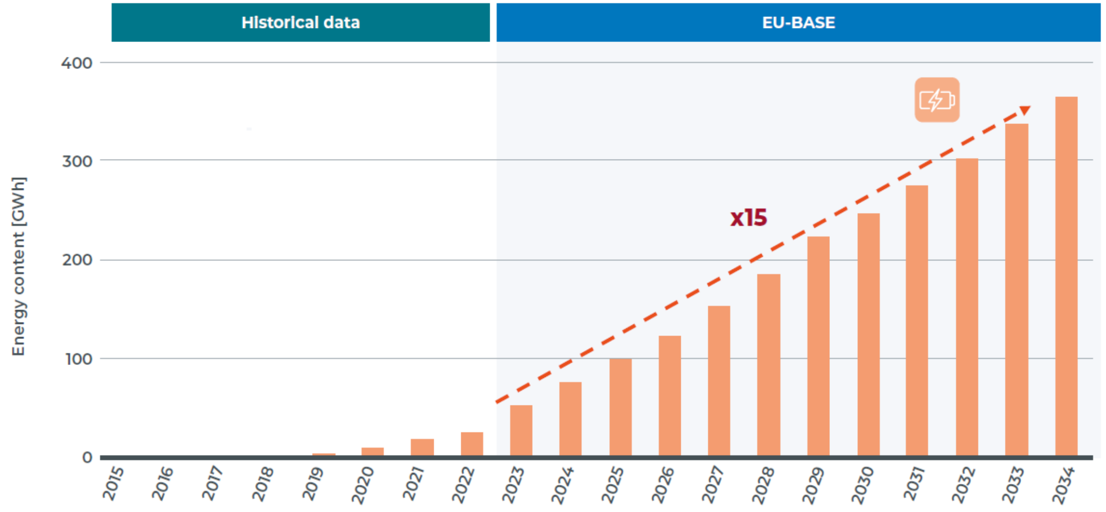
2022 - 2030

-67 GW

**Small units assumed as still running after (or not 100% full biomass)*
***Coal-fired unit in Sardinia assumed to run until end 2027.*

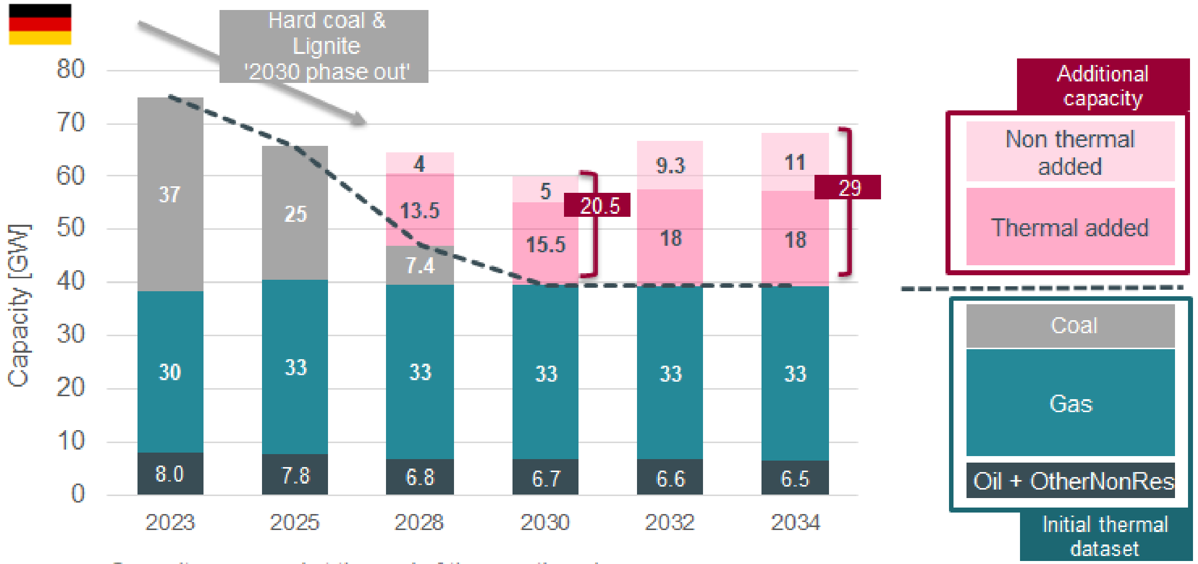
Expected evolution of storage and new capacities to comply with the reliability standard in each country

STORAGE



Energy assumed in Europe (incl. UK, NO, CH) at the end of the mentioned year.
Historical data based on Bloomberg BNEF data and IEA data.

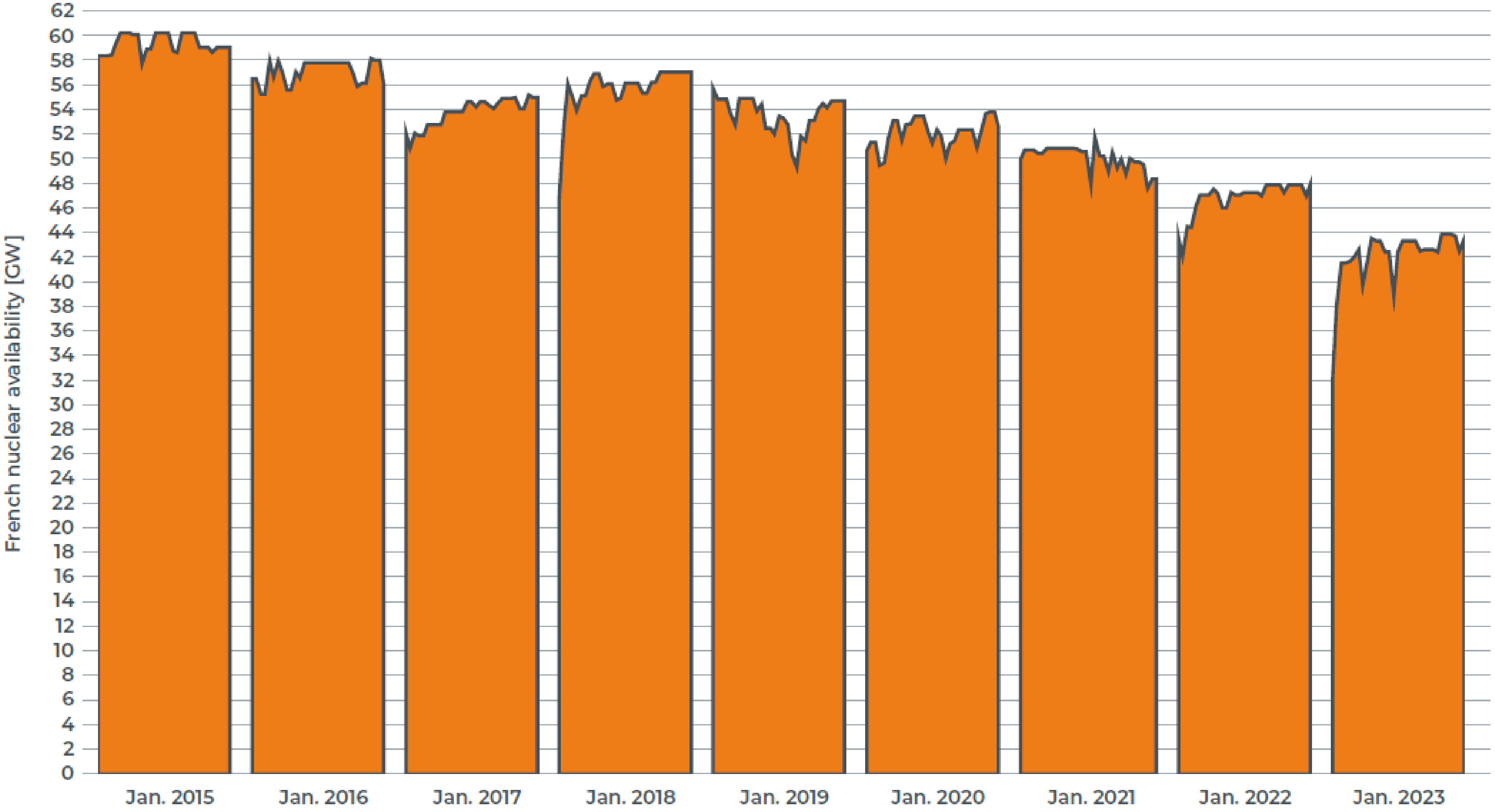
NEW CAPACITY ADDED



Capacity assumed at the end of the mentioned year.

French nuclear availability during winter has strongly decreased since 2015

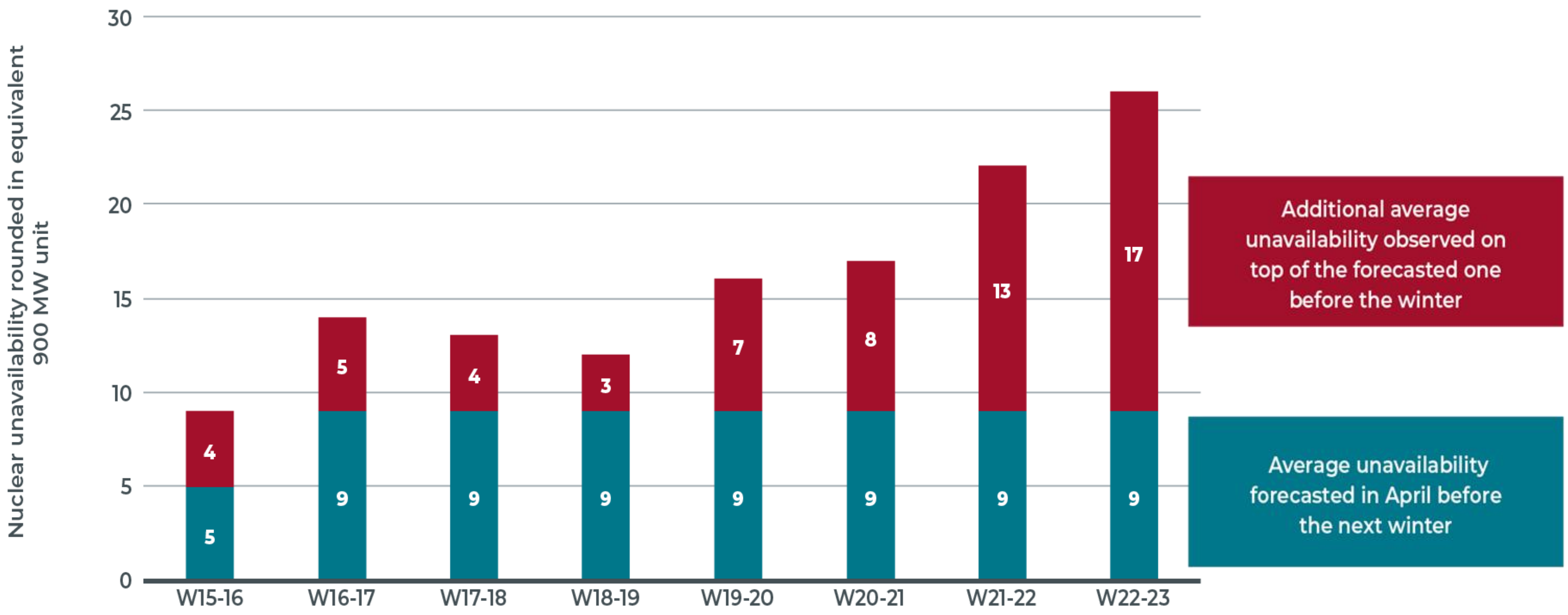
DAILY FRENCH NUCLEAR AVAILABILITY DURING THE MONTH OF JANUARY SINCE 2015

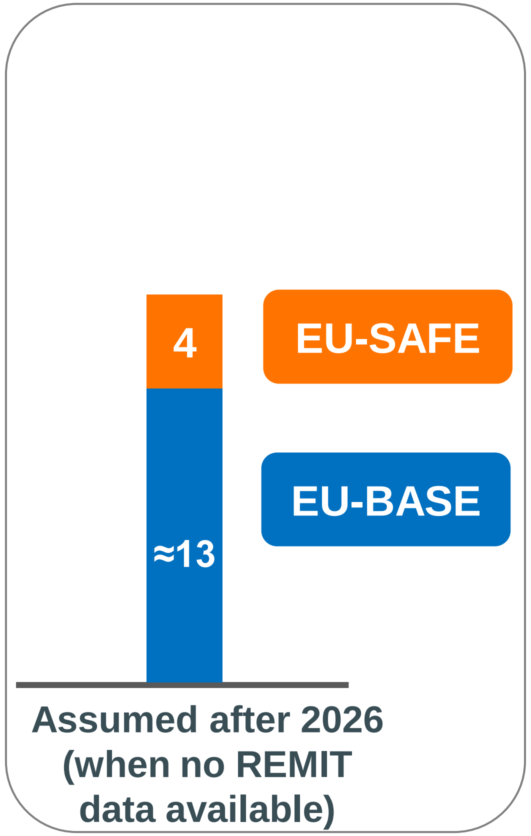


Source: EDF data

The unavailability of French nuclear units was found to be underestimated in the past 6 years. The impact is assessed through the 'FR-NUC' sensitivities.

AVERAGE FORECASTING ERROR OF THE FRENCH NUCLEAR UNAVAILABILITY OVER THE PAST 6 WINTERS (BASED ON REMIT DATA)





The nuclear availability in France is based on:

- Until 2025: REMIT data calibrated to the EDF generation forecasts (min. and max. forecasts)
- As from 2026: profiles provided by RTE to ERAA2022 and applying several sensitivities (2, 4, 6, 8 units assumed unavailable on top of those profiles)

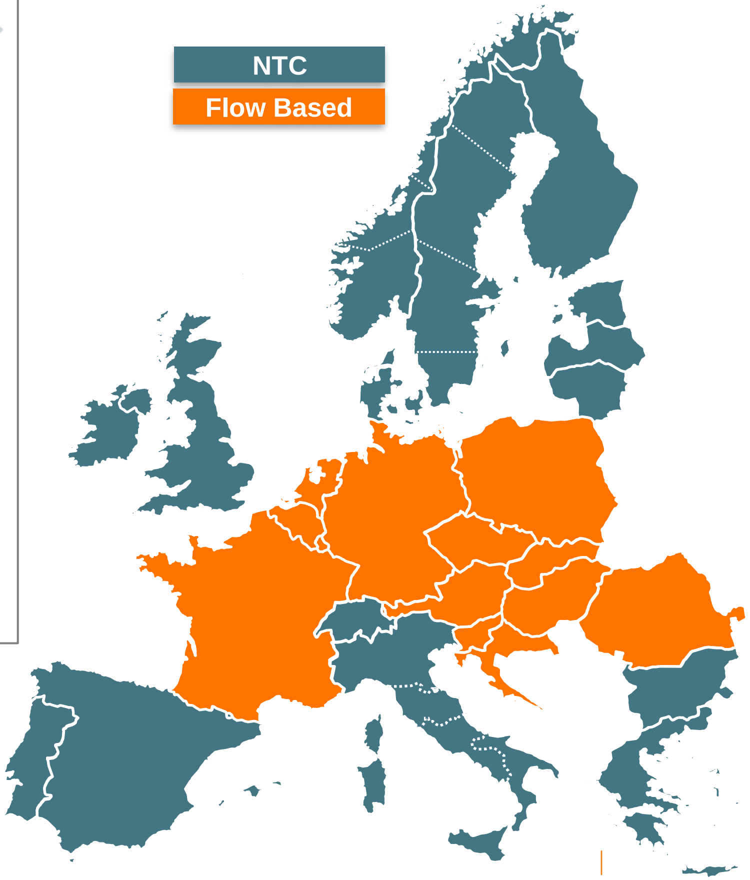
Assumptions regarding the grid and cross-border exchange capacities

Flow-based is modelled for the Core region and assumptions capture the expected market design and grid infrastructure evolutions

- The **bidding zones** are assumed to **remain as defined today** for all future time horizons.
- The **flow-based perimeter considered is Core** for all time horizons (BE, FR, DE+LU, NL, AT, CZ, PL, HR, HU, RO, SI, SK)
- As from 2025, domains are created for the **whole Core region using Advanced Hybrid Coupling (AHC)** for the connections between a BZ in core and a BZ outside Core. **Standard Hybrid Coupling (SHC) is assumed for the Channel interconnectors**

	2023	2024	2025	2026	2028	2030	2032	2034
Grid reinforcements taken into account for Belgium (Federal development plan ID between brackets)*	HTLS Meerhout – Van Eyck (28); Zandvliet-Rilland (35)	HTLS Mercator - Buggenhout (31)	PST Aubange (615)	Brabo III (38); PST Achène - Gramme (7); HTLS Buggenhout - Bruegel (31); HTLS Masssen hoven – Meerhout (28)	Ventilus (53)	Boucle du Hainaut (54); HTLS Gramme – Van Eyck (34); Nautilus (3)	Lonny – Achène - Gramme (8); TritonLink (4)	Van Eyck – Maasbracht (9)
Minimum CNEC capacity given to the market	minRAM 70% + actions plans and derogations	minRAM 70% + actions plans and derogations	minRAM 70% + actions plans and derogations	minRAM 70%	minRAM 70%	minRAM 70%	minRAM 70%	minRAM 70%
Treatment of external flows	Standard Hybrid Coupling	Standard Hybrid Coupling	Advanced Hybrid Coupling (beside channel interconnectors)	Advanced Hybrid Coupling (beside channel interconnectors)	Advanced Hybrid Coupling (beside channel interconnectors)	Advanced Hybrid Coupling (beside channel interconnectors)	Advanced Hybrid Coupling (beside channel interconnectors)	Advanced Hybrid Coupling (beside channel interconnectors)
CNEC selection	XB CNECs + internal CNECs 5%	Only XB CNECs	Only XB CNECs	Only XB CNECs	Only XB CNECs	Only XB CNECs	Only XB CNECs	Only XB CNECs

*Full list of projects and exact timings available in approved Federal Development Plan 2024-2034 (document published on Elia website)



Sensitivities

- Delay on Gramme-Rimière (assumed in 2025 for the CENTRAL scenario)
- Delay on Boucle du Hainaut (assumed in 2030 for the CENTRAL scenario)
- Delay on Nautilus (assumed in 2030 for the CENTRAL scenario)
- Delay on TritonLink (assumed in 2032 for the CENTRAL scenario)

Exchanges within/with Core countries are modelled with flow-based domains

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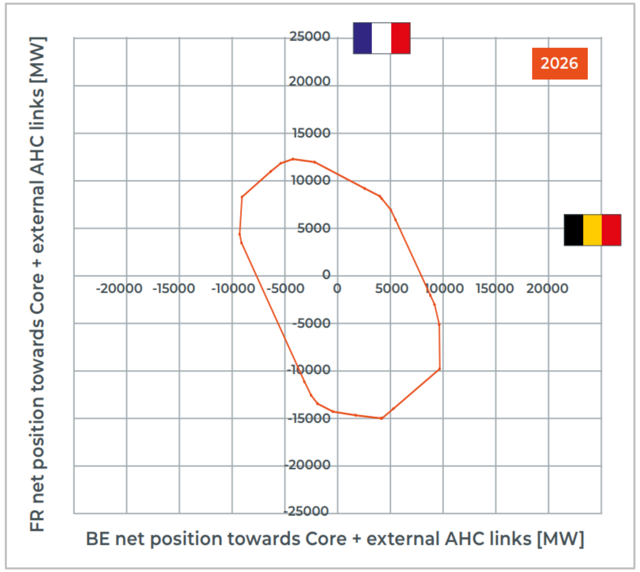
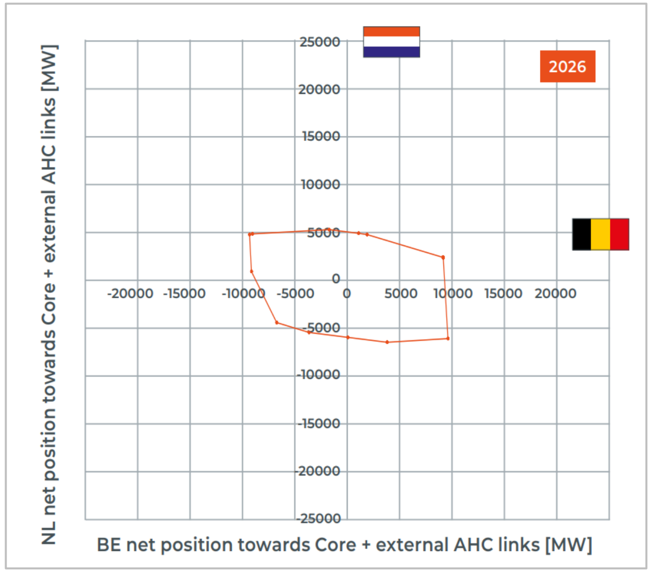
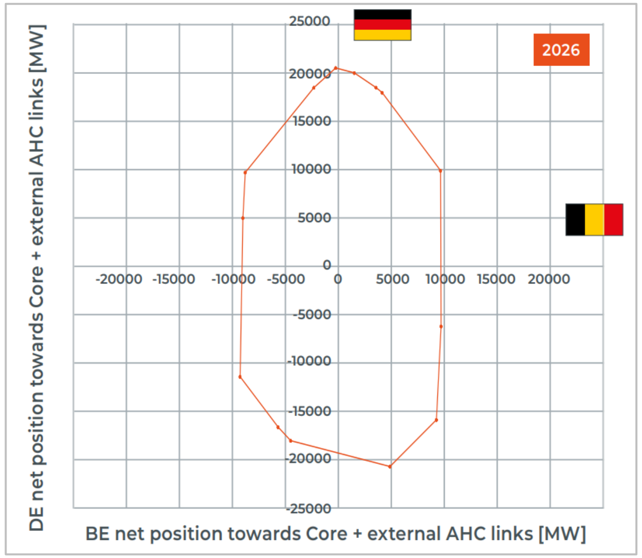
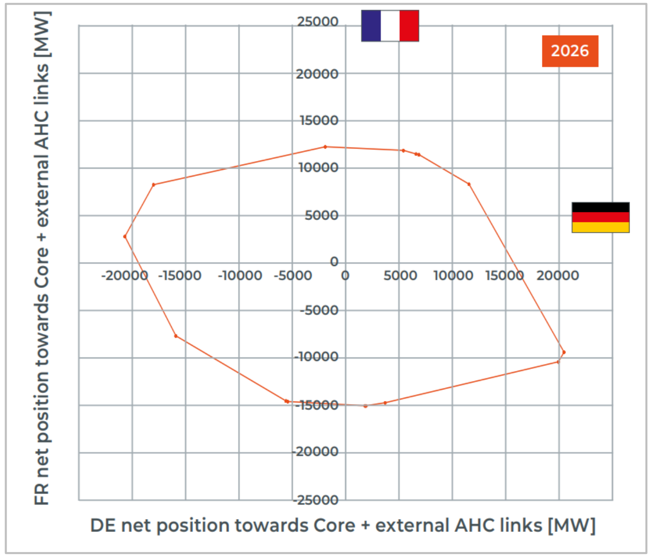
PROJECTION OF ONE OF THE MULTI-DIMENSIONAL FLOW-BASED DOMAINS FOR 2026









- Elia uses flow-based domains since 2015 in its adequacy studies given the central position of Belgium
- 41 dimensional domains
- Exchanges are accurately modelled between Core countries and between non-Core countries and Core

Sensitivities

XB–RAM70	It is assumed that only 70% of XB capacity is given for market exchanges (not less, not more). This is different to giving at least 70% which is assumed in the ‘EU-BASE’ scenario
XB–RAM50	It is assumed that only 50% of XB capacity is given for market exchanges (exactly 50%, which means not less and not more)
XB–Delayed	Assesses the risks of delays in grid development abroad

Economic assumptions

Prices follow the World Energy Outlook (2022, IEA) "Announced Pledges" scenario on the long term and forward prices where available

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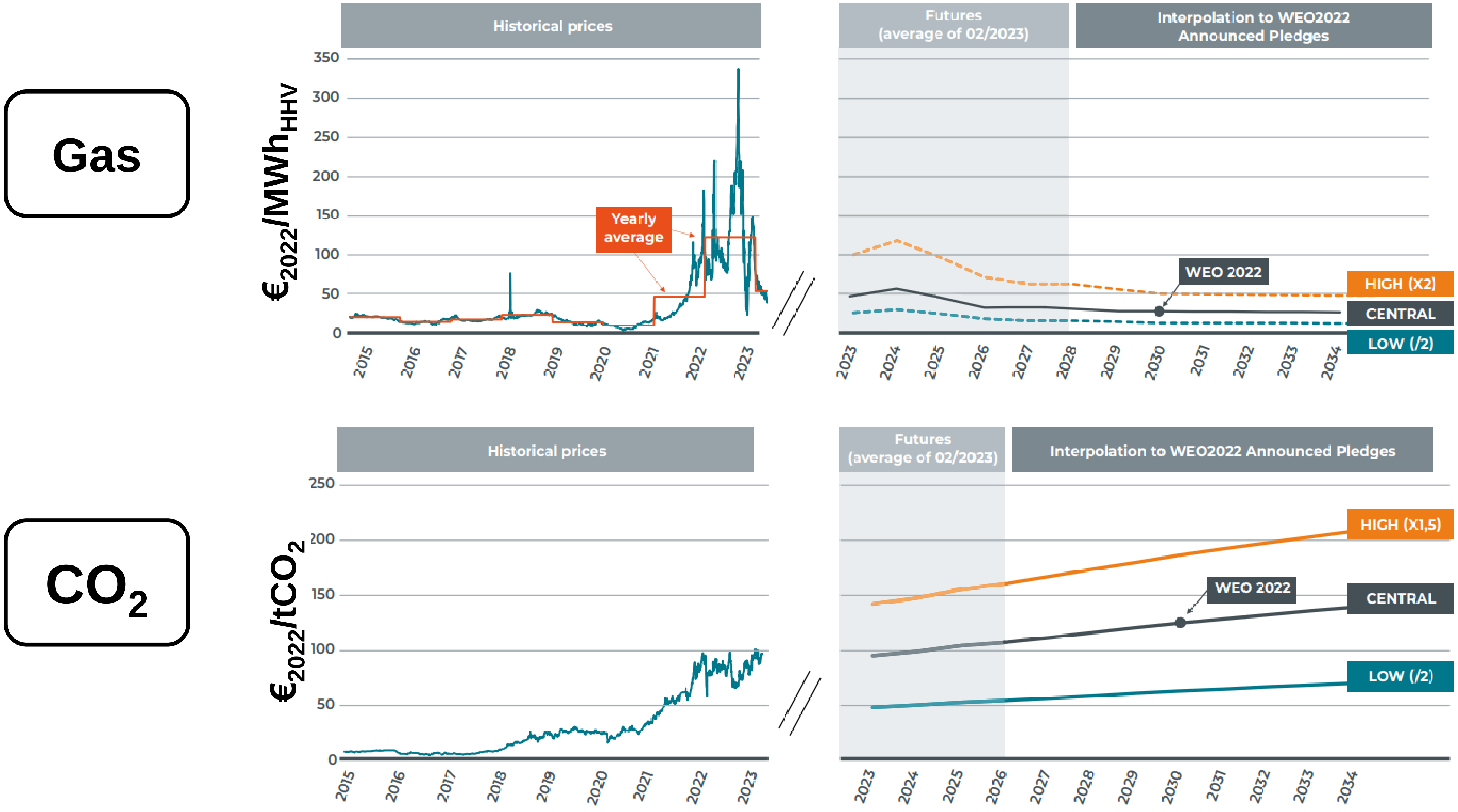
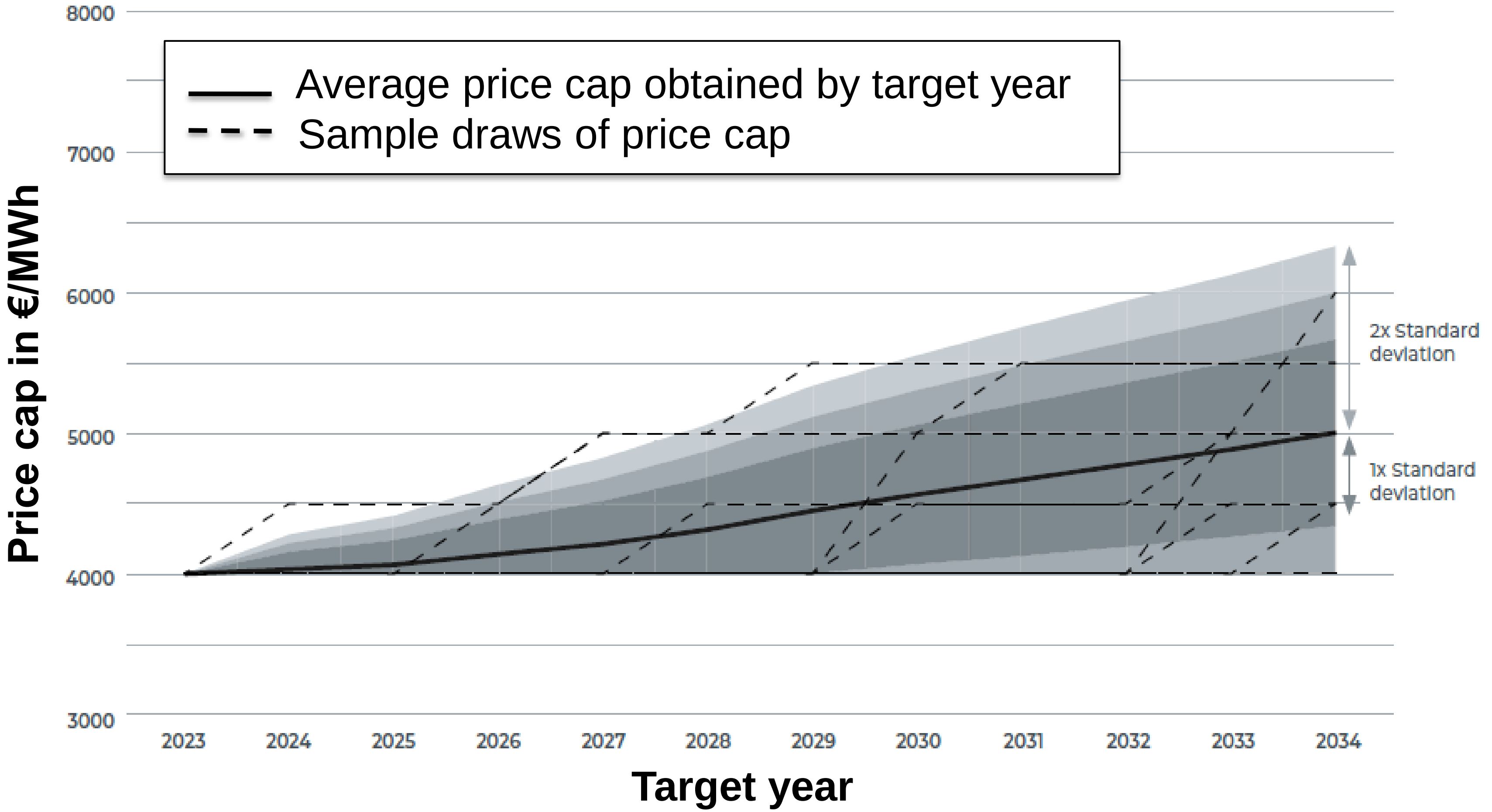
ASSUMED EVOLUTION OF GAS AND CO_2 PRICES



The price cap follows the latest ACER HMMCP rules (01/23) and is dynamically calculated for each of the draws in the EVA

The price cap increase is taken into account when calculating revenues of the units for the EVA

- the price cap increase is taken into account as from the start of the simulated horizon
- the most recent rules from ACER are implemented (+ 500€/MWh when there are 2 MTUs with prices >70% in two different over a period of 30 rolling days...)



More assumptions and information can be found in the report

- For **existing and new** capacity:
  - **CAPEX**,
  - **FOM**,
  - **Hurdle rates**,
  - **VOM**,
  - **Construction times**
- Price assumptions for **coal**, **nuclear** and **lignite**
- **Ancillary services revenues**,
- Revenues from **heat and steam**,
- **Activation costs** for **flexibility**,
- **...**

This study meets the adopted European requirements and goes beyond what is planned to be implemented by ENTSO-E in the coming years (1/2)

	entsoe – ERAA public implementation plan		elia – ADEQUACY & FLEXIBILITY 2023
	Based on the implementation roadmap published by ENTSO-E on December 2022		*Based on the methodology used for this study published in June 2023*
TARGET YEARS	ERAA 2022	3 target years	12 target years (every year from 2023 and 2034) with a large amount of sensitivities
	ERAA 2023	4 target years	
CLIMATE CHANGE	ERAA 2022	Preparation of the forward looking database and temporary solution	Forward looking climate database from Météo-France (200 synthetic climate years)
	ERAA 2023	Test climate change impact on model*	
ECONOMIC VIABILITY ASSESSMENT	ERAA 2022, ERAA 2023	Enhanced economic viability assessment (multiyear, inclusion of storage etc..)	• Methodology based on academic expertise, in-line with the ERAA methodology, extended to consider multi-year, of European perimeter and with investment decisions within the 10 target years of the study and endogenous price cap increase. • Full adequacy FB simulations, adequacy patch and all climate years are considered in the EVA simulations

ERAA: European Resource Adequacy Assessment

This study meets the adopted European requirements and goes beyond what is planned to be implemented by ENTSO-E in the coming years (2/2)

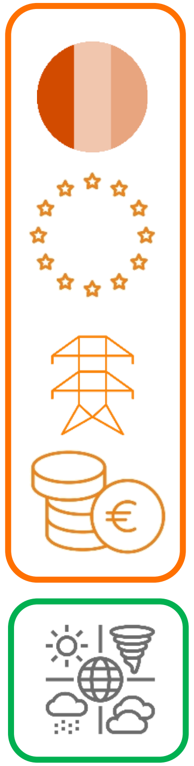
	entsoe – ERAA public implementation plan		elia – ADEQUACY & FLEXIBILITY 2023
	Based on the implementation roadmap published by ENTSO-E on December 2022		*Based on the methodology used for this study published in June 2023*
FLOW-BASED MARKET COUPLING	ERAA 2022	FB for at least Core in Central Ref Scenario (FB domains for 2025)	• FB for Core perimeter for all the horizons • FB domains for 2023, 2024, 2026, 2030, 2034 • Advanced Hybrid Coupling as from 2025
	ERAA 2023	Extension of the geographical scope*	
DEMAND SIDE RESPONSE	ERAA 2022	Improve Implicit DSR/Enhance Explicit DSR	• Improved modelling of Electric Vehicles and Heat Pumps (natural, local and market optimisation including V2G) • Enhanced modelling of Small Batteries (local and market optimisation) • Inclusion of DSR for newly electrified processes in industry and data centres
	ERAA 2023	Price dependent Implicit DSR	
SECTORIAL INTEGRATION	ERAA 2022	Test electrolyser modelling	• Enhanced modelling of additional electrolysers • New modelling of P2Heat (Heat Pumps and e-boilers) in industry
	ERAA 2023	Prepare further integration of P2X	

ERAA: European Resource Adequacy Assessment

Adequacy

Methodology

The adequacy methodology used is in line with the ERAA methodology. Hourly simulations are performed on several hundreds of 'Monte-Carlo' years.



INPUT DATA

For each of the simulated areas

- Consumption
- Centralised thermal production facilities
- Decentralised thermal production facilities
- Renewable production
- Hydro
- Storage
- Demand flexibility
- Interconnection capacity between countries (NTC/FB)

New forward looking climate database (200 climate years)

METEO FRANCE

antaressimulator

Monte Carlo years

SIMULATIONS

Hourly dispatch optimisation to minimise total costs of the system

MODEL OUTPUT

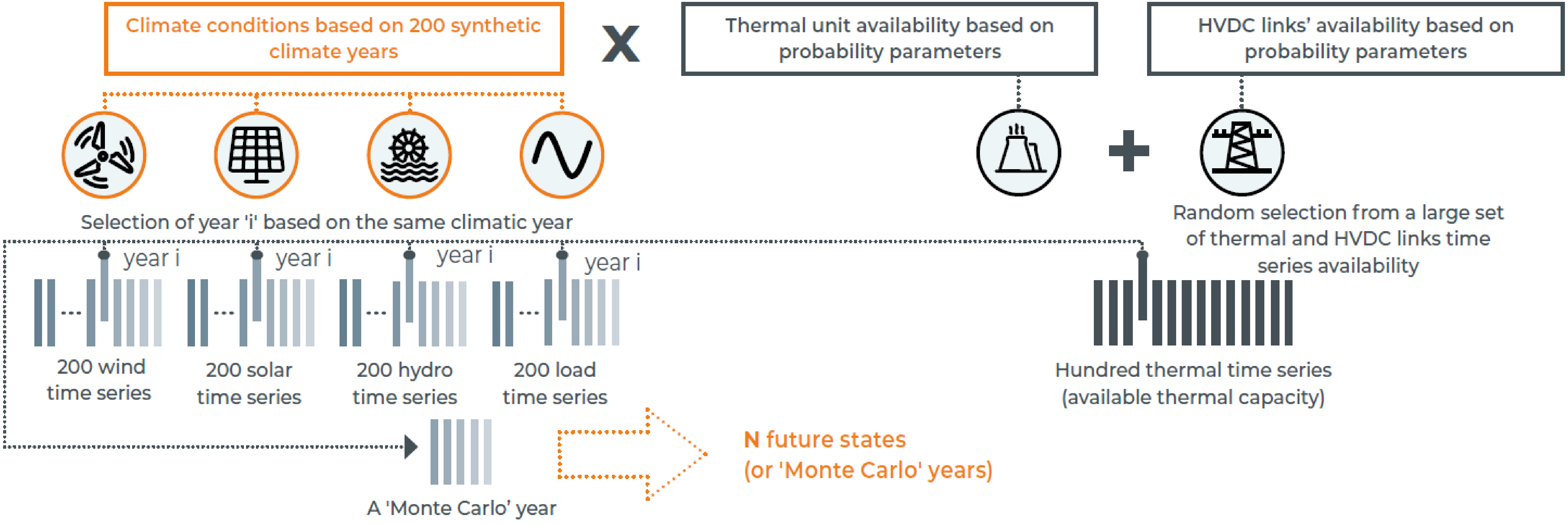
- **Hourly dispatch** for all units in each area
- **Commercial exchanges** between areas
- **Hourly marginal prices**

↓

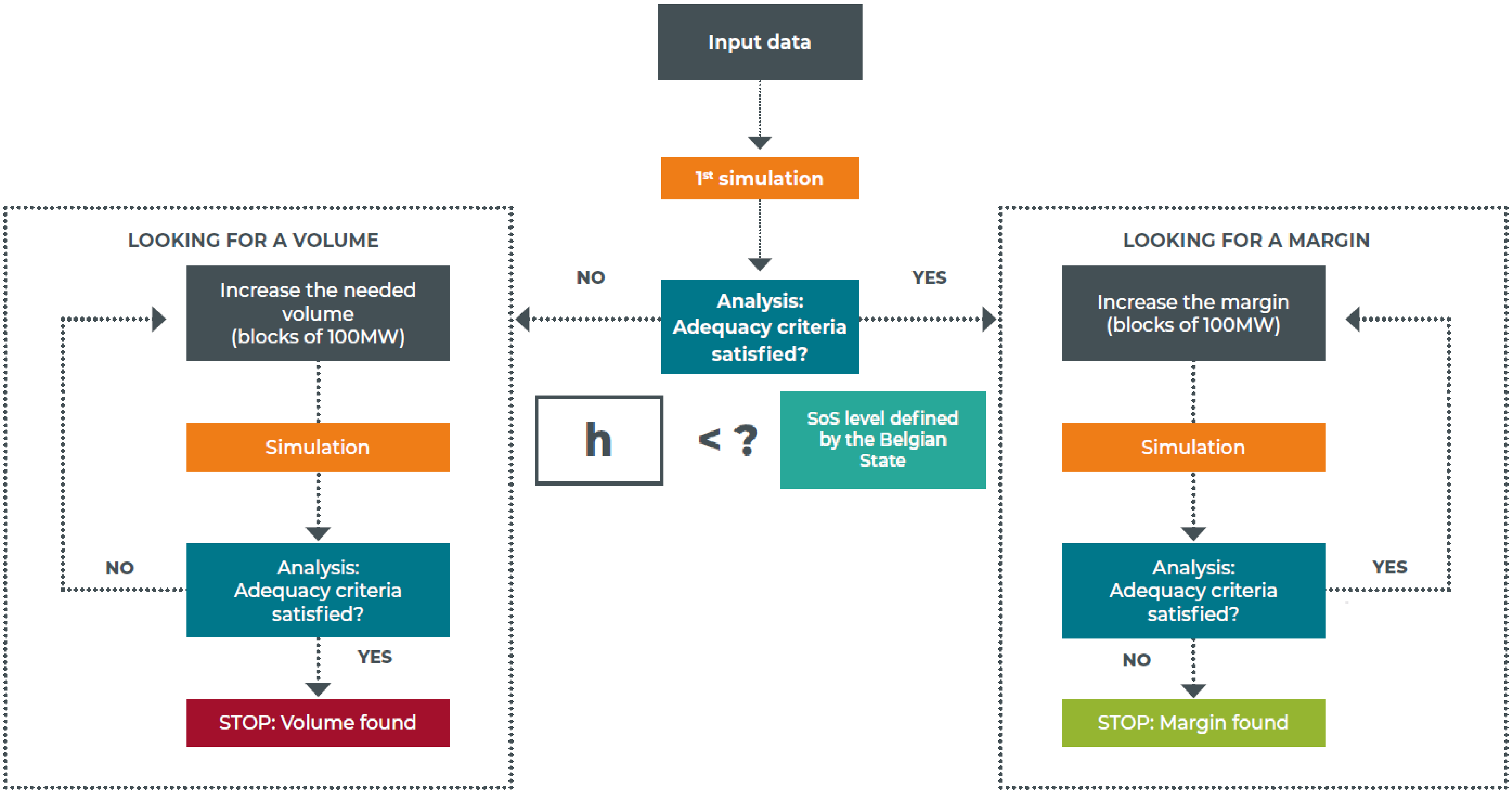
- **Adequacy** indicators
  - LOLE, EENS
- **Economic** indicators
  - Market welfare, total costs, unit revenues, running hours
- **Sustainability** indicators
  - Emissions, RES share
- **Dispatch** indicators
  - Imports/exports, generation per type

- The **adequacy methodology** is fully compliant with the **ERAA methodology**
- The **amount of Monte Carlo** years simulated is based on a **convergence criterion**
- The currently **set reliability standard** for Belgium is used = **3 hours of Loss of Load Expectation (LOLE) on average**

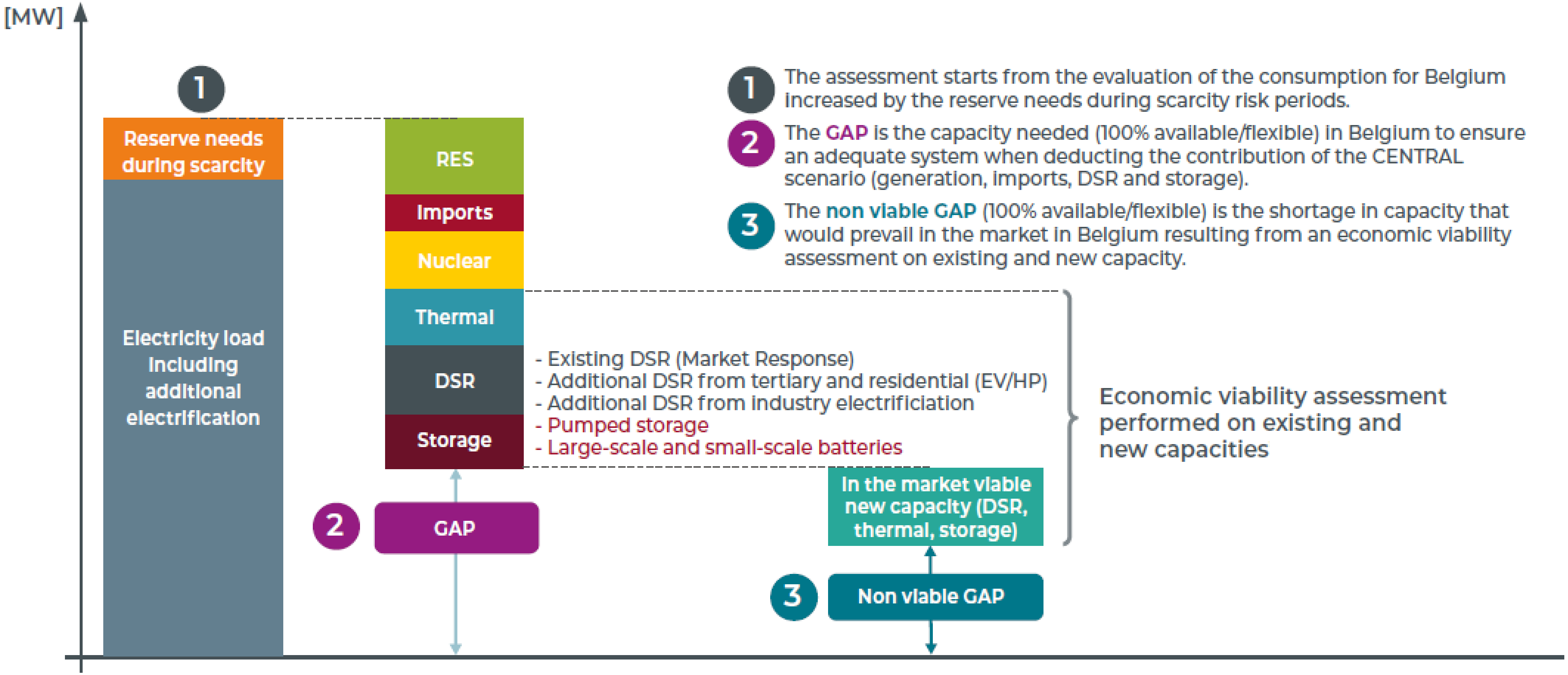
For each scenario/sensitivity, a large amount of Monte-Carlo years are simulated in order to reach convergence of the relevant indicators



An iterative process is performed to determine the needs or the margin for Belgium to meet the adequacy criteria



The adequacy assessment aims to determine the GAP while the EVA aims to calculate the non viable GAP



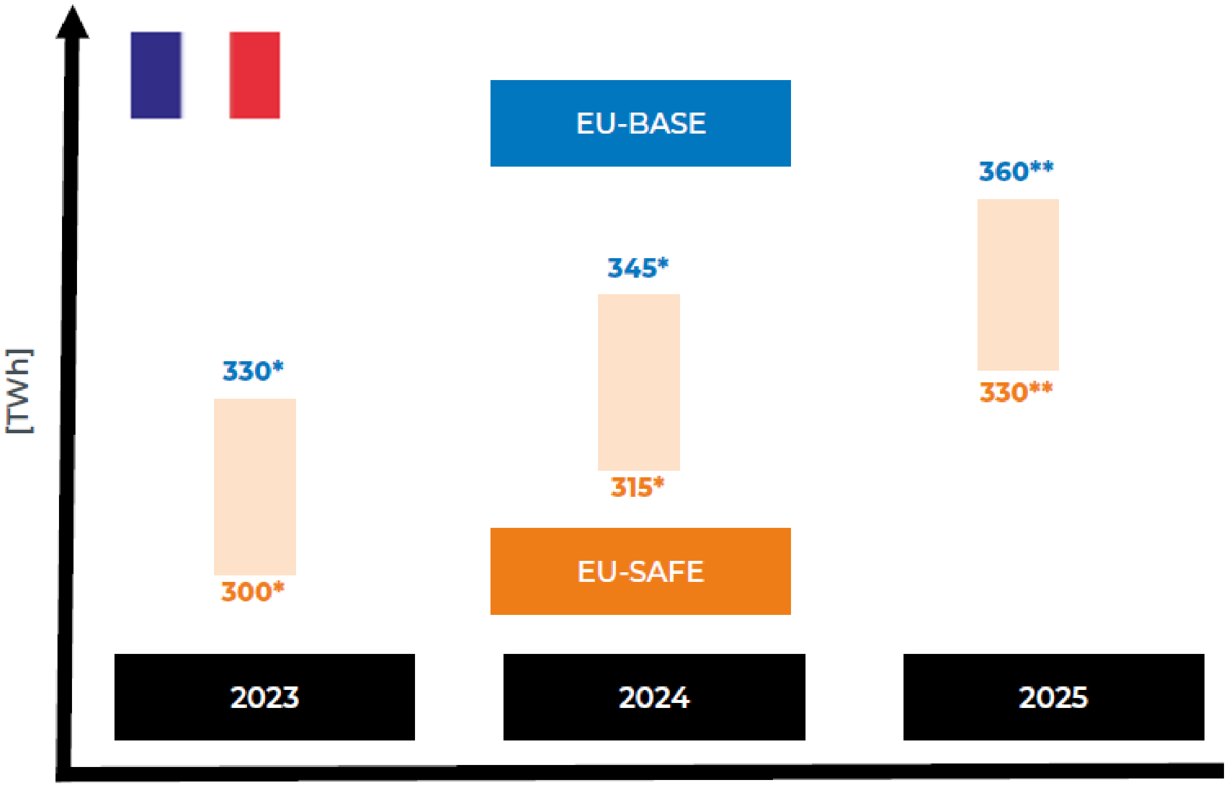
GAP = additional capacity 100% available needed

Adequacy

Results

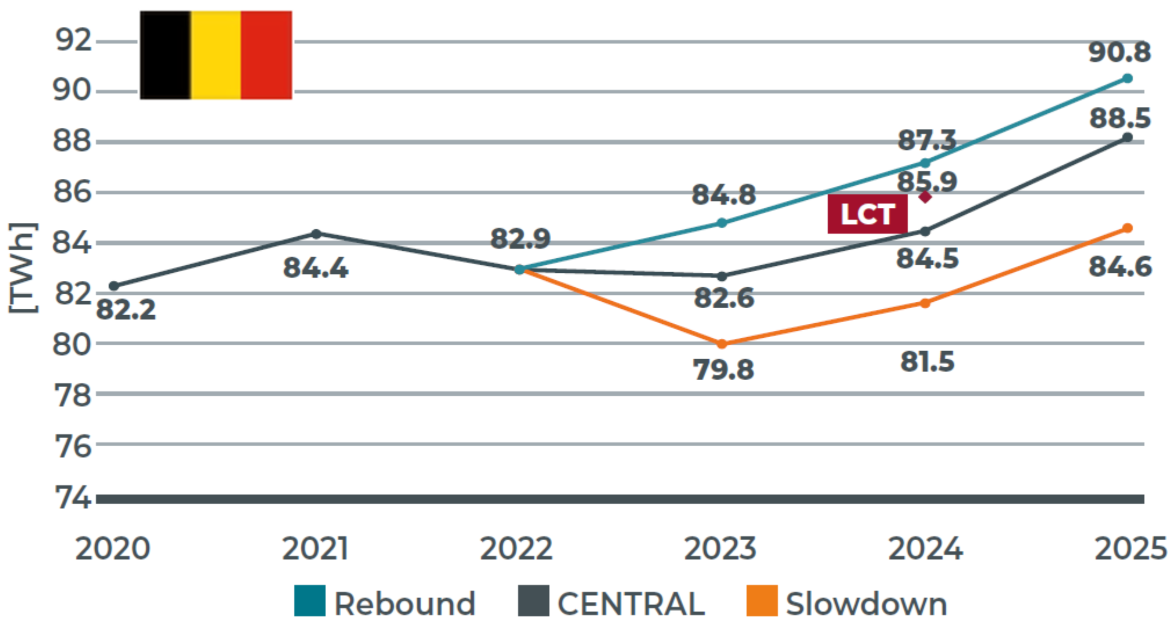
On the **short-term**, EU-BASE and EU-SAFE scenarios are determined based on nuclear availability information from EDF forecasts.
Several sensitivities were assessed regarding Belgian electricity consumption.

Yearly France nuclear generation forecast



* EDF min/max forecast
** Assumption (+15 TWh)

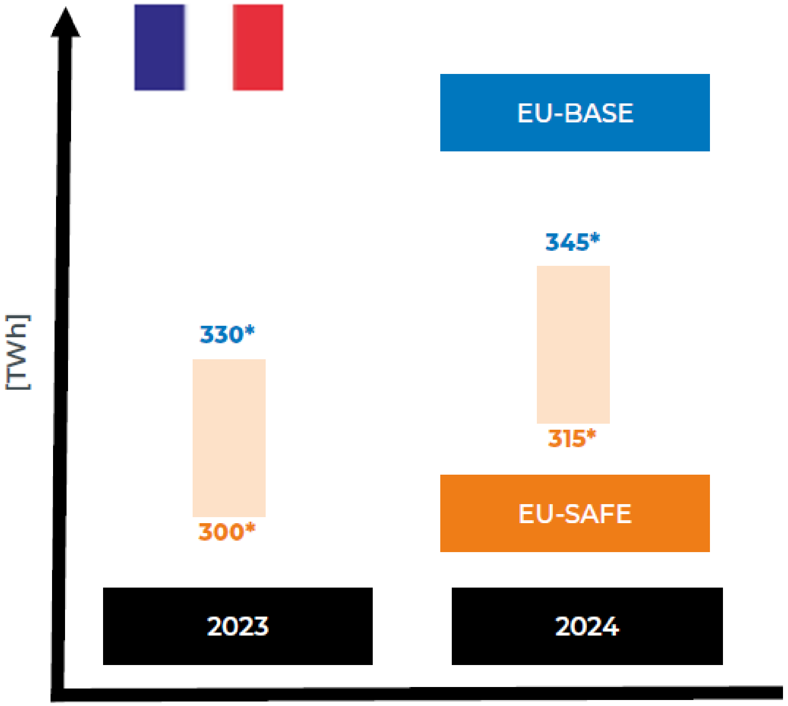
Belgian normalised yearly total electricity consumption under different sensitivities



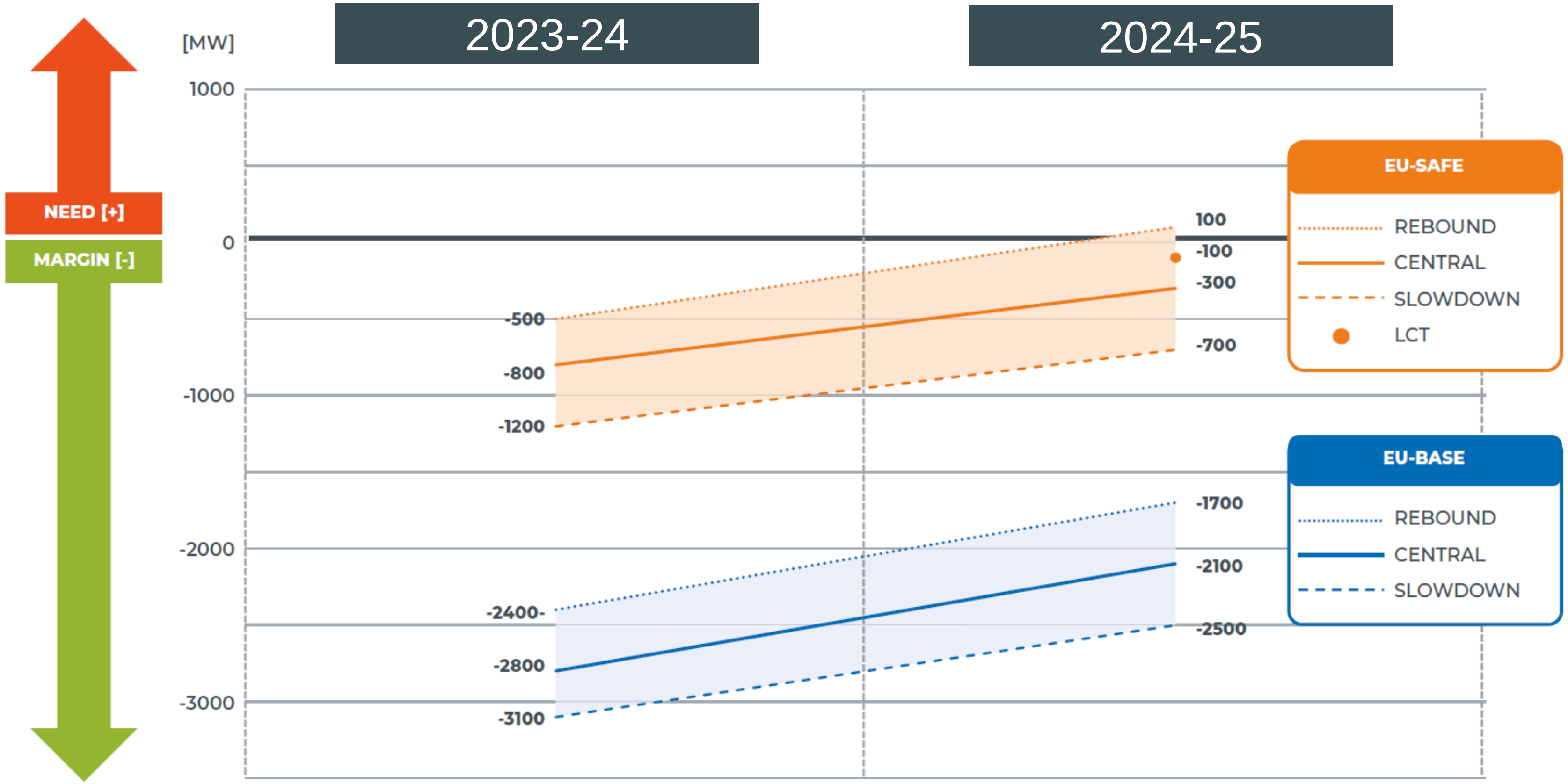
For the **next 2 winters**, Belgium is expected to have enough capacity to comply with its reliability standard.

Only one scenario (EU-SAFE combined with a Rebound consumption) exhibits a need for capacity (100 MW) in 2024-25.

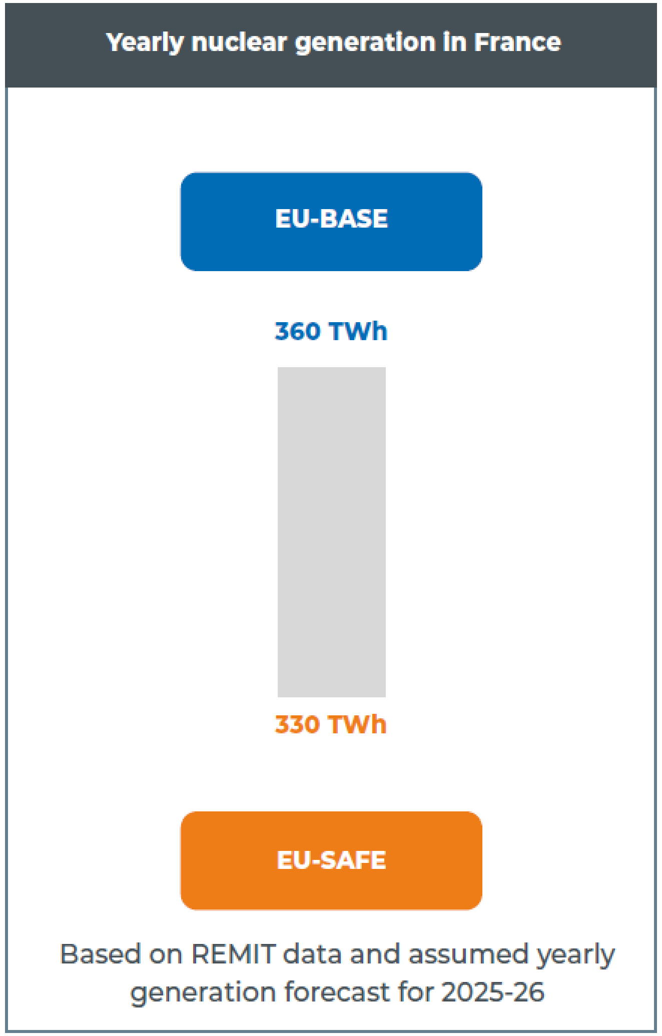
Yearly France nuclear generation forecast

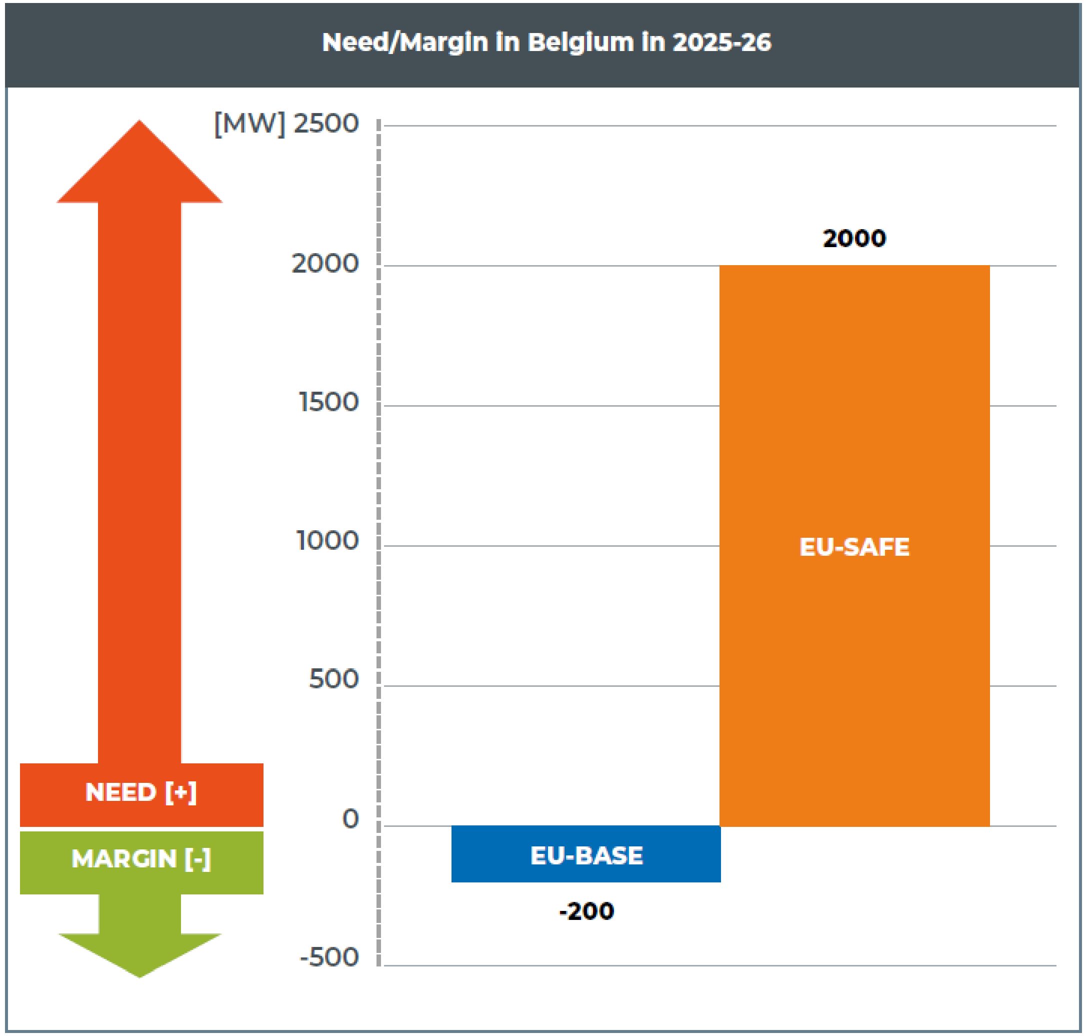


* EDF min/max forecast



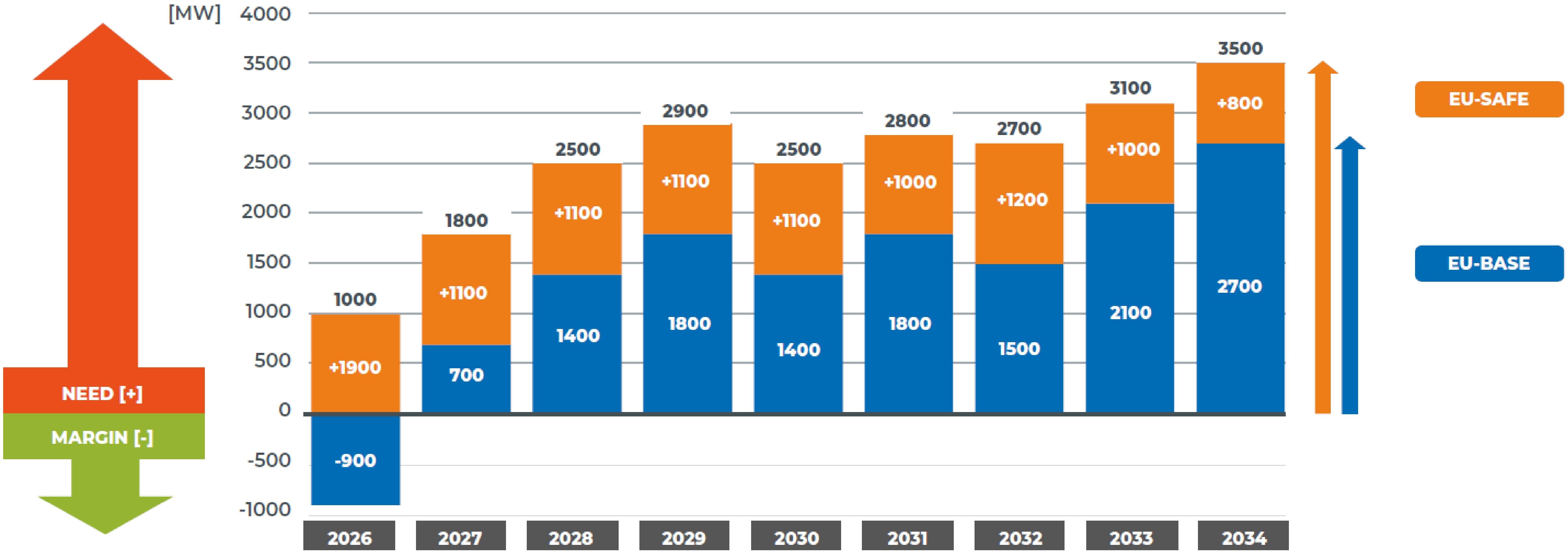
In 2025, while a margin is still foreseen in the EU-BASE scenario, a GAP of 2 GW is identified in the EU-SAFE scenario





Note that no nuclear generation in Belgium is assumed for winter 2025-26 in the CENTRAL scenario.

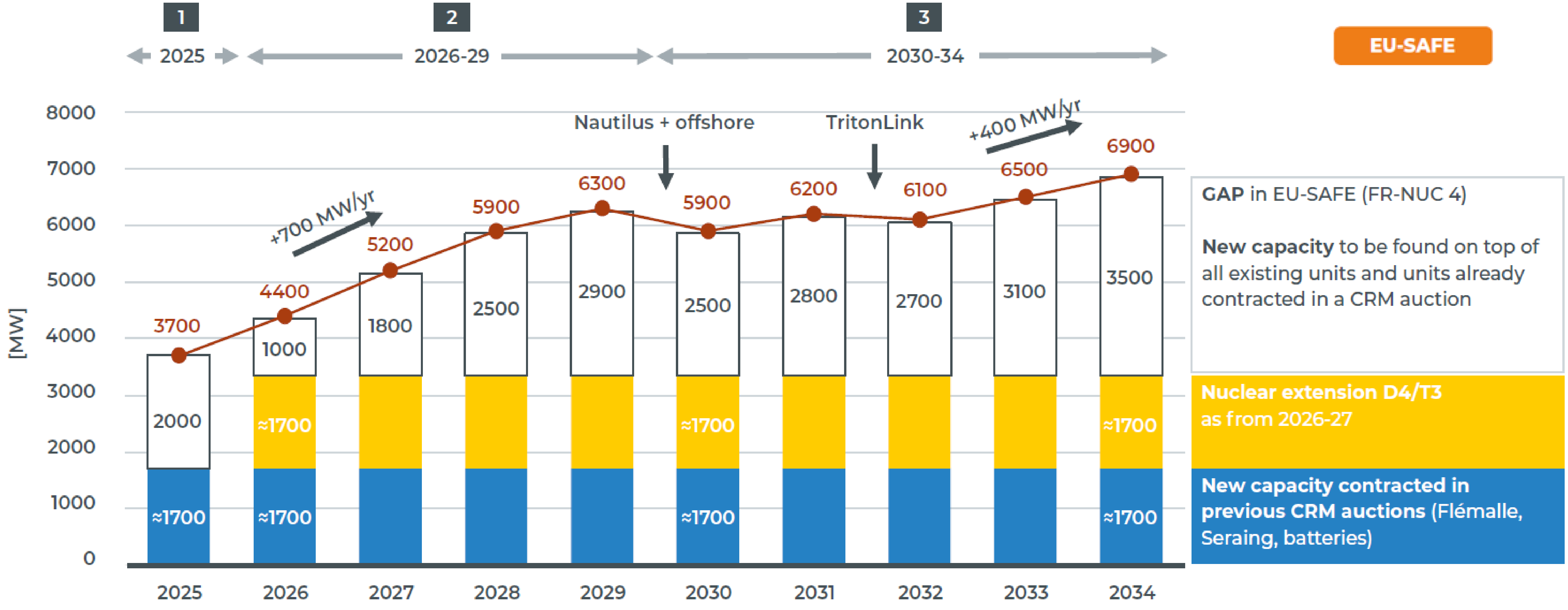
A need for new capacity is foreseen in all simulated scenarios, except in EU-BASE for 2026. The need grows until 2029 and then stabilizes until 2032, with commissioning of additional ICs. In 2029, the GAP is expected to reach 1800 MW in EU-BASE and 2900 MW in EU-SAFE.



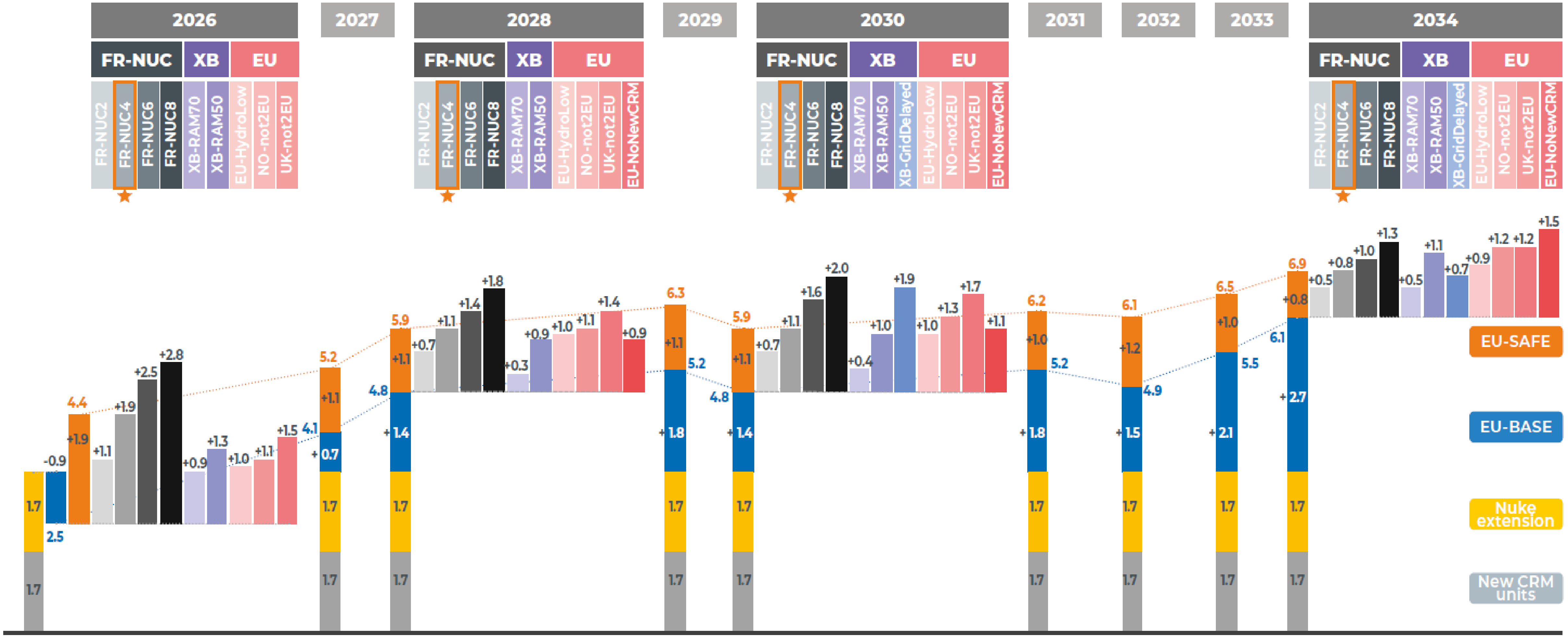
1 In 2025, a GAP of 2 GW is found

2 Electrification in Belgium and in Europe leads to an increase of the GAP

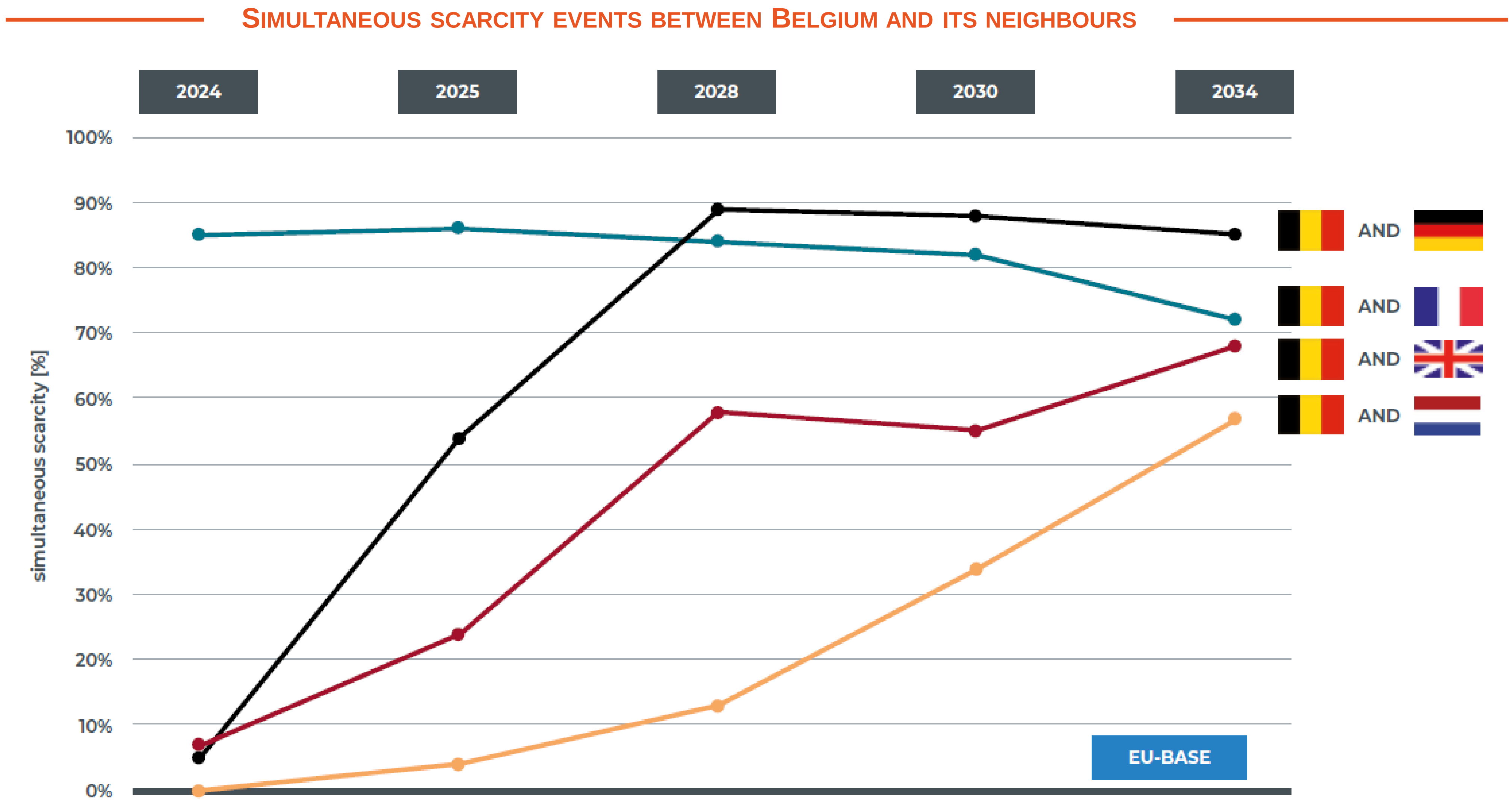
3 The GAP is expected to stabilize with the commissioning of major projects impacting Belgium



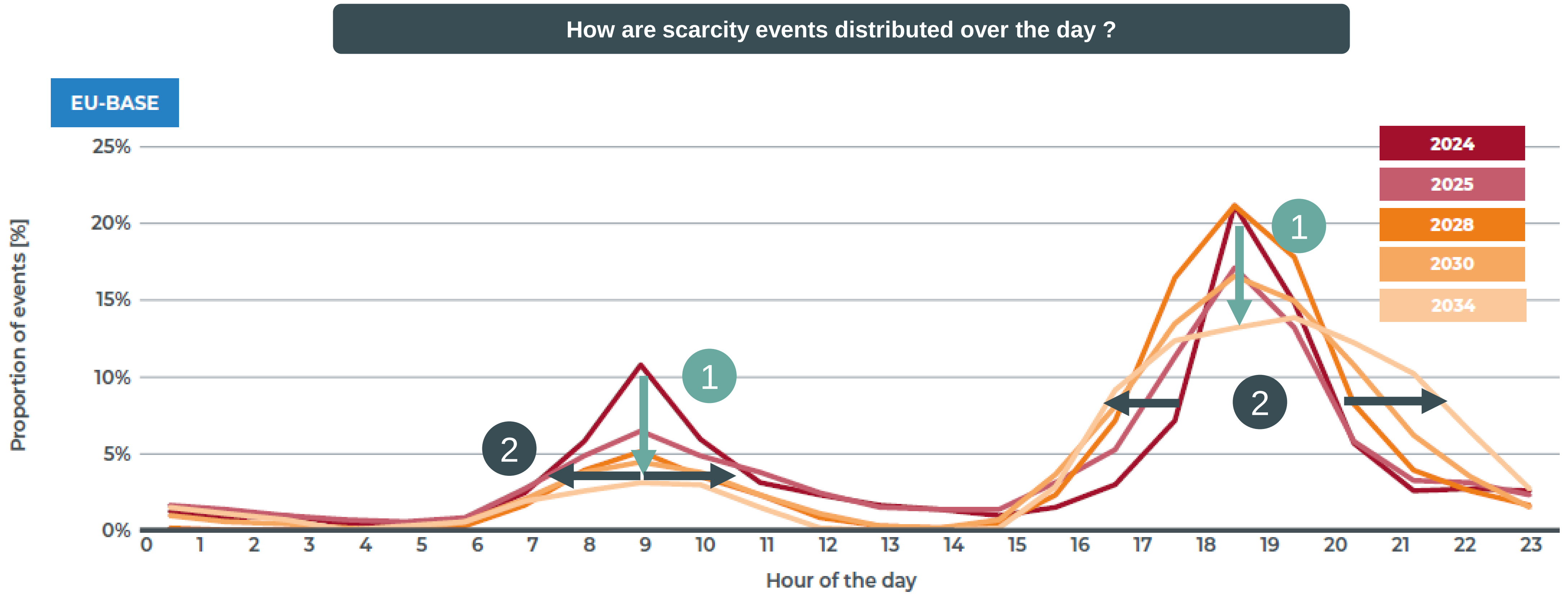
A need for new capacity is foreseen in all simulated scenarios/sensitivities, except in EU-BASE for 2026. This need is calculated on top of the nuclear extension and new units contracted in CRM auctions. The chosen representative sensitivity for the EU-SAFE is the FR-NUC4.



- **On the short-term, scarcity in Belgium is mainly correlated with France.**
- **For later years, the correlation of scarcity events with other countries increases: first with Germany, then with Great-Britain and finally with the Netherlands.**



In the future, the scarcity events will tend to be less concentrated during the daily peaks and more spread around it, leading to longer scarcity events on average

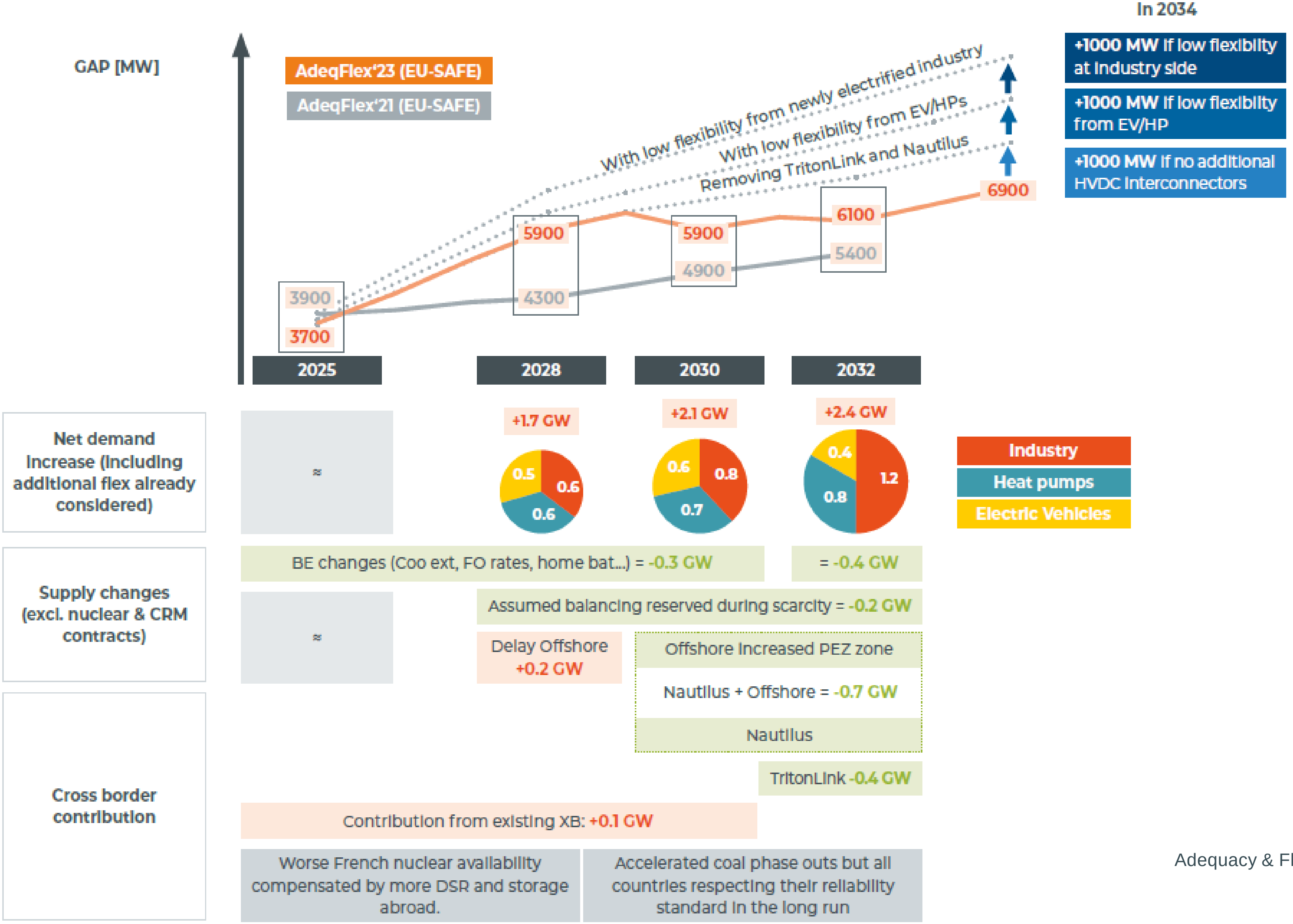


1 Reduction of morning / evening peaks

2 Extension of scarcity periods around the peaks

Note that in an adequate scenario (LOLE = 3h), the average amount of scarcity hours remains the same.

Several changes can explain the differences with AdeqFlex'21.
Increase in Belgian electricity consumption can explain most of the differences
Unlocking flexibility and commissioning new grid infrastructure will be key.



Different sensitivities were performed on the electricity consumption. Depending on the electrification trajectories from the different sectors, an increase or decrease of the GAP can be observed.

Transport electrification

	2028	2030	2034
HIGH # EV	+200 MW	+200 MW	+400 MW
LOW # EV	-200 MW	-200 MW	-300 MW

Industry new usage and electrification (incl. data centers)

	2028	2030	2034
e-IND. 2Y ACCEL.	Between +200 MW and +400 MW		
e-IND. 2Y DELAY	Between -200 MW and -400 MW		

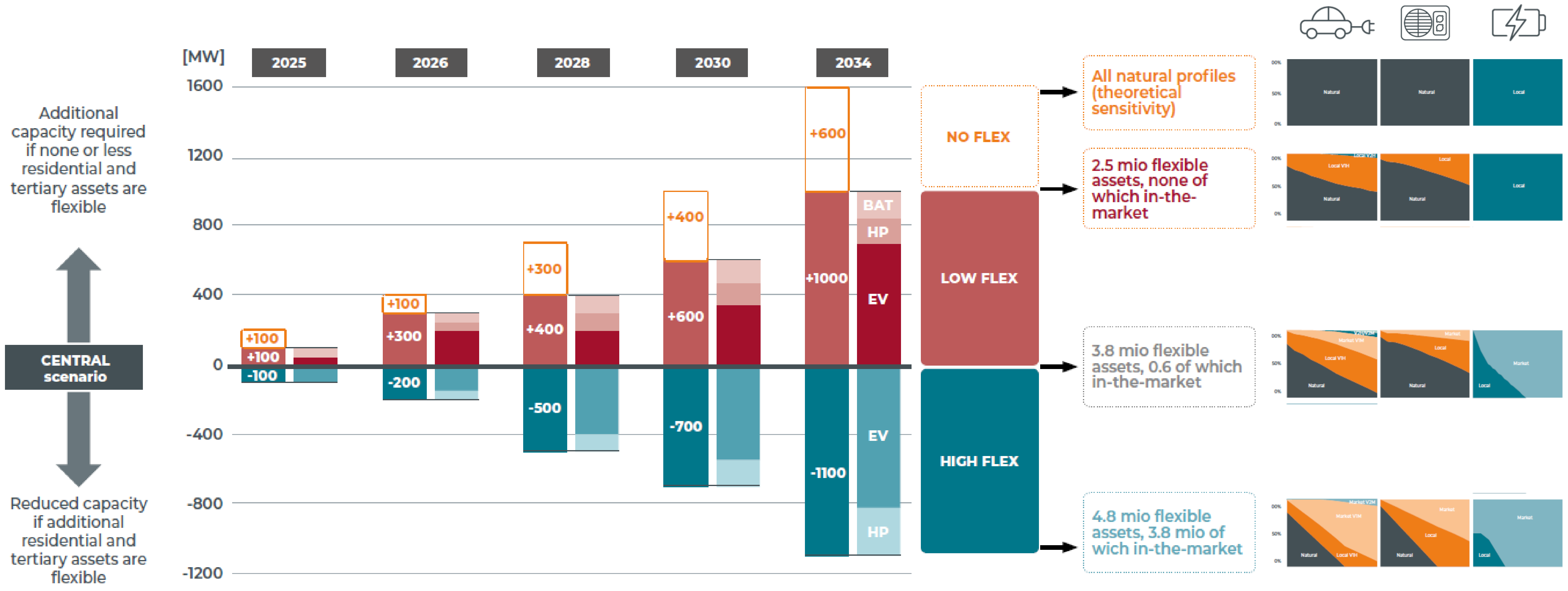
Buildings heat electrification

	2028	2030	2034
HIGH # HP	+200 MW	+300 MW	+700 MW
LOW # HP	-200 MW	-200 MW	-300 MW

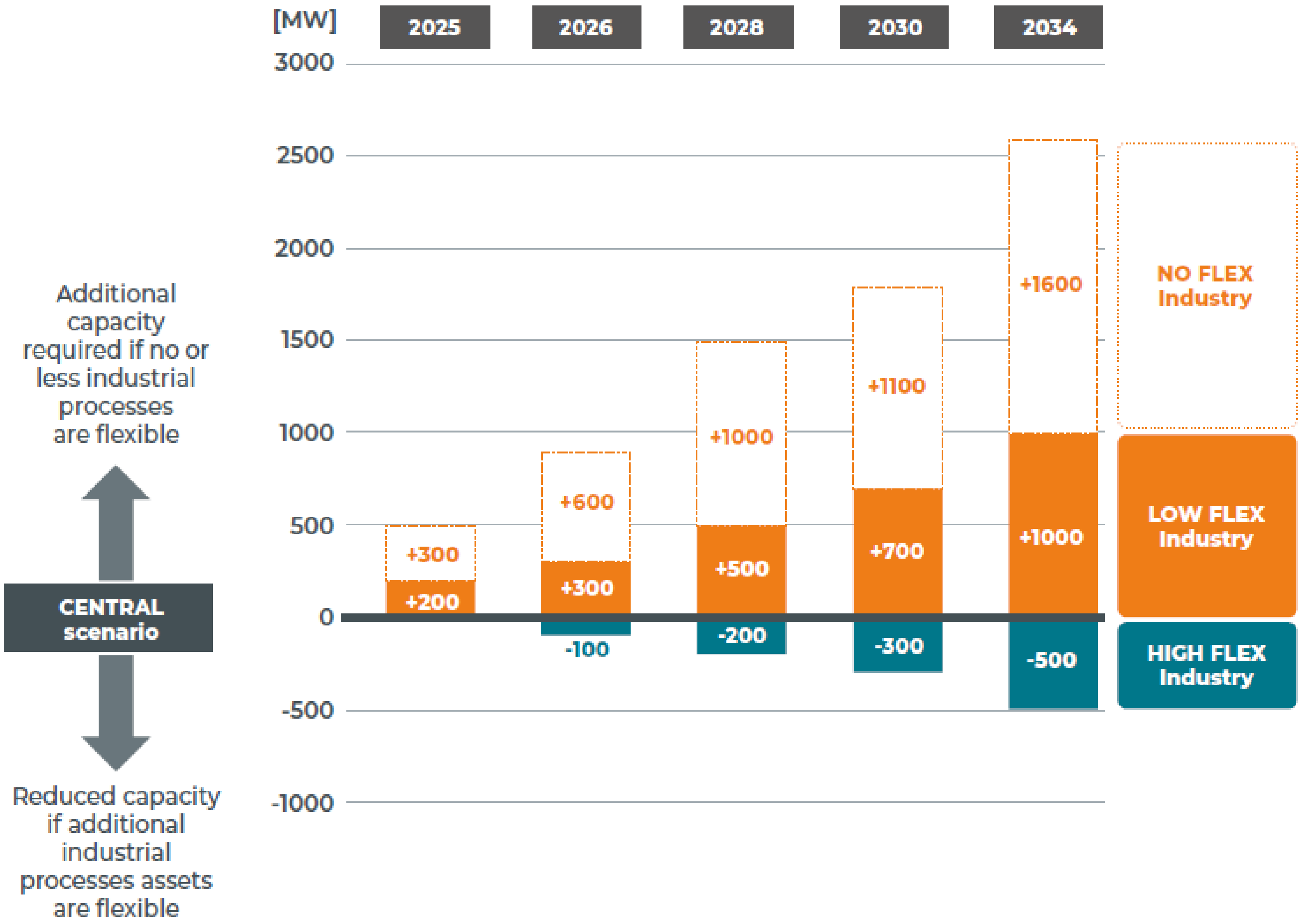
Gas & CO_2 price and impact on the consumption

	2028	2030	2034
HIGH GAS PRICE	← -500 MW →		
LOW GAS PRICE	← +100 MW →		

- **CENTRAL scenario regarding end-user flexibility already considers a significant share of flexibility from EV, HP and residential batteries**
- **Unlocking higher flexibility or having lower flexibility in the system has a 1300 MW range impact on the GAP in 2030 (from LOW FLEX to HIGH FLEX)**



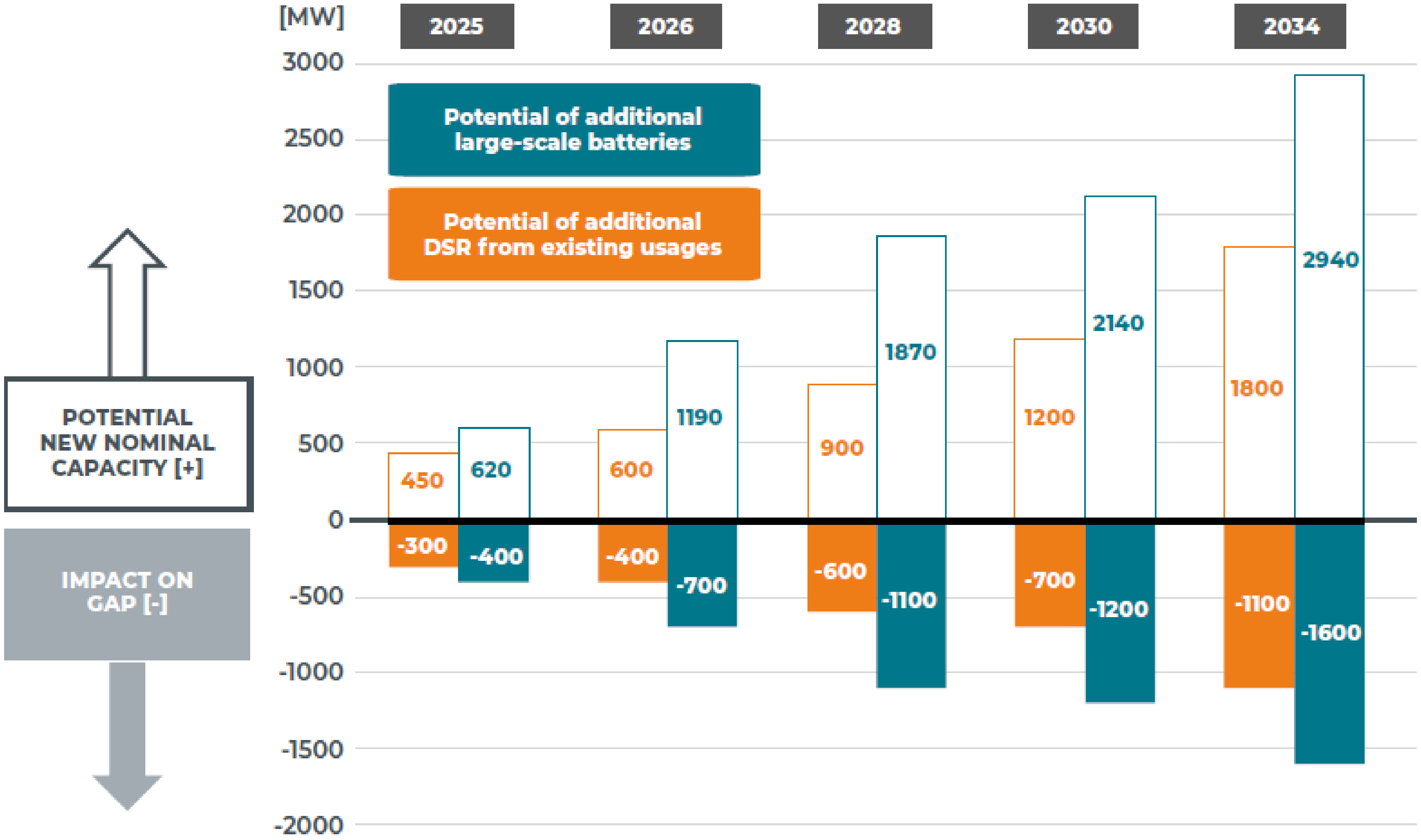
A significant share of flexibility from industry is already integrated in the CENTRAL scenario



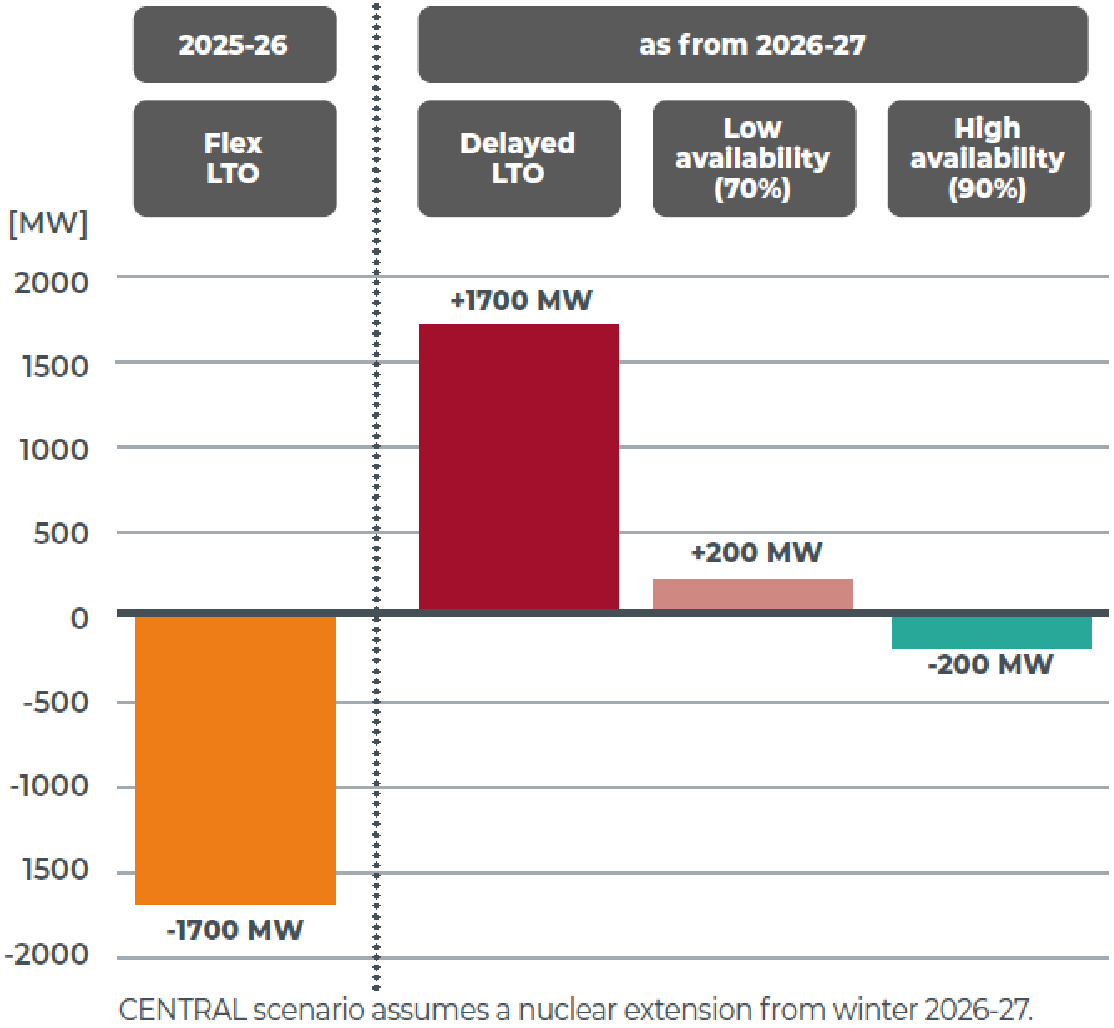
Flexibility shares

	LOW	CEN	HIGH
e-boilers	80%	100%	100%
HP	20%	80%	90%
DRI-EAF	25%	75%	100%
Data Centers	0%	50%	75%
CCS	0%	0%	50%
Electrolysers	100%	100%	100%

- **In 2025, developing the identified potential of large-scale batteries and DSR (700 MW) is not sufficient to cover the GAP identified in the EU-SAFE scenario (2000 MW).**
- **In 2030, the identified potential of large-scale batteries and DSR could reduce the GAP respectively by -700 MW and -1200 MW.**

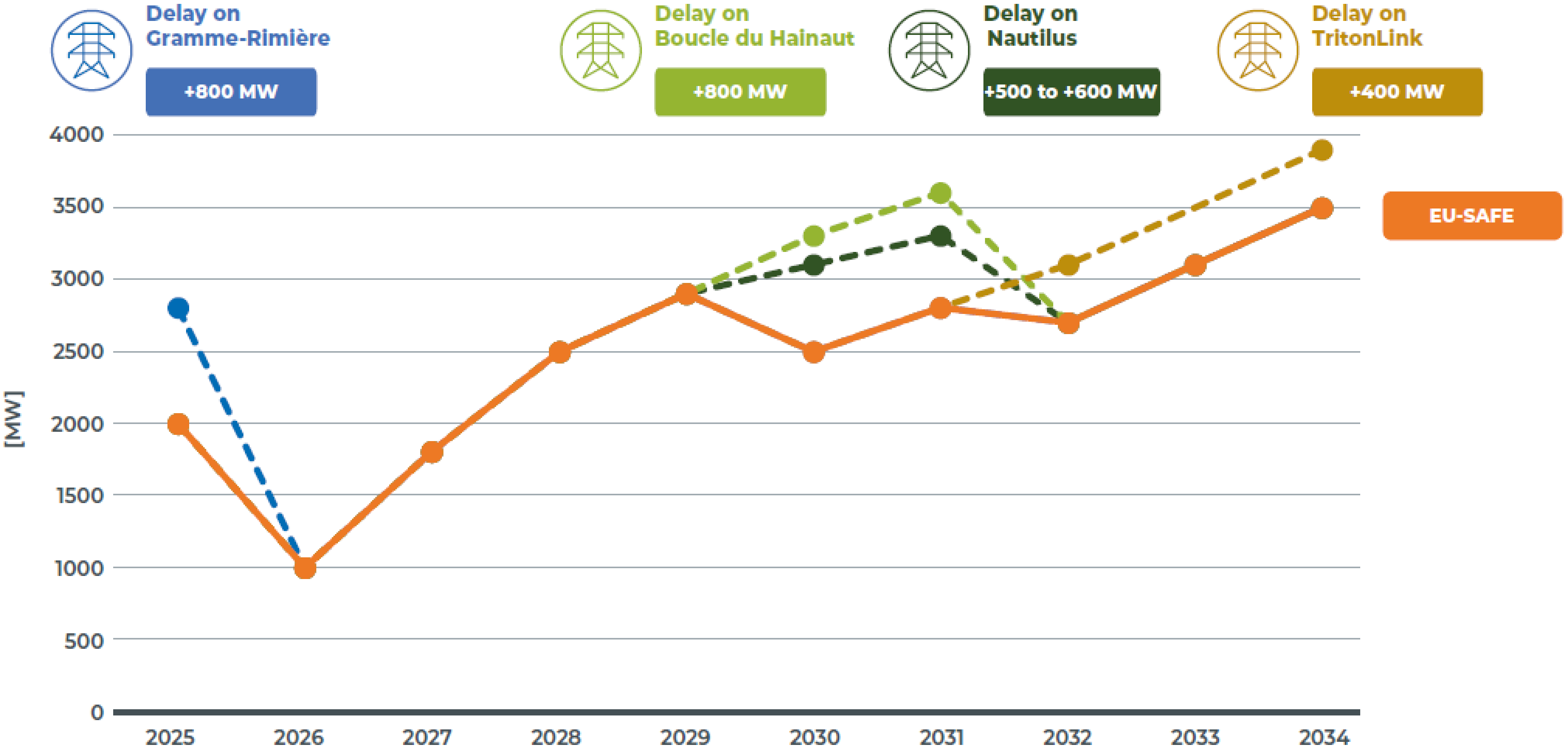


Several sensitivities were performed regarding Belgian nuclear availability



- '**Flex-LTO**' sensitivity considers Doel 4 and Tihange 3 available as from 2025-26, reducing the GAP by 1700 MW for this time horizon
- The other way around, a '**Delayed-LTO**' would increase the GAP by the same amount as from 2026
- Finally, the **availability** of the 2 extended nuclear units could
  - decrease the GAP by 200 MW in case of better availability
  - increase the GAP by 200 MW in case of worse availability

- **A delay of the Gramme-Rimière project would prevent the commissioning of Flémalle CCGT**
- **Any delay on future grid infrastructure will result in a significant impact on the GAP as from 2030.**



AGENDA

(and indicative timings)

- **Regulatory** framework and **stakeholder** interaction **[9h00-9h15]**
- **Scenario** framework and assumptions **[9h15-10h00]**
- **Adequacy** results **[10h00-10h40]**
- Break 15min **[10h40-10h55]**
- **Economic viability** assessment **[10h55-11h15]**
- **Flexibility** needs and means **[11h15-11h45]**
- **Other** insights & **main messages** **[11h45-12h00]**

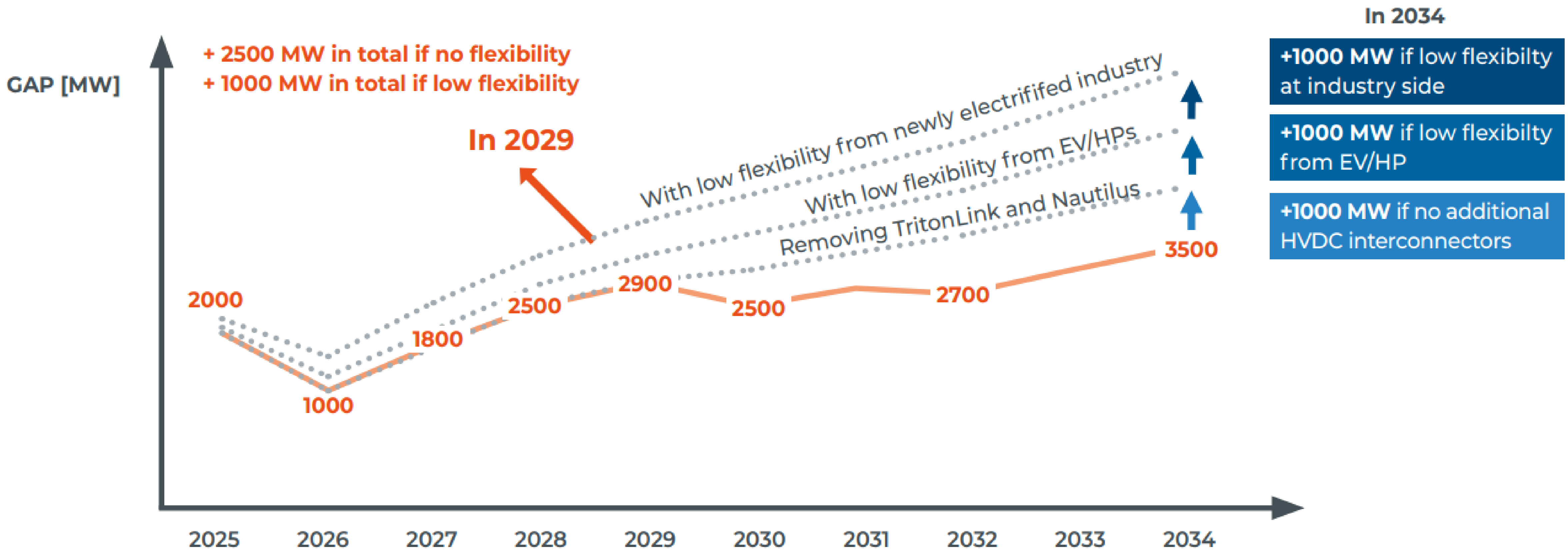
Adequacy

Main results

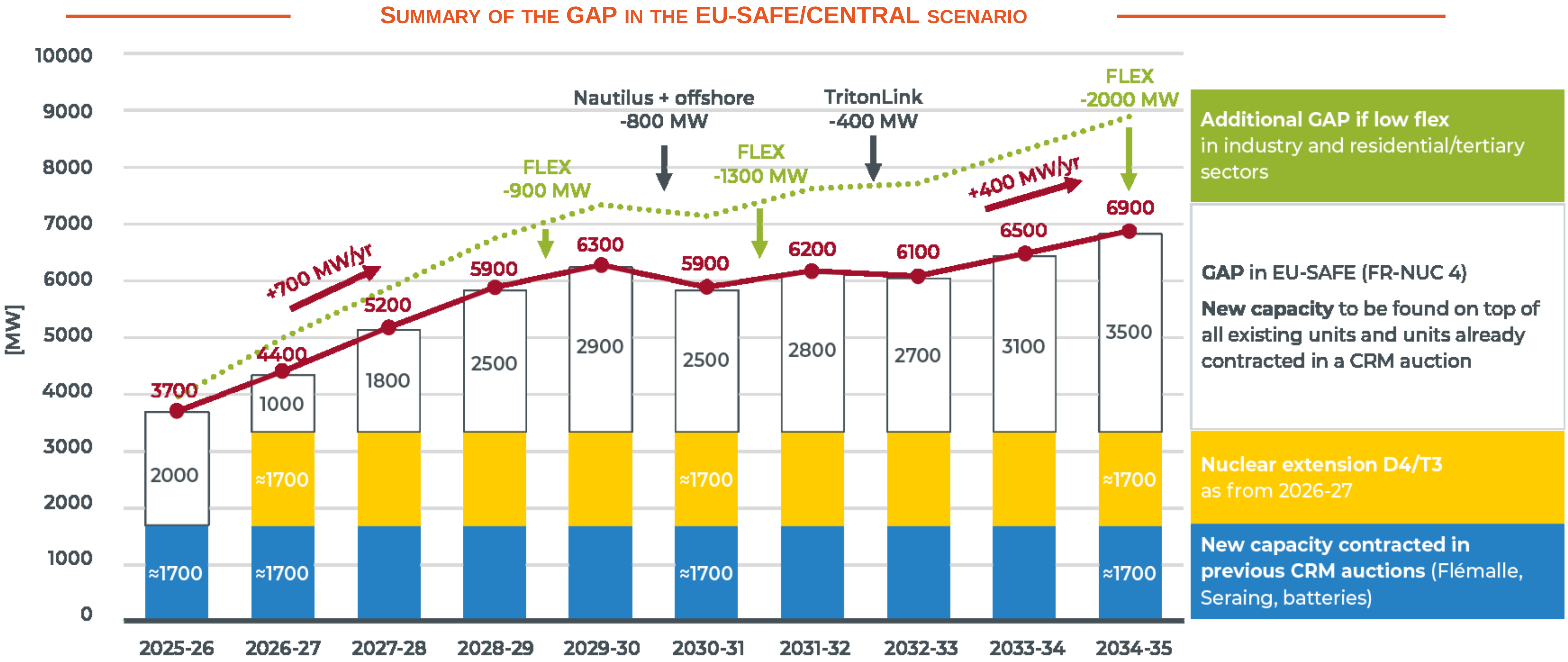
The CENTRAL scenario already assumes that:

- **70%** of newly electrified **industry** is assumed to be able to be reduced at times of scarcity
- **2/3 of EVs** and **1/3 of HPs** are assumed to exhibit some level of intelligent charging
- **Grid development** projects are realized as assumed in the CENTRAL scenario (TritonLink, Nautilus...)

GAP IN EU-SAFE WITH BENEFITS OF FLEXIBILITY AND INTERCONNECTIONS



Summary of adequacy results



Economic Viability Assessment

Methodology

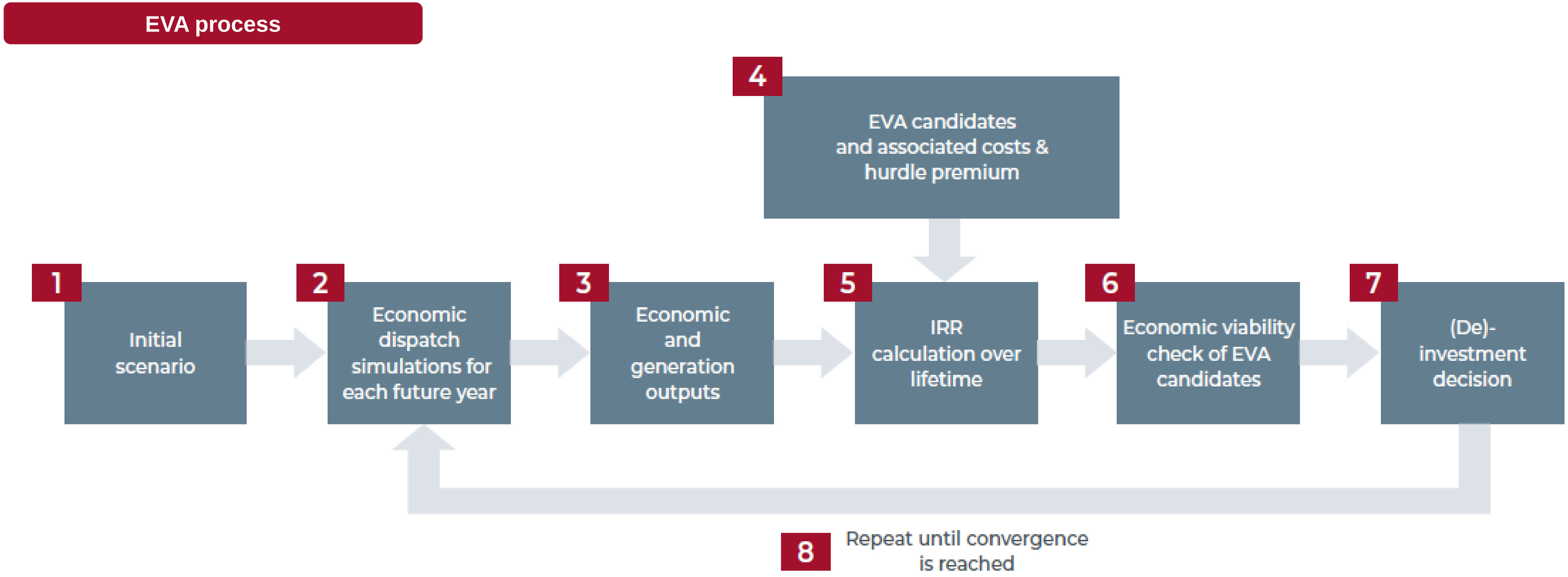
What is the Economic Viability Assessment (EVA)?

Will the Belgian reliability standard be met without 'market' intervention (i.e. no CRM)?

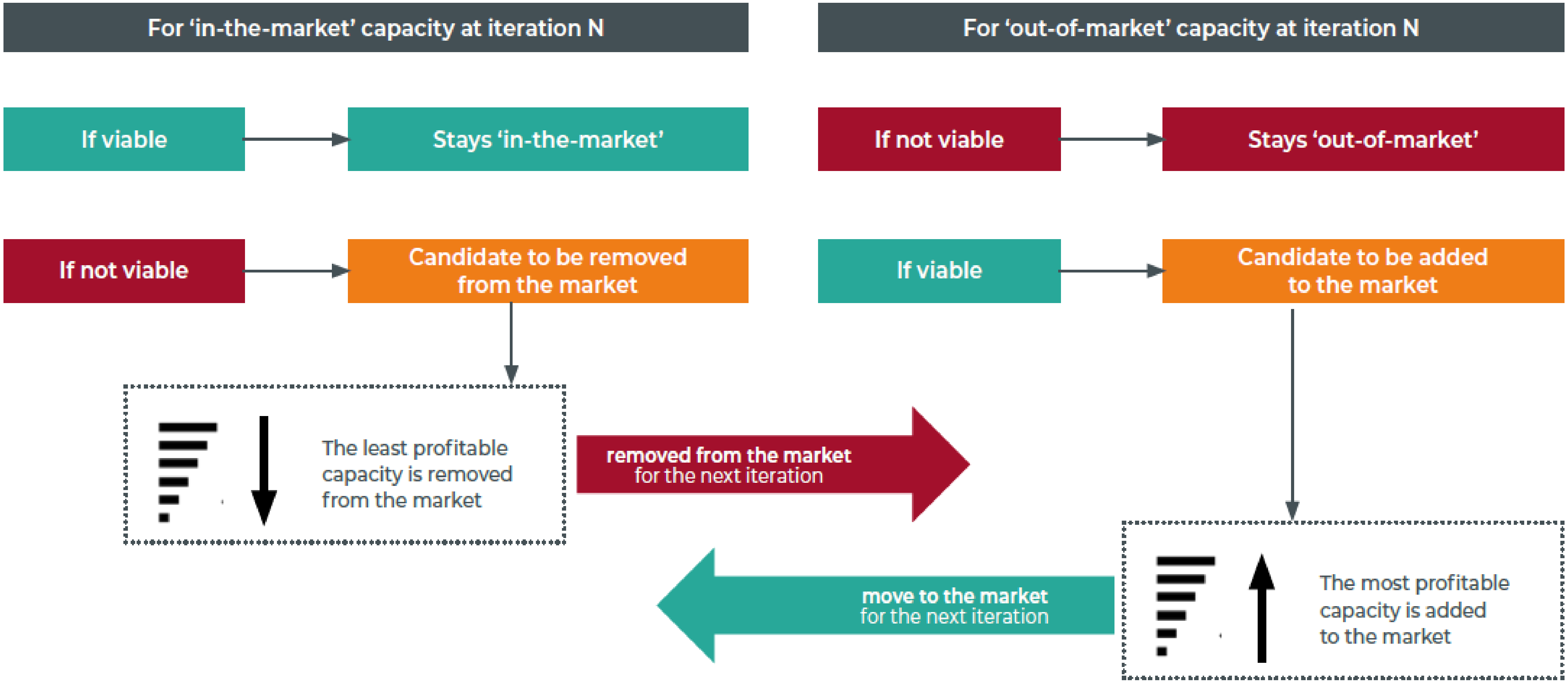
The EVA is a **complex** but **crucial** analysis which allows us to answer this question. Elia's EVA in particular:

- was co-developed in **close collaboration with academia** (prof. K. Boudt);
- takes into account the latest (10/01/2023) **ACER decisions on price cap increases**;
- considers **recent market evolutions** following an **update of the parameters** by prof. Boudt;
- is **fully multi-year**, making it a **front-runner in EVA's** for adequacy and economic studies;
- …

Following an iterative approach an EVA equilibrium is found.



The EVA process: how do we end up with a converged result?



'in-the-market' means 'capacity was not activated in this iteration'
'out-of-market' means 'capacity was activated in this iteration'

A sign of a converged EVA simulation is that no more capacity is marked for addition/removal.

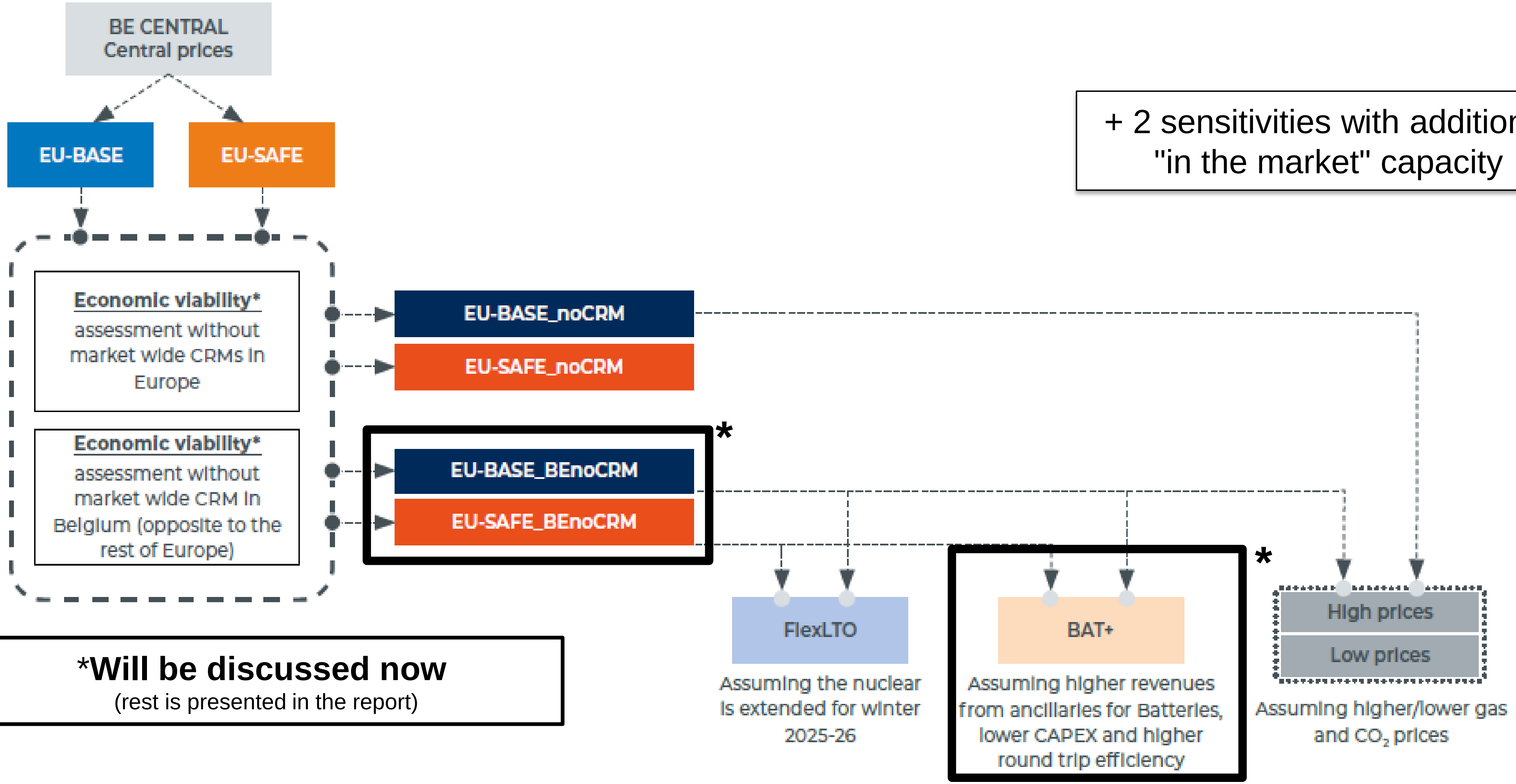
‘in-the-market’ means 'capacity was not activated in this iteration'
‘out-of-market’ means ‘capacity was activated in this iteration'

Economic Viability Assessment

results

Multiple sensitivities for the EVA are studied in this years' Adequacy and Flexibility study.

+ 2 sensitivities with additional "in the market" capacity



***Will be discussed now**
(rest is presented in the report)

**Economic viability assessed in most impacting countries for Belgium's adequacy (representing more than 70% of European thermal generation capacity)*

Existing and new capacities were assessed in the EVA

List of candidates for the EVA in Belgium

	Capacity type	Initial capacity (as from 2025, nominal)	In the EVA
CENTRAL scenario	CCGTs (incl CCGT-CHP)	6.2 GW	Yes, Units not under CRM contract
	OCGTs	0.9 GW	
	TJs (peakers)	0.14 GW	
	RES, DSR, Storage, Decentralised CHP, Nuclear	CENTRAL scenario assumptions	No, Assumed viable (including new DSR part of newly electrified processes and small scale storage)
NEW	CCGT	Start at 0 GW (unless already contracted under the CRM)	Yes, CH4 and H2
	OCGT		
	DSR		Yes, Potential defined for each target year
	Large scale storage		Yes, new capacities on top of the ones already assumed in the 'CENTRAL' scenario with 3 sizes (1h,2h,4h) and potential defined for each target year
	CHP		Yes, with 3 must-run operation modes

Only a limited amount of Large-scale batteries are economically viable if only EOM revenues are relied on

However, it should be noted that the estimated **net revenues might in certain cases turn out to be higher** due to;

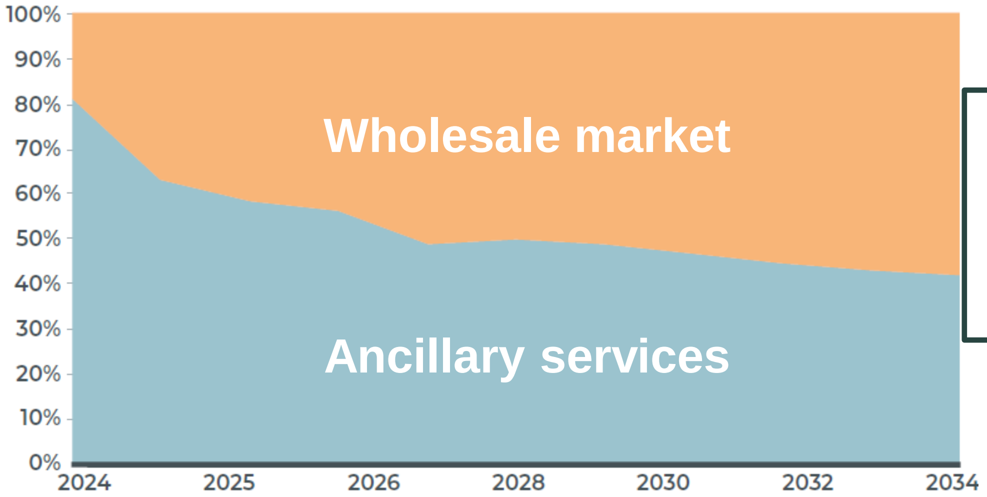
- **Activation of balancing** products (e.g. aFRR)
- Trading in **intraday and/or from reactive balancing**
- Specific individual **portfolio effects**

Other considerations to take into account:

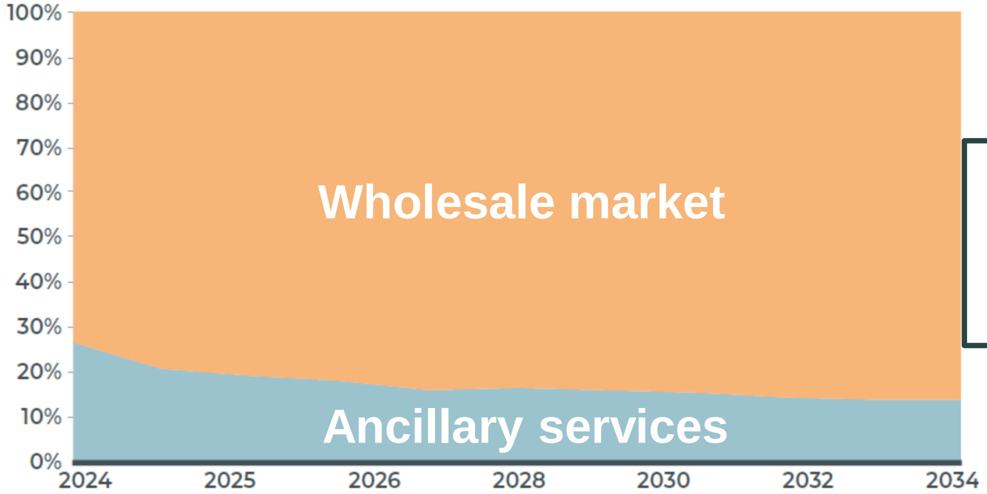
- **Large amounts** of new storage/flexibility **already assumed** in the scenarios
- **Lower risks** for investors if CRM contracts already exist/will be awarded
- Uncertainties regarding the **costs**

➡ Inclusion of a **BAT+** sensitivity
- Higher roundtrip **efficiency (90%)**
- **Lower CAPEX** (level of 2034)
- **All aFFR revenues** attributed to batteries

Where do batteries get their revenues from in the EVA?

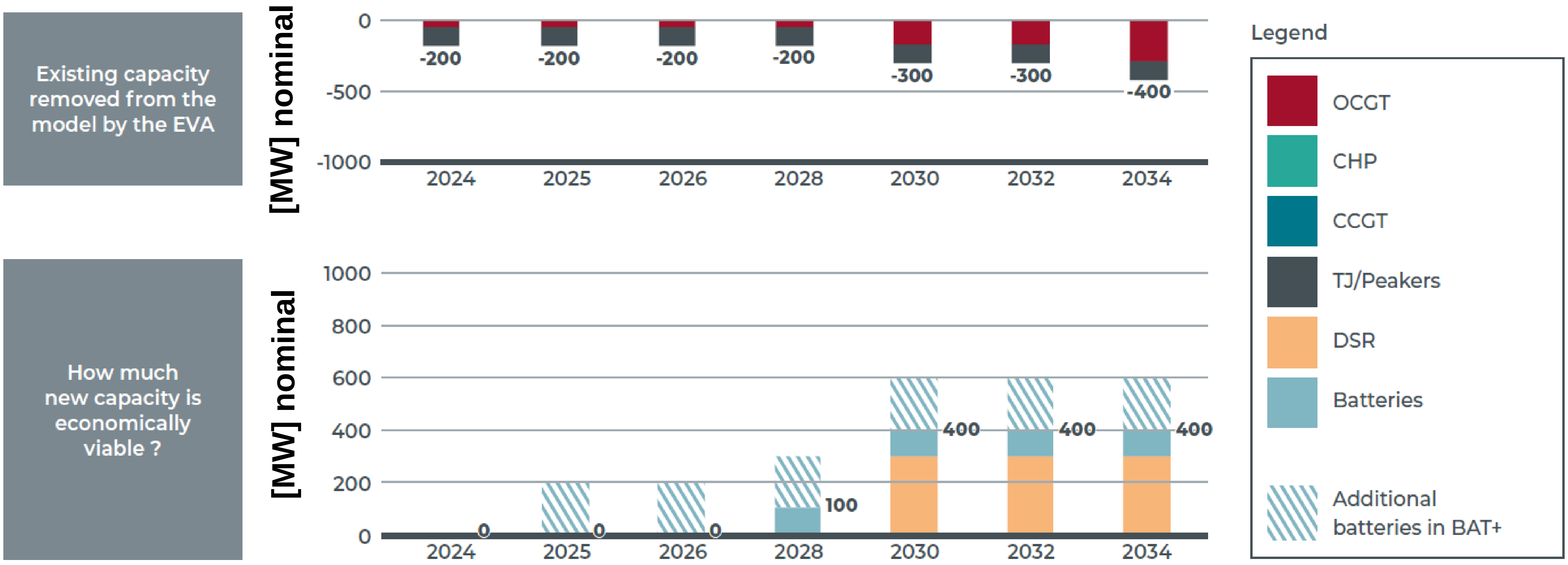


CENTRAL assumptions (~300 MW of batteries)



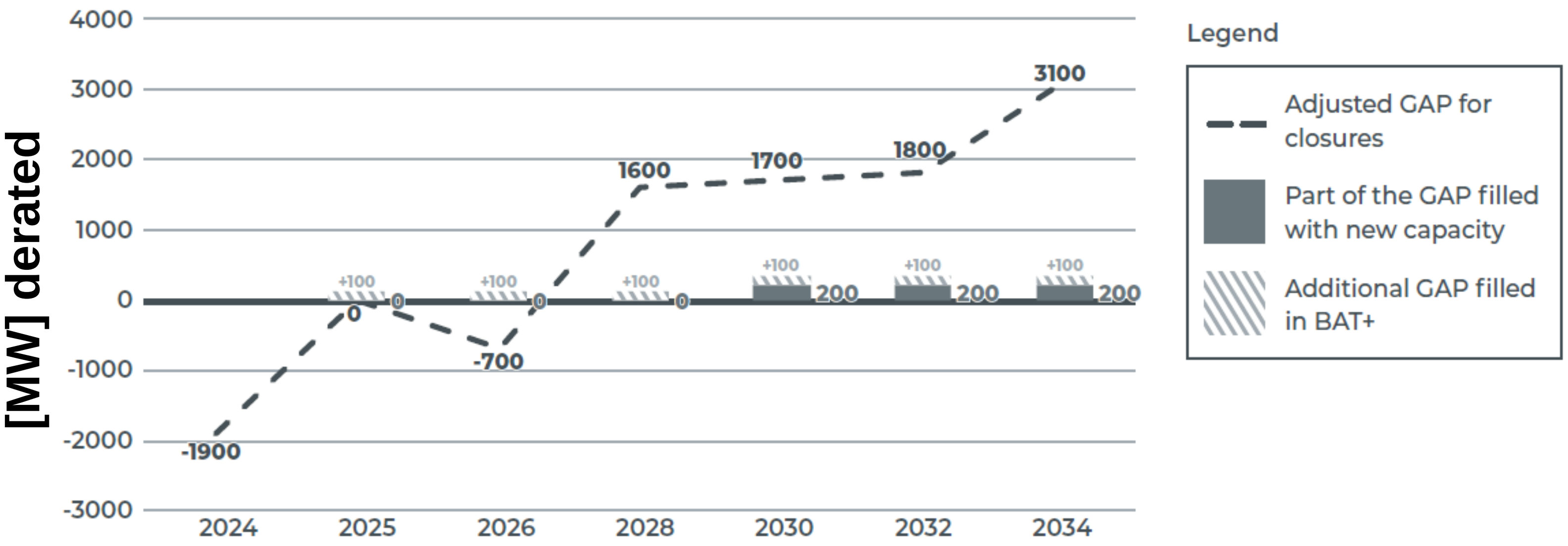
Assuming 1000 MW of batteries

In EU-BASE_BEnoCRM some TJ and OCGT leave the market, new DSR and batteries (1h) enter the market

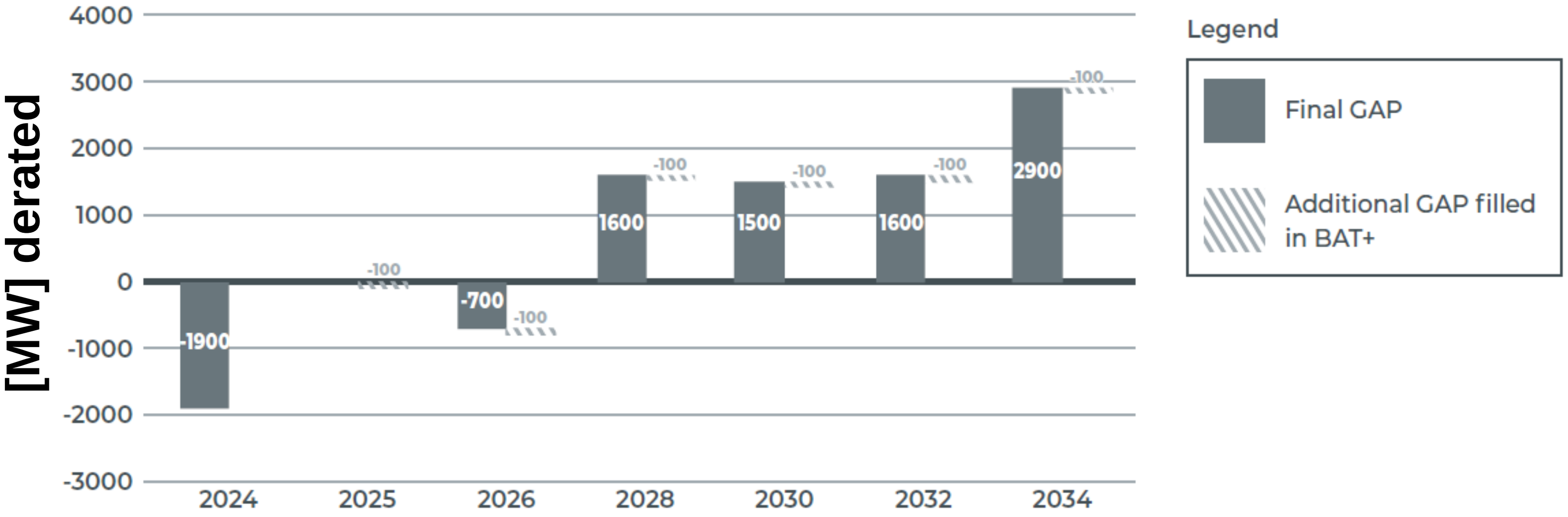


A non-viable GAP remains as of 2028 in EU-BASE_BEnoCRM

How much new capacities are economically viable compared to the required volumes to be adequate ?

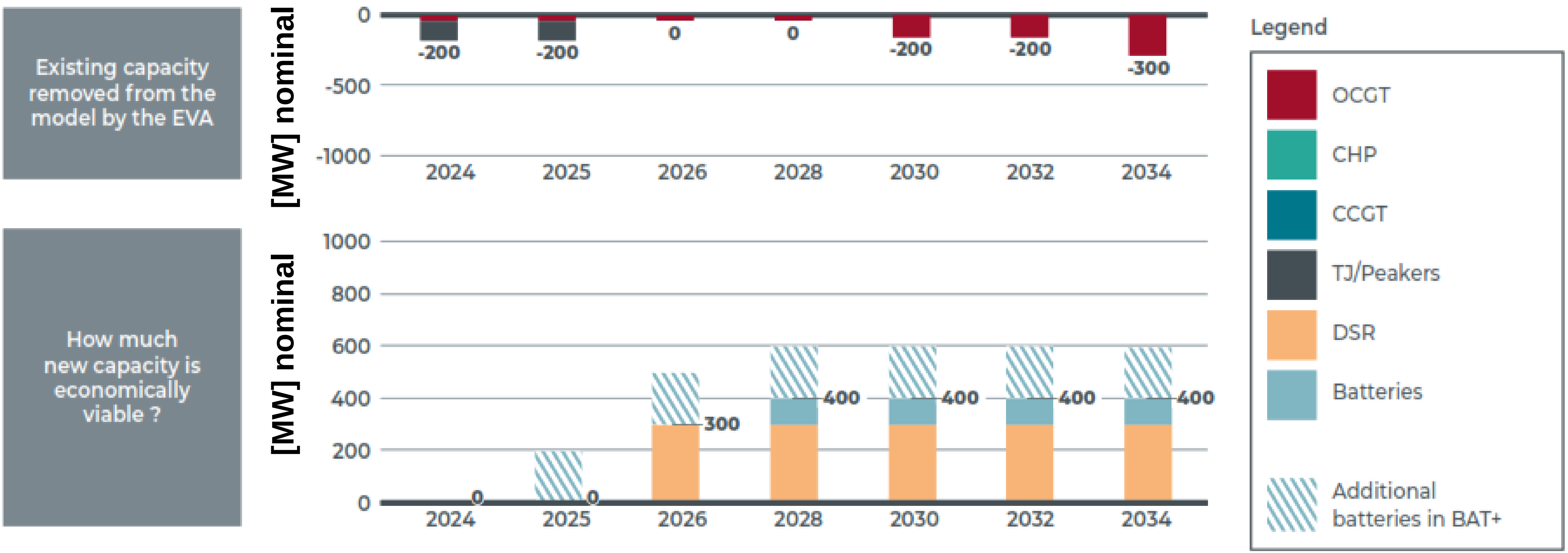


Resulting non viable GAP



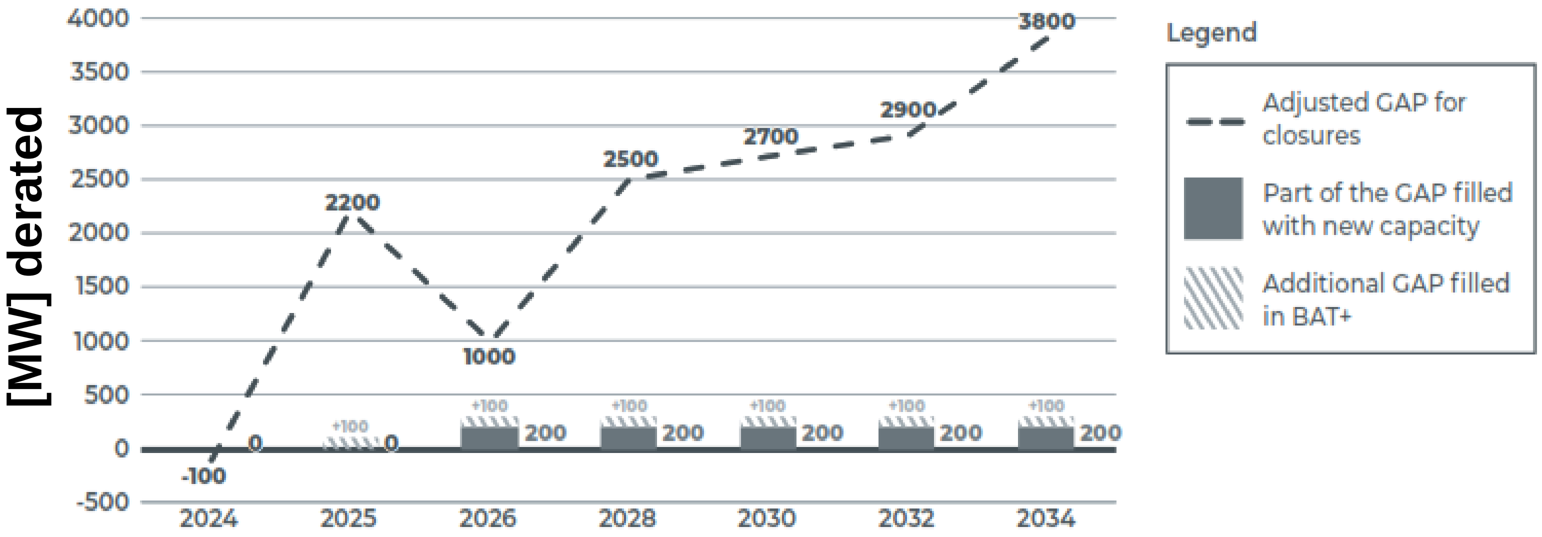
*the **Belgian reliability standard** (under the assumptions taken) is **not respected***

In EU-SAFE_BEnoCRM some TJ and OCGT leave the market, new DSR and batteries (1h) enter the market

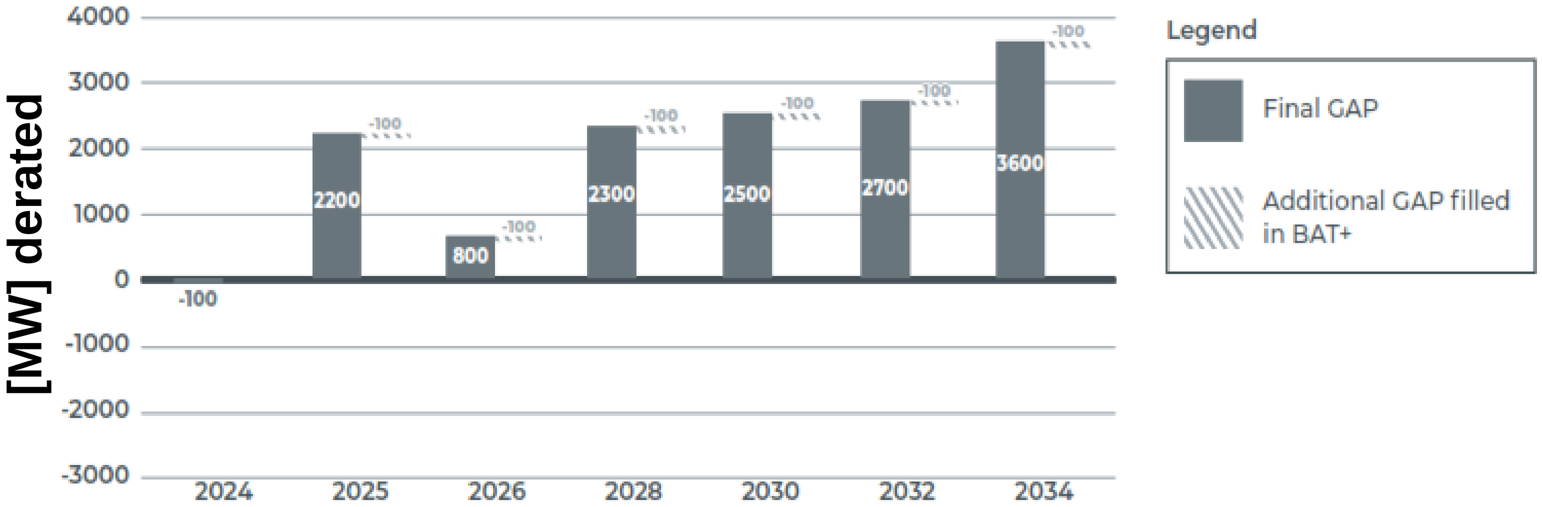


A non-viable GAP remains as of 2025 in EU-SAFE_BEnoCRM

How much new capacities are economically viable compared to the required volumes to be adequate ?



Resulting non viable GAP



*the **Belgian reliability standard** (under the assumptions taken) is **not respected***

What is the Economic Viability Assessment (EVA)?

Will the Belgian reliability standard be met without 'market' intervention (i.e. no CRM)?

No, the EVA showed that for Belgium, under the assumptions taken and without intervention:

- **A non-viable GAP remains** as of 2028 in the EU-BASE scenario (and as of 2025 in the EU-SAFE scenario).
- If the **reliability standard for Belgium would be respected**, some capacities present in the system would **not be not economically viable** (without intervention).
- The **need for a market-wide support mechanism** is therefore **clear**.

Flexibility

Context, methodology and data

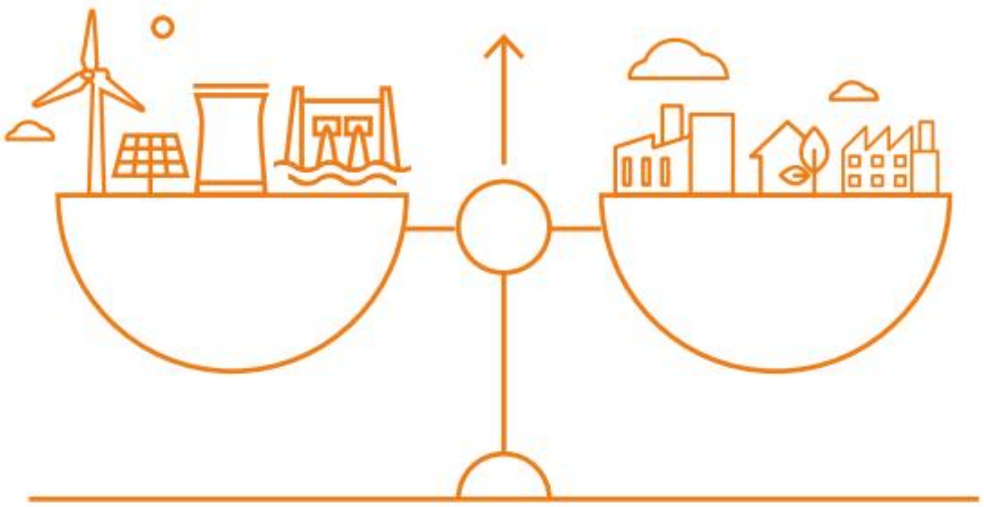
FLEX

| Elia Group

Definition of flexibility

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

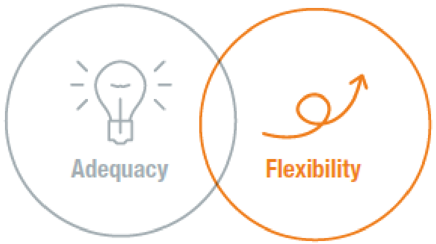
FLEXIBILITY DRIVERS
- Variability of the demand
- Variability of generation
- Forced outages



FLEXIBILITY SOURCES
- Generation units
- Demand-side assets
- Electricity storage
- Interconnectors

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.

Context

APR 2016

Adequacy & Flexibility
2017 - 2027

Adequacy Flexibility

In 2016, Elia published the first adequacy and flexibility study. The flexibility analyses focused on :

- Setting the scene : definition of flexibility and analysis of the residual load variability
- Determining Elia's balancing capacity needs towards 2027

JUN 2019

Adequacy & Flexibility
2020 - 2030

Adequacy Flexibility

New legal requirement in the federal electricity law to publish a bi-annual adequacy and flexibility study for Belgium. Elia developed a new methodology to assess the future flexibility needs of the system

- **NEW SCOPE :** enlarging scope from Elia's balancing capacity needs to the system's total flexibility needs
- **NEW OBJECTIVE** : anticipate on balancing challenges following the renewable energy transition
- **NEW METHODOLOGY :** based on a probabilistic analysis of flexibility needs and available flexibility means

- The new methodology was discussed with NRA, Federal Public Services and stakeholders.
- The data and assumptions were subject to a public consultation.

JUN 2021

Adequacy & Flexibility
2022 - 2032

- The new flexibly assessment is published on June 25, 2021
- Methodology, data and assumptions have been subject to a public consultation

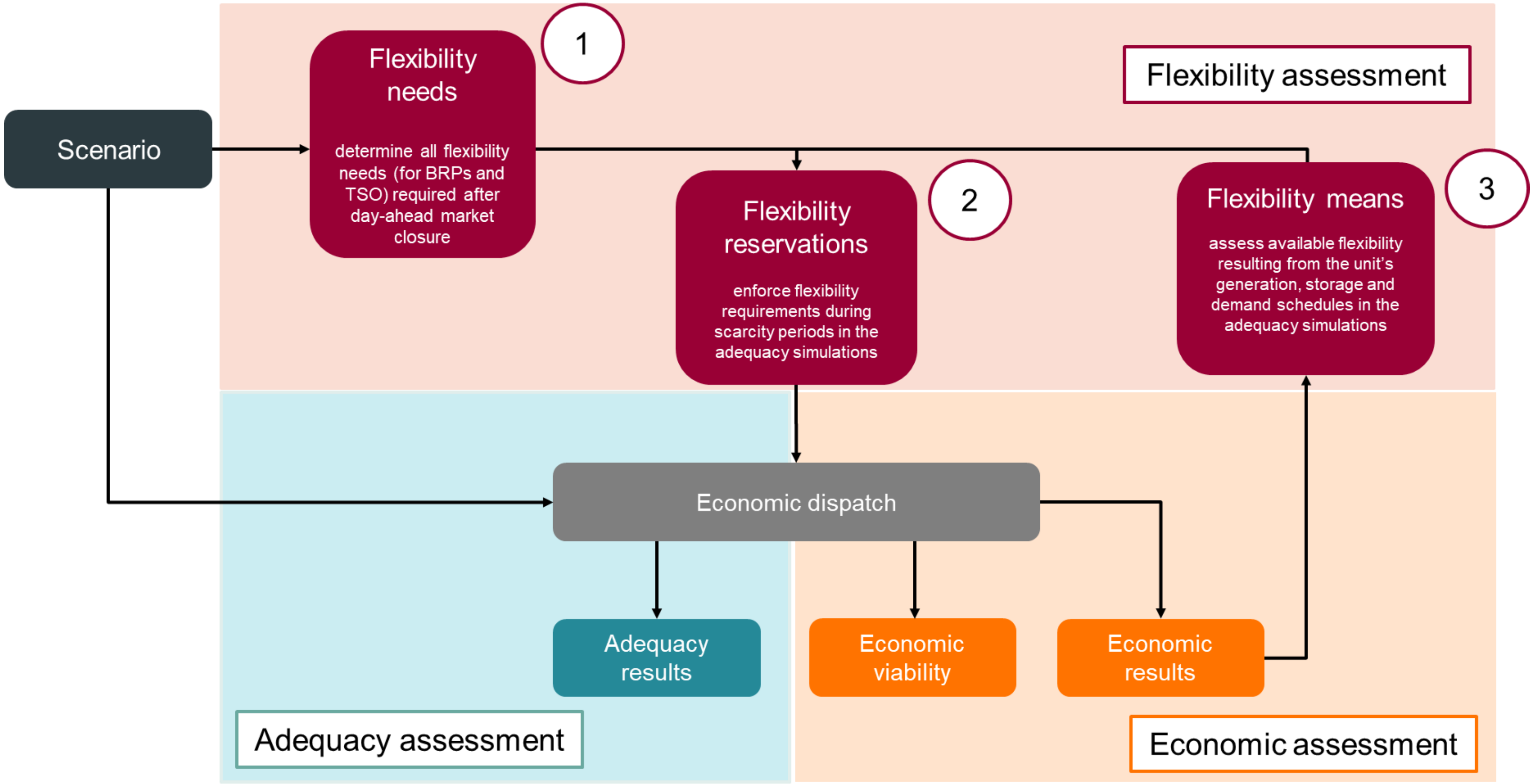
JUN 2023

Adequacy & Flexibility
2024 - 2034

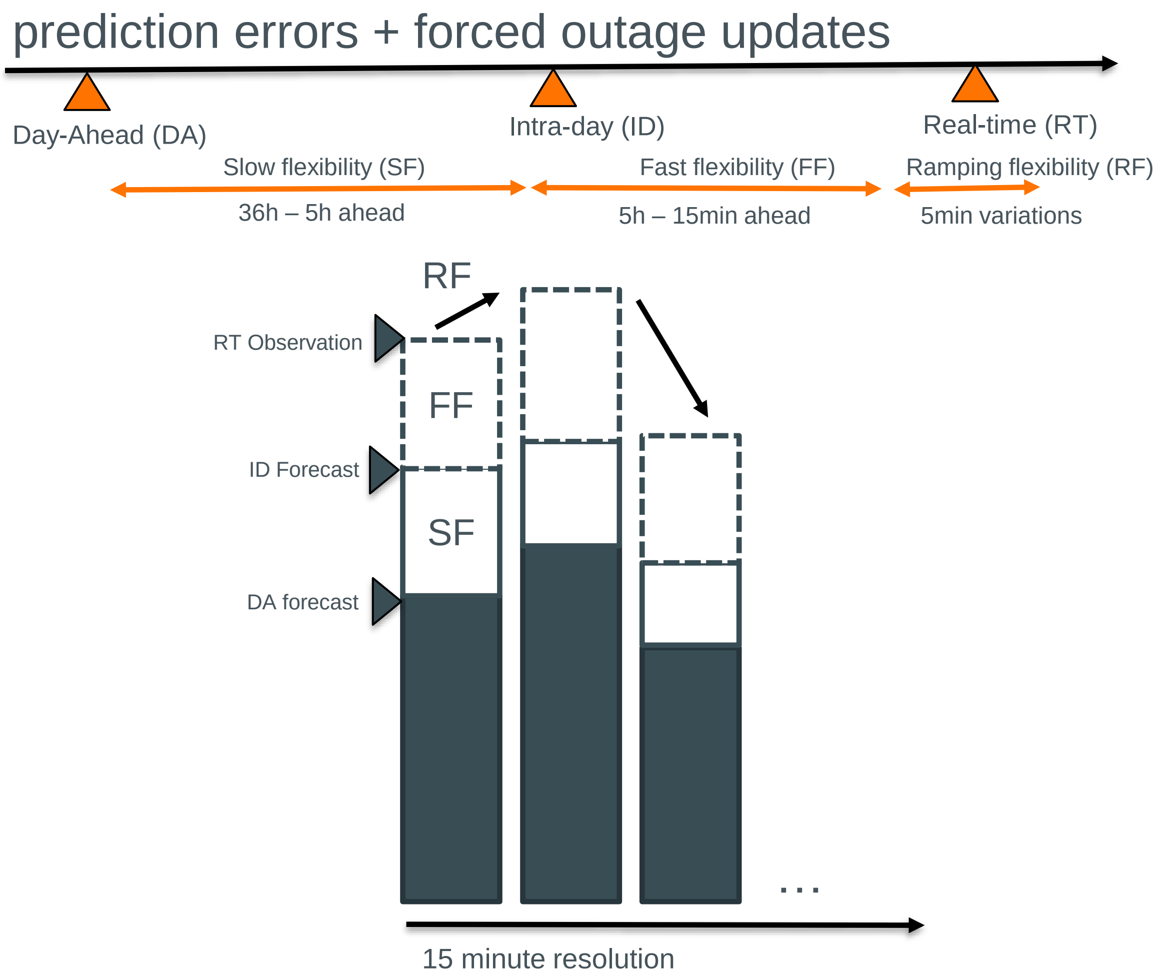
- The new flexibly assessment is published on June 29, 2023
- Methodology, data and assumptions have been subject to a public consultation
- New update of the calculations, with particular **attention to the value of unlocking new flexibility**

Methodology overview

The flexibility study complements Elia's economic dispatch simulations, based on a perfect forecast assumption and hourly resolution, with an assessment of the short-term flexibility needs to deal with fast and unexpected variations of generation and demand after day-ahead.



The flexibility needs assessment is build around three metrics applied on historic time series of prediction errors of demand and generation, as well as forced outages of generation and transmission assets



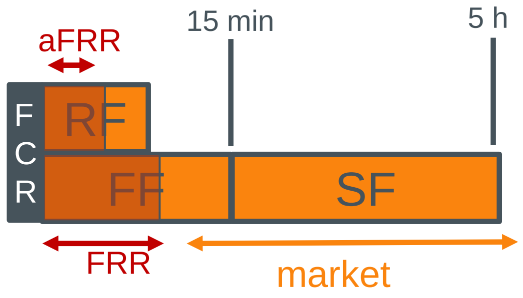
Type of Flexibility	SF Slow Flex	FF Fast Flex	RF Ramping Flex
Definition	Capacity which can be started or shut down until a few hours before real time	Capacity which can be regulated up- or downward close to real time	Capacity which can be regulated up- or downward in a timeframe of minutes
Objective	Deal with intra-day prediction updates of residual load and enduring forced outages	Deal with unexpected variations of residual load and forced outages	Deal with fast variations of residual load
Indicator	Future residual load forecast errors between day-ahead and intra-day	Future residual load forecast errors between intra-day and real-time	Variations residual load forecast errors between intra-day and real-time

Flexibility needs | 2 Flexibility reservations | Flexibility means

The flexibility needs during scarcity risk periods are included in the adequacy simulations to ensure that the system has the capacity installed to deal unexpected variations, also during scarcity risk periods

- In line with the ERAA methodology, Elia reserves the system's reserve capacity needs on generation, storage and demand assets.
- FCR is calculated by ENTSO-E on a yearly basis and allocated towards LFC blocks trough share in total load and generation in Continental Europe..
- FRR / aFRR / mFRR are calculated on a daily basis on the dimensioning incident (approx. 1040 MW) and forecasted LFC block imbalance risks

Link with balancing reserves

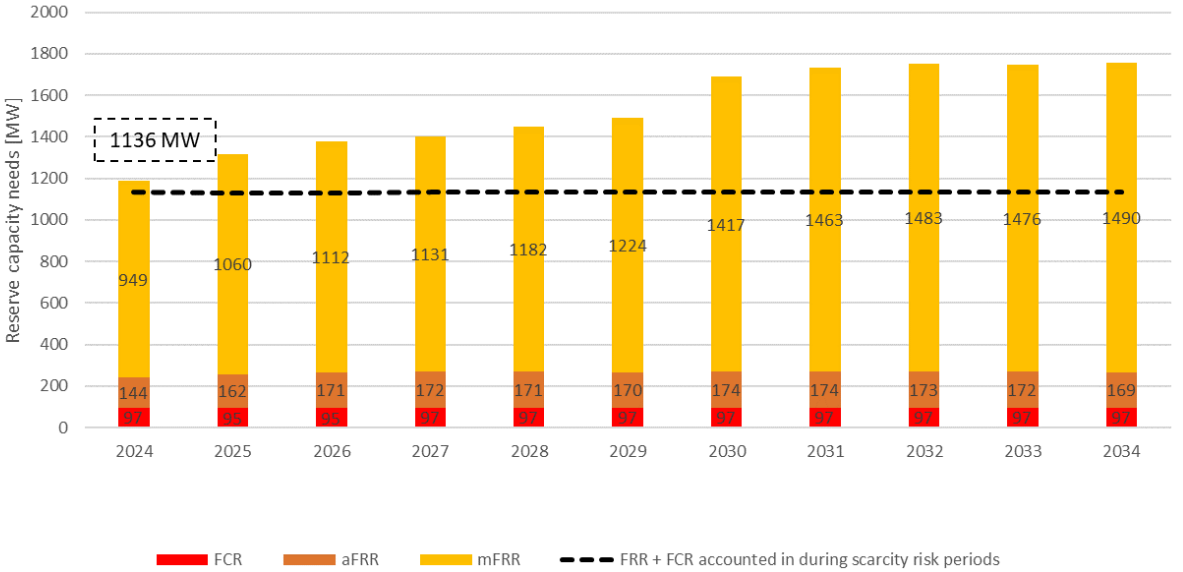


Part of the flexibility cannot be covered by the market and results in residual imbalances to be covered by FRR (aFRR/mFRR)*

FCR is a separate flexibility type, driven by foreign CE N-1 conditions

- FCR are based on extrapolation of demand and generation and is expected to slightly increase to around 95 – 97 MW with the implementation of a probabilistic method
- FRR reserve capacity requirements 'reserved' are capped to the dimensioning incident value (i.e. 1040 MW, Doel 4) because prediction errors which may result in balancing shortages are observed to be lower during periods related to scarcity. This is explained as no or limited renewable generation is expected.

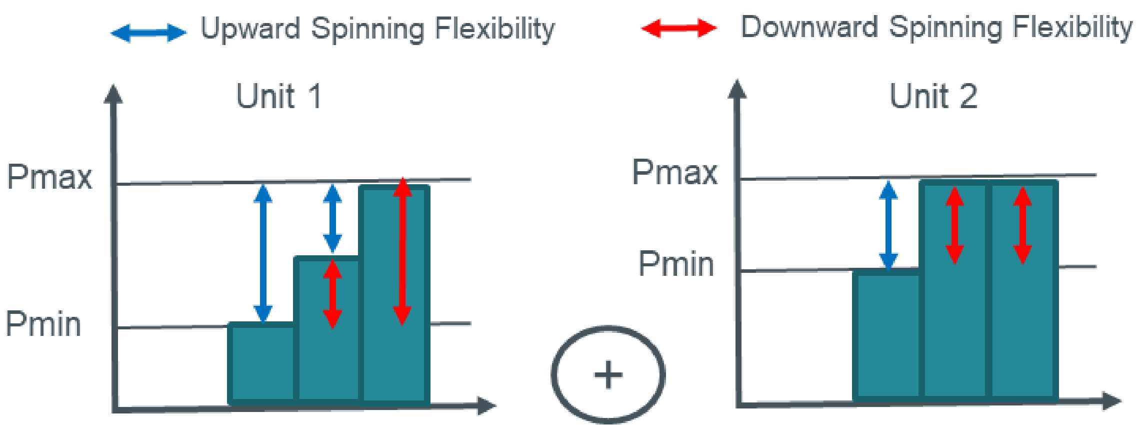
Elia's best estimate projections (CENTRAL scenario)

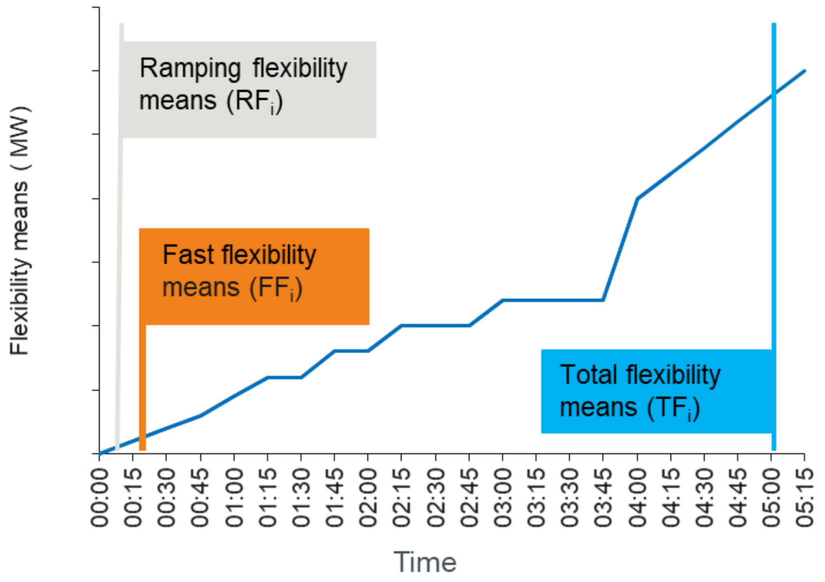


The flexibility means are determined based on simulated day-ahead schedules of individual hourly generation, storage and demand response units

- **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)
  - Including demand response, batteries and pumped storage (energy limits)
  - Complemented with available cross-border flexibility

- **This allows to determine total available flexibility for each hour and Monte Carlo simulation :**
  - How much capacity can be ramped in 5 minutes (RFi)?
  - How much capacity can be available in 15 minutes (FFi)?
  - How much capacity can be available in 5 hours (TFi)?
- **These time series of available flexibility are analyzed by means of statistical indicators (average, distributions, percentiles).**





Data and assumptions

Input data

Prediction data

Elia's forecast observations 2020-2021
Expected forecast improvements

- *Onshore wind*
- *Offshore wind*
- *Demand*
- *Solar*
- *Decentral must-run*

Forced outage characteristics

ENTSO-E observations 2015-2021

Technology flexibility characteristics

Literature, expert view and consultation

Installed capacities

Scenario selection

Scenario	Target years					
	2024	2026	2028	2030	2032	2034
Needs						
CENTRAL	Existing generation fleet	Planned generation fleet and relevant HVDC transmission assets				
H/L RES						
H/L DEMAND						
Means						
CENTRAL	Existing generation fleet	+ Efficient Gas				
		+ Mix				
		+ Energy Limited Resources				
H/L FLEX		+ Efficient Gas				

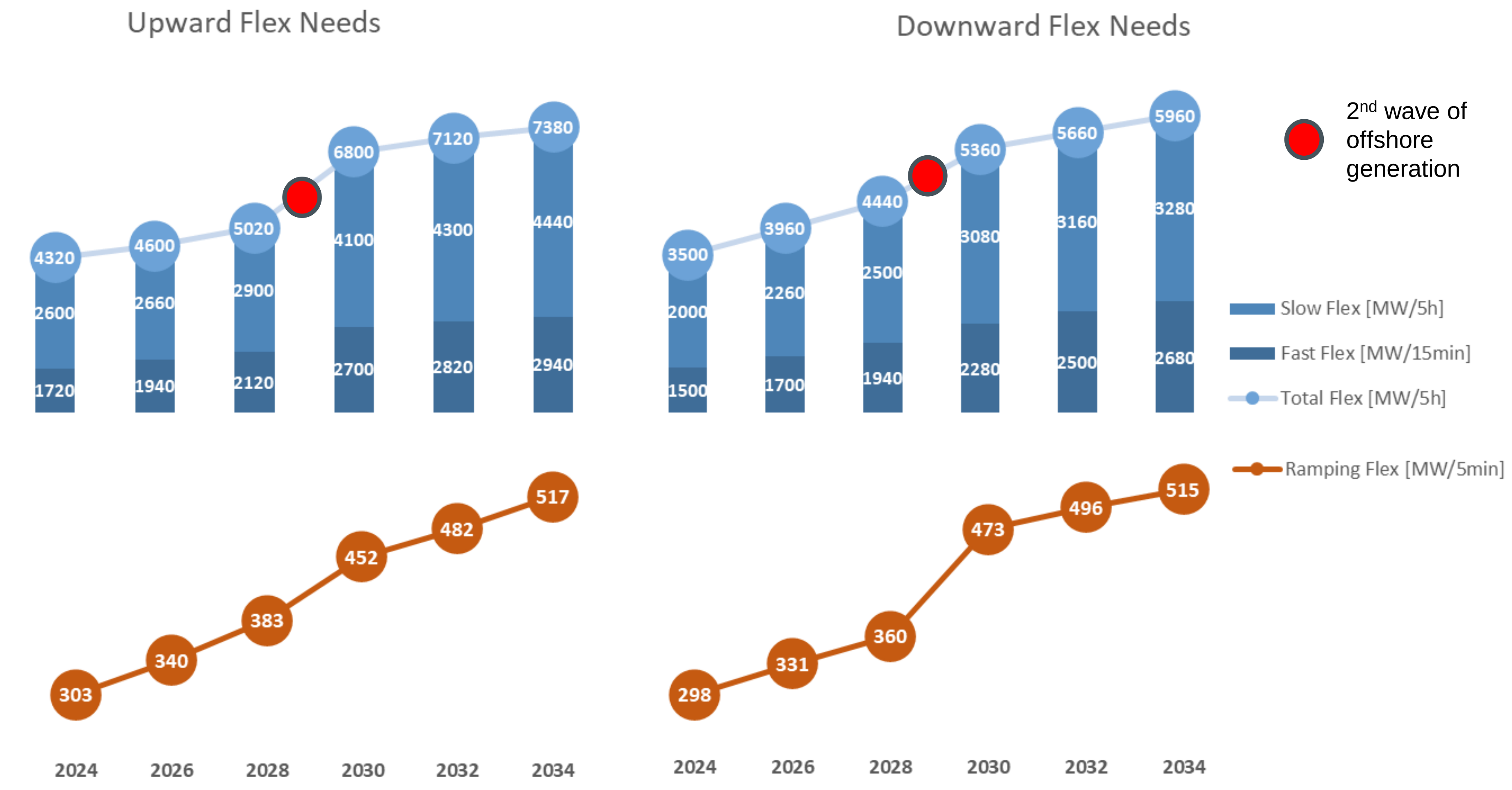
Flexibility

Results and conclusions

FLEX

Evolution of the flexibility needs towards 2034

Latest analyses re-confirm increasing flexibility needs following increasing renewable capacity



By 2034, the Belgian system will require

- 6 - 7 GW of flexibility in the last hours before real time,
- of which almost 3 GW needs to be able to react in the last quarter hours,
- and up to 0.5 GW needs to react within 5 minutes.

Flexibility needs should be covered as much as possible by the market and only the residual imbalances are to be covered by Elia.

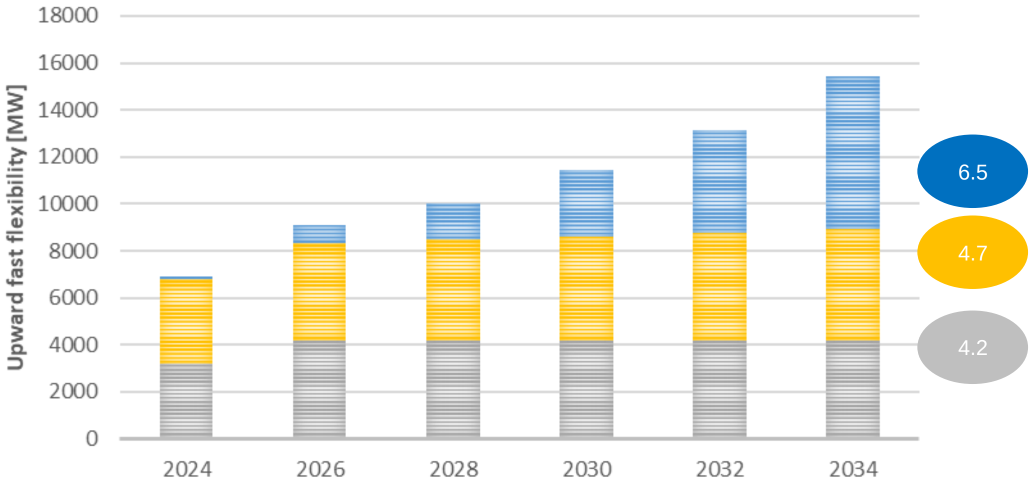
If the system is adequate, and new flexibility is unlocked, sufficient flexibility will be installed to cover the flexibility needs

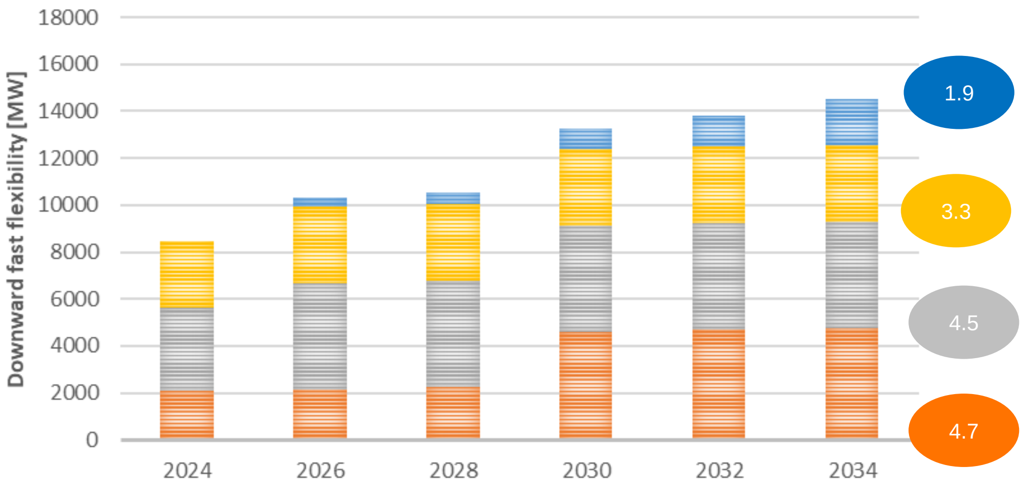
1. Available flexibility increases substantially towards 2034, in particular in upward direction through ambitions on unlocking decentral end-consumer flexibility
2. Renewable generation management, at least provided by large controllable parks, will provide an important contribution to the available downward flexibility (cf. additional offshore wind in 2029-30)
3. Non-thermal flexibility is mainly delivered today with pumped-hydro storage and DSR, complemented by new large batteries and electrolysers by 2034.
4. Thermal flexibility is expected is mainly delivered today through peakers and CCGTS, complemented with two new units as from 2025

+ Additional flexibility (not shown on this figure) is expected from capacities needed to cover the adequacy needs after 2025 (thermal, DSR, large batteries, …)

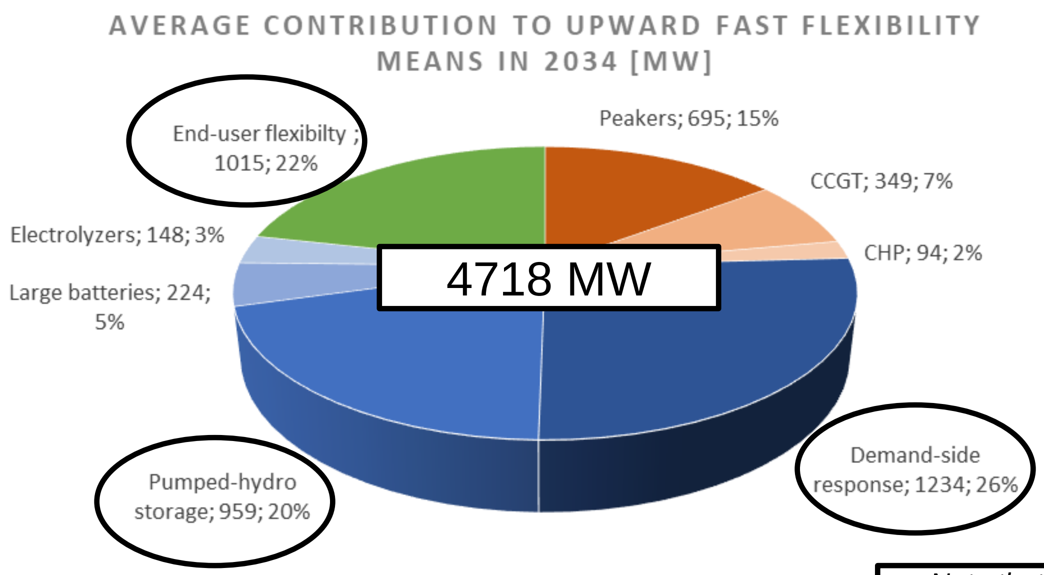
+ Additional flexibility (not shown in this figure) is expected through interconnectors and integration of national balancing markets

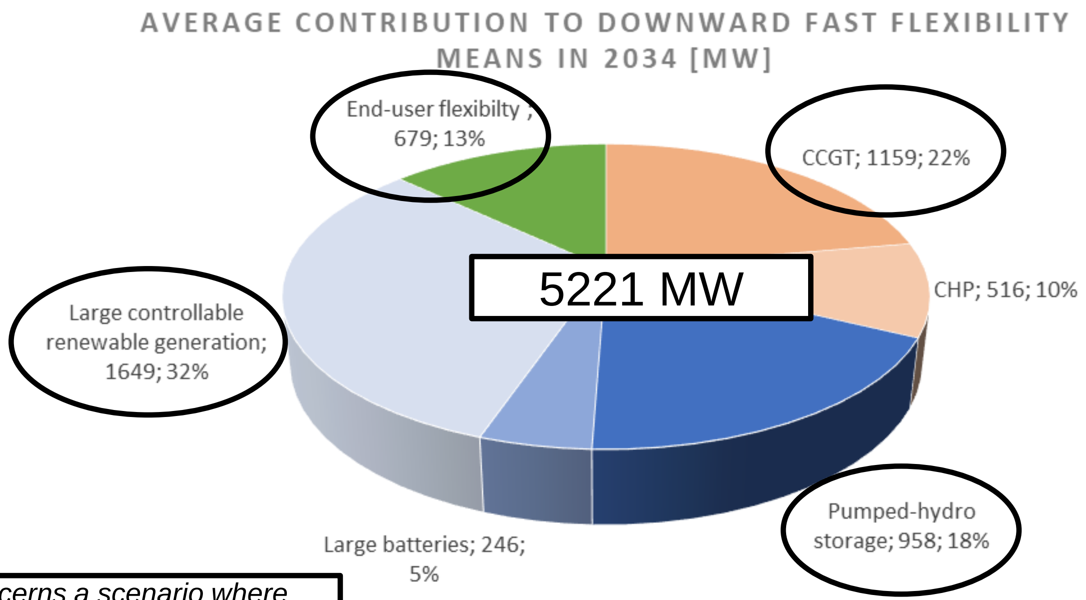
Flexibility per technology which can be delivered in 15' under optimal conditions, i.e. on units dispatched at minimum or maximum power





Operational availability of flexibility means in Belgium in 2034 relies on capacities of which the flexibility must be unlocked



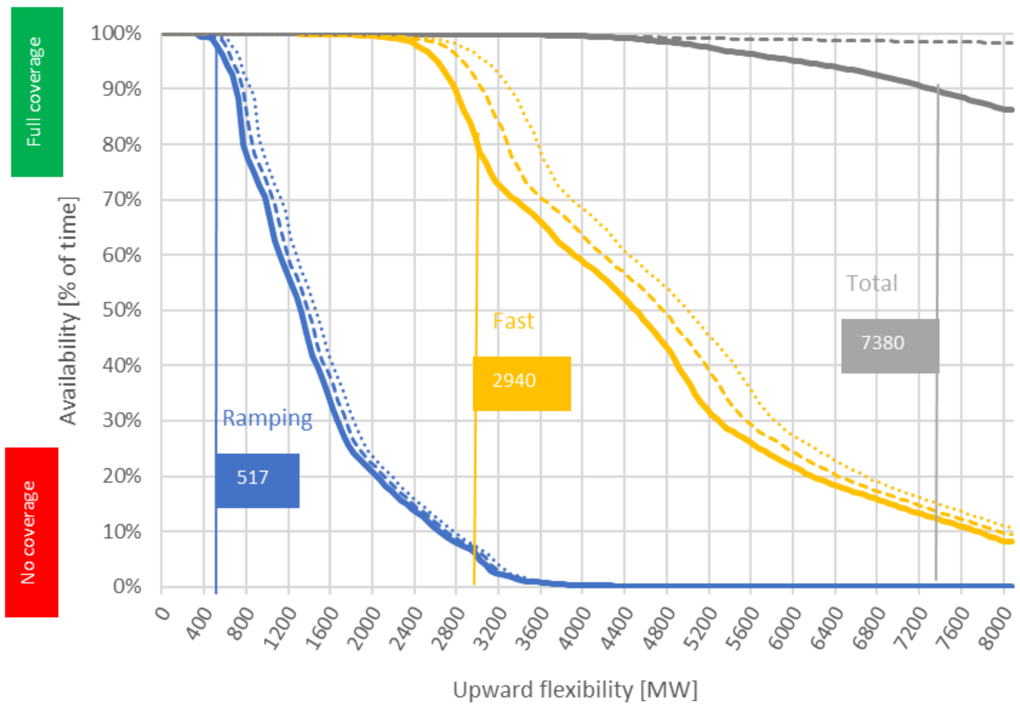


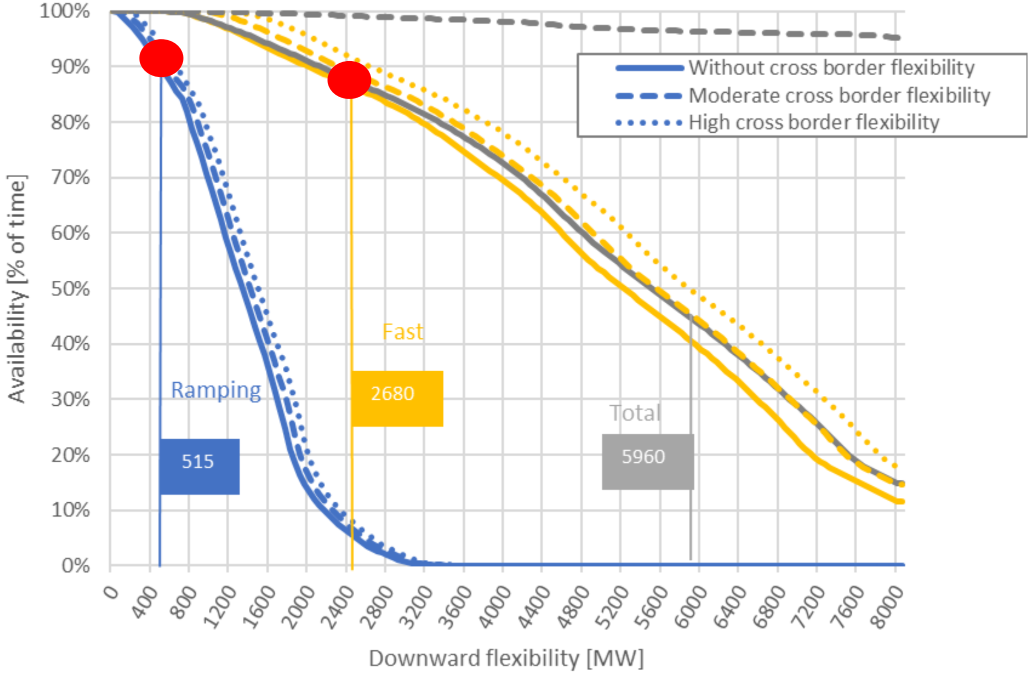
Note that this concerns a scenario where additional adequacy needs are covered with DSR and CCGT.

- For both upward and downward side, operational availability of flexibility relies strongly on the development of end-user flexibility
- For upward side, besides PHS and DSR (of which part might still to be developed),
- For downward capacity, besides the large-scale RES, pumped-hydro storage and CCGTs (of which part might still to be developed)

Evolution of operationally available flexibility means towards 2034 without upfront reservations*

*Other than the dimensioning incident during scarcity risk periods





- Ramping flexibility can be guaranteed up to 98%
- Fast flexibility can be guaranteed up to 82%
- Total flexibility can be guaranteed up to 90%

Even a fairly limited ‘firm’ contribution of cross-border energy can increase this coverage to 99%; 93% and 99%.

- Ramping flexibility can be guaranteed up to 89%
- Fast flexibility can be guaranteed up to 85%
- Total flexibility can be guaranteed up to 44%

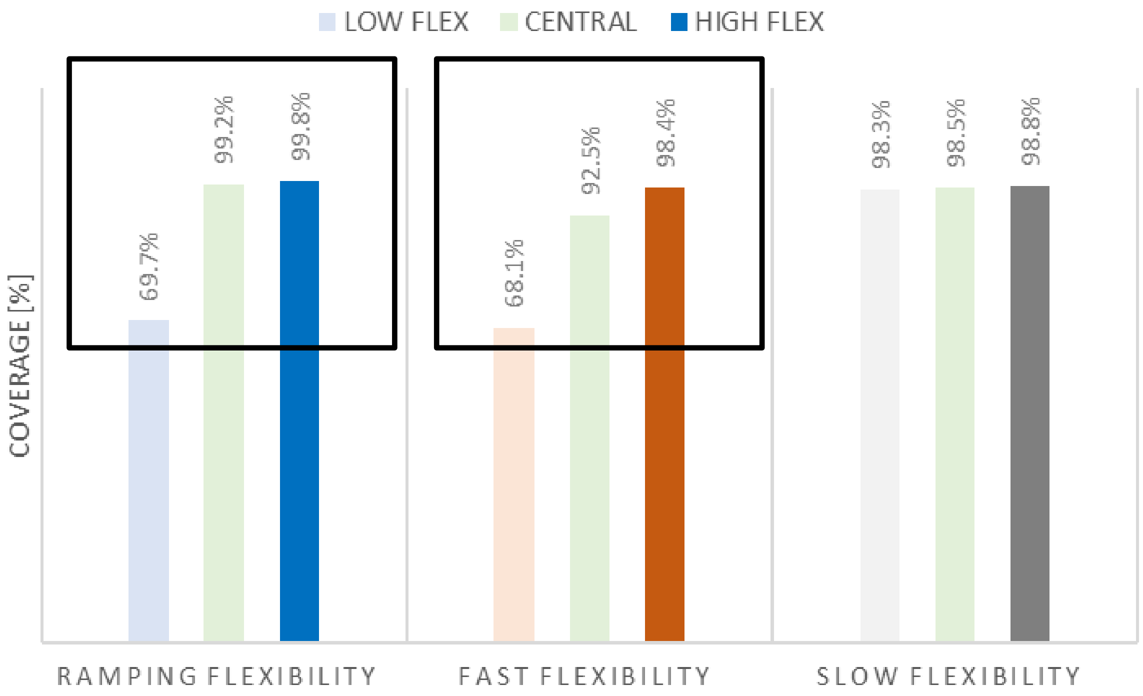
Even with contribution of cross-border capacity; downward flexibility coverage only reaches 91%, 87% and 96%

With the contribution of cross-border flexibility, upward flexibility needs is expected to be covered most of the time by 2034 without upfront reservation

Coverage of downward flexibility is expected to be insufficiently covered in 2034 without additional measures

In the CENTRAL and HIGH FLEX scenarios, upward flexibility needs toward 2034 can almost always be covered without upfront reservations

Share of time [%] in 2034 that flexibility needs are covered with moderate cross-border flexibility

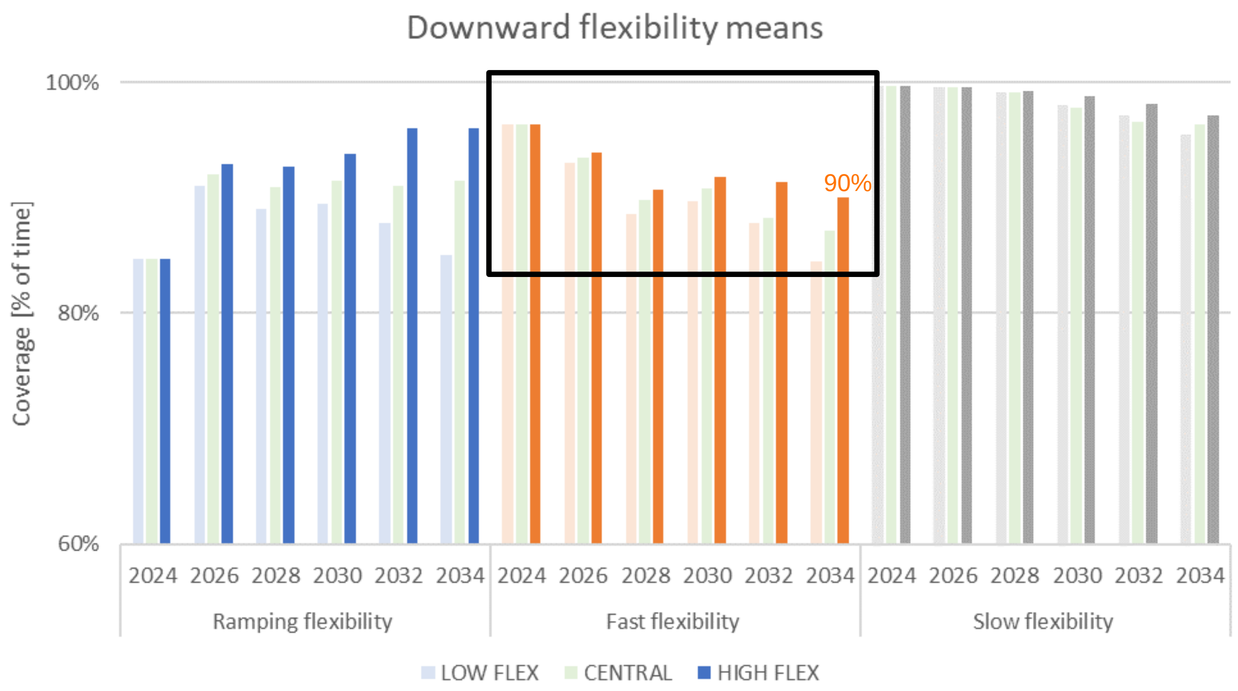


- Towards 2034, upward flexibility needs are expected to be covered for most of the time without upfront reservations
  - *Slow flexibility is assumed to be almost fully covered when assuming a liquid intra-day market*
  - *Unlocking new flexibility in the CENTRAL scenario increases the coverage of ramping and fast flexibility needs to 99% and 92% of the time*
  - *Additional flexibility in a HIGH FLEX scenario can even increase these capacities to almost full coverage*
- Further investigation show that :
  - *Some uncovered needs can probably be resolved under high cross-border flexibility*
  - *Other uncovered needs relate to regional tight market conditions (situations in which no availability of cross-border flexibility is expected) and require balancing capacity reservations*

Under such conditions, Elia's balancing capacity procurement can be reduced through dynamic partial procurement strategies, and even to almost zero towards 2034 in HIGH FLEX scenarios (with exception from tight market conditions)

Downward flexibility requires additional measures to avoid issues with incompressibility with the further uptake of PV volumes across Europe.

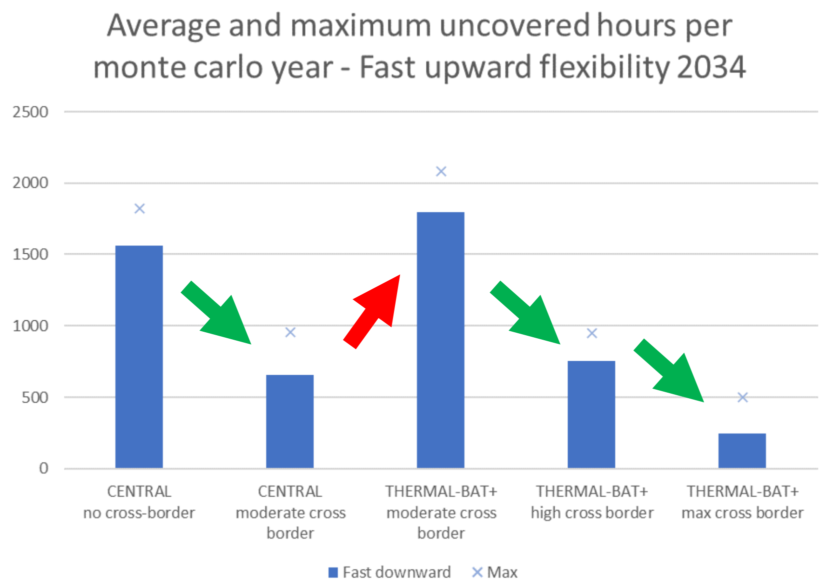
Share of time [%] in 2034 that flexibility needs are covered with moderate cross-border flexibility

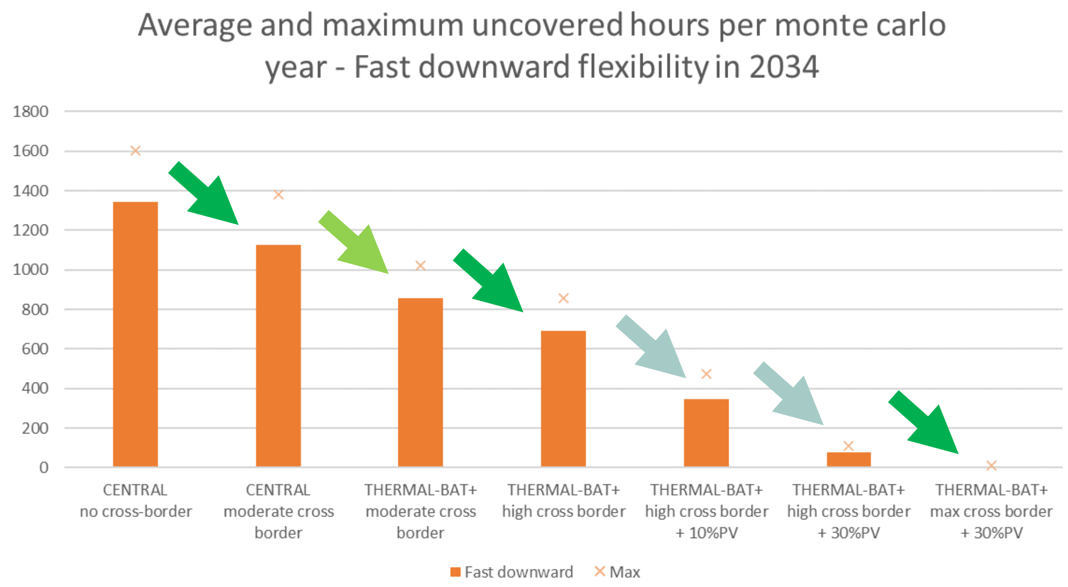


- Towards 2034, downward flexibility needs are inadequately covered without taking additional measures
  - *Slow flexibility is assumed to be covered for 96% of the time when assuming a liquid intra-day market*
  - *Unlocking new flexibility in the CENTRAL scenario increases the coverage of ramping and fast flexibility needs to 92% and 87% of the time respectively*
  - *Additional flexibility in a HIGH FLEX scenario can even increase these capacities to 96% and 90%*
- While some periods can be covered by assuming additional cross-border flexibility, most of the issues occur during low prices in which cross-border downward flexibility is not guaranteed.

To balance the system, measures are needed to better align the demand to the generation (e.g. by means of additional storage), complemented with the participation of decentral PV installations

Results of the sensitivities on uncovered flexibility needs



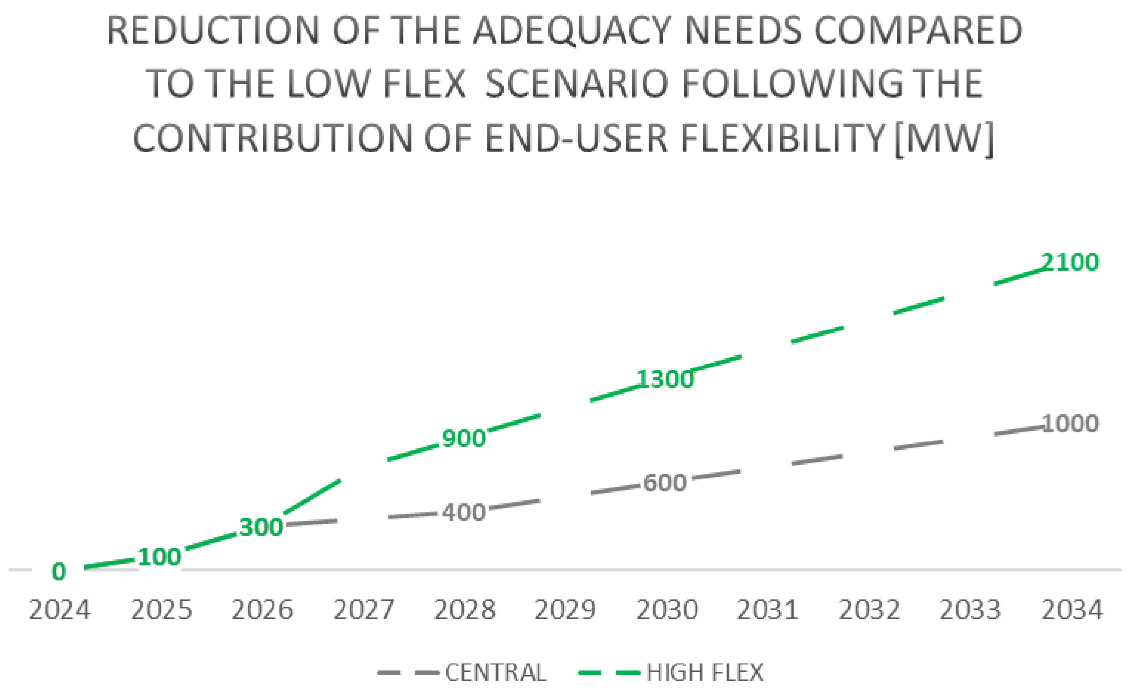


- The sensitivities on the **liquidity within the EU balancing energy platforms** (providing more cross-border ramping and fast flexibility) show a clear contribution of additional liquidity
  - *Even without liquidity constraints during normal conditions, flexibility needs cannot be fully covered with cross-border flexibility due to occurrence of tight market conditions*
- Sensitivities where adequacy gap is covered by means of more **large-scale batteries** instead of DSR units increases the uncovered fast flexibility needs periods
  - *This follows the assumption that batteries are more frequently dispatched (at lower prices) compared to DSR*

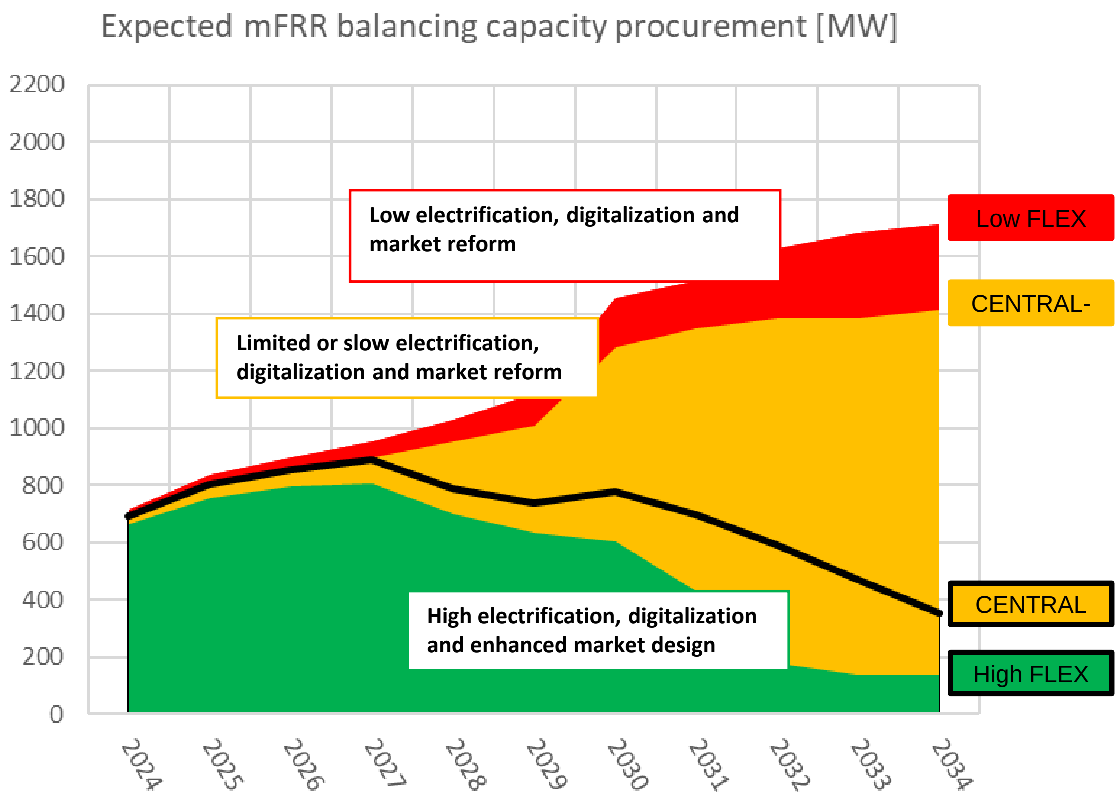
- The sensitivities on the **liquidity within the EU balancing energy platforms** (providing cross-border ramping and fast flexibility) shows a clear contribution of additional liquidity
- Sensitivities where adequacy gap is covered by means of more **large-scale batteries** instead of DSR units positively contributes to the coverage of the flexibility needs.
- Additional **contributions of decentral PV** (on top of large installations) allows to fully cover flexibility needs without upfront reservations

Unlocking end-user flexibility creates substantial benefits for society in terms of ‘Flattening the curve’ and ‘System operation’

Flattening the curve



System operation



Value of flexibility for the system towards 2034

Unlocking new flexibility towards a "HIGH FLEX" scenario is estimated to bring substantial gains in terms of adequacy and system operation costs compared to a "LOW FLEX" scenario

1. System operation cost savings
   - A. aFRR balancing capacity savings
   - B. Upward mFRR balancing capacity savings
   - C. Downward mFRR balancing capacity savings
2. Adequacy cost savings
   - D. Flattening the curve

Gains M€ / year [MIN - MAX]	2026	2028	2030	2032	2034
1.A. aFRR BC savings	*8 - 23*	*11-30*	*19 - 58*	*21 - 65*	*29 -97*
1.B. Upward mFRR BC savings	*15 – 19*	*33-43*	*70 - 92*	*105 - 138*	*112 - 148*
1.C. Downward mFRR BC savings	*3 – 25*	*5 - 39*	*7 - 58*	*8 - 69*	*9 - 75*
2 .D Flattening the Curve	*8 – 17*	*23 -51*	*34 – 73*	*44 - 96*	*55 - 119*
TOTAL	*33 – 84*	*72 - 163*	*130 - 282*	*178 - 368*	*205 - 438*

**Based on extrapolated prices from 2021-23 (higher bound) and 2020 (lower bound)*

Additional gains on grid investment savings and improved customer services will complement these expected benefits.

Enablers

We expect 0.8 million EV chargers in Belgium by 2030 with a gradual uptake of bi-directional chargers as from 2028

We expect almost 5 million smart meters in Belgium as from 2030 with already an uptake of 80% (almost 3 million) in Flanders as from 2024

Central-scenario

End-user flexibilty able to provide short-term flexibility in the 'CENTRAL scenario' in 2034

Home batteries : Around 143,300 home batteries in-the-market (= 100% of assets)

Electric vehicles

- Smart charging: around 930,000 vehicles (33% of vehicle fleet)
- Vehicle-to-Grid: around 120,000 vehicles (4% of vehicle fleet)

Heat pumps: around 300,000 heat pumps (16% of units)

Low FLEX: no flexibility in-the-market (but contribution to adequacy through local optimization)

High FLEX: most flexibility actively participates in-the-market (82% and 10% for EV and 64% for HP)

In order to make these secnarios reality, several barriers are still to be lifted:

- *Effective installation of physical assets (related to governmental policy)*
- *Facilitation of facilitating market framework (related to market access and price signals)*
- *Control and metering of the delivery of flexibility (related to smart metering assets)*
- *Communication interface/data exchange and control between devices (interoperability)*
- *Engagement of the consumer (related to new business models)*

Elia is investigating the solutions in its upcoming Viewpoint on flexibility in November 2023

Main messages and Elia's call for action

Provided that the Belgium system is adequate and that new flexibility is unlocked :

- The increase in Elia's reserve needs can be reduced from a factor 2 to a factor 1.3;
- The volume of mFRR balancing capacity to be procured by Elia can be reduced to almost zero towards 2034;
- Downward flexibility can be managed without procurement of balancing capacity;
- An effect of 'flattening the curve' can reduce adequacy needs with more than 2 GW

Elia estimates that facilitating the contribution of end-user flexibility can realize substantial cost saving for society, i.e. up to around 200 – 450 M€ per year in adequacy and balancing capacity procurement costs by 2034.

Downward flexibility requires additional measures to avoid issues with incompressibility with the further uptake of PV volumes across Europe.

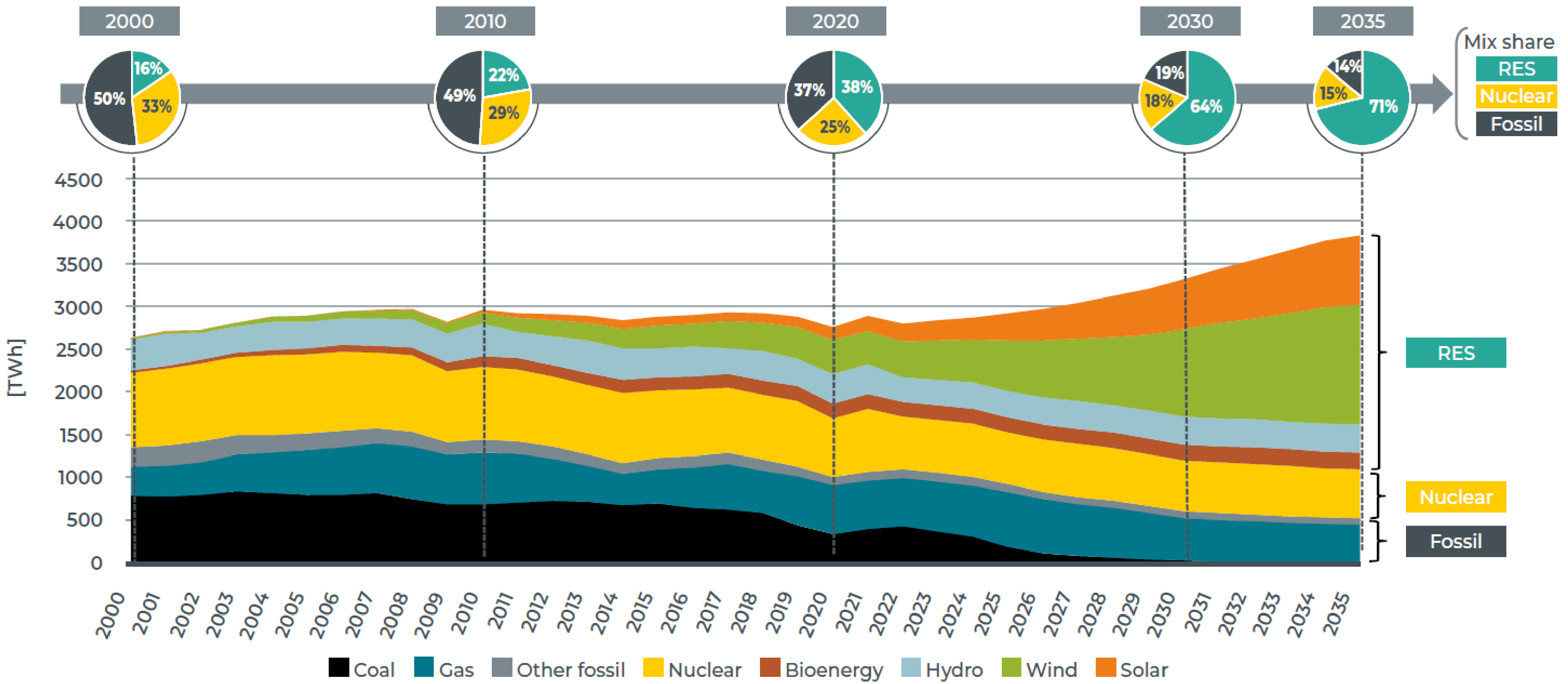
The system will start to face significant issues with downward flexibility in case the demand is not better aligned with renewable generation (e.g. though storage) and it is to be explored how newly installed PV capacity can reduce infeed in case of excess energy in the system.

Elia's Call of action

- **To manage the integration of renewable energy by 2034 and keep the costs of the energy transition under control for the end-consumer, several barriers are to be lifted.**
    - Besides creating an enabling market framework, additional efforts are needed on the level of deployment of metering infrastructure, creating interoperability of devices and engaging the consumer. Elia is investigating solutions which will be presented in its upcoming Viewpoint in November 2023.
- **Covering downward flexibility, particularly during low residual demand, requires imminent action. It has to be investigated how newly installed PV needs can contribute, together with other technologies, to re-balance the system during moments of excess energy.**

Additional insights

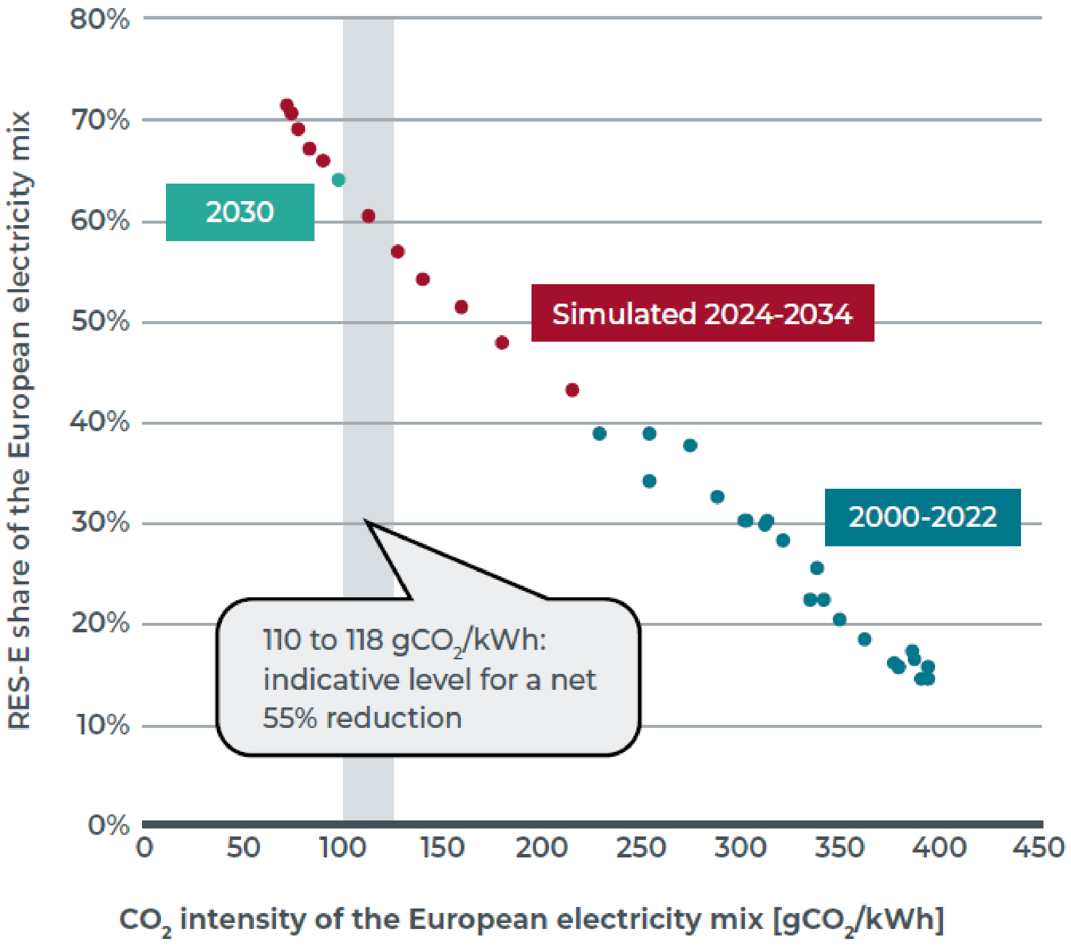
The share of RES in the European system is expected to significantly increase over time in order to cover the need related to electrification.



Sources: EMBER for 2000-2022. Elia's simulations of the EU-BASE scenario for future years.

The direct CO_2 intensity of the European electricity mix is calculated to be around 100 gCO_2/kWh in 2030, in-line with expected levels to be Fit for 55

RES-E share and CO2 intensity of the European electricity system



Sources:
2004-2022: EEA data for EU27 complemented with EMBER data for 2022
Simulated: EU27 (excluding Malta & Cyprus)
***Indicative levels** from EEA data ("They are consistent with scenario ranges in the staff working document accompanying the 'Fit for 55' policy package").*

Only direct emissions taken into account. The simulations give an indicative level of emissions under the assumptions taken for this study. Those do not constitue an official or validated assessement by authorities but are aiming to give an indication of the trend.

Additional electrification delivers large benefits in terms of direct domestic CO_2 emission reduction

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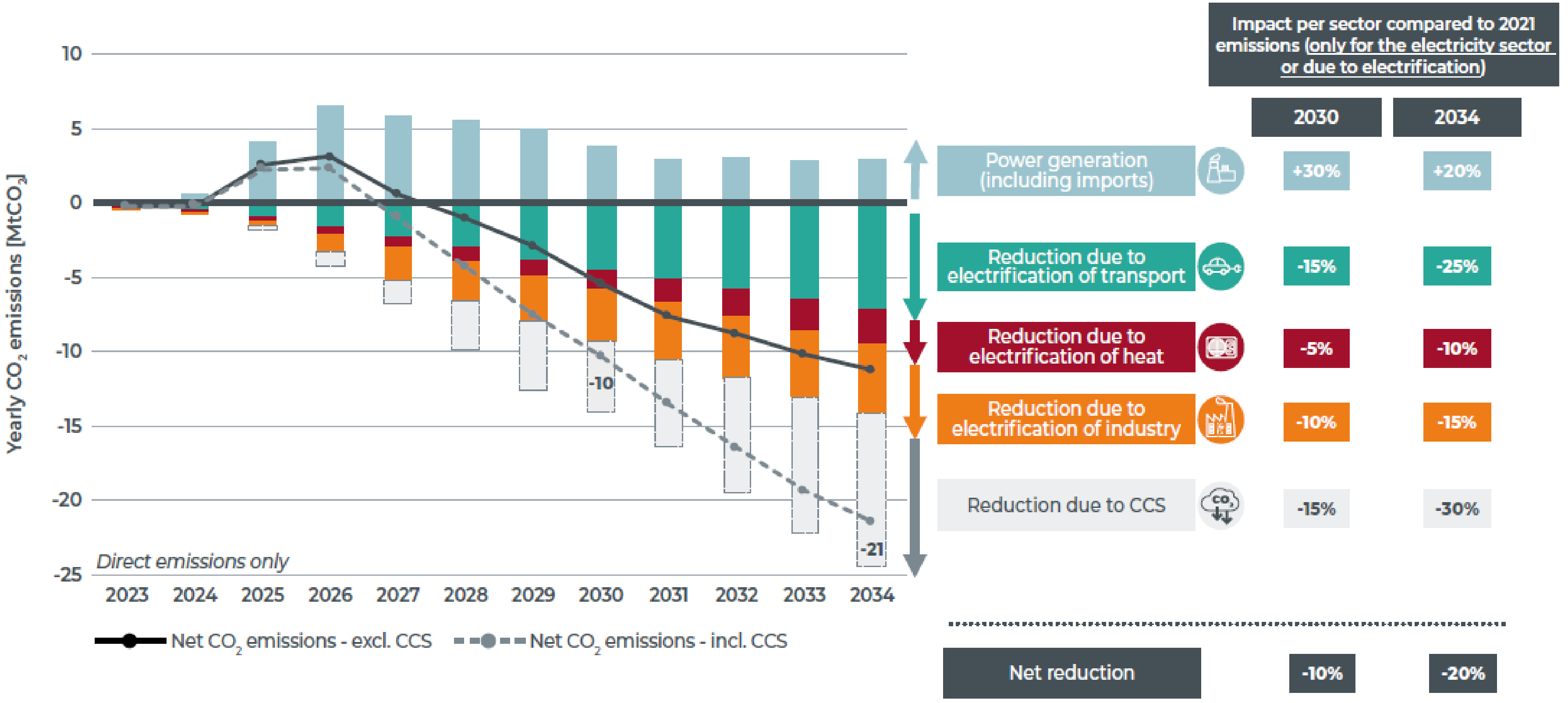
DIRECT DOMESTIC CO2 EMISSIONS OF THE BELGIAN ELECTRICITY SYSTEM ACCOUNTING FOR THE OFFSETS DUE TO ADDITIONAL ELECTRIFICATION IN OTHER SECTORS



Electrification gains only. This excludes other measures such as insulation, modal shift, energy efficiency in industry, ban of oil boilers for heating...
Power generation emissions are an output of the electricity market model and include emissions from imports as well as assuming 1 new CCGT in Belgium from 2028 (on top of the already 2 new CCGT contracted).
Heat pumps emissions reductions are compared to a gas boiler as alternative in new and renovated buildings.
EVs emissions reductions are compared to gasoline cars, whereas vans, buses and trucks are compared to diesel vehicles
Industry: assumption that e-boilers and HPs replace gas based heating systems

Based on the EU-BASE/CENTRAL and 'Mix' GAP filling scenario

Main messages

1

Electrification is spreading across society both earlier and at a faster speed. The war in Ukraine and rising gas prices have resulted in new targets and action plans linked to ensuring an independent, resilient and climate-neutral energy system. This is creating additional capacity needs, which can be addressed by the CRM.

2

Flexible consumption has the potential to flatten consumption peaks and manage RES variability, so directly contributing to security of supply. It is an important lever for reducing capacity needs linked to Belgium's rising electricity demand.

3

Electrification reduces primary energy consumption levels whilst maintaining consumer comfort. This significant efficiency improvement therefore delivers large benefits in terms of CO_2 reduction - an effect that will become even more prominent as the share of renewable energy in the energy mix grows. In addition to important climate benefits, electrification also provides solutions to our country's economic and geopolitical challenges.

4

Any delay in unlocking flexibility or realising grid infrastructure will result in additional capacity needs. If Belgium's security of supply is to be achieved in the most (cost-)efficient way possible, investing in accelerated digitalisation is as important as investments in the timely build-out of grid infrastructure.

Equal attention must be paid to short-, medium- and long-term measures

2025-2026

Short-Term measures

- Flex-LTO of 2 Belgian nuclear unites

2027-2029

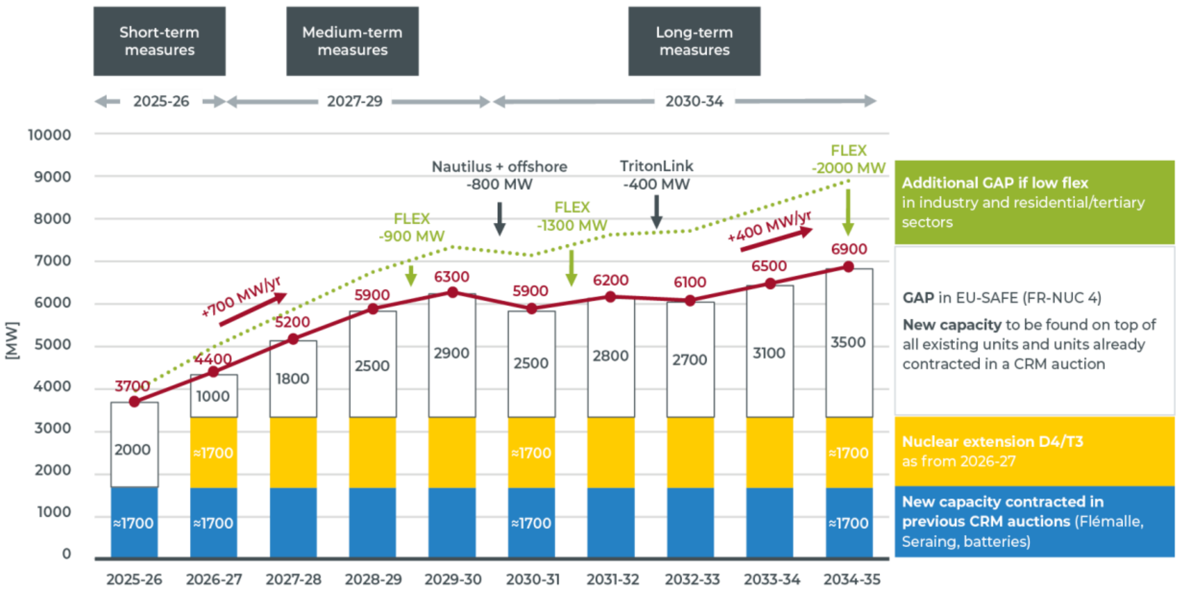
Medium-Term measures

- Unlocking new flexibility
- Prompt realisation of grid infrastructure
- Refinement of the CRM mechanism
- Managing periods of excess energy

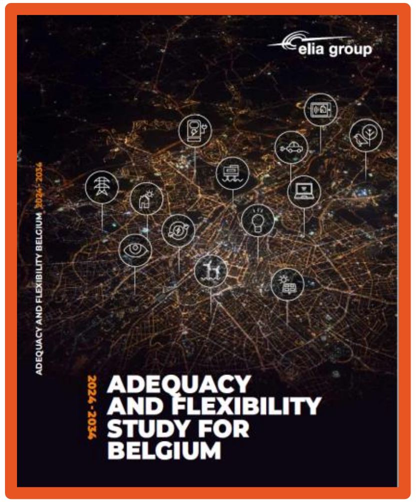
2030-2032

Long-Term measures

- Additional offshore wind ambition in BE North Sea (8GW)
- Investigate additional interconnectors with countries with de-correlated generation surplus



AdeqFlex'23 is a state-of-the-art study assessing the capacity requirements of the Belgian system both for adequacy & flexibility



12 target years (2023-34) assessed

28 countries simulated for each analysis

270 references/sources used

300 sensitivities performed

378 graphs/figures included in the report

467 pages

40k hours of simulations

120TB of data analysed

Report content

- Executive summary
- Introduction
- Methodology
- Scenarios and data
- Adequacy needs assessment
- Economic viability assessment
- Short term flexibility assessment
- Economic and dispatch assessment
- Appendix on the methodology
- Appendix on the scenarios & data

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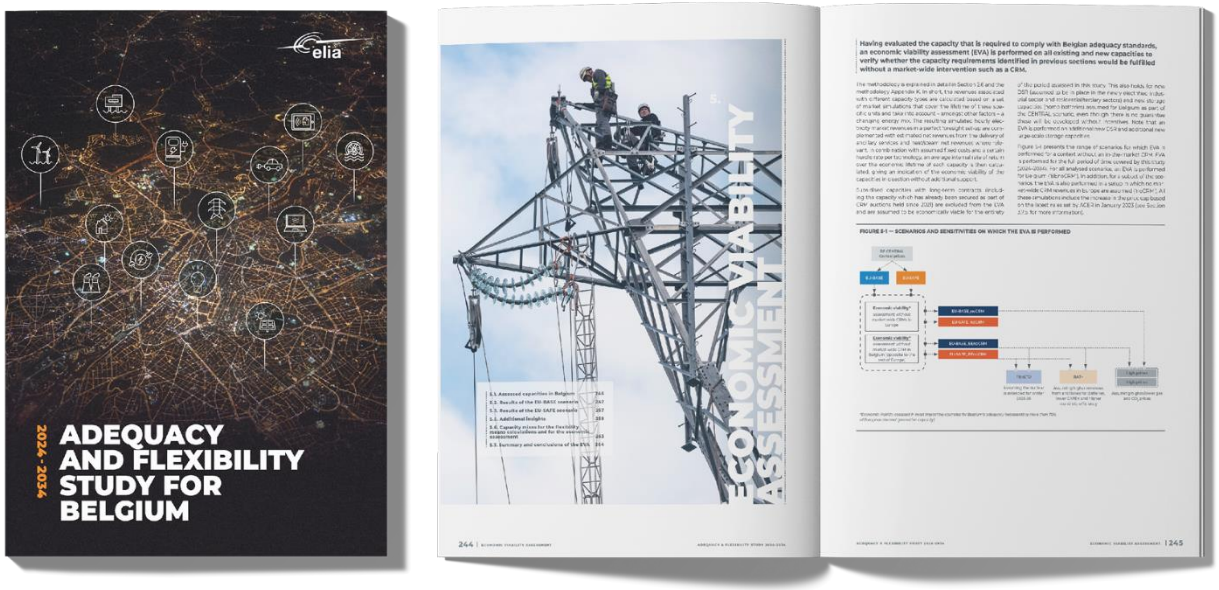

THANK YOU VERY MUCH FOR YOUR ATTENTION

- This presentation is given as a primeur to the Users Group
- A press conference will be held in the afternoon
- We therefore kindly ask you **to not share any information regarding the study before 4PM this afternoon.**
- A printed version of the report (version from a few days ago) will be provided to all of you at the end of this presentation
- The final report will be published this afternoon

2024 - 2034

ADEQUACY AND FLEXIBILITY STUDY FOR BELGIUM

elia

THANK YOU