Adequacy assessment of WB6 countries

Training on Electricity System Adequacy and Capacity Mechanisms

14 May 2019

COMPASS
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Content of the presentation

The FTI - Compass Lexecon team is experienced in the design of European capacity mechanisms

With more than 30 offices globally, we are one of he leading economic and financing consultancies

- A global economic consulting firm providing expert economic advice on competition policy, economic and financial regulation, public policy, corporate development and pricing, and the assessment of damages in complex disputes.
- More than 30 offices across the US, South America, Asia-Pacific and Europe
- 145 PhD economists and econometricians, and faculty from leading universities and institutes including two Nobel Prize winners.

Focus on our Energy practice	
FTI - Compass Lexecon is one of the leading advisory firms for economic and policy analyses in the European energy industry	Policy and market design
	Investment decision support
	Energy markets modelling
	Financial valuation of assets
	Business model development
	Corporate strategy design
	Economic expertise in commercial litigations

We have been working on Capacity Mechanisms in more than 12 European countries

- Over the last five years, Compass Lexecon has participated in the design and state aid analysis of the Capacity Mechanisms in at least 12 European countries.

Content of the presentation

European Commission State Aid guidelines for introduction of CRM in EU Member States

The European Commission has developed a **set of guidelines for the design of CRM to ensure their compliance with State Aid regulations**. Although these state aid regulations do not apply to WB6 countries, they are a useful reference for the design of CRM:

Key State Aid criteria	Implications	
1 Contribution to well-defined objective of common interest 2 Need for state aid intervention	**Justification**	• Must be clear need for state intervention and the objectives must be clearly defined • Objective must be consistent with phasing out environmentally harmful subsidies
3 Appropriateness of the aid measure 4 Incentive effect 5 Proportionality of the aid (aid to the minimum)	**Proportionality and design**	• Aid should not change the behaviour of market players and be non discriminatory • Aid to the minimum: the amount paid should tend to zero as capacity available approaches the required level • Must have reasonable rates of return a competitive bidding process is encouraged
6 Avoidance of major undue negative effects on competition and trade between member states 7 Transparency of aid	**Impact on competition and internal market**	• Operators from other member states should be allowed to participate • Negative effects on the internal market should be avoided • Should not reduce incentives to invest in interconnection

A forward looking adequacy outlook taking into account the anticipated revenues of power plants needs to be conducted

1. Define security of supply by setting target indicators

- The security of supply target is usually defined as **Loss of Load Expectation (LOLE)** or **Energy not served (ENS)**
- For example, **LOLE target of 3 hours** per year in France and the UK set by law.

2. Forward adequacy modelling in order to identify whether there is a need for intervention

Adequacy model

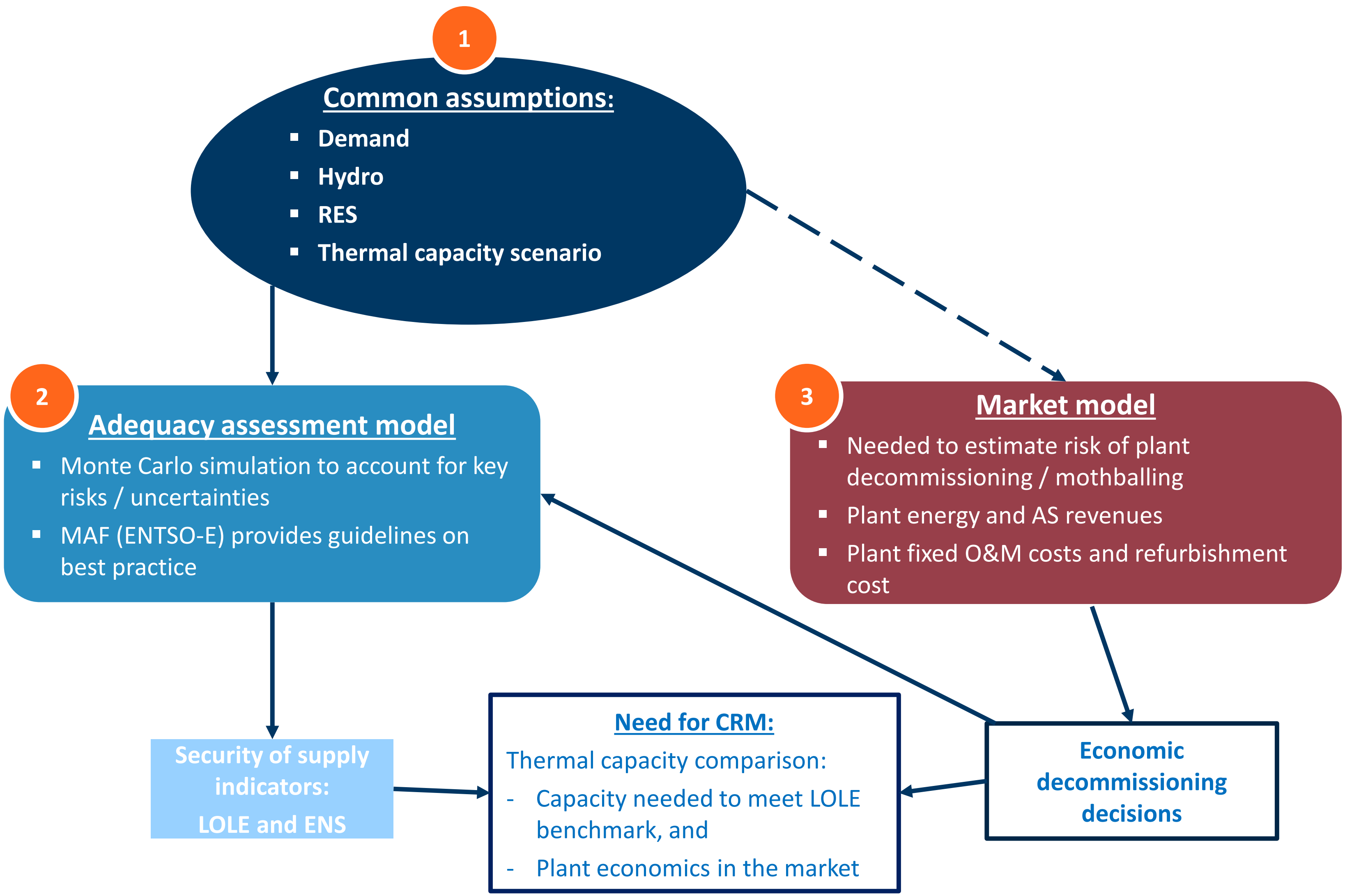
- Whether the **installed capacity expected** in the future would be necessary to ensure the achievement of the **security of supply targets**
- Account for **expected market developments** and the likelihood for power plants to stay online / retire / be added to the system
- The model runs in **several scenarios of installed capacities** corresponding to potential retirements and additions

Market model

- Combined with adequacy model for the analysis of **market outcomes and generation mix**
- **Incentives for capacity generation, market entry or exit** in presence or in the absence of the CRM
- Key to understand the **likely revenues of power plants** in absence of any intervention.

The adequacy assessment requires both a system model and a market model to evaluate risk of plant decommissioning

- Assessing the future reliability of the system is done using the following modelling sequence of **the Adequacy assessment model and Market model:**



Energy Community commissioned a study to assess generation capacity and recommendations on defining a CRM in WB6

- The Energy Community has attributed to Compass Lexecon and DLA Piper through a public tender procedure a study to **assess generation adequacy** for **six Western Balkans countries** (WB6), along with neighbouring countries and provide **recommendations on defining a capacity mechanism** in the WB6 given strong interdependencies between these power systems
  - Western Balkans countries: Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia and Serbia
- Our work is organised around **two main tasks**:

Task 1: Analyses of system and generation adequacy

- Analysing whether there is an adequacy issue in the WB6 region
- Assessing whether this adequacy issue can be solved without a CRM intervention but through reform of the energy only market

Task 2: Design of capacity mechanisms

- Identifying the high level options for design of such CRM, benchmarked with other European countries' experience;
- Discussing the pros and cons of different CRM design options based on multi criteria assessment;
- Evaluating the eligibility to the CRM of the different generation units depending on their environmental regulation compliance.

This presentation focuses on the first task and presents the findings of the adequacy assessment performed in line with the European Commission State Aid Guidelines.

In line with TSO TYNDPs, adequacy concerns arise when accounting for decommissioning and implementation of additional EU emissions norms (e.g. EU ETS).

** This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.*

Content of the presentation

Content of the Adequacy assessment of WB6 section

Adequacy assessment methodology overview

- As set out by the European State Aid guidelines, the forward adequacy assessment necessary to identify whether there is a need for intervention needs to encompass a two step modelling:

Adequacy model:

- Whether the installed capacity expected in the future would be necessary to ensure the achievement of the security of supply targets
- Account for expected market developments and the likelihood for power plants to stay online / retire / be added to the system
- The model runs in several scenarios of installed capacities corresponding to potential retirements and additions

Market model:

- Combined with adequacy model for the analysis of market outcomes and generation mix
- Incentives for capacity generation, market entry or exit in presence or in the absence of the CRM
- Key to understand the likely revenues of power plants in absence of any intervention.

- **As such, the methodology we follow to perform the adequacy assessment meets these different requirements and uses the state-of-art power modelling software and latest available data to date on:**
  - **Market modelling approach**
  - **Geographic scope**
  - **Climate and unavailability modelling**
  - **Power demand outlook**
  - **Power supply outlook**
  - **Cross-border capacity**

Assumptions are based on latest data available from TSOs and 2030 RES target

Monte Carlo Dispatch market optimisation based on detailed representation of power market fundamentals at an hourly granularity

Geographic scope

WB6 countries: Detailed modelling on a plant-by-plant basis

Countries interconnected with WB6 countries: Aggregated modelling on a technology level based on ENTSOE forecasts

Other countries: Not modelled (only the import/export volumes with the "blue countries" are considered, based on historical data)

Scenarios for market fundamentals based on latest TSOs' publications, 2030 RES target, and EU ETS implementation date

- **Supply outlook**
- **Demand outlook**
- **Cross-border capacity outlook**

Main assumptions

- **Fully competitive power market**
- **Perfect market coupling between countries**
- **Plexos based dispatch model**
- **Sample approach based on 3 representative weather samples * 10 outage patterns**

In order to assess the incentives sent by the current energy-only market to invest in new plants (if needed) or maintain existing plants, **future investments considered by the TSOs in their publications could be modified in our study**

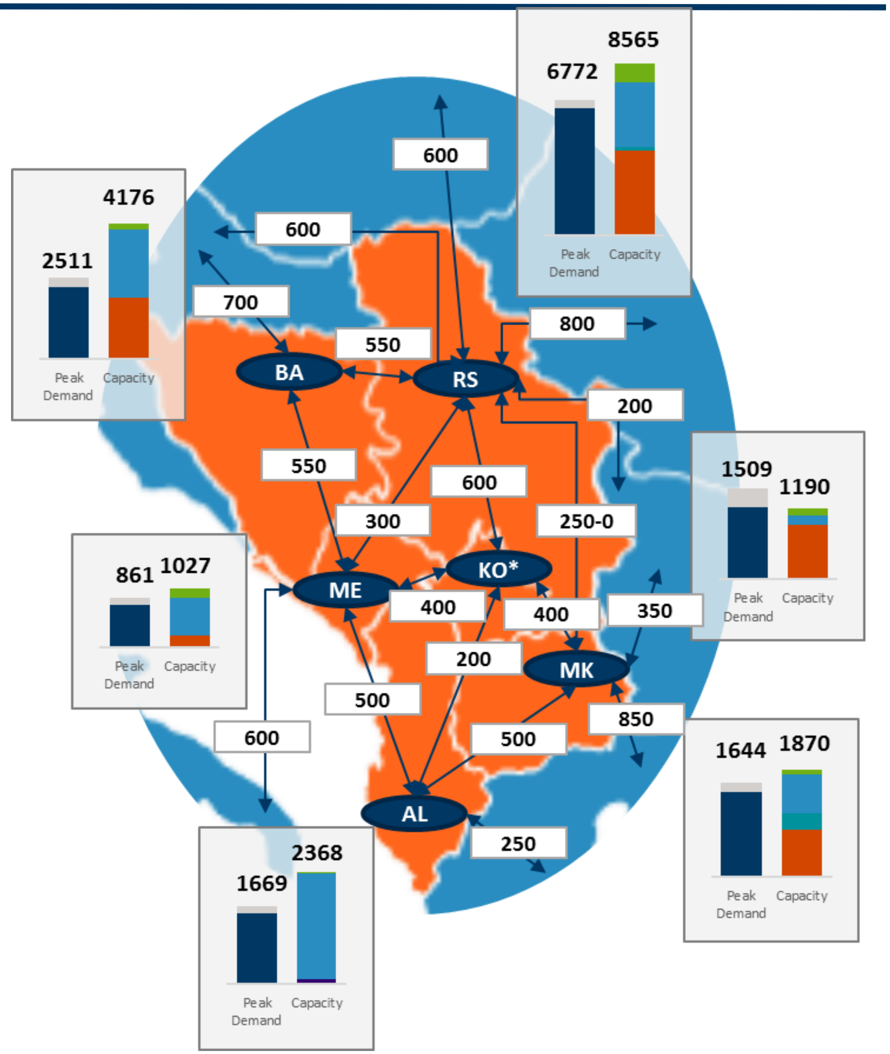
Time horizon

Existing system → 2020 → 2025 → 2030

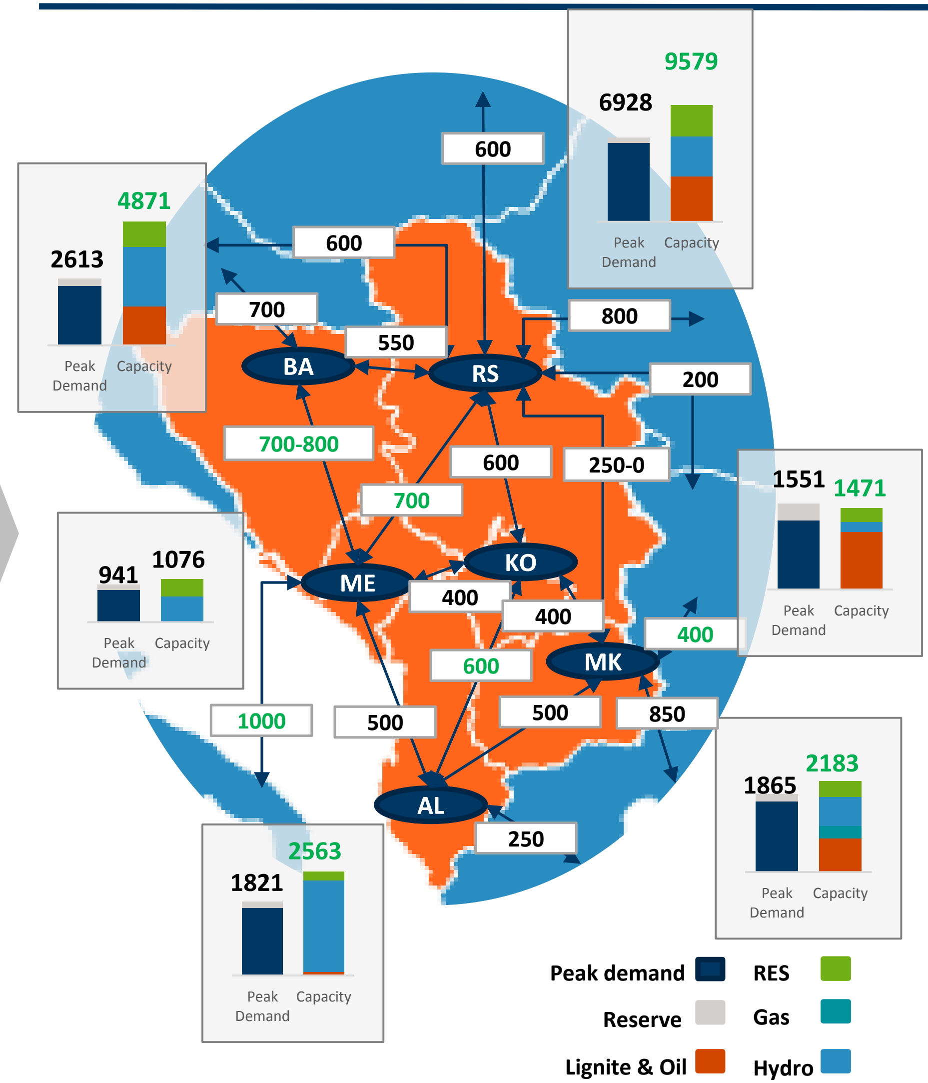
Adequacy assessment of WB6

Overview of the WB6 interconnected power markets in 2020 and 2025

Overview in 2020

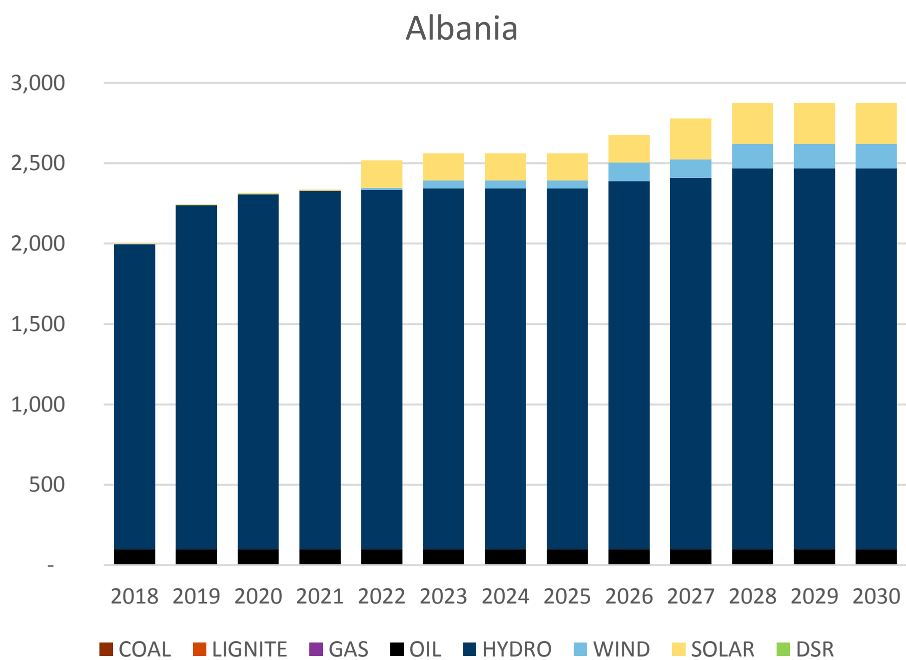


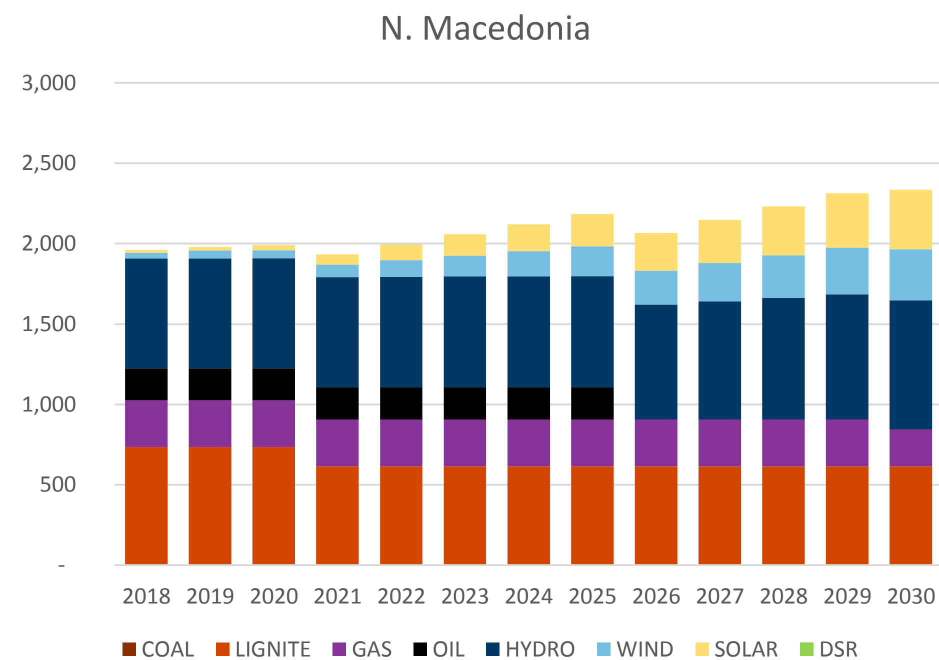
Overview in 2025



Overview of WB6 shows sufficient capacity in both 2020 and 2025 even without including future new investments especially as the inter and intra regional transmission grid keeps expanding

Resulting capacity outlook (MW) in Albania and North Macedonia





Almost 1 GW of new hydro plants is planned by 2030:

- c500MW are run-of
- c600MW are dispatchable hydro (turbines)

Of this only 250MW are considered in the adequacy analysis

Additional 150MW of wind and 255MW of solar are built by 2030

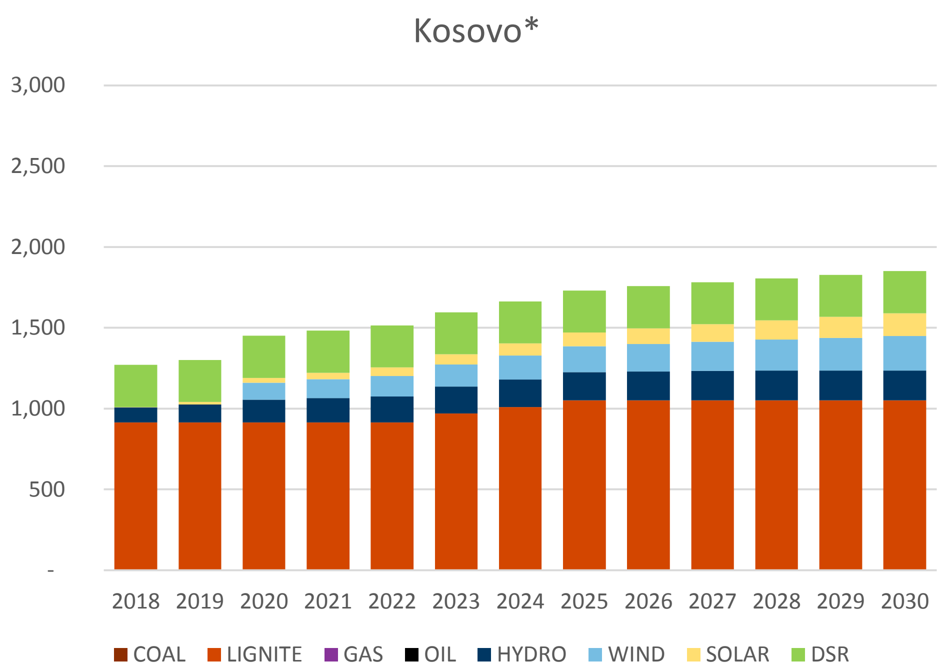
About 100MW of small hydro are expected to be commissioned by 2030

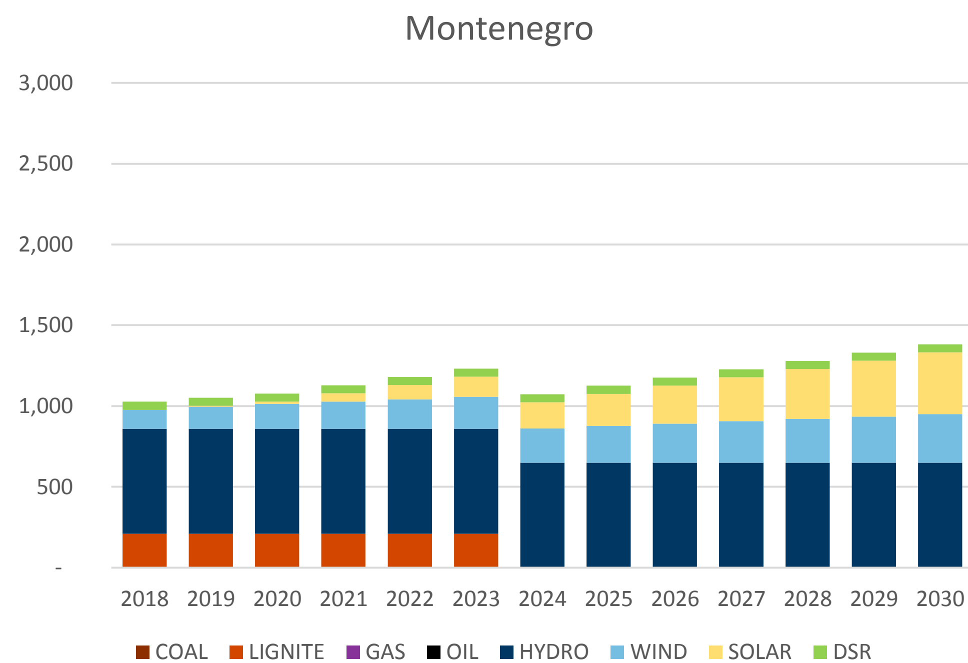
Almost 800MW of thermal plants are assumed to be commissioned in the next decade by the TSO.

- They are not considered in the adequacy study

Additional 270MW of wind and 340MW of solar are built to meet 2030 RES target

Resulting capacity outlook (MW) in Kosovo* and Montenegro are presented below





About 100MW of hydro are expected to be commissioned by 2030

A new lignite plant of 450MW and increase capacity of Kosovo B (80MW) are expected by 2025.

A 250MW pumped hydro storage is expected by the TSO in 2023. It is not considered in the adequacy study

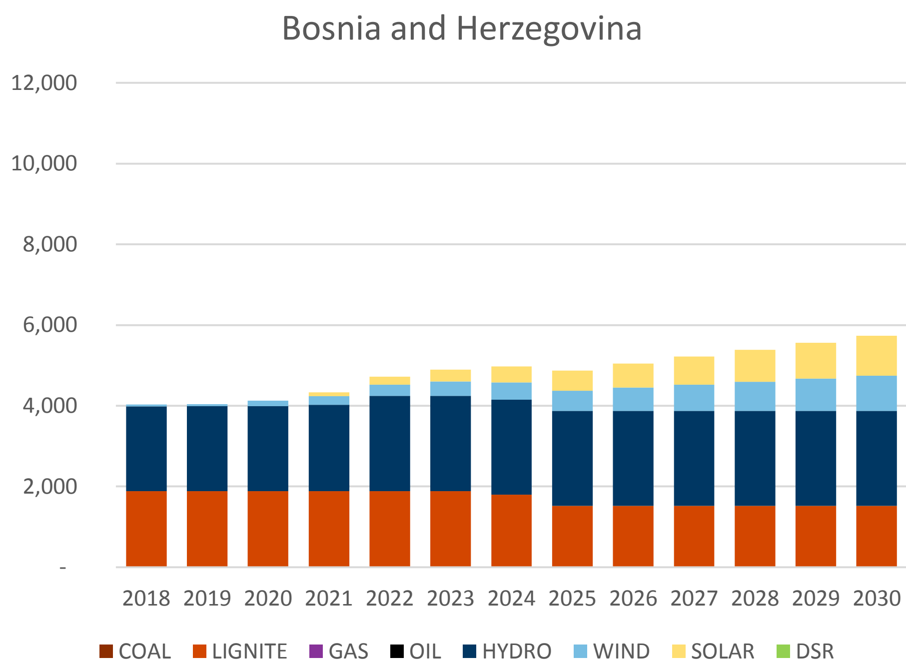
Additional 110MW of wind and 110MW of solar are built to meet 2030 RES target

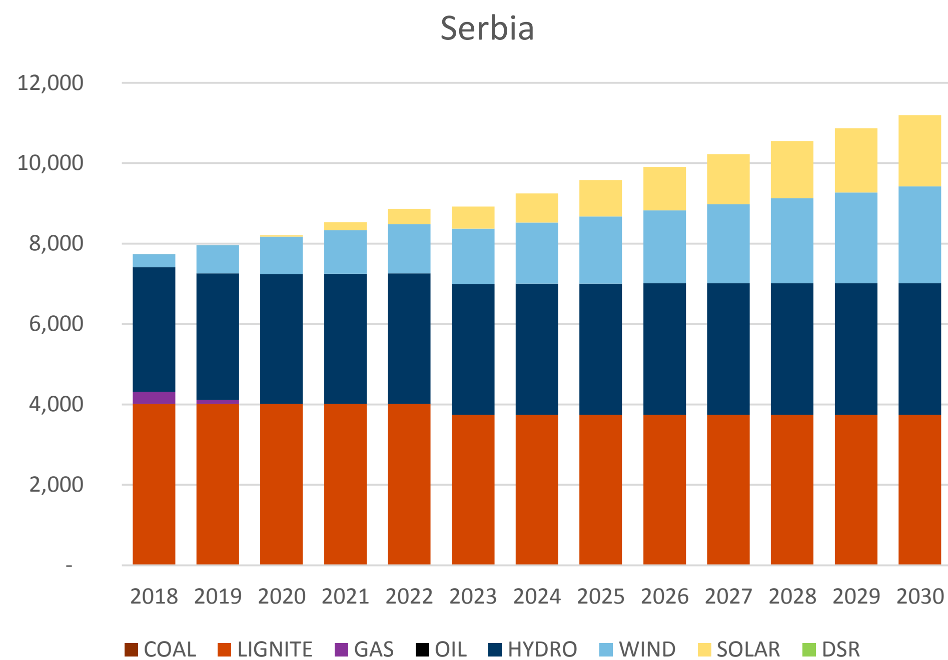
About 600MW of large hydro are expected to be commissioned by 2030: they are not considered in the adequacy study

The existing power plant is expected to be refurbished even though it is in the LCPD opt-out list: it is not considered in the analysis and the plant is assumed to close by 2023

Additional 150MW of wind and 370MW of solar are built to meet 2030 RES target

Resulting capacity outlook (MW) in Bosnia and Herzegovina and Serbia are presented below





Almost 2 GW of lignite and CCGT plants are assumed to be commissioned in the next decade by the TSO.

- They are not considered in the adequacy study

Additional 740MW of wind and 990MW of solar are built to meet 2030 RES target

Almost 500MW of lignite and gas plants are assumed to be commissioned in the next 5 years by the TSO.

- They are not considered in the adequacy study

Additional 1360MW of wind and 1640MW of solar are built to meet 2030 RES target

Adequacy assessment of WB6

3	**Adequacy assessment of WB6**
1	**WB6 methodology and assumptions**
2	**Capacity outlook per country**
3	**Adequacy model**
4	**Market model**

Adequacy analysis principles

- In the following slides, the adequacy margin of each WB6 country is studied. It considers differently expected investments in RES and in thermal plants.

- The margin is computed as:

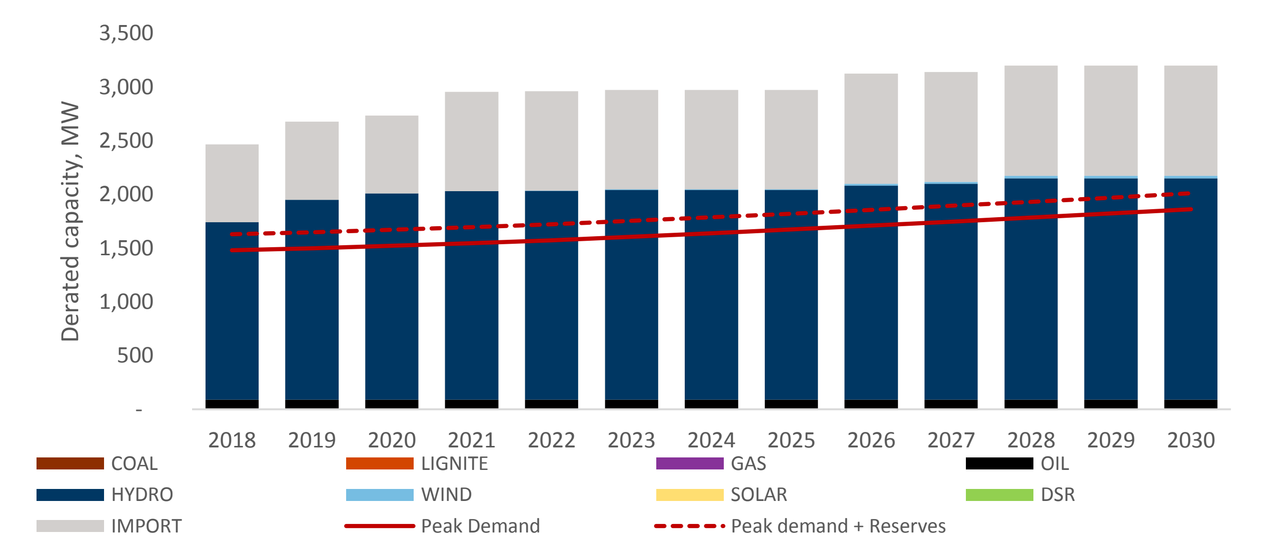
$$\boldsymbol{System\ Margin} \\ \boldsymbol{= Peak\ Load + Upward\ Ancillary\ Reserves\ - Derated\ installed\ capacity}$$

- Peak load is defined as the peak demand that could occur under specific climate conditions (e.g. 1 in 10 risk)
- De-rating factors for all technologies but hydro are based on standard values found in the literature (e.g. 88% for thermal plants as per the UK CM) and account for probabilistic unavailability of power plants due to forced outages or unavailability of energy resource.
  - For hydro plants, their availability during peak hours is defined based on historical data for 2016, 2017 and 2018 for each WB6 country

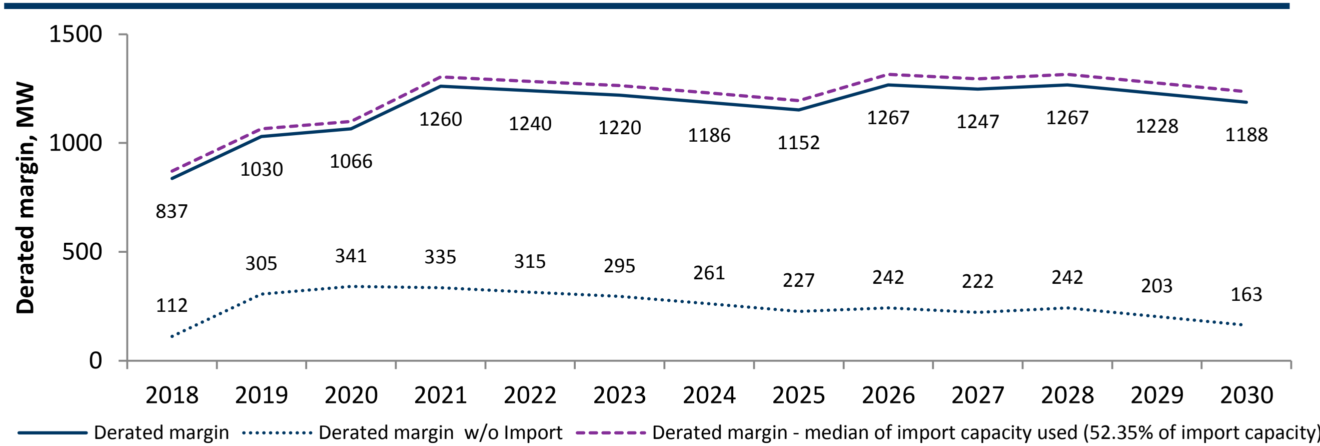
This adequacy assessment margin approach provides first results on the adequacy situation in WB6 countries. This method is used by several WB6 TSOs for their adequacy study (e.g. in Kosovo* or Serbia).

Albanian power market features a positive margin throughout the horizon

Peak demand and de-rated capacity, 2018-2030



System margin, 2018-2030



Input data

- Background assumptions are mainly based on data sent by OST.

Comments on static adequacy results

Capacity

- Almost 1 GW of new hydro plants is planned by 2030:
  - c500MW are run-of-river
  - c600MW are dispatchable hydro (turbines)
- Of this only 250MW are considered in the adequacy analysis

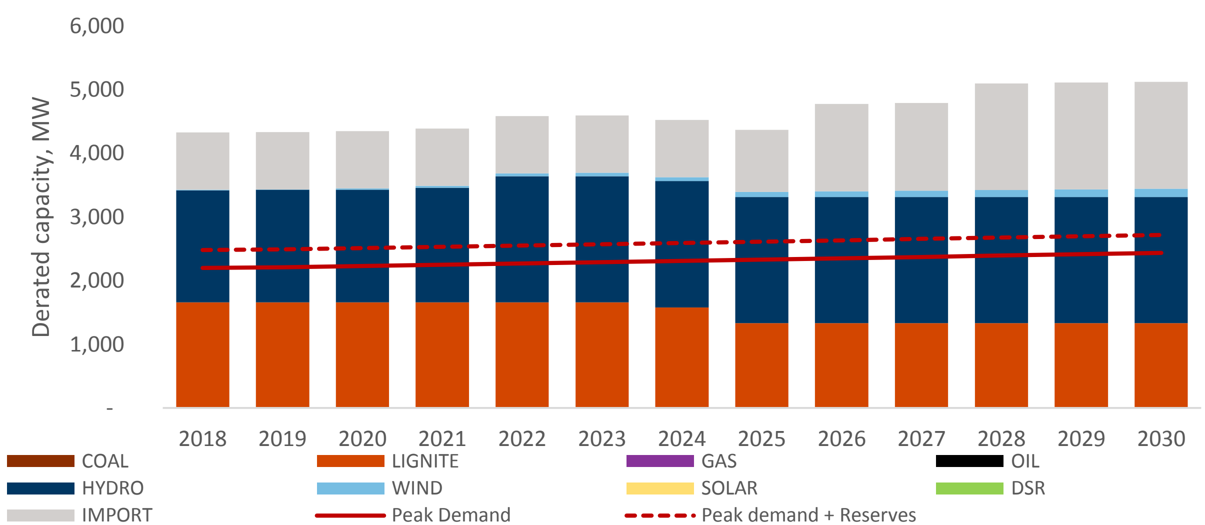
Availability

- Historical hourly hydro generation data (2016-2018) shows that Albanian hydro generation is available at 82% at peak time.
- Dispatch modelling shows that at peak load demand, import capacity can be relied upon c50% of import capacity

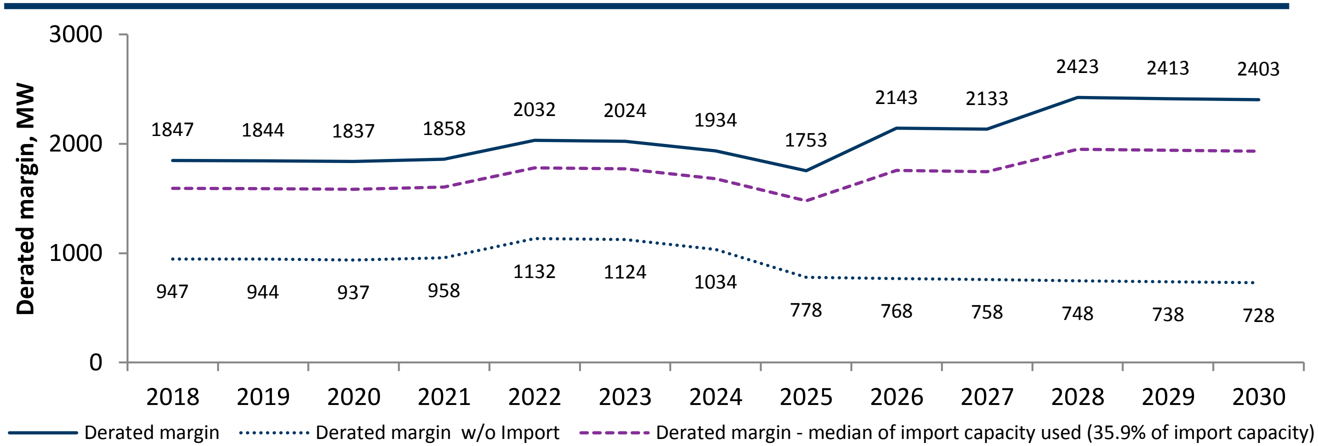
Albanian power market features a positive margin throughout the horizon, even if it tends to decrease due to consumption increase

Even by removing 2 GW of new plants, the Bosnian power market features a positive margin throughout the horizon

Peak demand and de-rated capacity, 2018-2030



System margin, 2018-2030



Input data

- Background assumptions are based on the latest national network development plan for 2019-2028 and discussion with the TSO

Comments on static adequacy results

Capacity

- Almost 2 GW of lignite and CCGT plants are assumed to be commissioned in the next decade by the TSO.
  - They are not considered in the adequacy study

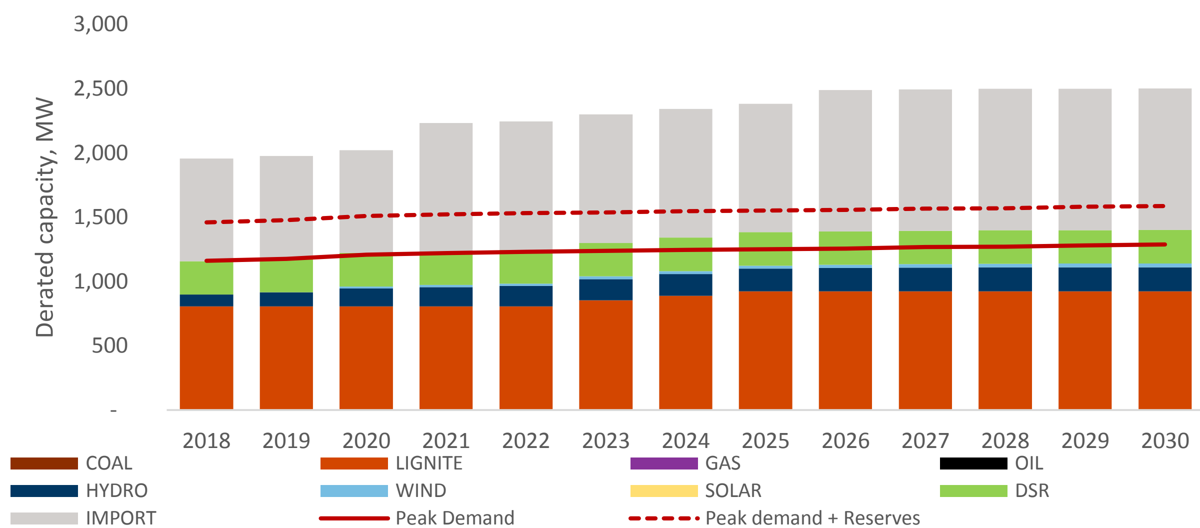
Availability

- Availability of existing thermal plants is based on data provided by the TSO
- Historical hourly hydro generation data (2016-2018) shows that Bosnian hydro generation is available at 80% at peak time.
- Dispatch modelling shows that at peak load demand, import capacity can be relied upon c35% of import capacity

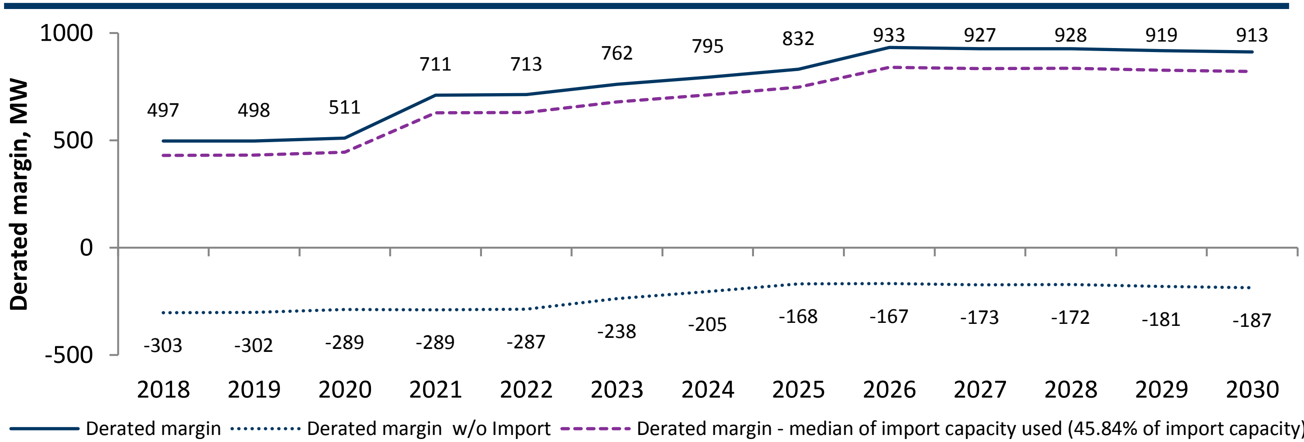
Even by removing 2 GW of new plants, the Bosnian power market features a positive margin throughout the horizon

Kosovar power market features a negative margin throughout the horizon, turning positive when accounting for import capacities

Peak demand and de-rated capacity, 2018-2030



System margin, 2018-2030



Input data

- Main assumptions are based on the baseline scenario of the latest national network development plan for 2018-2027, the adequacy study for 2019-2028 and discussion with the TSO

Comments on static adequacy results

Capacity

- About 100MW of hydro are expected to be commissioned by 2030
- A new lignite plant of 450MW is expected by 2023: given the advanced status in the tender for this plant, it is considered in the adequacy study
- On the contrary, the pumped hydro storage facility, expected in 2023, is not considered in the adequacy study

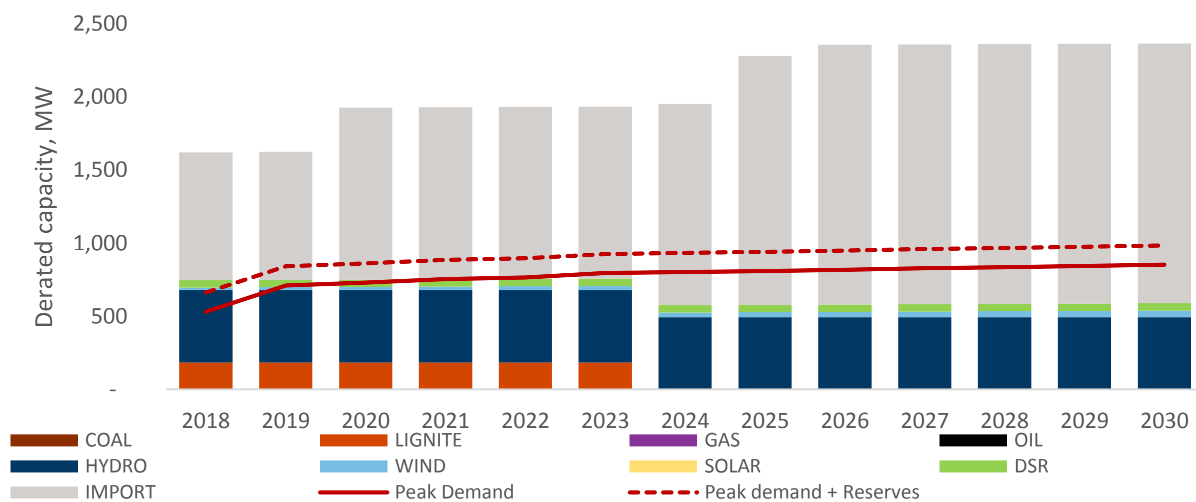
Availability

- Availability of existing thermal plants is based on data provided by the TSO
- Historical hourly hydro generation data (2016-2018) shows that Kosovar hydro generation is available at 90% at peak time.
- Dispatch modelling shows that at peak load demand, import capacity can be relied upon c45% of import capacity

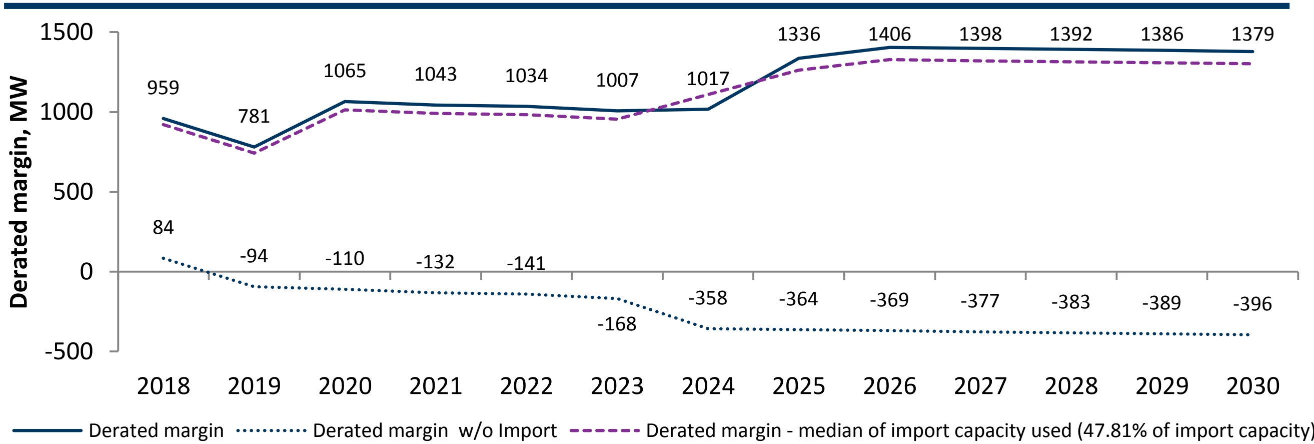
Kosovar power market features a negative margin throughout the horizon, turning positive when accounting for import capacities

Montenegro features a negative margin throughout the horizon, turning positive when accounting for import capacities

Peak demand and de-rated capacity, 2018-2030



System margin, 2018-2030



Input data

- Main assumptions are based on the latest national network development plan for 2019-2028 and discussion with the TSO

Comments on static adequacy results

Capacity

- About 600MW of large hydro are expected to be commissioned by 2030; they are not considered in the adequacy study
- The existing power pant is expected to be refurbished even though it is in the LCPD opt-out list.
  - This is not considered in the adequacy study: the plant will close by 2023

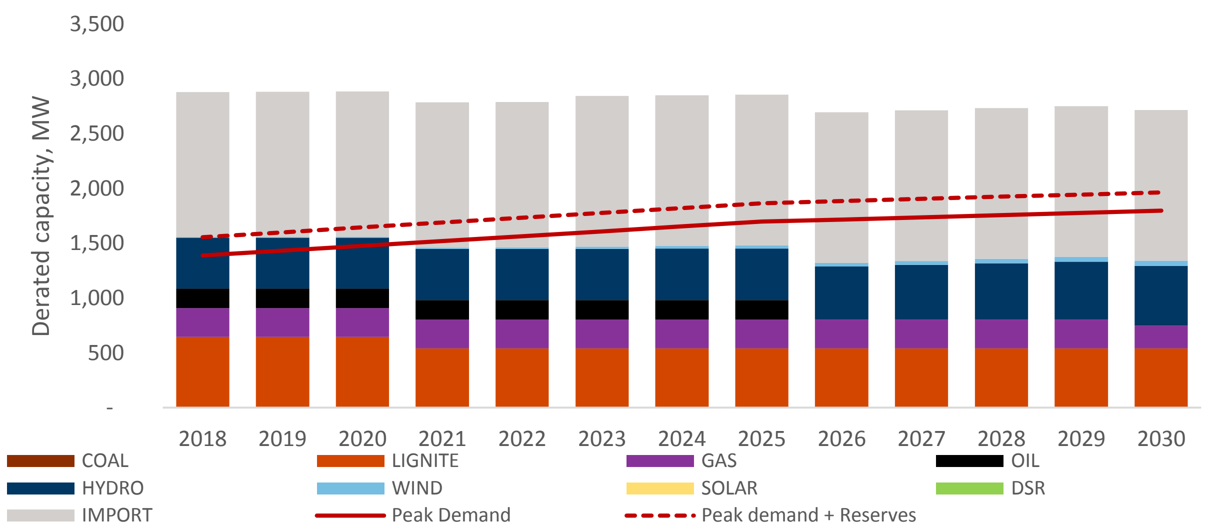
Availability

- Availability of existing thermal plants is based on data provided by the TSO
- Historical hourly hydro generation data (2016-2018) shows that Macedonian hydro generation is available at 76% at peak time.
- Dispatch modelling shows that at peak load demand, import capacity can be relied upon c50% of import capacity

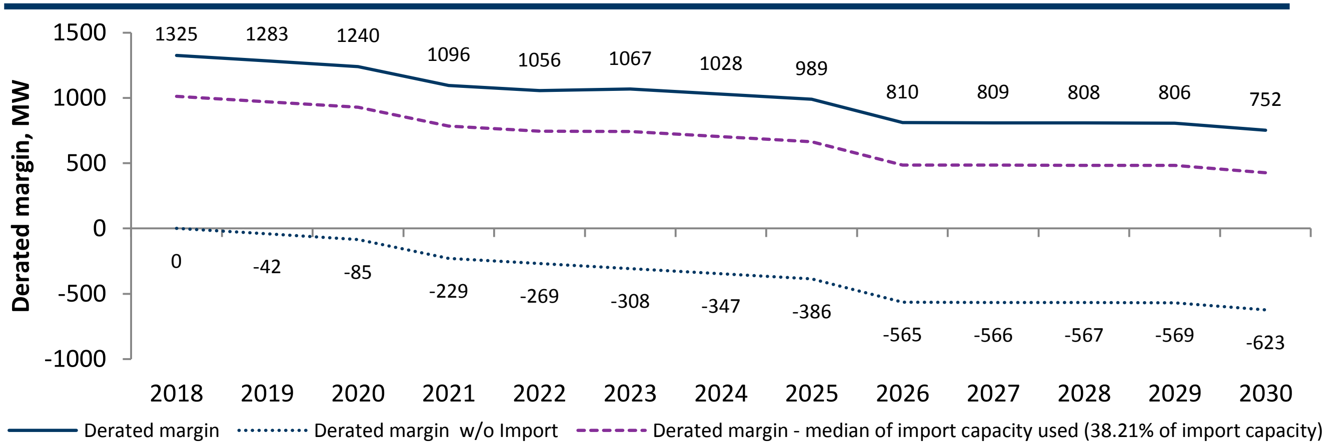
Montenegrin power market features a negative margin throughout the horizon, turning positive when accounting for import capacities

N. Macedonia features a negative margin throughout the horizon, turning positive when accounting for import capacities

Peak demand and de-rated capacity, 2018-2030



System margin, 2018-2030



Input data

- Background assumptions are based on the BAU scenario of the latest national network development plan for 2020-2040 and discussion with the TSO

Comments on static adequacy results

Capacity

- About 100MW of small hydro are expected to be commissioned by 2030
- Almost 800MW of thermal plants are assumed to be commissioned in the next decade by the TSO.
  - They are not considered in the adequacy study

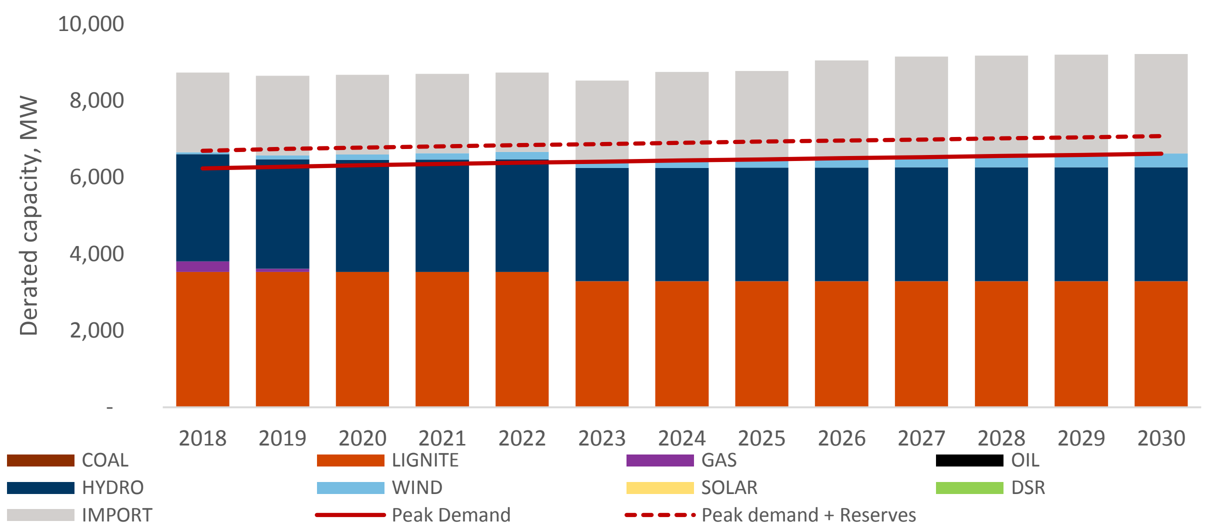
Availability

- Availability of existing thermal plants is based on data provided by the TSO
- Historical hourly hydro generation data (2016-2018) shows that Macedonian hydro generation is available at 68% at peak time.
- Dispatch modelling shows that at peak load demand, import capacity can be relied upon c40% of import capacity

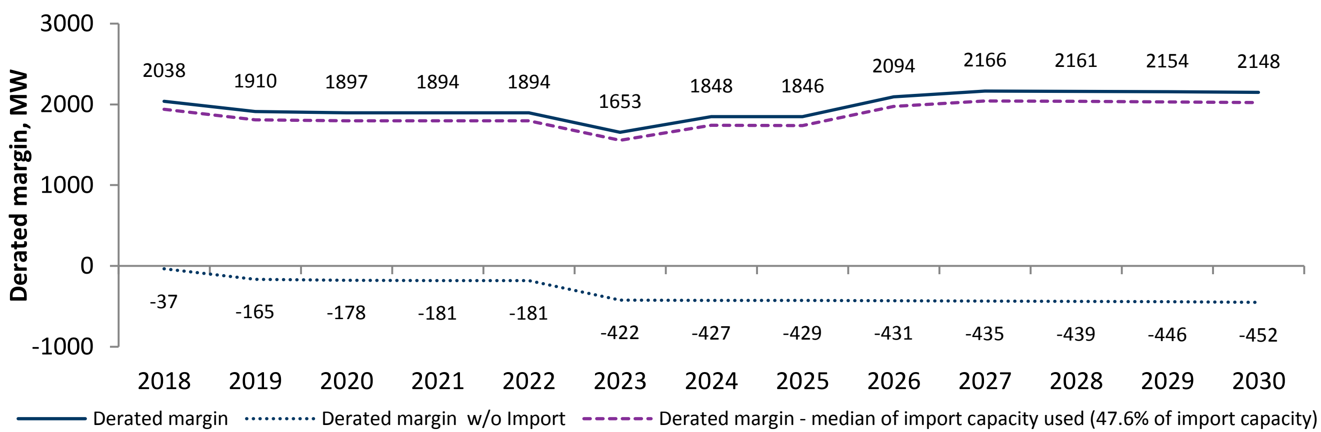
Macedonian power market features a negative margin throughout the horizon when new thermal investments are removed, turning positive when accounting for import capacities

Serbian power market features a negative margin throughout the horizon, turning positive when accounting for import capacities

Peak demand and de-rated capacity, 2018-2030



System margin, 2018-2030



Input data

- Main assumptions are based on the realistic scenario developed in the latest national network development plan for 2018-2027

Comments on static adequacy results

Capacity

- Almost 500MW of lignite and gas plants are assumed to be commissioned in the next 5 years by the TSO.
  - They are not considered in the adequacy study

Availability

- Availability of existing thermal plants is based on generic data assumed by ENTSOE
- Historical hourly hydro generation data (2016-2018) shows that Serbian hydro generation is available at 90% at peak time.
- Dispatch modelling shows that at peak load demand, import capacity can be relied upon c50% of import capacity

Serbian power market features a negative margin throughout the horizon, turning positive when accounting for import capacities

Limits of the adequacy study

- While the adequacy study show no specific concerns of security of supply in the next 5 to 10 years, the method suffers from **several limits:**

  - It considers **each WB6 country separately**: co-existence of tight situation is not considered and imports are assumed to be available at a fixed rate, regardless of the adequacy situation in the neighbouring countries
  - **Stochastic simulations** (random outages, several climatic years) are only implicitly considered through de-rating factors
  - **Loss of Load Probability** is not assessed
  - **Revenues from the energy market** cannot be computed: as a result, incentives sent by the current energy-only market to invest in new plants (if needed) cannot be assessed

These limits are addressed within the Market model using our Power Market Dispatch modelling capability presented in the next slides

Adequacy assessment of WB6

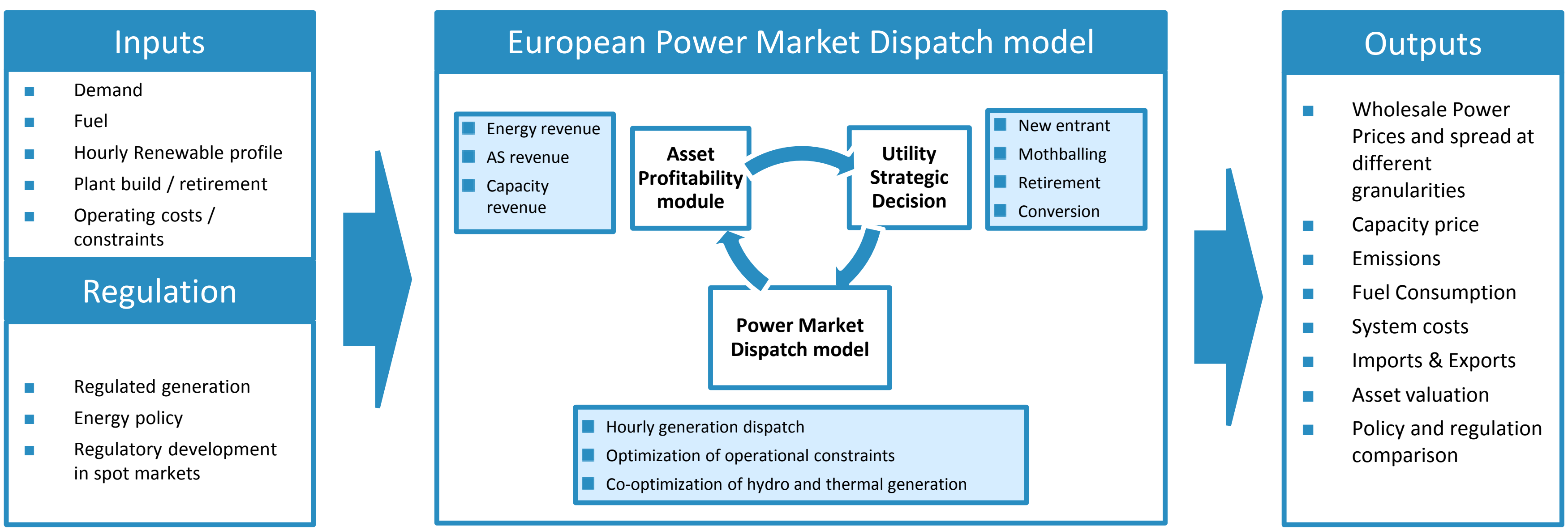
3	**Adequacy assessment of WB6**
1	WB6 methodology and assumptions
2	Capacity outlook per country
3	Adequacy model
4	**Market model**

Our dispatch market modelling approach uses state-of-art power modelling software and advanced modelling of hydro and RES

Dispatch optimisation based on detailed representation of power market fundamentals

- At the heart of FTI-CL Energy's market modelling capability lies a dispatch optimisation software, Plexos®, based on a detailed representation of market supply and demand fundamentals at an hourly granularity. Plexos® is globally used by regulators, TSOs, and power market participants.
- FTI-CL Energy's power market model is specifically designed to model renewable generation:
  - Wind: Hourly profiles are derived from our in-house methodology that converts consolidated wind speeds into power output.
  - Solar: Hourly profiles are derived from our in-house methodology that converts solar radiation into power output.
  - Hydro: Weekly natural inflows are derived from our in-house methodology that convert rainfall, ice-melt and hydrological drainage basin into energy. Generation is derived from a state-of-the-art hydro thermal co-optimization algorithm embedded at the heart of Plexos®.

FTI-CL Energy's modelling approach (input, modules and output)



To capture the future evolution of WB6 power markets, we designed 3 scenarios differentiating investment and EU ETS

- In line with the adequacy analysis, the market model analysis considers different scenarios for investments in RES and in thermal plants.
- In addition, the defined scenarios test the market functioning under distinct economic assumptions such as EU norms including the CO2 EU ETS market and the future emission norms.

- In summary, we have designed three set of scenarios:

Base Case:

- Based on **TSO base case** (e.g. includes all new investments in both RES and thermal plants) and **2030 RES Target**
- It assumes that WB6 do not enter the EU ETS market and do not apply the latest emission norms beyond the LCPD directive.

EU ETS EOM 2030:

- Based on TSO base case with **energy only economic investments and closure decisions**, and
- It assumes that WB6 countries **enter the EU ETS market from 2030 onwards** and do not apply the latest emission norms beyond the LCPD directive.

EU ETS EOM 2025:

- Based on TSO base case with **energy only economic investments and closure decisions**, and
- It assumes that WB6 countries **enter the EU ETS market from 2025 onwards** and do not apply the latest emission norms beyond the LCPD directive.

We run a sensitivity in which the **interconnection are constrained** limiting cross-border flow with neighbouring countries.

EU ETS EOM scenarios would represent the most challenging situation for the WB6 countries, as existing carbon intensive lignite plants would be heavily impacted by the carbon price implementation

Economic analysis principles in an Energy only market (EOM)

- Beyond the general wholesale power market outlook, the central question to be addressed in the adequacy assessment is the profitability of the power plants while ensuring security of supply.

- In this section, we analysed the energy only market long term equilibrium as follow:
  - ***As long as remaining power plants have not a Net Present Value (NPV) of future Net Profit positive, the less profitable plants are closed.***

- With net profit being defined as:
  - $\boldsymbol{Net\ Profit\ = Energy\ revenues + Reserve\ revenues\ - Variable\ Generation\ costs\ - Fixed\ Operation\ \&\ Maintenance\ Costs}$

- This analysis is performed on the full distribution of outputs from the 30 generated sample to capture the variation of energy revenues with the climate condition variations.
- Furthermore, the analysis is completed with one sensitivity on cross-border exchange limitations between WB6 and neighbouring markets, to capture the potential impact of cross-border market coupling limitation.

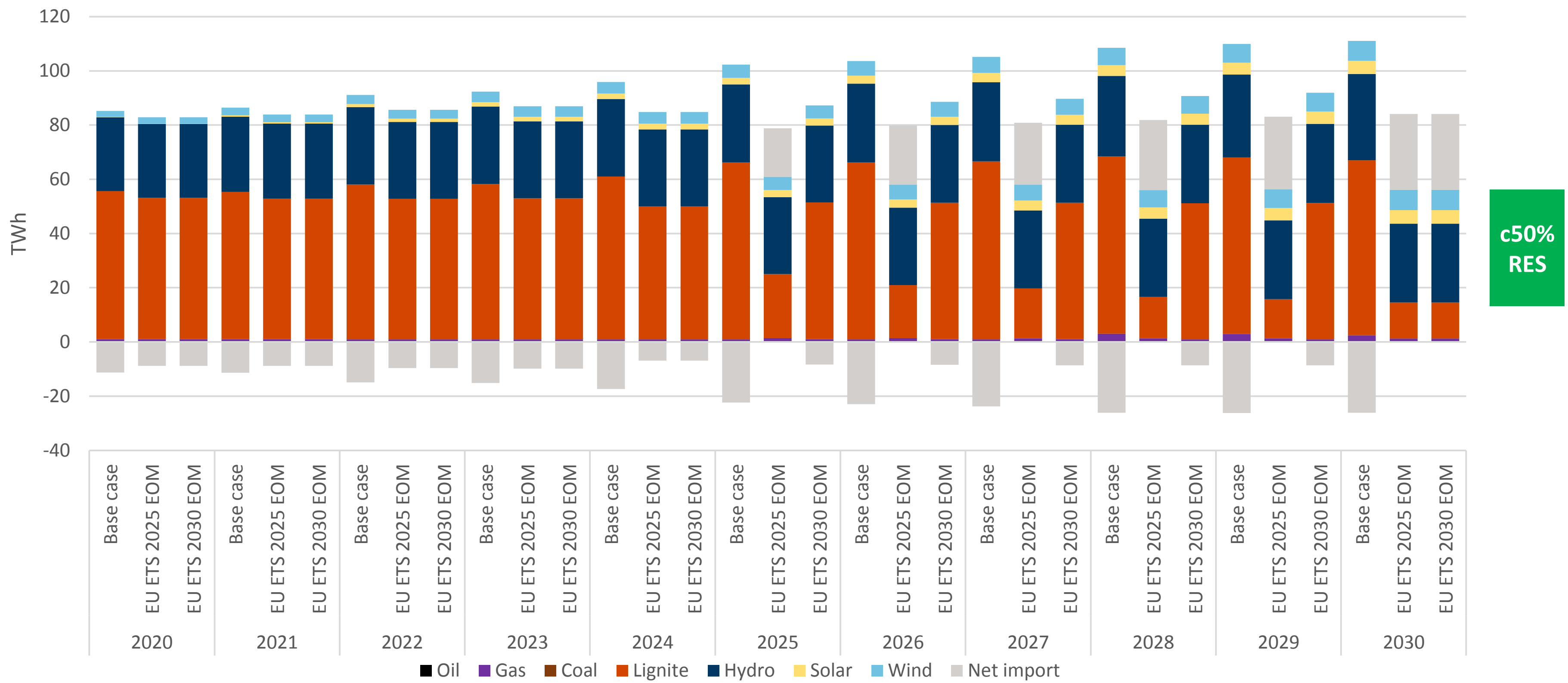
Our findings are highly dependant on the plant by plant features and fuel price used in the analysis.

- **To remove the impact of indirect subsidies on coal plants economics, the analysis uses a regional coal price of 8.3€/MWh (based on DG Energy) and a standard Fixed O&M of 40€/kW.**

Our findings shows that about 2.8GW of additional lignite plants would close by 2025 if EU ETS is implemented, and an additional 1.3GW of lignite plants would close by 2030.

Generation outlook to 2030

Generation outlook by technology in the WB6 region, 2020-2030



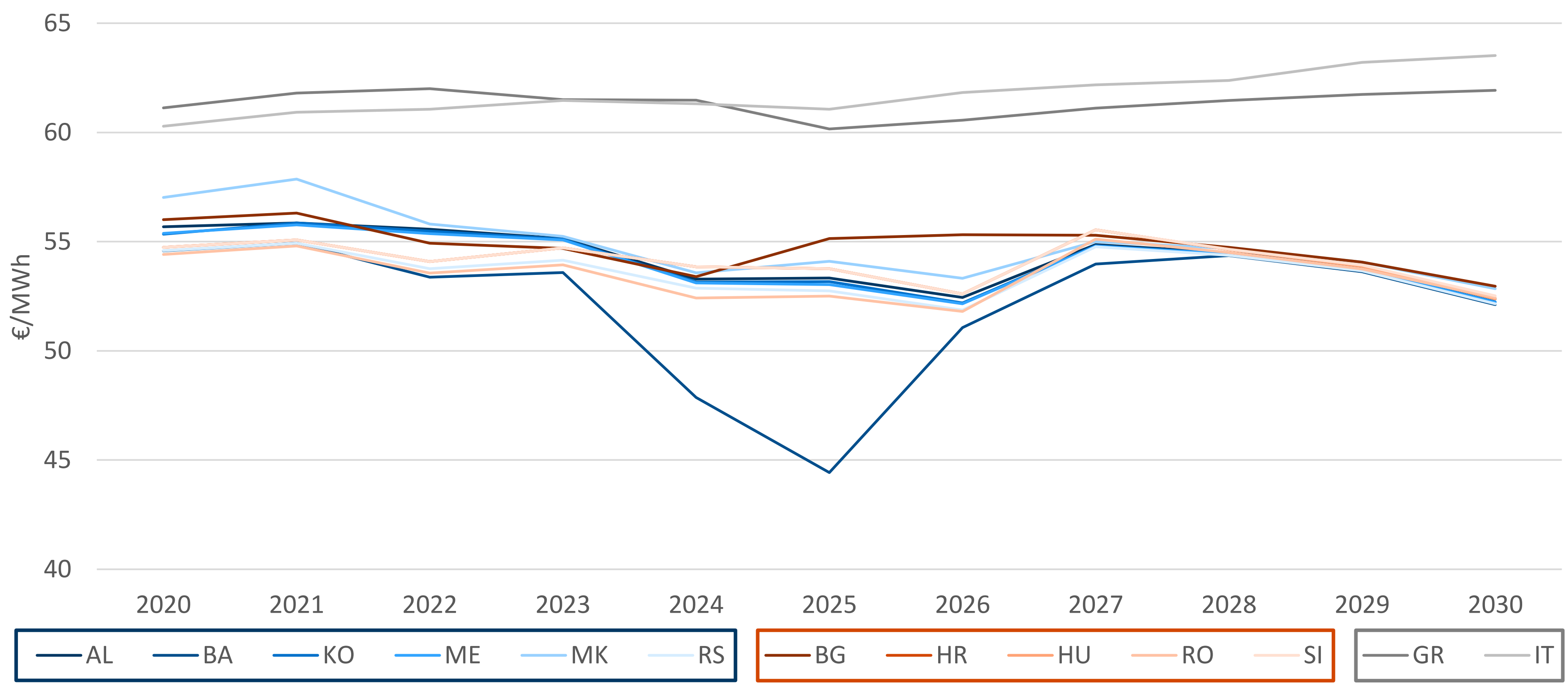
Base case scenario: total generation increases and WB6 countries, as a whole, export electricity to neighbouring countries

EU ETS EOM 2030 scenario : In 2030, generation from lignite plants in WB6 countries decreases due to the reduced competitivity of lignite plants. As a result, net import becomes positive.

EU ETS EOM 2025 scenario: From 2025, generation from lignite plants in WB6 countries steadily decreases due to the reduce competitivity of lignite plants. As a result, net import becomes positive.

Power prices outlook in the base case scenario over 2020-2030

Power prices outlook in the base case scenario , 2020-2030

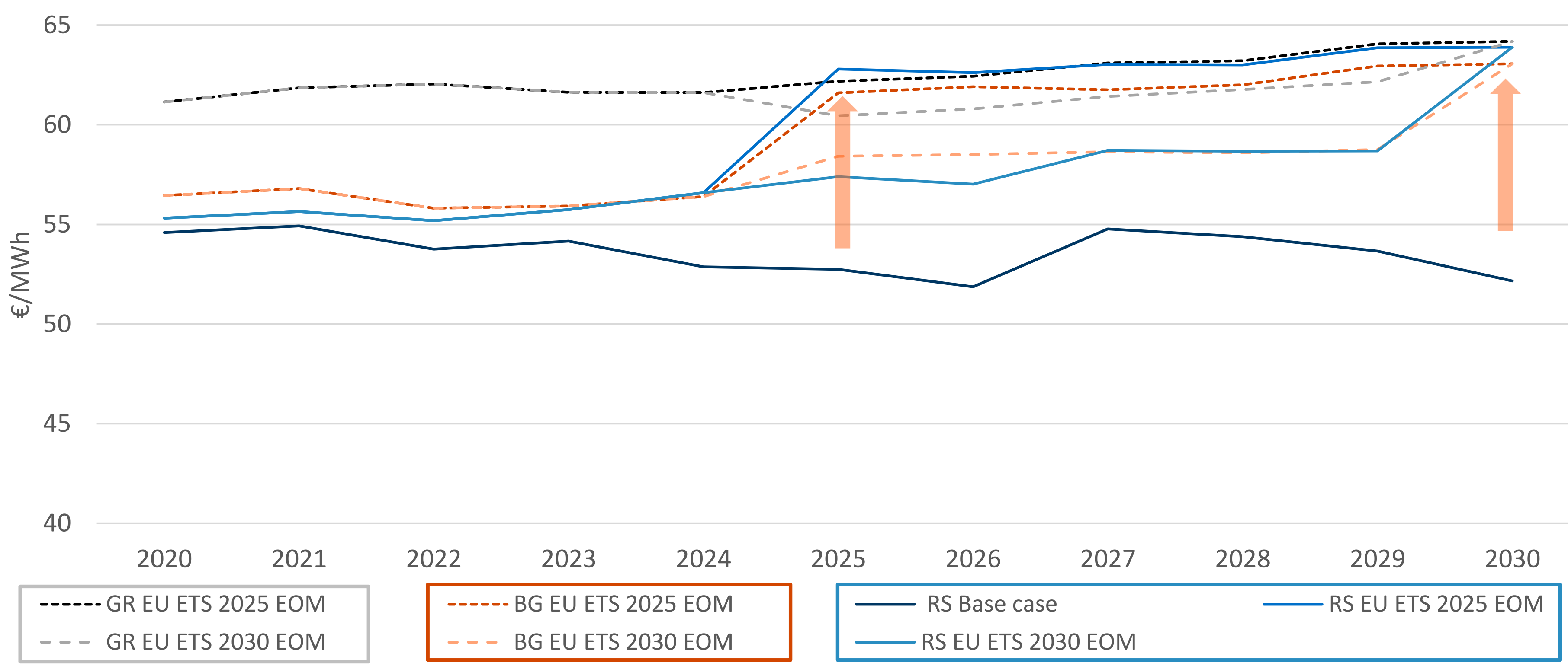


Except for Bosnia and Herzegovina in 2024-2025, annual average prices in WB6 countries are stable up to 2030 and are mainly driven by power prices in neighbouring countries, aligned with the costs of thermal plants already subject to CO2 price.

High price convergence is partly explained by the assumption of perfect market coupling.

Comparison of selected power prices outlook by scenario over 2020-2030

Comparison of selected power prices outlook by scenario, 2020-2030

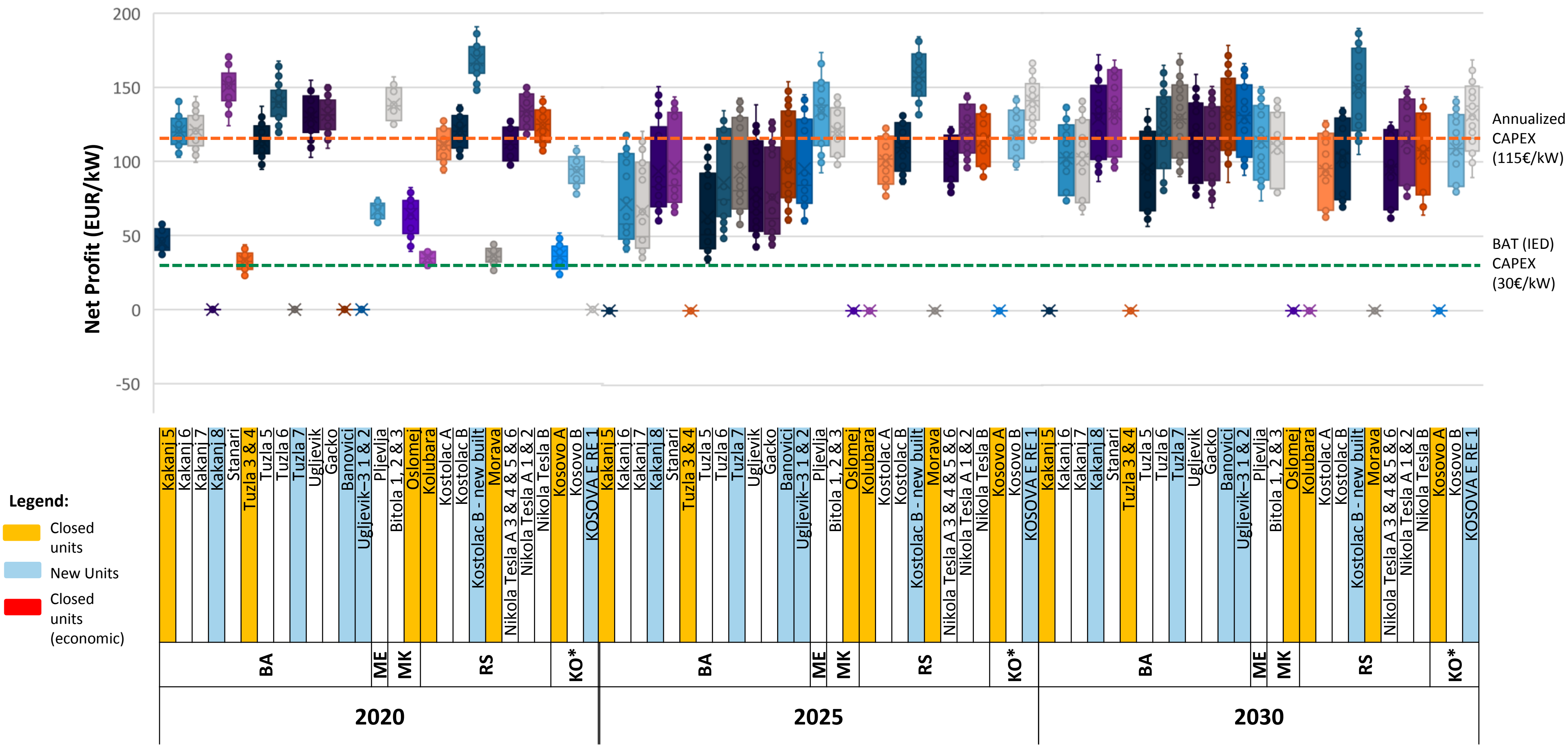


EU ETS EOM 2030 scenario: From 2020 onwards, power prices are higher than in the Base Case scenario as new plants are not commissioned before 2030. In 2030, with closure of un-economic plants, power prices converge to neighbouring countries already subject to CO_2 price.

EU ETS EOM 2025 scenario: From 2025 onwards, power prices converge to neighbouring countries already subject to CO_2 price.

* Above results shows power prices with No New investments and with all existing plants

In the base case scenario, net profits of existing and new investments are comparable with new investment annuity



In the base case, net profits of large thermal power plants remain comparable with the annualised CAPEX of a new coal power plant (c115€/kW/year).

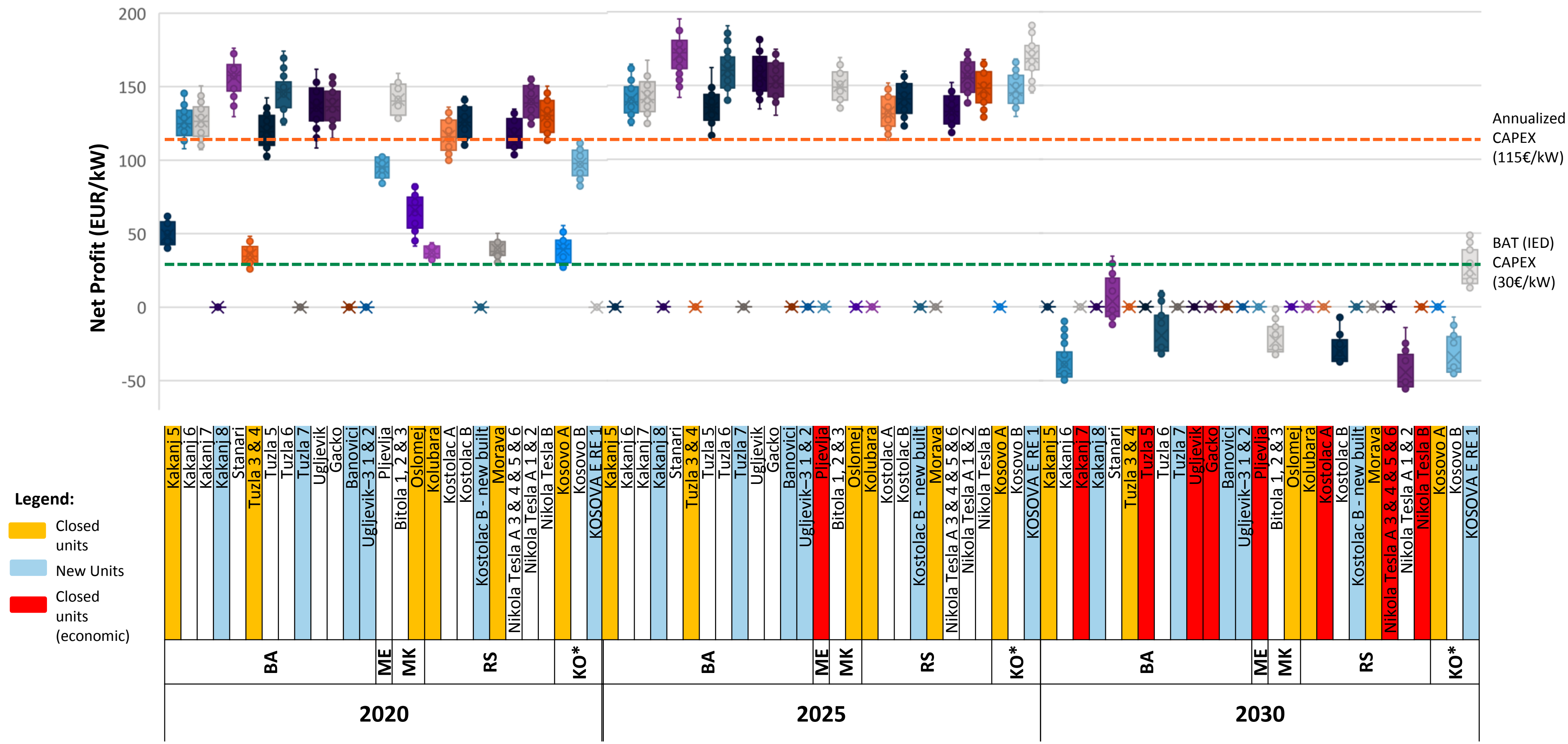
Thermals plant having opt-out from LCPD (subject to the 20,000hrs running hours cap) feature much lower Net Profits by definition.

In the EU ETS EOM 2030 scenario, upon implementation of the EU ETS in 2030, existing lignite plants become uneconomic, …

As soon as CO2 EU ETS price is introduced in 2030, the net profit of the large thermal plants significantly decrease to a level much lower than new investment (115€/kW) or BAT refurbishment (30€/kW) levels. They start to become non-profitable power plants.

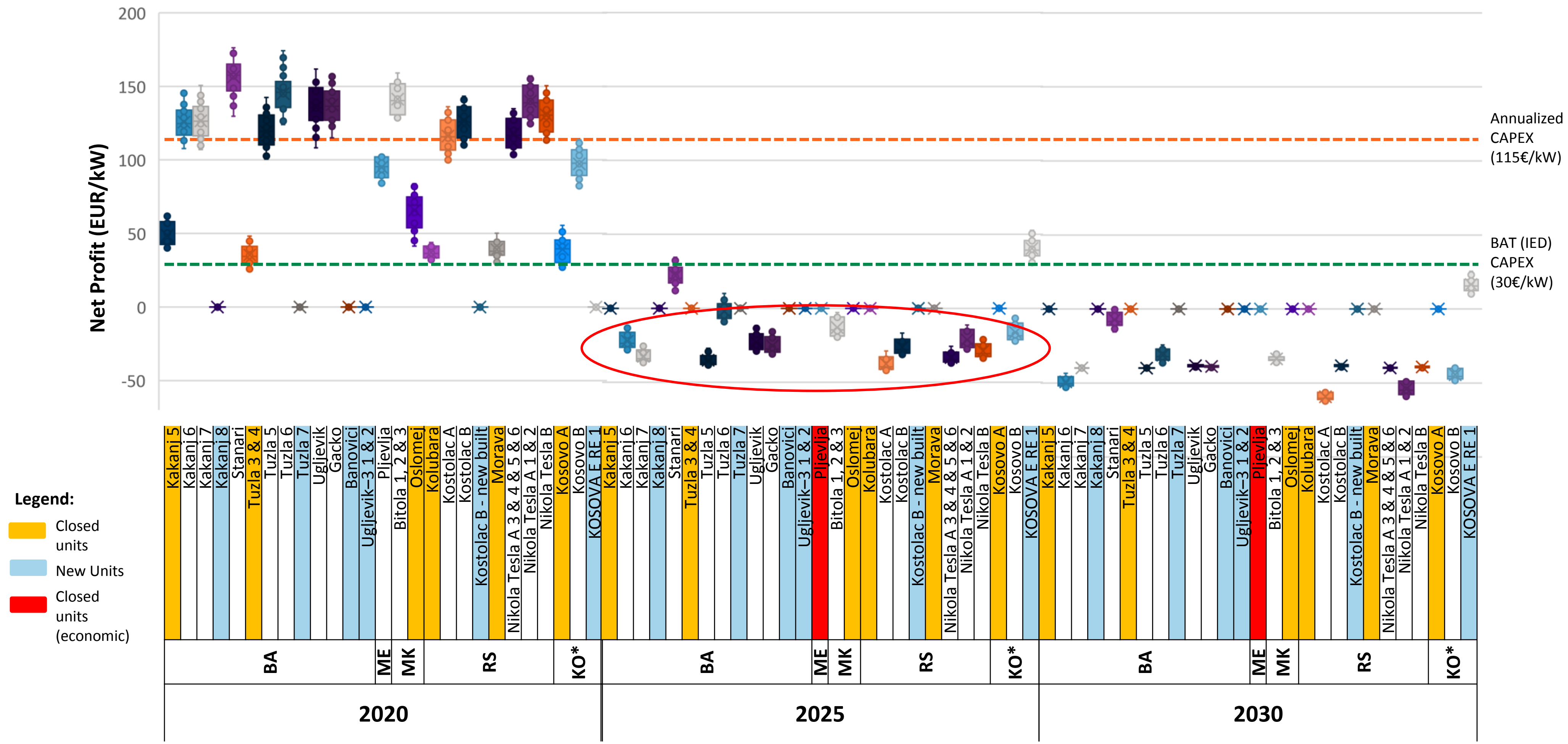
* Above results shows profitability with No New investments and with all existing plants

… leading to closure of 4.1GW of lignite plants across WB6 by 2030



In the EU ETS 2030 EOM scenario under energy only market long term equilibrium, upon carbon price implementation in 2030, 4.1GW of lignite plants would close across WB6, leaving remaining plants barely economic in 2030.

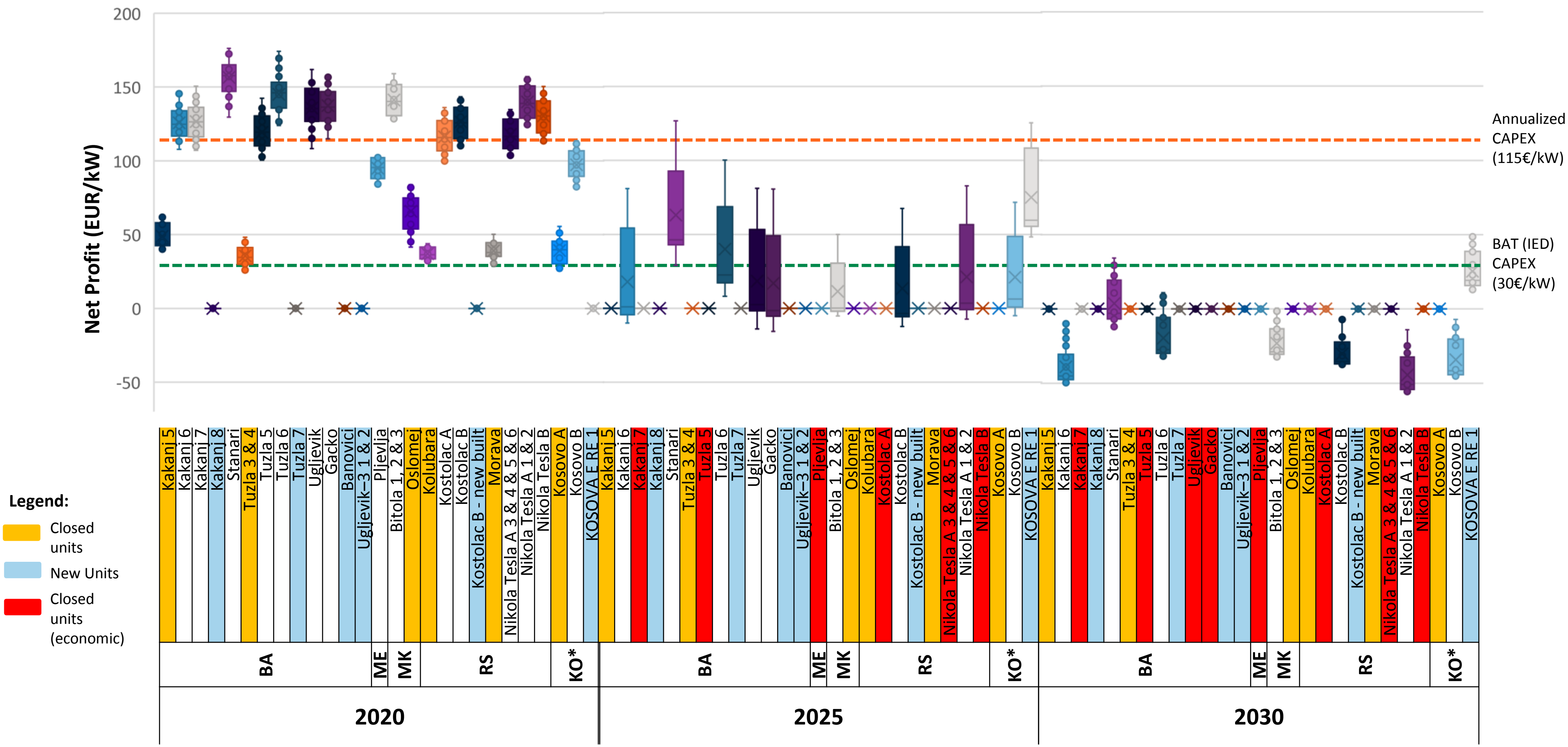
In the EU ETS EOM 2025 scenario, upon implementation of the EU ETS in 2025, existing lignite plants become uneconomic, …



As soon as CO2 EU ETS price is introduced in 2025, the net profit of the large thermal plants significantly decrease to a level much lower than new investment (115€/kW) or BAT refurbishment (30€/kW) levels. They start to become non-profitable power plants.

* Above results shows profitability with No New investments and with all existing plants

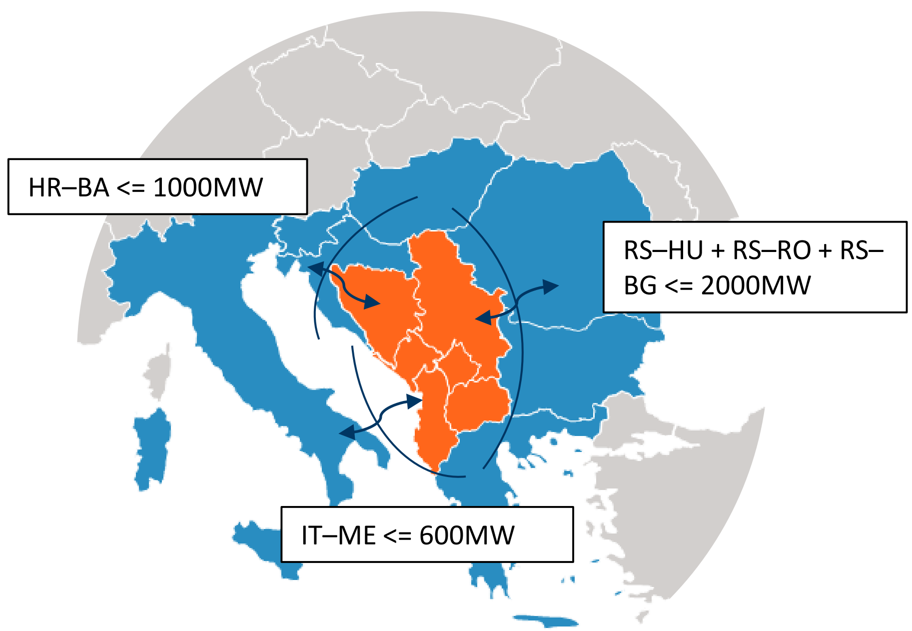
… leading to closure of 2.8GW of lignite plants across WB6 by 2025



In the EU ETS 2025 EOM scenario under energy only market long term equilibrium, upon carbon price implementation in 2025, 2.8GW of lignite plants would close across WB6, with 1.3GW additional in 2030, leaving remaining plants barely economic in 2030.

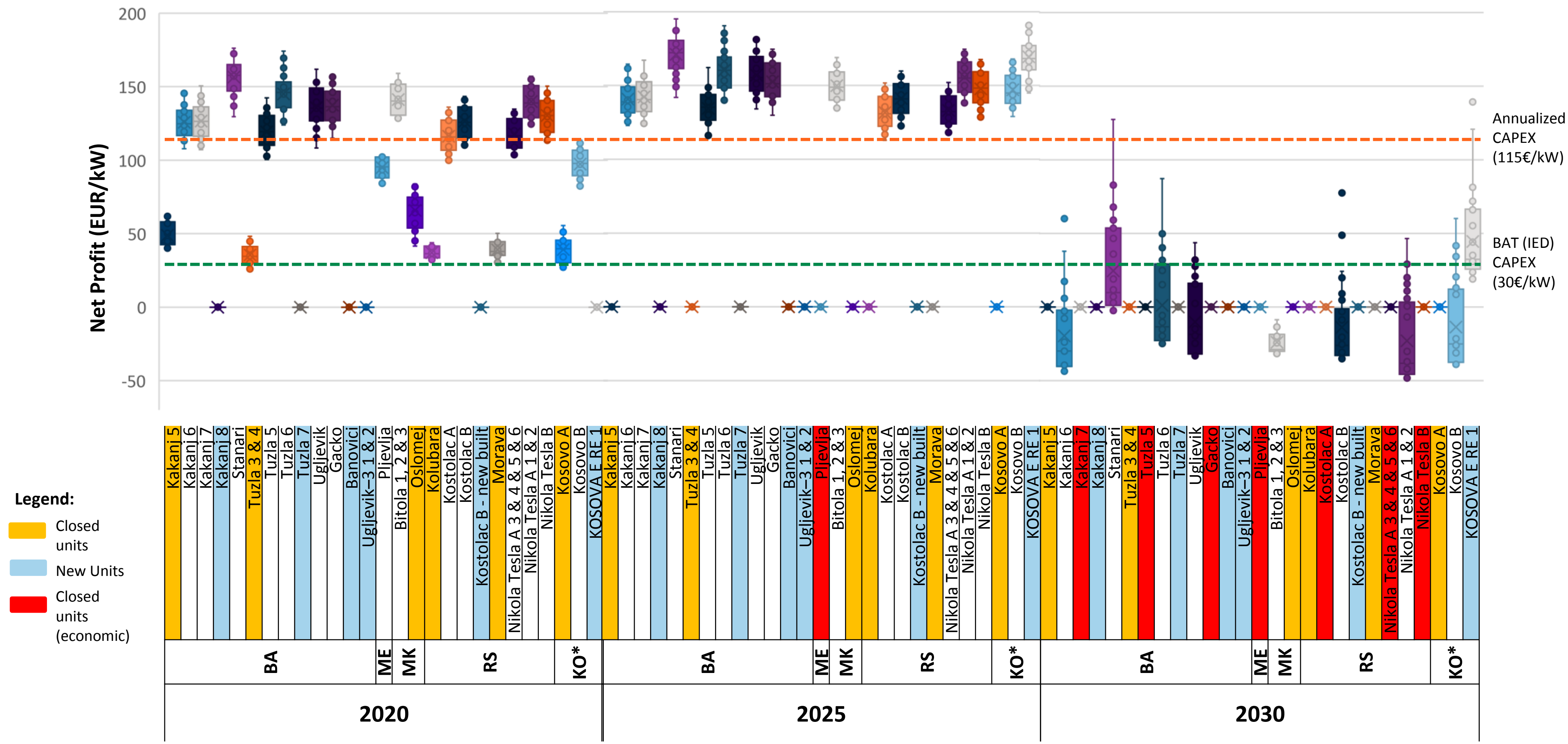
In addition to perfect market coupling modelling, we tested a sensitivity with constrained cross-border flow

- To assess the sensitivity of the above results, we design a sensitivity with constrained cross-border interconnection between WB6 and neighbouring countries as follow:
  - Serbian maximum cross-border imports from Hungary, Romania and Bulgaria are capped at 2GW, or 700MW less than maximum import capacity
  - Bosnian cross-border imports from Croatia are capped at 1GW, or 300MW less than 2030 import capacity
  - Montenegrin cross-border imports from Italy are capped at 600MW, or 400MW less than 2030 import capacity



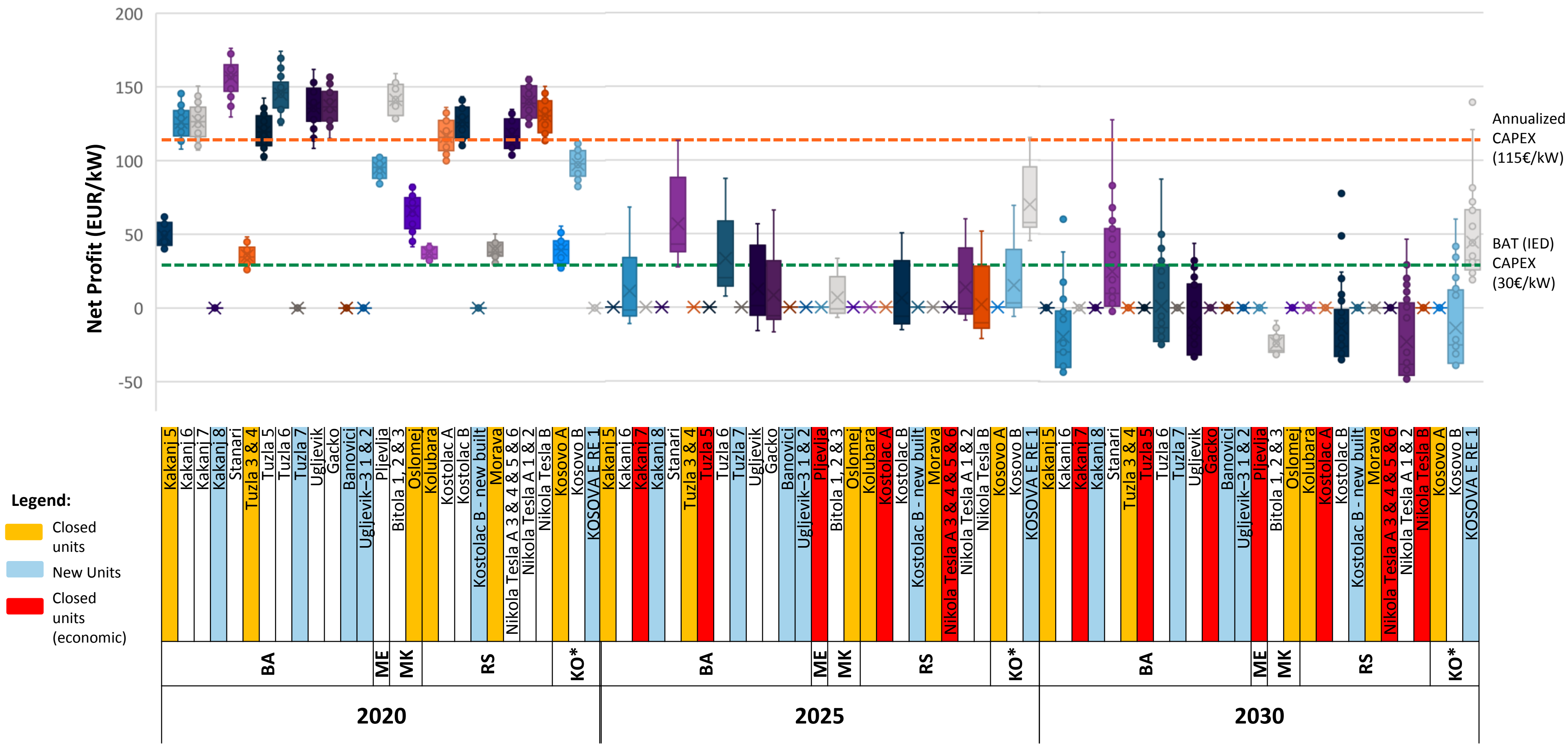
Our findings shows that 2.2GW of lignite plants would close by 2025 if EU ETS is implemented, and a additional 1.4GW of lignite plants would close by 2030.

In the EU ETS 2030 constrained cross-border flow sensitivity, 3.6GW of lignite plants would close across WB6 by 2030



In the EU ETS 2030 EOM constrained cross-border flow sensitivity, upon carbon price implementation in 2030, 3.6GW of lignite plants would close across WB6, leaving remaining plants barely economic in 2030.

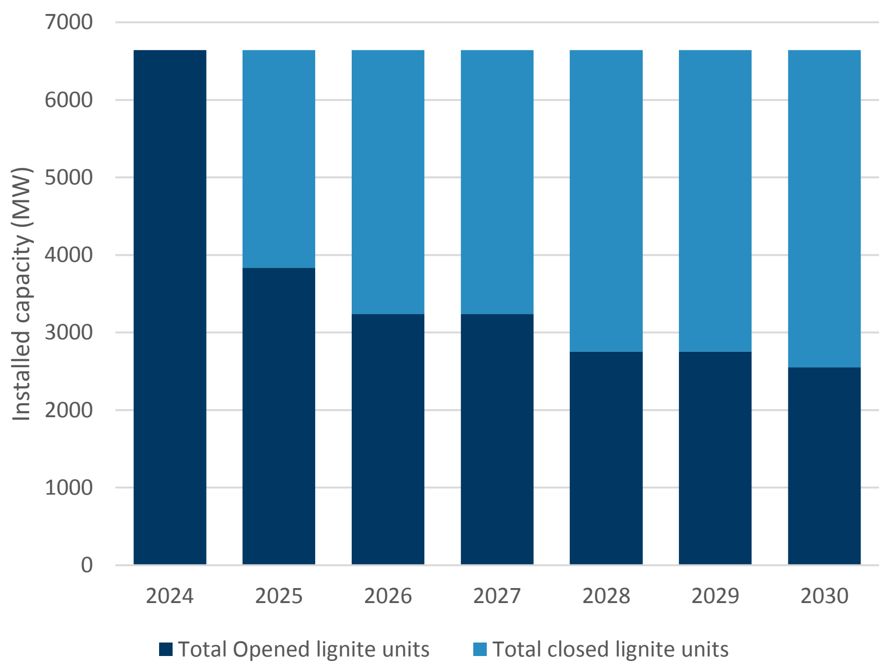
In the EU ETS 2025 constrained cross-border flow sensitivity, 2.5GW of lignite plants would close across WB6 by 2025



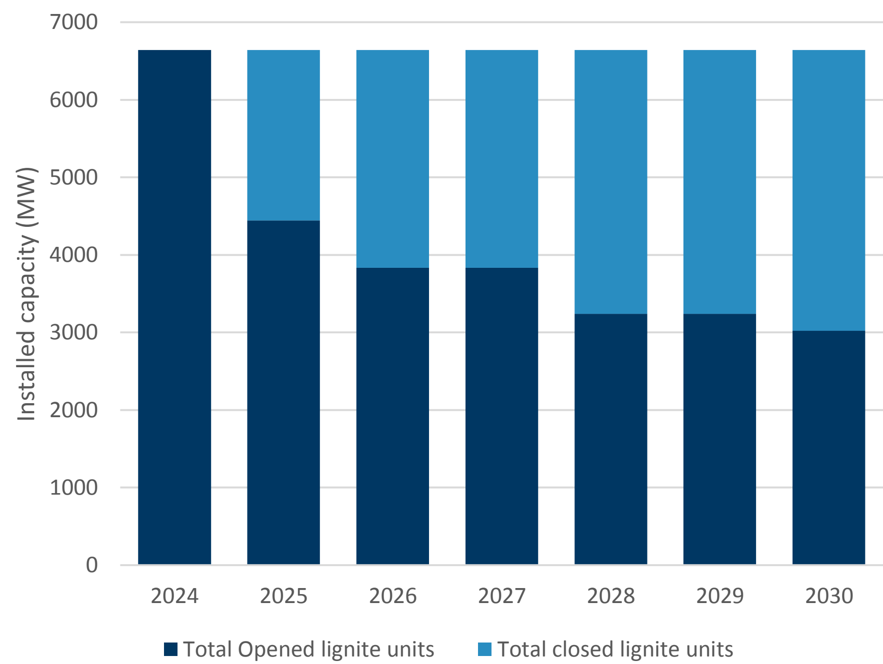
In the EU ETS 2025 EOM constrained cross-border flow sensitivity under energy only market long term equilibrium, upon carbon price implementation in 2025, 2.2GW of lignite plants would close across WB6, with 1.4GW additional in 2030, leaving remaining plants barely economic in 2030.

Power plants closure in the energy only market equilibrium and sensitivity to constrained cross-border flow

Net capacity (in MW) of lignite plants in WB6 countries - EOM scenario



Net capacity (in MW) of lignite plants in WB6 countries - Cross-border flow constraint scenario

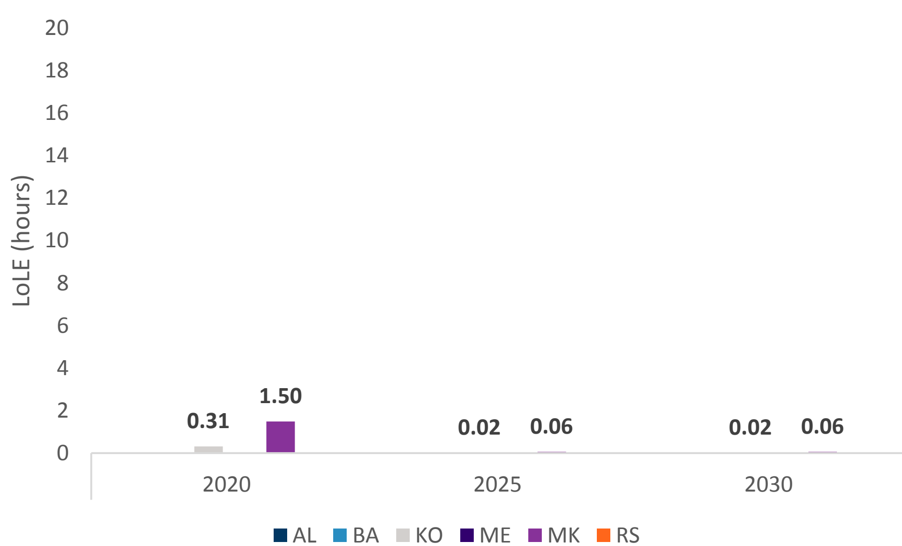


Fewer plants are decommissioned in the constrained cross-border flow sensitivity. Indeed, limited imports from neighbouring countries result in price increase in WB6 countries and higher profitability of lignite plants

Preliminary security of supply results in WB6 in the Base Case scenario shows no adequacy concerns

- We calculate the full (un)availability distribution matrix of WB6 using a stochastic multi-area Loss of Load Probability (LOLP) calculation using a probabilistic convolution algorithm
- It gives relevant results to assess the adequacy situation in WB6, in particular the **Loss of Load Expectation**, i.e. the expected number of hours per year when demand cannot be fully met by generation and import
- So far, these simulations have been run for a **limited number of years and scenarios** given the duration required for each run (about 24 hours)

Loss of Load Expectation for WB6 countries, in the Base case scenario (number of hours per year)



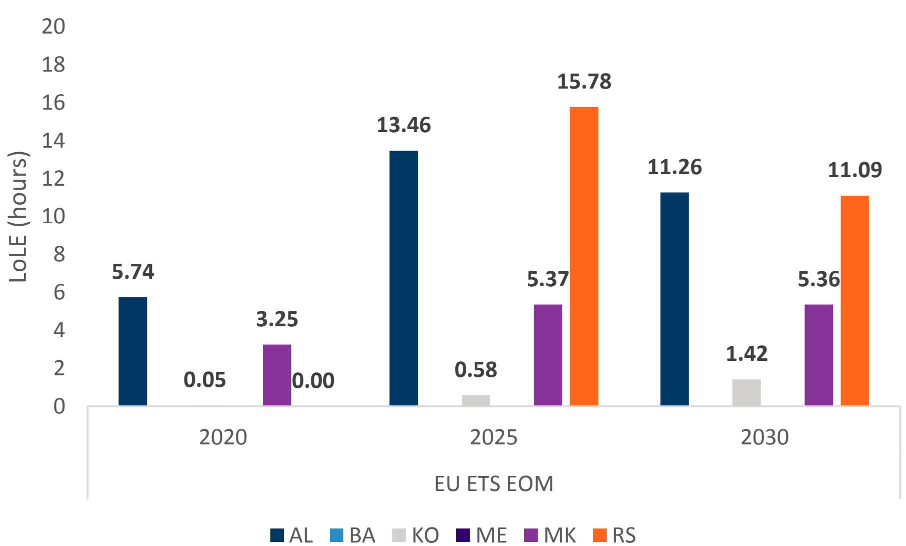
Preliminary results in the Base case scenario show that adequacy issues are almost entirely avoided in WB6 countries.

Results are aligned with the static adequacy analysis.

Preliminary security of supply results in WB6 in the EU ETS 2025 EOM scenario shows adequacy concerns in several WB6 countries

- We calculate the full (un)availability distribution matrix of WB6 using a stochastic multi-area Loss of Load Probability (LOLP) calculation using a probabilistic convolution algorithm
- It gives relevant results to assess the adequacy situation in WB6, in particular the **Loss of Load Expectation**, i.e. the expected number of hours per year when demand cannot be fully met by generation and import
- So far, these simulations have been run for a **limited number of years and scenarios** given the duration required for each run (about 24 hours)

Loss of Load Expectation for WB6 countries, in the EU ETS 2025 scenario (number of hours per year)



Preliminary results in the EU ETS 2025 EOM scenario show that adequacy issues occur upon economic closure of existing lignite plants

Albania, North Macedonia, Serbia, and to a lesser extent and Kosovo*, experience LoLE above 3 hrs

Content of the presentation

WB6 adequacy assessment key findings

➢ **The further integration of the WB6 power systems rules into European energy framework would have a structural impact on WB6 power systems and future adequacy:**

- While in the Base Case scenario under WB6 current emission regulation (e.g. LCPD and no EU ETS implementation), WB6 countries experience no adequacy concerns until 2030, and new investments currently in the pipeline would be economic in an energy only market.
- In a fully coupled power market system, as soon as the EU ETS is introduced in WB6, new and existing lignite plants would not be economic, leading to the closure of c3GW of lignite plants by 2025 and 4GW by 2030, or more than half of the existing lignite capacity, materially endangering the security of supply of WB6.
- Constrained cross-border interconnections with neighbouring countries would slightly reduce the economical closure of WB6 power plants (by c500MW) but would still lead to material security of supply concerns.

➢ **This looming capacity gap and security of supply concerns justifies the need to implement a CRM, especially considering further integration into the European energy system**

Content of the presentation

Critical Thinking at the Critical Time ™

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Content of the presentation

Appendix

To account for the regional impact on the WB6 power markets, we developed a regional power market dispatch model

Granularity of market modelling for the different countries

WB6 countries: Detailed modelling on a plant-by-plant basis

Countries interconnected with WB6 countries: Aggregated modelling on a technology level based on ENTSOE forecasts

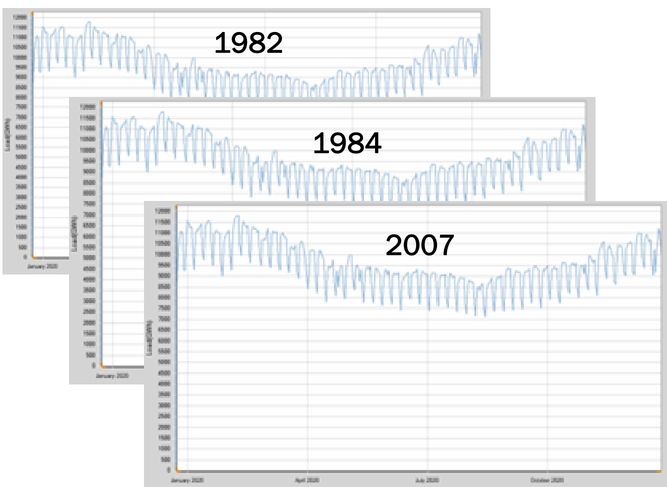
Other countries: Not modelled (only the import/export volumes with the “blue countries” are considered, based on historical data)

Our simulations are based on a range of possible supply-demand situations up to 2030

Existing system 2020 2025 2030

Sample approach

1) Demand and RES generation



Random draw of climatic year among 34 samples to define demand level, wind and PV time series and hydro conditions

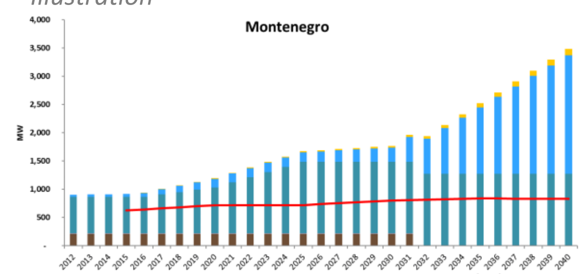
2) Availability of thermal units

Random outage draw for thermal units

Medium- and long-term scenarios for market fundamentals

- Supply outlook
- Demand outlook
- Cross-border capacity outlook

Illustration



Base case scenario for **demand** is based on the latest TSOs' publications

- The evolution of demand (peak demand and annual consumption) is based on the **latest scenarios considered by TSOs in their national network development plan** and their adequacy study when it exists
  - These scenarios represent the most up-to-date information and market developments, in particular compared to the MAF18 and TYNDP18
  - When several scenarios are considered, the **base case scenario** is considered as a reference
  - National network development plans are usually studied for 10 years: demand forecast can then be defined up to **2027-2028**
  - For the period 2028-2030, **the same growth as in the previous years** is assumed

- Moreover, to make the adequacy study as comprehensive as possible, **hourly demand forecast** are used based on the three publicly available samples released by ENTSOE, corresponding to climate years **1982, 1984 and 2007**

Base case scenario for **generation outlook** is based on the latest TSOs' publications and updated 2030 RES target

- For WB6 countries and for all technologies (renewable, nuclear and fossil-fuel technologies), our assumptions are based on the **latest scenarios considered by TSOs in their national network development plan** and their adequacy study when it exists updated with 2030 RES target communicated by Energy Community secretariat
  - These scenarios represent the most up-to-date information and market developments, in particular compared to the MAF18 and TYNDP18
  - When several scenarios are considered (e.g. green scenario, coal scenario…), the **base case/realistic scenario** is considered as a reference
  - Given TYNDP goes only to 2027-28, for the period 2028-2030, when data is not available from the TSO or other references, as a preliminary assumption, we consider that:
    - Evolution of RES and hydro capacity follows the same trend as in the previous years
    - Existing thermal plants are not decommissioned between 2028 and 2030
- **Assumed 2030 RES target communicated by Energy Community secretariat are the following:**

	Albania	BiH	Kosovo*	N. Macedonia	Monenegro	Serbia
2020	90.7%	59.6%	14.3%	26.8%	51.4%	36.6%
2025	90.7%	63.5%	15.7%	29.7%	55.3%	40.0%
2030	90.7%	67.4%	17.2%	32.6%	59.2%	43.4%

- For neighbouring countries, an **aggregated modelling on a technology level** is suggested. Assumptions on installed capacity for each technology are based on the **ENTSOE forecasts** (MAF and TYNDP)

Adequacy assessment considers differently expected investments in RES and in thermal plants

- As the aim of the adequacy study is to assess the incentives sent by the current energy-only market to invest in new plants (if needed), **future investments considered by the TSOs in their national development plans should not be taken as a given in our study**
  - The main idea is to assess whether there is an adequacy issue without new investments and, if so, **whether energy prices are high enough to send investment incentives** (or if a CRM should be implemented)

- More precisely, in our study, we distinguish between **merchant-based capacity and non-merchant-based capacity**

Merchant-based capacity

- Main revenues come from the wholesale energy market
- Investments are then **highly dependent on the power prices** and its evolution
- New investments should be made only if their NPV is positive
- E.g. : **thermal units, large hydro**

Expected investments **are not considered*** as they highly depend on revenues made on the energy market

Non merchant-based capacity

- Main revenues are not related with the wholesale market, e.g. **subsidies, PPA contracts**...
- Investments are then independent from incentives sent by the market and will be made regardless of market conditions (they mainly result from policy decisions)
- E.g.: **Wind, PV, small hydro**

Expected investments **are considered** in the adequacy study

** This assumption can be modified for plants financed through a PPA contract or other non-market-based instruments.*

- Similar assumptions will be taken regarding **refurbishment decisions** for thermal plants: they are considered only if they are economically justified

Cross-border development are based on the latest TSOs' assumptions

- The evolution of cross-border capacity is based on the **latest scenarios considered by TSOs in their national network development plan**
- The consistency of cross-border capacity forecasts between neighbouring TSOs is tested: in case of misalignment, the most conservative forecast is considered
- Moreover, impacts of these assumptions on adequacy results are tested considering a sensitivity scenario with **constrained cross-border interconnections** between WB6 and neighbouring countries