Analysis of the New Portuguese and Spanish NECPs using CEVESA market model

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***Abstract*— The recent updates of the National Energy and Climate Plans (NECPs) for Portugal and Spain have some significant changes compared to the previous 2019 versions, especially for the Portuguese side where a greater demand and renewable generation capacity are foreseen. This work assesses the impact of these new plans on the Iberian electricity market (MIBEL) main outcomes using CEVESA market model. Simulation results allow the analysis of the expected generation mix and prices, CO_2 emissions, system cost, system adequacy, interconnections capacity usage, H2 demand impact and its contribution to provide balancing flexibility, under different simulation scenarios.**

***Index Terms*— National Energy and Climate Plans, CEVESA, MIBEL, Market model, Electricity prices.**

I. Introduction

The European Union (EU) has set ambitious targets for energy transition and climate neutrality, as outlined in the European Green Deal [1] and the Fit for 55 package [2]. Central to these efforts are the National Energy and Climate Plans (NECPs) [3], which serve as strategic frameworks for member states to align their energy and climate policies with EU-wide objectives. These plans are periodically revised to reflect evolving technological, economic, and policy landscapes. In 2024, Portugal and Spain published updated versions of their NECPs [4], [5], revising the original plans submitted in 2019. Among other, these revisions introduced new targets for renewable energy (RE) deployment, industrial demand growth, and the integration of hydrogen as a key component of the energy system.

The updated NECPs for Portugal and Spain emphasize significant increases in RE capacity, particularly wind and solar, as well as the development of hydrogen production infrastructure. These changes are expected to influence market dynamics, including electricity prices, generation mix, CO_2 emissions, and the utilization of interconnection capacities. Additionally, the inclusion of hydrogen as a highly flexible demand source provides a new flexibility tool for balancing the grid and enhancing the penetration of variable renewable generation.

This work builds on previous studies [6], [7], which analysed the new draft of the NECPs for Portugal and Spain using the CEVESA model [8], [9], [10], [11]. By extending this analysis to the new NECPs and considering together both the Portuguese and Spanish power systems, highly interconnected, this paper provides insights into how the revised targets for installed capacity, RE penetration, industrial demand, and hydrogen generation will affect the MIBEL's market.

The remainder of this paper is structured as follows: Section II describes the CEVESA model and its application to the MIBEL. Section III provides defines the case study scenarios with an overview of the updated NECPs for Portugal and Spain, highlighting key changes and their implications. Section IV presents the simulation results of the case study scenarios and discusses the implications of the results. Finally, Section V concludes the paper with some policy recommendations and directions for future research.

II. Data Gathering and Methodology

CEVESA is a long-term market model for the MIBEL. It jointly dispatches energy and secondary reserve, integrating hydro and thermal generation units. It can also consider investments in both utility-scale and behind-the-meter distributed generation (DG). The model has hourly resolution and includes the main operational technical constraints of conventional thermal units. Demand, RE and non-dispatchable technologies are modelled using their hourly generation profiles, while water units are optimized on a weekly basis, with energy and reserve generation weekly constraints derived from historical data. Nuclear units, which usually operate continuously at maximum capacity in Spain (given that Portugal has no nuclear generation), are also represented.

CEVESA models single-price zones dispatching the energy exchanges between Spain and Portugal and implementing market splitting when interconnection capacities are fully utilized.

To evaluate the impact of the updated Portuguese and Spanish NECPs, CEVESA was recalibrated using the latest available historical data for 2023, and 2030 scenario was built by incorporating the revised targets outlined in the updated NECPs. Table I provides an overview of the primary data sources utilized in this process.

TABLE I. USED DATA SOURCES.

DATA	SOURCE
Thermal UOF decommission years	Previous work [6] and news articles [12], [13]
Historical data for RES profiles (solar, solar thermal, wind, small hydro plants, cogeneration, and other technologies)	OMIE [14] and SIMEE [15]
Historical Net Transfer Capacity (NTC) values	ENTSO-E [16]
Historical Hydro data	PHOF program [17] and P48 program [18]
CO_2 allowances	Portuguese updated NECP [3], Sandeco2 [19] and [20]
Dutch TTF spot prices	[21] (up until 2023)
Forecasted NTC	NECPs [3]
Historical Hourly Demand	[22]
Forecasted Demand	NECPs [3]
Installed Capacities for RES and other (non-thermal and hydro)	NECPs [3]

In addition, the 2030 hourly demand profile was adjusted to accommodate the higher system electrification, namely of the industrial type, that is expected to be almost constant (due to industry, data centres, etc.). The methodology used for this adjustment is described in [7]. Historical CO_2 allowances and fuel prices also follow the methodology described in [7], with historical values updated to the most recent available data – 2023. Future Co2 allowances are calculated using historical data and are projected up to 2030 following the methodology described also in [7].

III. CASE STUDIES' SCENARIOS

To assess the impact of the updated NECPs on the MIBEL, three distinct scenarios were developed – one historical scenario as a baseline and two future projections for 2030, as planned on the NECPs. These scenarios allow for a comparative analysis of how the different NECP versions compare with one another. They are as follows:

A. Historical Scenario

This scenario serves as a baseline, reflecting the current state of the MIBEL based on historical data from 2023. It includes the existing generation mix, demand patterns, and interconnection capacities between Portugal and Spain. The Historical Scenario provides the current reference from which the Old and New NECP scenarios evolve. Key features of this scenario include:

- Existing installed capacity for 2023 of RE and conventional generation technologies.
- Historical hourly profiles for 2023 for different generation technologies and demand.
- Existing interconnection capacities for 2023 and their utilization patterns.

This scenario does not incorporate any future policy targets or assumptions, allowing for a clear comparison with the other scenarios.

B. Old NECP Scenario

The Old NECP Scenario reflects the objectives and targets outlined in the initial NECPs for Portugal and Spain, as designed in 2019. This scenario represents the transitional phase between the current system and the updated policy framework. It includes:

- The planned increases in RE capacity (wind, solar, and hydro) as per the 2022 NECPs.
- Projections for industrial demand growth and electricity consumption based on the initial NECPs.
- The integration of hydrogen as an emerging flexible demand component, albeit at a preliminary stage (compared with the latest NECP versions).
- Interconnection capacity expansions and upgrades planned under the original NECPs.

This scenario provides insights into how the MIBEL would have evolved under the initial policy framework, serving as an intermediate benchmark for comparison with the New NECP Scenario.

C. New NECP Scenario

The New NECP Scenario incorporates the updated targets and objectives outlined in the revised NECPs for Portugal and Spain, published in 2024. This scenario represents a most ambitious vision for the MIBEL, with significant changes compared to the Old NECP Scenario. Key elements of this scenario include:

- Substantially higher targets for RE capacity, particularly wind and solar, to achieve greater decarbonization – 81.4% increase on for Portugal and 31.5% increase on for Spain.
- Increased industrial demand projections, reflecting accelerated electrification and economic growth – total demand increase of 13%.
- A prominent role for hydrogen as a flexible demand source, including dedicated infrastructure for hydrogen production and storage – which was not considered in the old NECPs.
- Interconnection capacity expansions and upgrades planned under the latest NECPs – new NECPs values are the same as old NECPs for 2030.

The New NECP Scenario aims to capture the full impact of the updated policy framework on the MIBEL, including its implications for generation mix, electricity prices, CO_2 emissions, and system flexibility.

The following section presents the simulation results derived from these scenarios, focusing on key metrics such as generation mix and market prices.

IV. Simulation and Results

This section entails the key results of the simulated scenarios described in section III. Figure 1 illustrates the aggregated electrical and hydrogen demand by scenario.

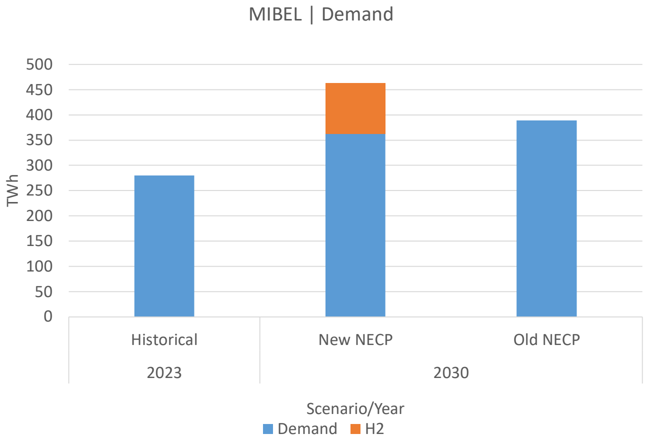

Figure 1 – Aggregated electrical and H_2 demand by scenario.

As can be seen, both NECPs expect a higher system electrification which, consequently, increases the demand values for 2030 when compared to 2023 scenario. However, the New NECP considers H_2 flexible demand whereas the original NECP (Old NECP) did not. Overall, the new NECP considers a higher system electrification than the old NECP.

Figure 2 illustrates the total generation by technology for each scenario (C – Coal, CC – Combined Cycle, CHARG – Battery charge, Cog – Cogeneration, DCHARG – Battery discharge, ENS – Energy not supplied, Excess – Energy surplus, Hydro – Hydro generation, NU – Nuclear, Others – Other technologies, Pump – Hydro pumping, Solar – Solar photovoltaic, Solar T – Solar Thermal, Spill – Renewable spillages, Wind – Wind generation).

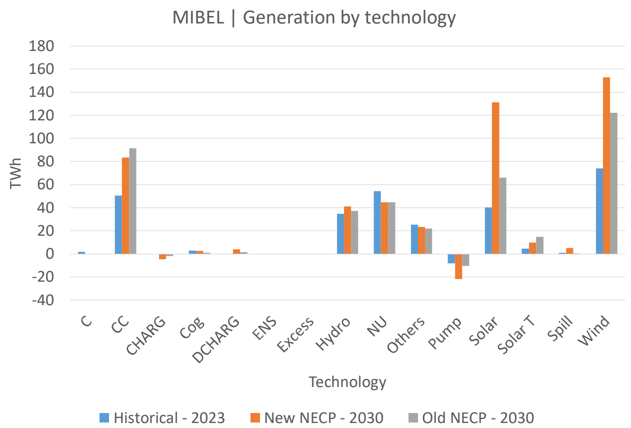

Figure 2 – Total generation by technology and scenario.

It is possible to notice that the low system flexibility on scenario Old NECP allied with the low RE capacity, when compared to the New NECP, makes Combined Cycle (CC) generation produced more. On the other hand, the lower RE capacity on the Old NECP scenario, decreases the RE spillages (spill) when compared to the New NECP scenario. The high installed capacity of RE in the New NECP scenario, allied with the higher pumping and hydro installed capacity, contributes to the increase of the spillages and the charging/discharging batteries cycle. This means that the increased flexibility of the New NECP, even with H_2 and storage, seems to be not enough to accommodate all the RE.

When compared to the Historical scenario, it is possible to notice that both NECP scenarios increase the CC generation for 2030. This is due to the higher electrification, but also to the planned decommission of some nuclear units (as can be seen in Figure 2).

Figure 3 illustrates the hourly average market price by scenario.

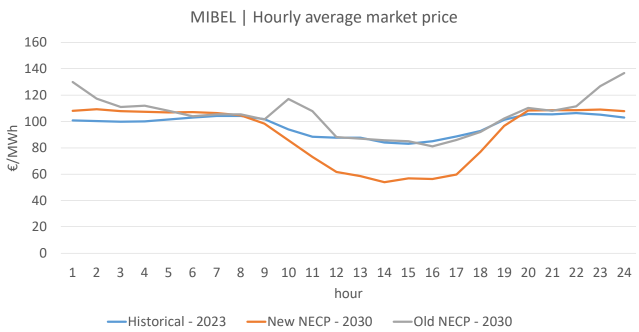

Figure 3 – Hourly average market price by scenario.

The higher installed capacity of solar and wind technologies decreases the hourly average market price mainly in the intermediate hours of the day, where solar irradiance is at its maximum. This effect is more evident in the New NECP scenario, that has the highest installed capacity of RE technologies. Nevertheless, the weekly hydrogen demand from the New NECP scenario increases system flexibility and flattens the market price, reducing the typical duck-shape curve. Details on this effect can be found on an already existing studied done in [7].

Figure 4 illustrates the number of hours with null price by scenario.

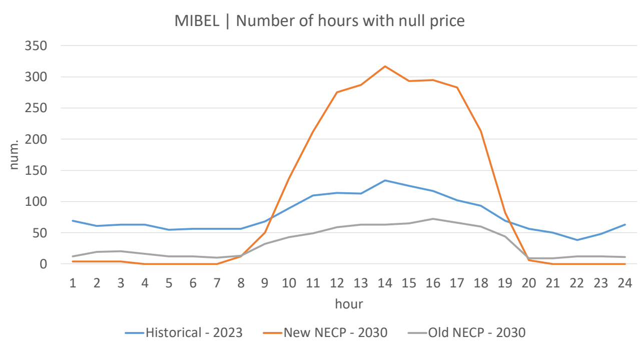

Figure 4 – Number of hours with null price by scenario.

As expected, the higher installed capacity of RE technologies, mainly solar, increases the hours with null price when the solar technology becomes marginal. This is more prominent in the intermediate hours of the day, where solar irradiance is high, being more evident in the New NECP scenario. When looking at the Old NECP scenario it is noticeable that high system electrification along with the low investments on RE (when compared to the New NECP scenario) does not lead to so much null-price hours when compared to the Historical 2023 scenario.

Figure 5 illustrates the estimated number of startups and shutdowns of CC units for each scenario.

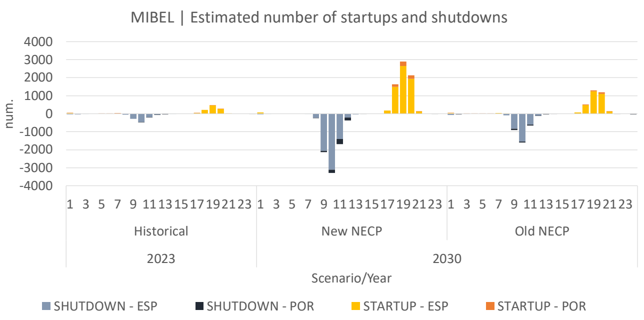

Figure 5 – Estimated number of startups and shutdowns of CC units.

Comparing both NECPs scenarios to the historical scenario it is noticeable that the number of startups and shutdowns of CC units increases, with CC units shutting down mainly at the hours of higher solar irradiance and starting up mainly at the end of the day when demand increases and RE decreases. The New NECP scenario shows a higher number of startups and shutdowns compared to the Old NECP scenario, due to its higher RE share that force additional CC cycling due to RE intermittency.

Finally, Figure 6 illustrates the CO_2 equivalent emissions by scenario.

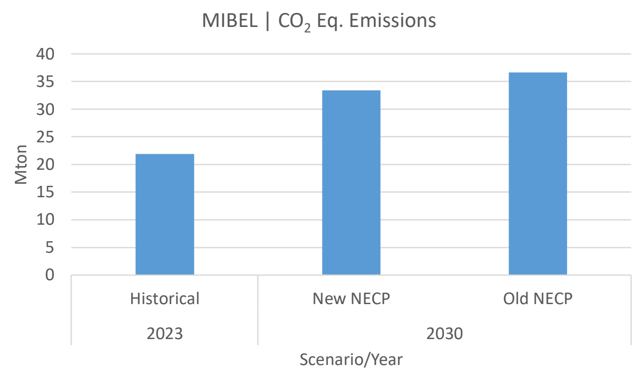

Figure 6 – CO_2 Equivalent emissions

Both NECP scenarios have higher CO_2 equivalent emissions when compared to the historical scenario, since Figure 2 already showed larger CC productions in these scenarios due to the larger demand. Nevertheless, introducing hydrogen in the system (on New NECP scenario) increases system flexibility and helps reducing CC generation and the corresponding CO_2 emissions when comparing to the Old NECP scenario.

V. Conclusions

This study provides a comprehensive analysis of the impact of the updated National Energy and Climate Plans (NECPs) for Portugal and Spain on the Iberian electricity market (MIBEL) using the CEVESA market model by simulating three distinct scenarios: Historical, Old NECP, and New NECP. The findings underscore the significant role of RE deployment, industrial demand growth, and hydrogen integration in shaping the future of MIBEL.

The Historical Scenario serves as a crucial reference point in evaluating the evolution of the market. By reflecting the market conditions of 2023, this scenario provides a baseline against which the impacts of the Old and New NECPs can be assessed.

The New NECP Scenario, with its ambitious targets for renewable energy (RE) capacity and hydrogen production projected to 2030, demonstrates a clear pathway toward decarbonization and enhanced system flexibility. The results reveal that the increased penetration of wind and solar technologies, coupled with hydrogen as a flexible demand source, leads to a reduction in average market prices. However, the higher RE capacity also results in increased spillages and a greater number of hours with null prices, particularly during peak solar generation periods. This highlights the need for further developing storage and grid flexibility to fully harness the potential of RE.

In contrast, the Old NECP Scenario, which reflects the original 2019 targets projected to 2030, shows a more modest impact on the market dynamics. The combination of lower RE capacity, reduced demand, and the absence of explicit hydrogen demand in this scenario results in greater dependence on combined cycle (CC) generation and fewer hours with zero prices. This scenario serves as a valuable benchmark, illustrating the incremental progress achieved under the initial policy framework and the transformative potential of the updated NECPs.

In conclusion, this study underscores the critical importance of ambitious and well-designed energy and climate policies in driving the transition toward a sustainable and resilient energy system. The updated NECPs for Portugal and Spain provide a robust framework for achieving these objectives, but their success will depend on continued innovation, investment, and collaboration across the energy sector.

Acknowledgment

This work is financed by China Three Gorges International-New Business Development & Research Centre, whose support has been crucial in shaping the broader objectives and outcomes of this research. The study aligns with the objectives of the New Business Development & Research Centre, particularly within the domain of new business origination and the assessment of technical and market operational performance. In Europe, CTG stands as a relevant promoter of renewable energy, with an

installed capacity up to 2 GW, between solar and wind assets, in Germany, Grece, and mainly in Spain.

CTG recognizes that the rapid evolution of energy markets, particularly in the Iberian Peninsula, is driven by increasing renewable penetration, the phase-out of firm capacity, and growing market volatility. These dynamics create an urgent need for independent power producers (IPPs) to enhance their understanding of market trends and future scenarios, enabling them to optimize both investment decisions and asset operation strategies. Moreover, CTGE believes that a decarbonized energy system, coupled with the increasing integration of renewable assets and heightened market volatility, demands sophisticated modeling and simulation capabilities.

This work is conducted as part of CTGE's "Power Market Analysis in Iberia" project, whose objective is to provide CTGE with the analytical tools and strategic insights necessary to navigate the evolving MIBEL. Projects like this are vital in today's energy markets context, where the accelerated deployment of renewable energy sources and the push for carbon neutrality present both opportunities and challenges for market participants. For CTGE, the insights derived from this work are not only aligned with its strategic goals of expanding renewable energy portfolios but also essential for maintaining a competitive edge in a market undergoing significant regulatory and technological transformations.

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