Weekly Summary

Economics of Climate Change

March 14, 2025

The power grid, the overlooked cornerstone of the energy transition

The divide in Spain's electricity landscape, the lack of storage and the intermittency of renewables pose great challenges to optimizing electricity generation from clean energy sources. In recent years, most efforts have focused on increasing the installed capacity of wind and solar power, but their integration into the electrical grid also plays a key role in the energy transition.

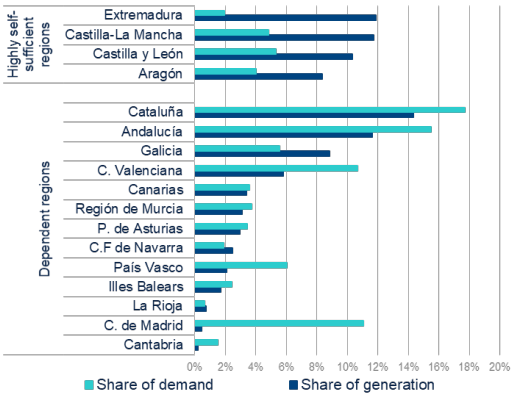
Spain's electricity landscape reveals a stark territorial divide: bustling urban areas consume far more energy than they produce, while other regions generate surpluses that keep the lights on nationwide. The highly self-sufficient regions[1] produced 42% of the total electricity generated in Spain in 2024, while they only consumed 12.1% of the total electricity demanded in 2024 (**Fig 1**). This mismatch existed before the introduction of renewables in Spain, but the effects of the delocalization of electricity supply and demand have been exacerbated by the high variability of renewables. This situation calls for improvements to the electrical grid to prevent bottlenecks that could hinder the supply of renewable electricity.[2] Moreover, a higher concentration of renewable energy generation—aimed at leveraging Spain's natural endowments and meeting the expected increase in electricity demand—could exacerbate negative effects, ultimately diminishing the positive impact of renewables on electricity prices.

Regional electricity 'autonomy' gap. In 2024, Spain's capital region consumed 27,487 GWh of electricity but produced only 1,213 GWh, covering a mere 4,4% of its demand. Other high-consumption regions include Catalonia (85% of its demand), Andalusia (79%), The Valencian Community (57%) and Cantabria (14%). These areas, home to major cities and industrial hubs, rely heavily on electricity imported from less populous regions or other countries. **By contrast**, Extremadura, a sparsely populated region, generated more than 6 times its own consumption -31,108 GWh versus 4,800 GWh demanded. Its surplus, driven by solar farms and the Almaraz nuclear plant, powers other Spanish regions (11,9% of total electricity supply in Spain is produced by this community). Similarly, Castilla y León (206% surplus), Castilla-La Mancha (255%) and Aragón (219%) leverage wind and solar to offset urban and industrial supply deficit (**Fig 2**).

1: It includes Castilla-La Mancha, Extremadura, Castilla y León and Aragón, with a production-to-demand ratio above 200%. All other regions are considered 'dependent'

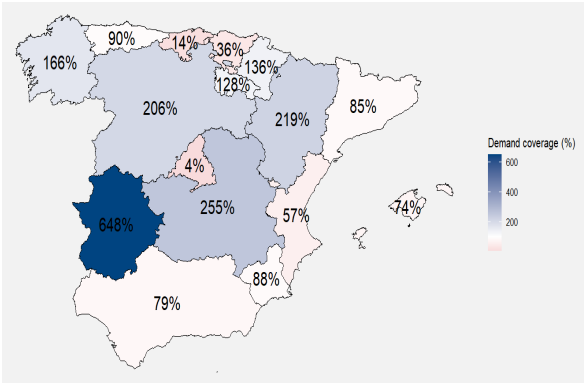
2: How grid operators can integrate the coming wave of renewable energy

Figure 1. **Spanish regions. Electricity demand and supply.** %. 2024



Source: BBVA Research from REData.

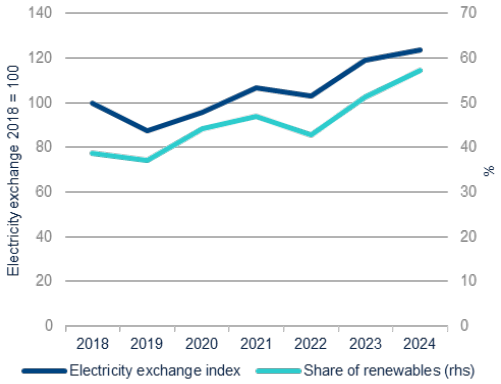
Figure 2. **Spanish regions. Electricity demand coverage[3]**. 2024



ource: BBVA Research from REData.

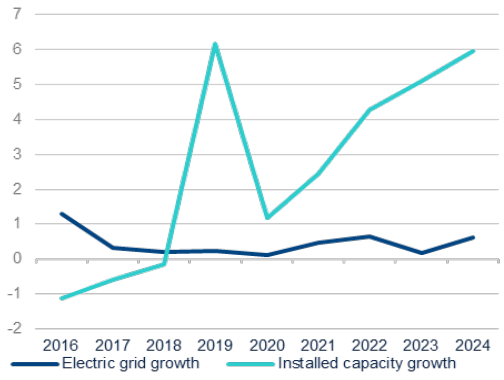
The Spanish installed capacity of renewable energy had grown significantly in the last 5 years, leading to an increase in the electricity exchange across regions. Even though the length of the high-voltage transmission lines had not. The concentration of renewable energy in a few regions with abundant sun and wind[4] necessitates the transmission of electricity from these sources to transformation substations near consumption sites, which in turn creates challenges related to power transmission (**Fig 3)**. This supply concentration, together with the new technical challenges posed by renewables, calls for improvements to the power grid to ensure the efficient transport of the generated electricity, an improvement that has not been observed, at least in the length of the high voltage grid (**Fig 4**).

Figure 3. **Interregional electricity exchange[5] and the share of renewables.** Index



Source: BBVA Research from REData.

Figure 4. **Evolution of installed capacity and electrical grid[6] (%)**



Source: BBVA Research from REData.

3: The demand coverage is estimated as the production per region divided by its demand. Notice that this does not imply that one region consumes all the electricity that they generate. As there is no available data of electricity flows in Spain across regions, we don't know how the electricity generated by each region is split across the Iberian Peninsula or if it is exported.

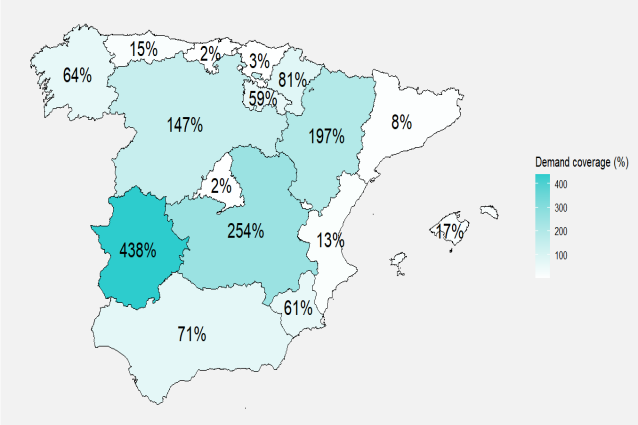
4: Renewables: Wind north, solar south -strong growth yet falling short of targets | BBVA Research. March 7, 2025.

5: Electricity exchanget = Σi|Productiont,i - Consumptiont,i|; i = region ; t = year. As was specified before, there is no data available of electricity flows, but it could be understood that there might be a positive relation between the gap of production and consumption of all the Spanish regions and the electricity that needs to be transported. Nevertheless, due to lack of data, the level of geographical and temporal granularity are not optimal. Therefore, this index has to be interpreted carefully.

6: Is considered as an electrical grid the circuit of km of the national transmission grid over 220 kV.

The geographic shift in renewable energy generation places it far from historically high-demand areas, further exacerbating challenges related to electricity transmission. When looking at the demand covered by electricity generated from renewable sources in each region (**Fig. 5**) compared to the demand covered by electricity generated as a whole (**Fig. 2**), it can be seen that the regions most affected are precisely those with the highest electricity demand, such as the industrial corridors along the Cantabrian and Mediterranean coasts. As the share of renewables in total electricity generation is expected to continue to increase, the relevance of potential bottlenecks in the electrical grid would be higher.

Figure 5. **Electricity demand coverage with renewables by CCAA.** 2024

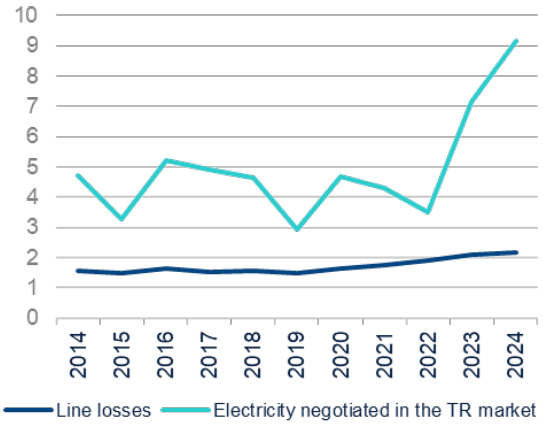


Source: BBVA Research from REData.

The congestion of the electrical grid, combined with the lack of storage made Spain to waste around 1% of its renewable energy in 2023, according to ACER[7]. The technical constraints market aims to match electricity generation to the quality, reliability and security requirements that must exist in the electricity generation market. Since renewables began entering the market, the volume of energy traded there has increased (**Fig 6**). This has two negative effects, one on prices and the other on the environment. Firstly, it has an upward effect on wholesale electricity prices, since it means that a new item is added to the market price, attributable to the payment for the electricity that has to replace the curtailed one. In the last few years, the share of the wholesale price that can be attributed to the technical restrictions have been increasing, reaching 20% in 2024 (**Fig 7**). In addition, most of the energy sources that enter this market are manageable sources, including fossil fuels, which increase the emissions of the power sector as a result of the renewables curtailment.

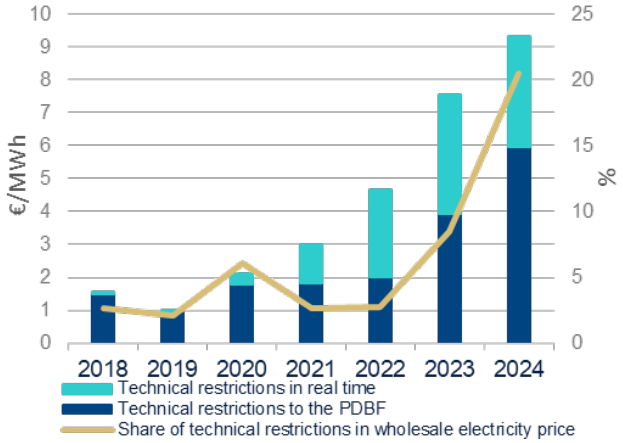
7: Transmission capacities for cross-zonal trade of electricity and congestion management in the EU

Figure 6. **Shares of wholesale electricity loss and negotiated in technical restrictions markets** %



Source: BBVA Research from REData.

Figure 7. **Effect on prices of the technical restrictions markets.** €/MWh and %



Source: BBVA Research from REData.

In recent years, most efforts have been made to increase the installed capacity of renewables, but their integration into the electrical grid also plays a key role in the energy transition. According to the IEA[8], 0.7€ has to be invested in the electrical grid per 1€ invested in renewables. This number is above the target in the PNIEC, 0.45€ per € invested in renewables[9]. **Improvement is needed in this area, because an increase in the installed capacity without an improvement of the electrical grid would have a negative effect on the profitability of renewable projects, which could discourage further investment**. Countries are starting to make nationals grid a key priority, but now they are facing problems in the supply chain, which is becoming a limiting factor, according to the IEA[10]. Nevertheless, permitting remains as the primary cause of the transmission project´s delays.

All in all, Spain has a competitive advantage over other European countries due to its abundant renewable resources, positioning it well to lead the transition to cheaper and cleaner energy. This energy transition poses many challenges, two of which are to enlarge and to adapt the grids to the new circumstances of renewable energy[11]. On the one hand, adaptation, because the new renewable sources cause problems in the current grids due to their intermittency, which is leading to the creation of smart grids[12] capable of minimising this problem. On the other hand, an enlargement[13] is also needed to increase the amount of electricity that can be transported, since, according to the PNIEC target, electricity demand have to increase by 43% over the next 6 years[14].

8: Papel de las redes eléctricas en la transición energética, industrial y digital
9: Moreover, the objectives of the PNIEC weren't feasible before mid-2024, because there was a limit of investment in the electrical grid established by the government in 2013. This limit was recently removed in order to enhance the investment in the electrical grid.
10: Building the Future Transmission Grid
11: Electricity Grids and Secure Energy Transitions
12: Smart Grids and their role in energy decarbonisation
13: El mundo necesita una red eléctrica de 152 millones de kilómetros, la misma distancia que hay entre la Tierra y el sol
14: The PNIEC target is a 34% increase in the electricity demand by 2030 vs 2019. In the last few years, the electricity demand has decreased in Spain, thus, the demand will have to increase 43% compared to the electricity demand observed in 2024.

Highlights of the Week

- **Global | The Net Zero Banking Alliance is worth saving**. Change in requirements may help the body to broaden membership.
- **Global | Rising component prices and supply chain pressures are hindering the development of transmission grid infrastructure - News - IEA.** Global grid expansion is struggling to keep pace with surging demand for electricity as procurement lead times and costs for essential parts have nearly doubled since 2021.
- **USA | U.S. Energy Secretary Pledges to Reverse Focus on Climate Change - The New York Times.** To applause from oil and gas executives, Chris Wright said natural gas was preferable to renewable energy and climate change was a "side effect of building the modern world."
- **USA | E.P.A. Targets Dozens of Environmental Rules as It Reframes Its Purpose - The New York Times.** Lee Zeldin, the E.P.A. administrator, said the agency's mission was to make it cheaper to buy cars, heat homes and run businesses.
- **South America | Extreme Weather Events, Agricultural Output, and Insurance: Evidence from South America.** While insurance could help protect farmers against severe losses, coverage in the region is low, and barriers remain high.
- **Europe | From flood to fire: is physical climate risk taken into account in banks' residential mortgage rates?.** On average banks seem to demand a physical climate risk premium from mortgage borrowers and the premium has increased over recent years. However, there is significant heterogeneity in bank practices.

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