APE

APPUNTI DI ENERGIA

THE OVERCOMING OF PUN

May 2024

APE on DAM

Briefly

Italy is the only European zonal Day-Ahead Market (DAM) where buyers pay energy at a uniform purchase price, called PUN – *Prezzo Unico Nazionale*, regardless of the zone in which they are in, while selling offers are subject to the price of the zone to which they refer. The European Commission has requested Italy to **phase out the PUN from 2025**, aiming for greater harmonization of the European internal market. **Therefore, starting from 2025, only zonal prices will be in place in Italian's DAM**. What could be the impact of phasing out the PUN on electricity markets? What would have happened in the past if there hadn't been the PUN? And in the future, how will price differentials between market zones be?

History of PUN

The Italian electricity system is characterized by the presence of **multiple market zones**, unlike most other European countries, which are primarily characterized by a single zone. Market zones correspond to areas of the electricity system that are interconnected by transmission lines that are most frequently subject to capacity saturation, known as "congestion." If there is a flow of electricity between two zones that does not saturate the interconnection capacity, the two zones will have the same market price, effectively forming a single macro-market zone.

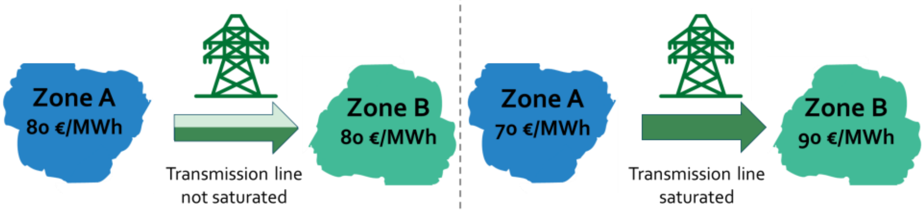


Figure 1. Example of price formation in the case of a non-saturated line (on the left) or a saturated line (on the right).

When the interconnection capacity between two market zones is saturated, these zones separate, creating a price differential: the exporting zone will be characterized by a lower price, while the importing zone will experience a higher price. Due to congestions, a higher price will occur in the importing zone because it is not able to import all the energy needed from the exporting zone characterized by a lower price.

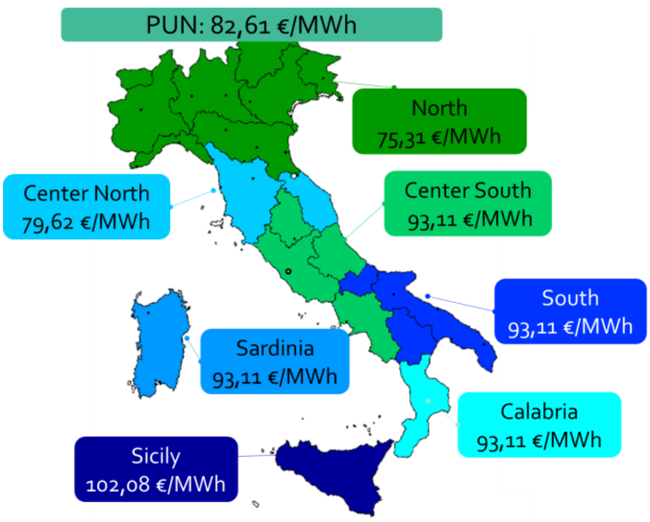


Figure 2. Zonal prices and PUN of 1 June 2021 at 11pm. ***Source: RSE processing of GME data.***

The **Uniform Purchase Price (PUN)** was introduced from the beginning of the Italian Electricity Market to **overcome, from the buyer's point of view, the price differences between zones**, thus avoiding gaps among consumers caused mainly by an uneven localization of generation plants on the peninsula, characterized also by different efficiencies, along with limited network transport capacity, unable to flow all the required energy from low-price zones to high-price zones.

[1] With the exception of pump purchases, foreign zones, and storage systems, provided that the electricity withdrawn through the respective connection point is solely intended to power auxiliary services and storage systems.

Market outcomes (GME)

The PUN is the purchase price to which all energy buyers (traders, large consumers) accessing DAM[1] are subject, regardless of their market zone of origin. Consequently, while sellers are subject to a zonal price (dependent on the market zone in which they submit sales offers), buyers see the same purchase price, regardless of their specific market zone of origin. The PUN is an hourly price that corresponds to the average of zonal prices in DAM weighted by the total purchase volumes subject to the PUN.

Historically, zonal prices have always exhibited differences.

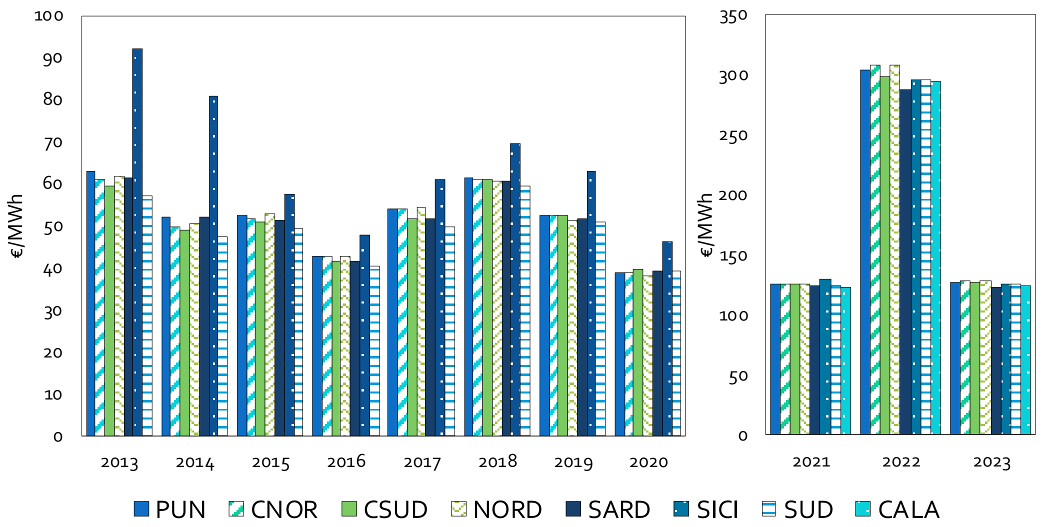


Figure 3. Annual average of zonal price and PUN. *Source: RSE elaborations on GME data.*

Historical analysis

Historically, the Sicily bidding-zone has been characterized by higher prices, due to limited interconnection capacity with the rest of the country. The interconnection saw an initial expansion in 2016, with further significant developments expected upon the future commissioning of the new "Tyrrhenian Link" high-voltage direct current submarine cable, connecting Sicily with the mainland and Sardinia.

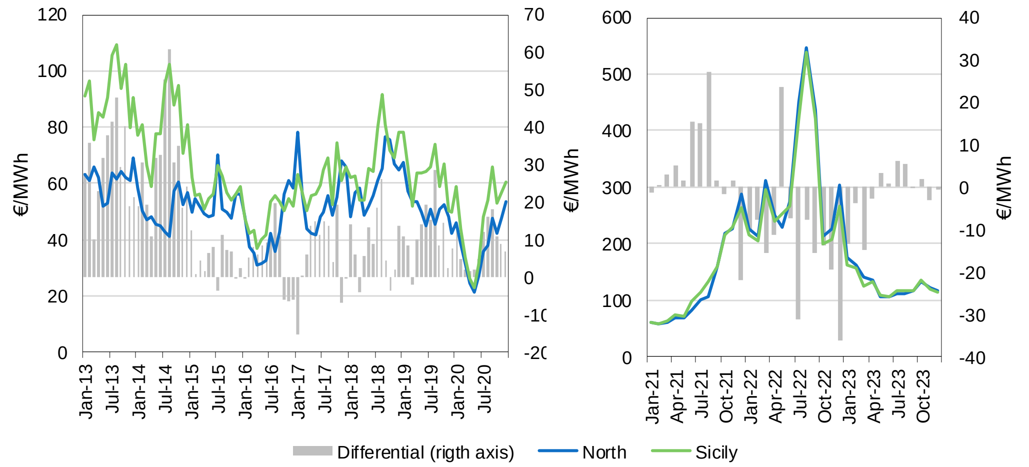


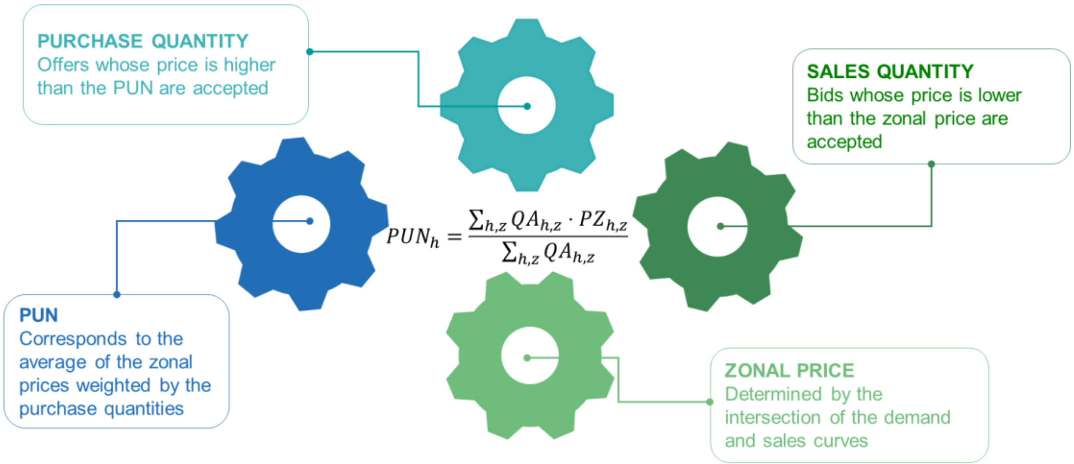
Figure 4. Annual average price of North (blue line), the Sicily (green line), and the trend of the price differential between the Sicilian zone and the Northern zone. *Source: RSE elaborations on GME data.*

Over the years, price differences between zones have changed, but they still exist today, and they are the reason why the PUN has continued to exist.

What if the PUN had not been there?

To better understand the impact that the PUN has had on Italian consumers, a methodology has been developed to compare the outcomes of the Italian market with the PUN and a theoretical purely zonal Italian market for the years 2019, 2022, and 2023. **The developed analysis aims to show how the solution may change depending on whether the constraint of the PUN is taken into account or not.**

Indeed, without this constraint, not only the purchase price can differ, but also the selling price and the accepted volumes. This occurs because in the electricity market, purchase bids with a price higher than the market clearing price (or sales offers with a price lower than the market clearing price) are accepted. Considering a new reference price for purchases (the zonal price rather than the PUN), certain bids that were previously accepted may be rejected, and vice versa, depending on the zone they are presented. Consequently, zonal purchase volumes change and, due to the balance constraint between supply and demand, zonal sales volumes are also redistributed, changing what was accepted and rejected considering the PUN; thus, in general, new prices can be established for each market zone.



To better understand the impact of the PUN on all market variables, let's consider the following example, consisting of two market zones with different quantities for sale and purchase: this example is constructed from a real case in which the market zones had two different price levels, thus forming two distinct macro-zones. Suppose the South zone has lower quantities for sale and purchase compared to the North zone, and that the market price is also lower. The PUN is equal to 55,33 €/MWh, a value closer to the price of the zone with higher quantities for purchase.

Zonal results in the case of market with PUN

	Zonal Price (€/MWh)	Purchase quantity (MWh)	Sell quantity (MWh)
North	58,31	20 380	28 300
South	42,13	7 376	5 124

PUN: 55,33 €/MWh

Suppose we now simulate this market without considering the PUN; we would have the situation reported in the table below. Not only do zonal prices change, as expected, but also the total quantities sold and purchased.

Zonal results in the case of a market without PUN

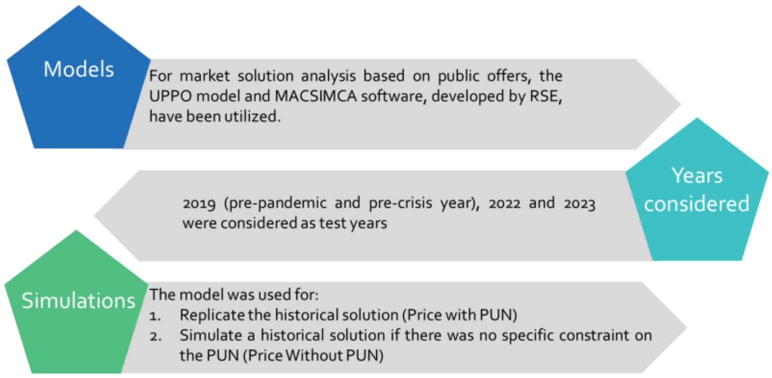
	Zonal Price (€/MWh)	Purchase quantity (MWh)	Sell quantity (MWh)
North	57,49	20 315	28 225
South	46,12	7 375	5 140

In particular, the price of the North zone decreases by 0,82 €/MWh, while that of the South zone increases by 3,99 €/MWh. The simulation results also highlight a secondary effect of the presence of the PUN, namely that the uniformity of the price for purchase bids results in an increase in the price difference on a zonal basis for sales offers; the removal of the PUN, therefore, would result in a greater alignment of zonal prices.

The UPPO model is capable of simulating the Italian DAM based on the public offers from GME.

The MACSIMCA software, using the UPPO model, can solve DAM by either using historical input offers or defining sensitivity scenarios by modifying input data.

The impact of the hypothetical removal of the PUN on past market results was therefore assessed by simulating the market both with and without the PUN.

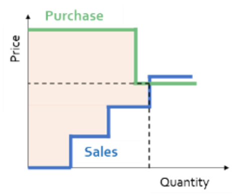


Compare a market with PUN and without PUN in the historical market

From these simulations, the results were analyzed and compared to evaluate the impact on market outcomes with the PUN and zonal prices. Specifically, the results were compared in terms of Social Welfare, costs for buyers, and levels of zonal prices.

SOCIAL WELFARE

The Social Welfare (SW) is calculated as the buyers' surplus minus the sellers' surplus, representing the area under the two supply curves (shaded area in the figure).



For all the years considered, the SW was calculated in historical simulations with PUN and in simulations without PUN. Then, the difference was calculated hour by hour between the social welfare without PUN and with PUN

Average of the NoPUN-withPUN differentials	Total	2019	2022	2023
(€)	250.8	65.9	509.2	177.3
%	0.021%	0.007%	0.04%	0.017%

The average hourly difference over the three years is 251 €, which is 0,02% of the SW. Therefore, on average, **the SW without PUN is (albeit slightly) greater than the SW with PUN**.

	Total	2019	2022	2023
Number of times with positive differentials	8798	4363	2457	1978
%	33%	50%	28%	23%

The maximum difference over the three years is 112.134 €, which is 7% of the social welfare.

The buyers' surplus is the savings compared to the offered price, while that of the sellers is the gain compared to the offered price.

Throughout the simulated period, the social welfare with PUN is never greater than that without PUN, while in 33% of the hours, the social welfare without PUN is higher.

COSTS FOR BUYERS

The overall cost of purchasing at zonal prices compared to purchasing at PUN was evaluated.

Average of differentials NoPUN-withPUN	Total	2019	2022	2023
(€)	-4500	-79.5	-13341	-79.9
%	-3%	-0,24%	-9,02%	-0,28%

The average hourly difference over the three years is -4500 €, equivalent to -3% of the costs (so on average, **purchasing at zonal prices costs less than purchasing at the PUN**). The difference is more substantial in 2022 due to the very high prices that occurred in that year.

In 82% of the simulated hours, purchasing at zonal prices is more advantageous than purchasing at the PUN.

	Total	2019	2022	2023
Number of times noPUN costs < PUN costs	21500	6807	7325	7368
%	82%	78%	84%	84%

	Total	2019	2022	2023
Total cost with PUN – total cost without PUN (k€)	118265	696	116869	670

Purchasing at PUN incurs an overall higher cost of approximately €118 million over the three years compared to purchasing at zonal prices.

COMPARISON BETWEEN ZONAL PRICES

As a final analysis, the difference between zonal prices with PUN and zonal prices without PUN was evaluated. In case of a positive difference, the zonal price without PUN is higher than the zonal price with PUN. In case of a negative difference, the zonal price without PUN is lower than the zonal price with PUN. The two zones experiencing a decrease in zonal prices in the absence of PUN are the Center North and the North.

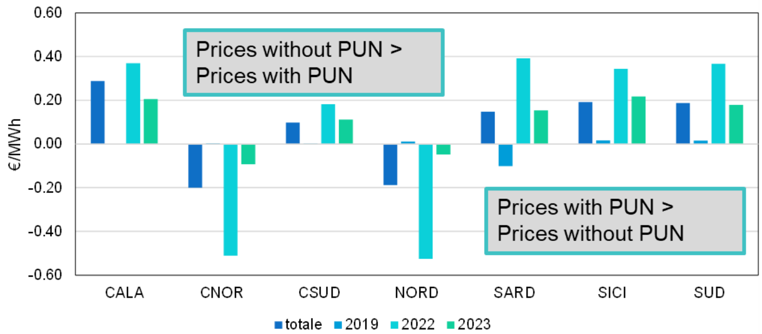
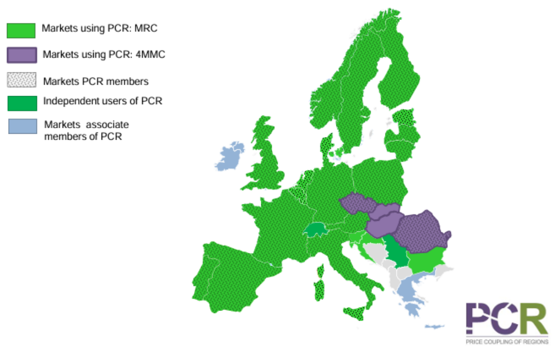


Figure 5. Average of hourly differences in zonal prices without PUN and with PUN.

PCR

What happen from 2025

Italy is part of the **Price Coupling of Regions (PCR)**, the initiative launched to develop a single price coupling solution across Europe's day-ahead market. This is crucial for achieving the goal of a harmonized electricity market throughout the EU area. PCR is based on three main principles: a single algorithm, effective operation, and responsibility of each electricity exchange.



Euphemia public description (Pan-European Hybrid Electricity Market Integration Algorithm)

One of the key elements of the PCR is the development of a **single algorithm for coupling called Euphemia** (acronym for Pan-European Hybrid Electricity Market Integration Algorithm), which is used for energy allocation calculation and price determination across Europe, maximizing social

The resolution of the PUN (as managed by GME) is the outcome of an interactive procedure: a PUN is set, and then the accepted quantity is determined. Next, the zonal model is solved, and zonal prices are calculated. If the PUN constraint is met, then a solution has been found. Otherwise, sensitivity analysis options of linear programming are utilized to see how changes in the accepted quantities affect prices, and then it is assessed whether there is a point within this range that satisfies the definition of the PUN.

Decree n. 210 of November 8, 2021

Arera's opinion on Aprile 9, 2024

MASE decree on April 18,2024

welfare and increasing transparency in price and flow calculation. Euphemia solves the PUN issue as one of its last sub-problems and is also one of the most complex to resolve.
Furthermore, starting from 2025, the day-ahead market will transition from an hourly resolution to a quarterly resolution. Euphemia will therefore need to solve not just 24 market sessions, but 96, further increasing the difficulty of resolution.
Italy is the only country in Europe to have such a single purchase price, and in view of greater harmonization of European markets, **the European Commission has requested Italy to plan an evolution of the national electricity market design to phase out the PUN starting from 2025, transitioning to a purely zonal market**. In this context, the Ministry of the Environment and Energy Security (MASE) has responded to this request (in Article 13 of Decree No. 210 of November 8, 2021, subsequently amended by Article 19 of Decree-Law 181/23), and after receiving the favorable opinion of the regulatory authority ARERA on April 9, 2024, on April 18, 2024, it published the decree for the phasing out of the PUN. Concurrently, GME communicated the following:

> Starting from January 1, 2025, the offers to purchase electricity on the Day-Ahead Market managed by GME will be valued at zonal prices. In continuity with the national single price, GME will calculate the reference price of electricity exchanged within the aforementioned market, as the average of zonal prices weighted by the quantities purchased for withdrawal in each geographical market area portfolio.
>
> It is highlighted that this reference price, calculated by GME in accordance with the above, will maintain the designation of PUN Index GME and will constitute, as expressly provided by the aforementioned Ministerial Decree, the reference index, among other things, for the quotation of long-term electricity contracts.

Decree 210/2021 stipulates that ARERA defines a **transitional equalization mechanism** among end customers to compensate for any differential between the zonal price and the reference price calculated by GME, along with the respective coverage modalities. ARERA has determined that this mechanism will be applicable at least until December 31, 2025, specifying further that its application is to be understood among dispatching users and not directly among end customers, as it pertains to economic transactions related to wholesale energy markets and not to retail markets.

And in the future?

The phasing out of the PUN from 2025 will not inherently result in a perfect alignment of zonal prices, which will continue to be misaligned due to limited inter-zonal transport capacities, as well as due to a significant penetration of non-programmable renewable sources, potentially heterogeneous across the national territory. For these reasons, it is interesting to evaluate the results also in terms of the impact on electricity markets of the modification of the generation technology mix due to the growth of renewable generation, the prospects for the active participation of demand in markets, and the development of networks by 2030.

RSE scenario based on "Aree Idonee" decree

To achieve this, a scenario for 2030 developed by RSE was considered and analyzed in terms of zonal prices. In the scenario, various criteria for allocating future installations of renewable energy plants are simulated, investigating the impact of different configurations on the operation of the national electricity system by 2030. Based on the zonal distribution and the allocation between rooftop and ground-mounted photovoltaic installations, different zonal price differentials will be observed.

Scenario A

A more balanced distribution of PV between rooftop and ground-mounted installations and between North and South: for photovoltaics, it is hypothesized that the new installed capacity will be divided between rooftop installations and utility-scale ground-mounted installations in a ratio of 45% / 55%, aiming to achieve a rooftop / ground distribution of 50%/50% by 2030

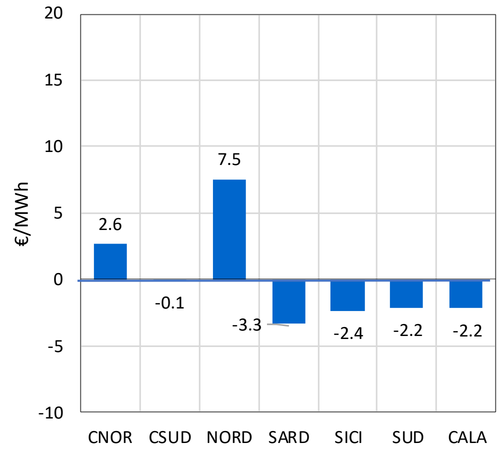


Figure 6. Difference between zonal price and average Italian price in the 2030-A scenario.

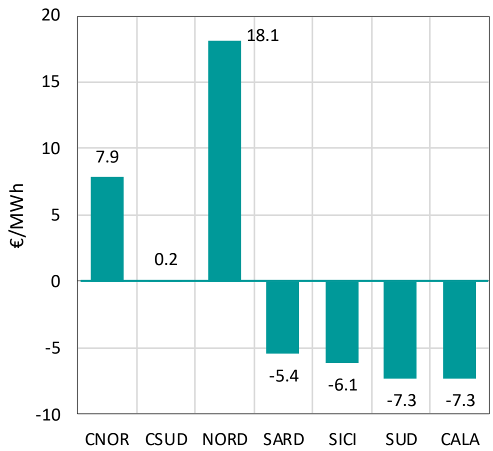


Figure 7. Difference between zonal price and average Italian price in the 2030-B scenario.

Scenario B

PV distribution mainly on the ground and in the south: based on wind and PV connection requests, which sees a preponderance of new installations of utility scale PV systems installed on the ground (19% roof / 81% ground) in the south and on the islands; in this scenario the roof-land distribution at national level by 2030 is equal to 31% / 69%.

Scenario C

PV distribution mainly on the ground, but more balanced north/south: it is similar to scenario A as territorial distribution and to scenario B as roof/ground distribution.

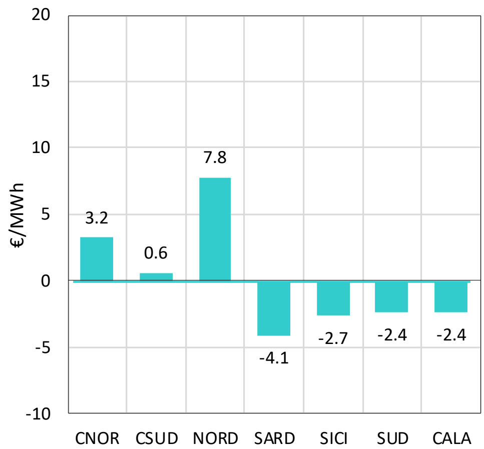


Figure 8. Difference between zonal price and average Italian price in the 2030-C scenario.

From the simulations, it emerges that the scenario with a higher penetration of ground-mounted photovoltaic systems in the South (scenario B) could lead to greater price differentials between zones (approximately 25 €/MWh difference between North and South). The Southern zones, experiencing a higher penetration of renewables, would record a lower price compared to other zones in the North in all scenarios.

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