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Estimating the effect of the Spanish gas price cap for electricity generation

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Research line

Green transition

Directed by Pedro Linares

KEY TAKEAWAYS

→ We estimate that, without the gas cap, electricity prices for 10M households directly affected in Spain would have been 24% higher than they were between June 15 and August 31.

→ At the same time, however, the measure has shown its risk of subsidizing those who do not finance it (e.g., French consumers) while increasing demand for gas-powered electricity generation, which conflates with EU-set goals towards savings and energy transition.

EXECUTIVE SUMMARY

One of the most significant measures enacted so far to moderate the escalation of electricity costs is the gas cap implemented exceptionally in Spain and Portugal. This so-called cap is a compensation paid to electricity companies using this fossil fuel to lower the price offered in the wholesale market. In doing so, it is intended to reduce the average electricity price in said market.

In this report, we present an innovative causal estimation of the effects of this measure on the regulated tariff, i.e., on the voluntary price for small consumers (VPSC), which is tied to the wholesale market. To do so, we compare the actual evolution of this tariff with a statistical model that produces a hypothetical price from an alternative world in which there is no gas cap.

Our results indicate that, with high confidence, the average electricity price for consumers in the regulated market would have been between 19% and 30% higher without the cap, with a point estimate of 24.4%. Moreover, our model indicates that this decline is unlikely due to other causes or random phenomena.

According to the estimates, an average Spanish household consuming 8 kWh daily will have saved €69 since June 15. Assuming that 10 million households in Spain have this regulated tariff bill, the savings since its implementation would be close to 690 million euros.

However, these savings come at a high cost. With this approximation, we estimate that while the measure is active, gas consumption for electricity generation has increased significantly: the effect would be 139 GWh per day for the whole period. We also note that this increase has coincided while the use of other technologies, especially cogeneration

and hydropower, has decreased. It should be borne in mind that the context of pronounced drought during this summer, which has hindered hydropower production, prevents us from attributing this drop to the new measure.

The data obtained does nonetheless suggest that, when it coincides with adverse events for clean technologies, the gas cap may reduce the incentive for transitioning to clean sources. In particular, the opposite effect might be provoked: encouraging gas consumption. This is undesirable in the current European context, which sets both short-term savings and long-term decarbonization targets.

In addition, we observe the evolution of the trade balance with the French electricity market, the most interconnected with the Spanish market since the measure came into effect. We conclude that:

1. Exports of electricity to France and Portugal have increased considerably: if the trend observed today continues, by the end of the year, exports will double those made in 2021.

2. At the same time, the price of electricity in France has become more variable, which cannot be reliably attributed to the current cap.

Both events occur against the backdrop of the failure of the French nuclear system, the cornerstone of France's electricity supply. This complicates the interpretation of our data. However, it serves as an example of what could happen with a measure like the Spanish gas cap applied throughout the EU. The interconnections of its member countries to the outside world might bring a "leakage" of the money invested in the form of increased consumption of gas-based electricity to border countries that would benefit from such investment at zero cost.

Russia's decision to reduce energy supplies to Europe in response to Western sanctions following the invasion of Ukraine has exposed the main structural weakness of Central European energy markets: the enormous supply power enjoyed by the primary producers of what we consume. This power comes from the fragmented nature of European demand and its short-term rigidity, especially in the residential sector. The inability to moderate or streamline consumption agilely is combined with a segmented supply. On the one hand, there are the sources under greater European sovereign control: nuclear (with the critical exception of uranium imports) or renewables (with the nuance that the technological equipment is manufactured to a considerable extent in other countries, such as China). These sources involve an extraordinary, fixed cost to start production, so they are not accessible for short-term capacity expansion, even though each additional unit of energy produced once installed is very economical. In other words, uranium is as cheap as wind or sunlight, but installing a nuclear power plant, solar panels, or windmills to convert it into energy is not achieved from one summer to the following autumn. On the other hand, there are energy sources more adaptable to demand but at a higher cost per additional unit included in the process: fossil fuels. Using each barrel of oil or tank of gas costs a little more than the previous one, drawing an exponential cost curve that can become almost vertical in a situation of scarcity.

Vladimir Putin is taking advantage of this structural weakness, as Sandbu (2022) explains: small reductions in supply under Russia's control end up producing disproportionate price effects precisely because they drive the need to increase capacity to that exponential part of the curve. The question for Europe today is how to take that pressure tool away from the Russian government. Given that the reductions and savings already proposed on the demand side are at relatively modest targets of between 7% and 15%, action on the supply side becomes essential. With the search for new energy sources (or the expansion of those dependent on us) precluded in the short term by the aforementioned start-up costs, the focus has logically shifted to the immediate regulation of current supply. While supranational bodies (mainly the EU and G7) try to articulate joint measures, the most affected countries have been taking autonomous decisions aimed at managing the uncontrolled increases favored by the hand of the Russian government.

One has stood out above all others for being more drastic and intervening more clearly in the functioning of supply: the mechanism that Spain and Portugal established in June 2022 on the wholesale electricity market to prevent the increase in the cost of gas from being passed on in excess to the final bill of electricity consumers. From the outset, the measure attracted attention for two reasons: the most immediate and clearest was the uncertainty as to its effectiveness. But the other, no less important, was the impact that an exceptional measure could have on European political balances in terms of shaping and sustaining common fronts for the necessary energy market reforms to align the old objective of energy transition towards decarbonized sources and Russia's new aim of independence. The latter dimension has become even more critical in recent months. The EU has set joint reform as an explicit objective, and a gas cap has become one of the alternatives proposed and considered.

This report seeks to make a distinctive contribution to this debate, which is crucial for Spain and the continent as a whole, by assessing the effect the gas cap has had on the Spanish market. We employ advanced econometric techniques that allow us to isolate its impact on three key dimensions: the final price of electricity as the primary metric, but also the consumption of gas for electricity generation since the start of the measure, and the possible "leakage" of the implemented system outside its scope of application. These last two areas are of particular relevance to the debate not only in Spain but also in Europe and help to present a balanced picture of the gas cap, with its pros and cons measured in a way that has not been done before.

The measure: the gas cap

In mid-June, a mechanism to decouple gas prices from price formation in the wholesale electricity market came into effect in Spain and Portugal. Implementing it was arduous,[1] as it involved convincing the other European partners and the Commission. Still, it will now be in effect for one year unless otherwise decided and agreed upon by the two countries concerned.

What is the gas cap, and how does it fit into the market? The "gas cap" is compensation paid to certain electricity generation facilities using fossil energy sources to reduce the wholesale electricity market price. Natural gas combined cycle power plants, coal-fired thermal power plants, and some cogeneration facilities are eligible[2]. These plants[3] usually bid at the highest price, which becomes the price of the entire market at that time. This design, known as "marginalist", means that the cleanest energies, which are also the least costly in production per additional unit, receive a benefit from the market that incentivizes their use over other more polluting and/or less efficient alternatives. Each unit of energy from gas or oil costs at least as much as its raw material, while each unit of energy from the sun, wind, water, or nuclear power costs much less because its raw material is also cheaper.

1 It took almost three months for its final approval since the initial one: the European Council of March 25 will be remembered for approving the "Iberian derogation", which allowed Spain and Portugal to implement a mechanism. The European Commission, however, reserved the final word on the measure. Negotiations began and were resolved on April 26 with the agreement reached on the proposal drawn up by the Spanish and Portuguese governments. As a result of this agreement, on May 13 the Council of Ministers approved Royal Decree-Law 10/2022, which temporarily establishes a production cost adjustment mechanism to reduce the price of electricity on the wholesale market, popularly known as the "gas cap". However, the mechanism would not enter into force until the Commission's express authorisation, which took place on June 8. On the same day, the Ministerial Order was published which determined the entry into force of the mechanism on June 14.

2 In this regard, article 2.1.c) of Royal Decree-Law 10/2022, of May 13, establishes that electricity production facilities belonging to group a.1 of article 2 of Royal Decree 413/2014, of June 6, and those covered by the first transitional provision thereof that have been covered by the second transitional provision of Royal Decree 661/2007, of June 25, are subject to the mechanism. of article 2 of Royal Decree 413/2014, of June 6, and those covered by the first transitory provision of the same that have been covered by the second transitory provision of Royal Decree 661/2007, of May 25, which regulates the activity of electricity production under the special regime, are subject to the mechanism, provided that these do not have any of the remuneration frameworks regulated in article 14 of Law 24/2013, of December 26, on the Electricity Sector, as well as cogeneration facilities that use natural gas as primary energy and that are covered by the general remuneration regime, under the terms set out in article 4. º-B of Decree-Law no. 23/2010 of March 25, 2010 ("Diário da República" no. 59/2010, Série I, of March 25, 2010).

3 It should be noted that generation facilities that have active bilateral contracts (PPAs) for the sale of their energy concluded before April 26, 2022 are excluded from the adjustment.

How the compensation is calculated, and who is affected. With this in mind, the approved compensation is calculated as the difference between the wholesale market offer of a combined cycle plant for two gas prices, a market price, and a reference price[4] set by the new Law: during the first six months, the reference price will be 40 €/MWh, and after that, it will increase by 5 €/MWh each month, until it reaches 70 €/MWh at the end of its application.[5] This compensation is communicated publicly so that the affected plants incorporate it into the price offers for the energy they bring to the wholesale market, expecting to reduce this price. This is how the internalization of compensation operates as a "cap" on the cost of gas, which (ideally) is passed on to the final price of electricity.

Given the marginalist functioning described above, the cap operates, in practice, as a limit to the benefits that "infra-marginal" technologies (solar, wind, hydro, nuclear) receive in the market. This cut in "windfall profits" modifies the original functioning of the market, which we described above as designed to encourage the adoption of these energy sources.

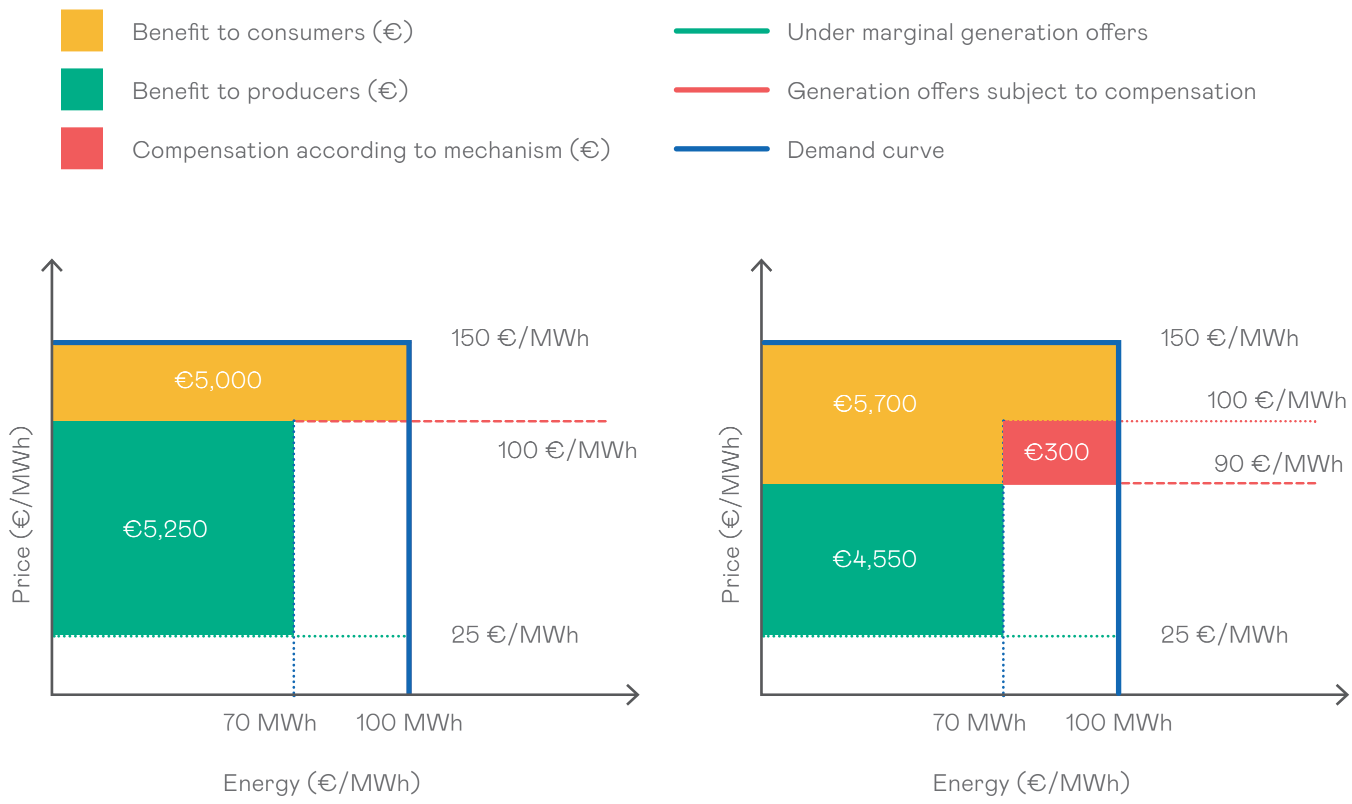
Who pays the compensation? The cost of financing the compensation paid by this mechanism is distributed among the demand in the wholesale market as a payment obligation. Thus, at the close of the market, the adjustment is paid to the plants entitled to receive the compensation so that their marginal costs are fully covered. Subsequently, this cost generated by the adjustment mechanism is passed on to consumers as part of the electricity tariff. Initially, this pass-on would only affect consumers on the regulated tariff, known as the Voluntary Price for the Small Consumer (VPSC). This is because these consumers are the first to benefit from the measure: the VPSC design directly replicates the wholesale market price, which means that the price drop induced by the gas cap will also help these consumers. However, this cost would also be shared among consumers on free market tariffs in a second phase. Where appropriate, the compensation cost component will only be integrated into bills resulting from new contracts or as and when contracts in effect at the entry into effect of the adjustment mechanism are renewed.

So, where are the savings for the consumer? Savings for consumers would occur as the compensation paid, despite being borne by them, is less than the remuneration foregone by these sub-marginal technologies. The difference translates into lower clearing prices than if the mechanism were not in place, and therefore into a higher consumer surplus. The comparison is illustrated by Paulo Brito (ITT-Comillas) in the following figure, the central part of this splendid publication. In the right panel is the uncapped situation. The yellow area represents the consumers' profit or surplus, defined as the difference between the market price (100€/Mwh) and their maximum willingness to pay for each unit consumed (the blue line). With the cap, the market price falls. Consequently, consumers can increase their profit even when compensation must be paid (red area in the left panel).

4 To calculate this difference, article 3.1 of Royal Decree-Law 10/2022 of May 13 provides that a reference price, set in the regulation itself, is subtracted from the gas price quotation and divided by the cycle yield (assumed to be 0.55). For its part, the market price of gas is calculated as the weighted average of all transactions in Daily and Weekend products, if applicable, with next day delivery of natural gas registered on the Iberian Gas Market (MIBGAS).

5 This way, one of the conditions required by the European Commission for the authorisation of the mechanism is met, which was that the average reference price for the duration of the mechanism should be 48 €/MWh. In doing so, the Commission sought to avoid creating a competitive advantage that could lead to comparative disadvantages with other Member States.

Figure 1. **Representation of potential savings for the consumer**



Source: LA "EXCEPCIÓN IBÉRICA" A DEBATE: ¿UNA OPORTUNIDAD PERDIDA? Paulo Brito. Blog 'Un grado y medio', June 2, 2022.

Estimating the impact of the gas cap on final electricity prices

To assess the measure, we must focus on the main stated objective: to reduce the final bill of the regulated market consumer. The reasonable thing to do is to observe whether, since its enactment, there has indeed been a significant reduction in the regulated price (VPSC from now on) and by how much. However, the cap may have other effects, which have been noted since it came into operation and which are also worth assessing, such as the possible increased use of combined cycle power plants or the increase in exports to France. Both would lead to a rise in gas consumption. Consequently, we believe it is necessary to extend the analysis to these two areas to enrich the present and future debate on the measure or its possible reforms.

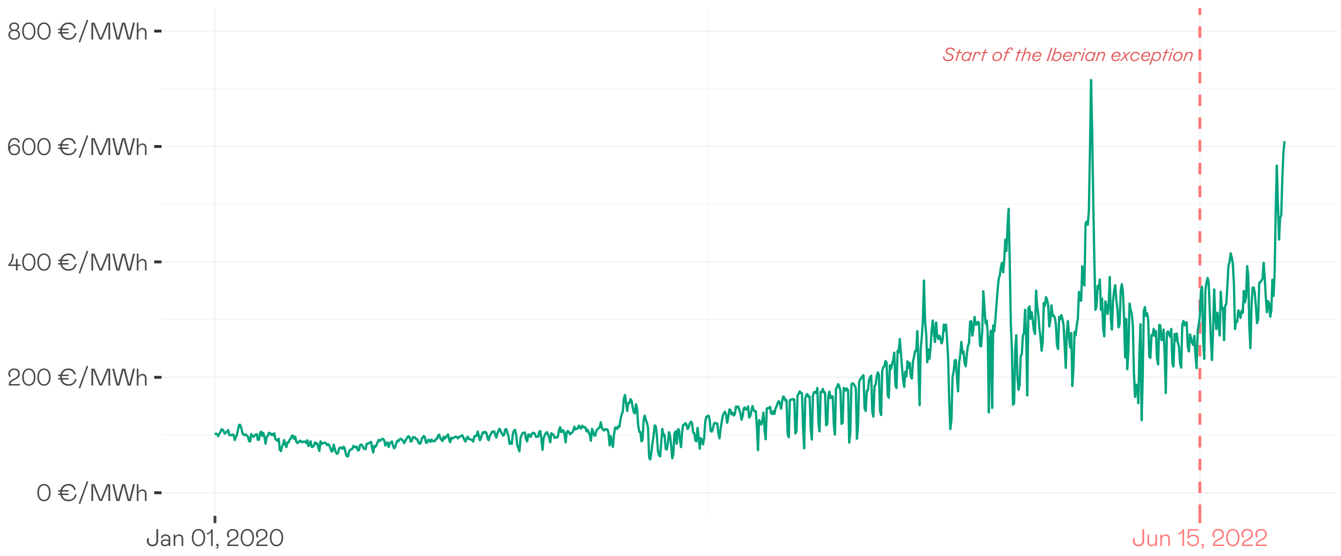
Estimating the effect on the VPSC

To estimate the effect of the gas cap, we need a model that best approximates the historical evolution of prices into the past. With this model, we can estimate a counterfactual into the future, or a "what if": an approximate series of plausible VPSC prices in a world where the measure would be the only difference. By comparing this hypothetical, no-cap-world series with the real one and assessing whether the difference is statistically significant, we will be able to understand whether there has been an effect of the measure in the desired sense.

Figure 2 shows the evolution of the daily series of the VPSC[6] in Spain from January 1, 2020, to August 31, 2022. With the outbreak of the energy crisis, prices increased significantly from the summer of 2021, breaking with the historical evolution. As explained in Collado, Galindo, and Hidalgo (2022), the marginalist design of the wholesale electricity market mentioned in the introduction is the main reason for this increase, as it is usually electricity from gas and other fossil fuels that sets the daily price.

6 The VPSC price shown in the figure, on which the analysis is based, is the one that already incorporates the tolls and charges, the marketing cost, the compensation to combined cycle plants foreseen in the mechanism, the cost of energy and other concepts such as adjustment services or capacity payments.

Figure 2. **Evolution of the VPSC**



Source: Own elaboration based on data from Red Eléctrica | EsadeEcPol

The cap should lead to a lower wholesale price of electricity, partially altering the marginalist market system. To check whether this has happened, we will develop a causality analysis that tries to isolate its effect as best as possible. This process takes place in two steps:

1. First, we choose the variables that, together with a model, allow us to extrapolate the series shown in Figure 1 with the least possible error.

2. Next, we use Bayesian structural models (BSTS) to estimate the counterfactual. These models allow us to estimate not only the difference between the two but especially the approximate probability that the difference is due to a random reason or the assumed cause, in this case, the gas cap. In other words, not only can we measure whether there has been a causal impact, but it is also possible to know how likely it is or is not due to the policy.

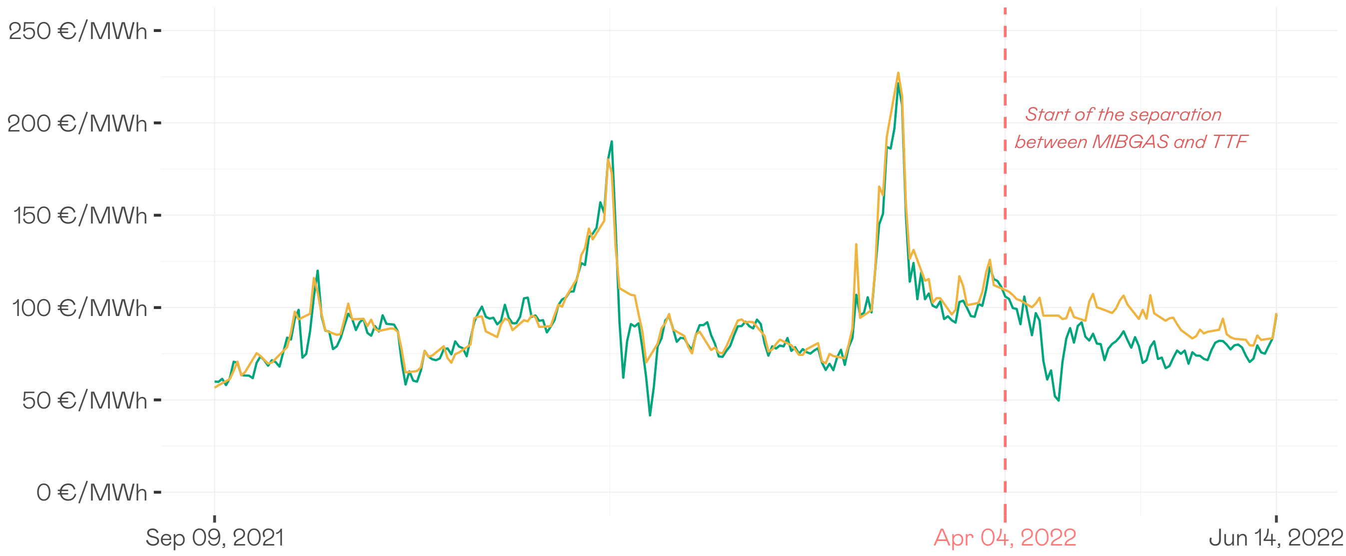
Step 1: THE HYPOTHETICAL PRICE SERIES

Thus, the first step should focus on the design of a model, together with the choice of the appropriate variables, that allows us to predict as closely as possible the VPSC over the available time series. To do this, we start by choosing which gas price series to use as a reference for estimating the VPSC. This choice is essential given the current existence of Spanish gas companies in two reference markets: the gas price on the virtual market in the Netherlands (Dutch TTF) and the price on the Iberian Gas Market (MIBGAS)[7]. Objectively, there is no evidence to inform a definite choice, as the market is currently dispersed and linked to both prices. For this reason, we have initially let the data speak for themselves. The main criterion for the selection has been that the gas price used to estimate the model should be the one that best approximates the VPSC price series statistically.

To this end, we have carried out a quantitative analysis. For most of the period for which both gas prices are available, it is observed that both the TTF and the MIBGAS have evolved similarly (Figure 3). However, this similar evolution breaks down as of April 4, 2022, when a period begins in which both prices start to diverge. There is one possible explanation for the entry into effect of the sanctions against Russia a few days later, which both markets had already anticipated by that date. Thus, the increase in uncertainty over gas supply to Europe was less in the case of the Iberian Peninsula due to the existence of more diversified channels for gas supply outside the Russian orbit. In this difference for this period, we find the opportunity to carry out a quantitative exercise that helps to discriminate both prices in terms of their capacity to emulate the evolution of the VPSC.

7 The TTF is a virtual market where gas that is already present in the Dutch gas system, i.e. after import, regasification and injection into the EU pipeline system, is traded. It is currently the largest and most liquid market in Europe and is therefore taken as a benchmark in the rest of Europe. MIBGAS is a platform where gas delivery products can be traded on the Iberian Peninsula. The latter market was created with the aim of taking advantage of the relative independence of the gas market in Spain and Portugal due to its particular configuration.

Figure 3. **Evolution of gas price: MIBGAS and TTF**



Source: Own elaboration based on data from Red Eléctrica | EsadeEcPol

Two models have been estimated, one for each gas reference price, from September 2021 (when we have a daily MIBGAS series) until April 3. Once we estimate these models, we use the series from April 4 to June 14 as a test group for the goodness of fit of each model. Specifically, we extrapolate both models for that period, comparing which of the two gas prices best approximated the evolution of the VPSC during those days[8].

The results obtained show that the reference price that best approximates the evolution of the VPSC in the days of the test period is undoubtedly the TTF, so this should be the price to be considered in the causal impact analysis[9]. However, although the data indeed discriminate in favor of the TTF, it is no less accurate that in the last year, MIBGAS has significantly increased its presence within the contracts made by the Spanish gas and electricity system, intensifying even more in recent months. This gain in share, which reached 20% in 2022, forces us not to underestimate its possible role, especially when the Iberian market could be gaining relevance in Spain. For this reason, we believe that it is an appropriate decision not to rule out its use.

Consequently, for the estimation of the VPSC prediction model, a weighted average of the TTF and MIBGAS reference prices will be used for the period in which both are available, i.e., from September 7, 2021. The weights will be 80% for the former and 20% for the latter. As long as both series

8 The following section explains which models have been used.

9 A standard procedure has been followed. The estimation of both models allows a series to be projected for the period of days from April 4 to June 14. Once these projections have been made, the square root of the root mean square error (rsme) has been calculated. In our case, using the TTF we obtain an rsme of 39.15 while using MIBGAS we obtain an rsme of 53.64. These results point to the TTF as the best option for approximating the evolution of the VPSC. A second procedure has been added to this one, to analyse its robustness. To do so, this exercise has been repeated using both prices at the same time or weighted averages of them. In all cases, the best model is always the one that uses the TTF as the gas reference price.

have evolved similarly, there will be no difference between this weighted price and either of the two separately. By the time the two series separate, the weighted series will be in between but closer to the TTF. In this way, we ensure that the TTF takes precedence over the MIBGAS (as the data say) but that the latter's evolution must be present in the estimates, primarily because of such a different evolution since April 2022.

Step 2: ESTIMATING THE EFFECT OF THE CAP ON THE VPSC

The model used to estimate the evolution of the VPSC incorporates, in addition to the weighted price described in the previous section, the same VPSC series but with a lag of one and seven days (variables that seek to capture the structure of the time series). Together with these, the daily production level of combined cycle and cogeneration plants in Spain is included, thereby attempting to capture the marginalist structure of the market. Finally, two interventions are incorporated into the model, one corresponding to the reform of June 1, 2021, and the other to that of September 15, 2021, whose effects on the price could be significant[10] [11].

The analysis of the regression results suggests that the validity of the model and of the variables included in the approximation of the daily evolution of the VPSC since January 2014 is difficult to question. Moreover, the capacity of the model to approximate the VPSC is very high (over 92%)[12]. Thus, once it has been proven that it is possible to design a model capable of approximating (and predicting quite accurately) the evolution of the price series, the next step is to use it to analyze the impact of the gas cap intervention on prices.

Figure 4 shows the impact analysis results for the evolution in the VPSC of the gas cap. According to the model estimates, the blue line plots the VPSC in an alternative world without a gas cap: what we would have observed between March 1, 2022, and August 31. Orange shows the VPSC series that took place in our world, with gas capping. Until June 14, the differences are minimal,

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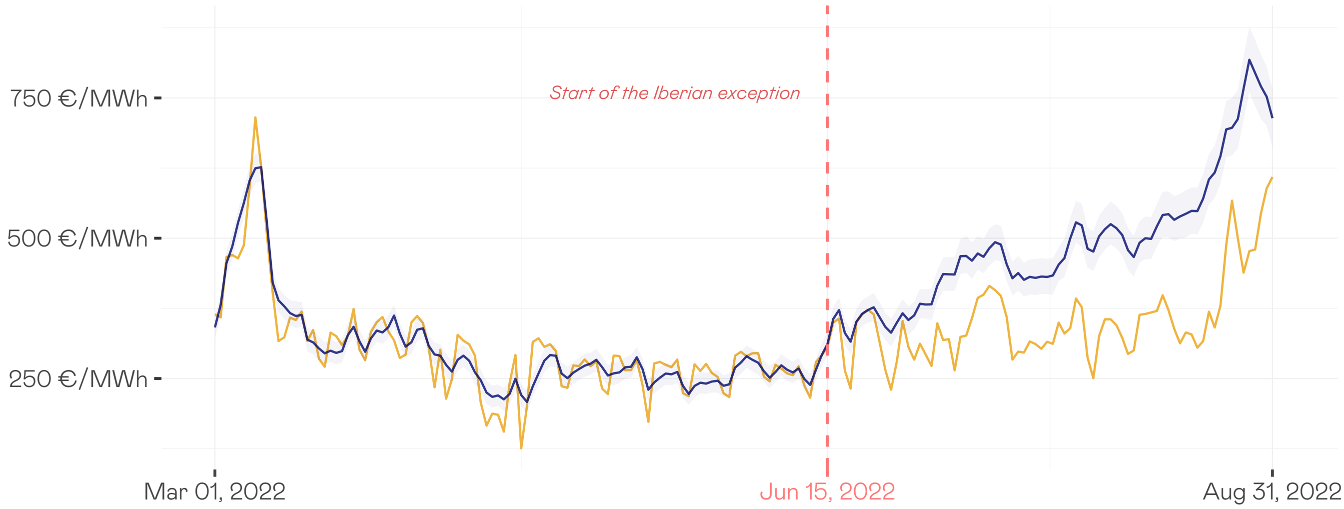
10 On June 1, 2021, the reform that modified the electricity tariff to introduce price discrimination by hourly segments came into force. The new tariff was divided into three segments, from highest to lowest cost: peak (10:00-12:00h and 18:00-22:00h), flat (8:00-10:00h, 14:00-18:00h and 22:00-24:00h) and off-peak (24:00h-8:00h and weekends and public holidays). However, this hourly discrimination ceased to operate systematically de facto after the 96% rebate on the amount of the charges with the entry into force of Royal Decree-Law 17/2021, of September 14, and other measures approved subsequently to contain the electricity tariff.

11 On September 15, 2021, Royal Decree-Law 17/2021 of September 14 was published in the Official State Gazette (BOE), which included important measures on the wholesale market and the electricity tariff. Specifically, it is worth highlighting the mechanism for reducing the excess remuneration of the electricity market caused by the high price of natural gas on international markets. This, in practice, implied deducting the revenues received by infra-marginal technologies, given a gas price, that were higher than those they would obtain if the gas price was 20 €/MWh. The logic of the reform was that the electricity generation facilities that operated as infra-marginal in the market (solar, wind, hydro and nuclear) had been deployed in a context in which a drastic increase in the gas price was not expected as it was happening now, so that the additional revenues obtained as a result of this circumstance should be considered "extraordinary" and therefore susceptible to be deducted to reduce the electricity tariff. The revenue obtained from the application of this mechanism was used to finance the rebate on the cost of electricity system charges, which in turn led to a reduction in the electricity tariff. The mechanism is still in force today, although with modifications aimed at making its application compatible with that of the gas cap.

12 For reasons of simplicity, regression results have not been included in the report. However, they can be shared upon request to the authors.

confirming the model's excellent calibration[13]. From June 15 onwards, the two series separate so that while the counterfactual continues on a clear upward trend, the observed price series does so, albeit with a lesser slope. The effect of the cap could therefore be assessed as the observed difference between the two series from its application on June 15, represented by the green dashed line axis.

Figure 4. **Results of the analysis of the impact of the gas cap on the VPSC.**
Estimated price without the gas cap and actual price

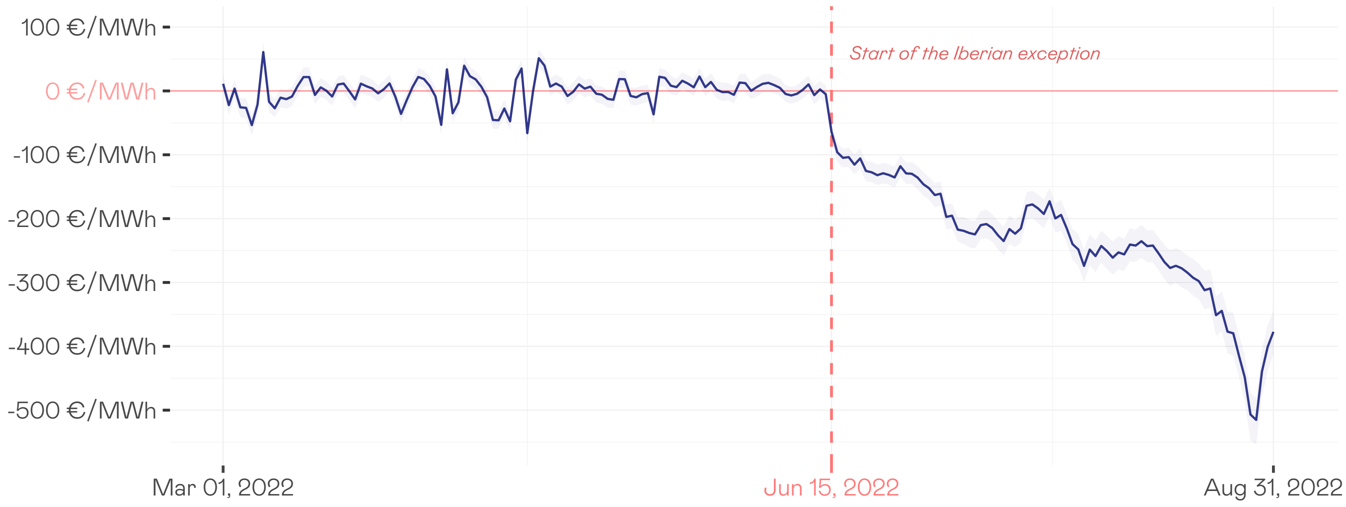


Source: Authors' own elaboration | EsadeEcPol

We show this in Figure 5. The blue line represents the estimated savings in € as the difference between the lines depicted in Figure 4. Up to June 14, this line oscillates around zero, which indicates that we are dealing with a random error corresponding to a model that meets the minimum requirements for its correct estimation. However, this line deviates significantly towards negative territory as of June 15, implying that the gas cap has led to an apparent reduction in the VPSC prices customers pay on this tariff. Moreover, these savings grew as the weeks progressed, reaching a maximum of almost 300 euros during the last week of August. **On average, the savings for an average Spanish household since its introduction have been 24.4%, with a 90% confidence interval between 29.7% and 19.5%.** These results align with Salas, Jérez and Álvarez (2022) who estimate a cumulative saving of 20.8%.

13 The observed price movements are largely outside the confidence band. The reason is that, although the model fits the series extraordinarily well for the period as a whole, it has suffered from enormous volatility which, although it has not modified its long-term trend (except from June 14, 2022), has meant that there have been important surprises in recent months.

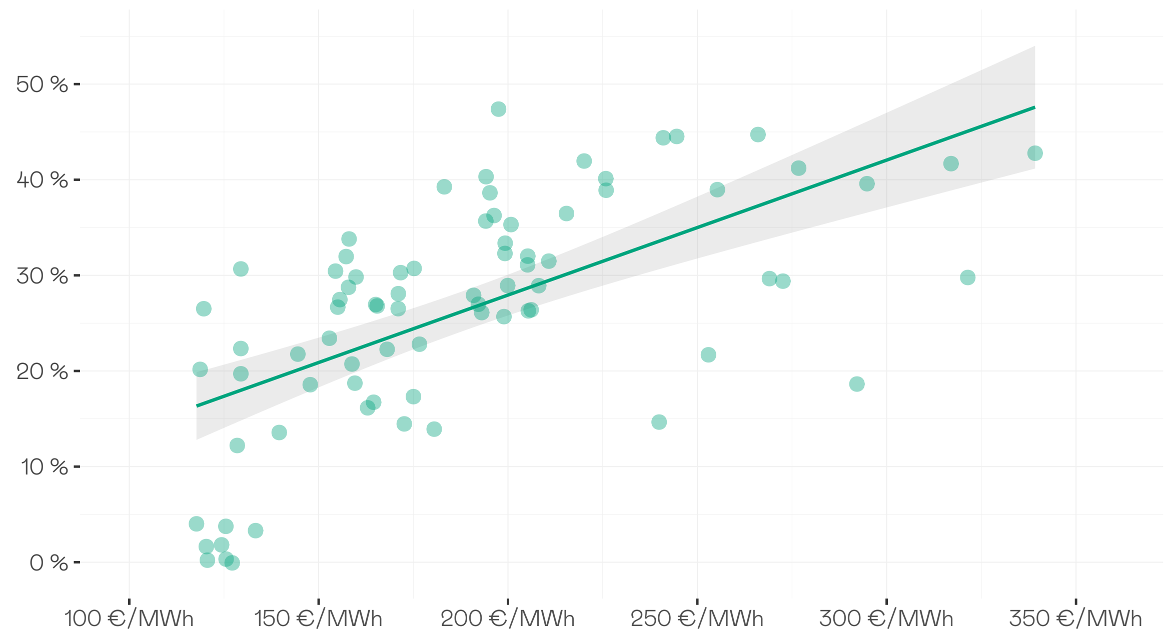
Figure 5. **Estimated VPSC savings from the gas cap**



Source: Authors' own elaboration | EsadeEcPol

The evolution of savings has much to do with gas prices. Figure 6 shows the relationship between these savings as a percentage of the counterfactual price and the gas price since the start of the measure on June 15. Although there is a particular dispersion due to the many factors involved in determining these savings, it seems clear that the higher the gas price, the more significant the difference between the price paid and the counterfactual price without the measure. We can also observe that such savings in percentage terms find a ceiling at 50 %.

Figure 6. **Relationship between cap savings and gas price**



Source: Authors' own elaboration | EsadeEcPol

In monetary terms, the average saving since June 15 would be around 113.9 €/MWh, representing an accumulated saving of 8,881.1 €/MWh since the start of the measure. Based on the information collected by the CNMC's Household Panel, if we assume that an average household consumes around 8 kWh per day, we can say that it will have saved about 69 euros on average since June 15. Assuming that 10 million households have this billing system[14], the savings since its implementation would be close to 690 million euros. To this must be added the indirect savings that will be produced in the almost 20 million households in the free market as they renew their contracts. The decrease in prices following the entry into effect of the mechanism will allow marketers to update their offers based on lower market prices than those expected in the absence of the cap. Thus, the policy will also benefit households with a free tariff, although these savings are more difficult to quantify. Considering that household spending on electricity exceeded 15 billion in 2021[15] and that, with the current price increase, it may triple by 2022, the savings are even more significant.

Given the Bayesian nature of the estimation, we can also provide a measure of the probability that this change is caused by an extraordinary event on June 15, not by a chance event. Thus, the estimation results indicate that **the likelihood that the observed difference in the original series was due to spurious or non-measured reasons is approximately 0 %.**

Effect on the use of the combined cycle

The gas cap may not only have affected the evolution of prices but also the use of the different technologies used in the Spanish electricity system to generate electricity and, thus, the potential savings that the measure could have achieved. Therefore, as a parallel exercise, the above analysis has been reproduced to see whether the introduction of the cap has generated incentives to divert production to or from specific technologies. Given that in its original design, the marginalist system sought to incentivize the use of clean energy and discourage the use of more polluting ones, it is essential to assess whether and to what extent a modification as severe as this cap undermines this objective. This is especially important in our current context: European countries seek to secure reductions in gas consumption for both independence and energy transition. Let us not forget that the EU has set ambitious targets for reducing consumption by 2022, ranging up to 15% in some countries (7% for Spain, which is equally notable).

14 CNMC data for the year 2021.

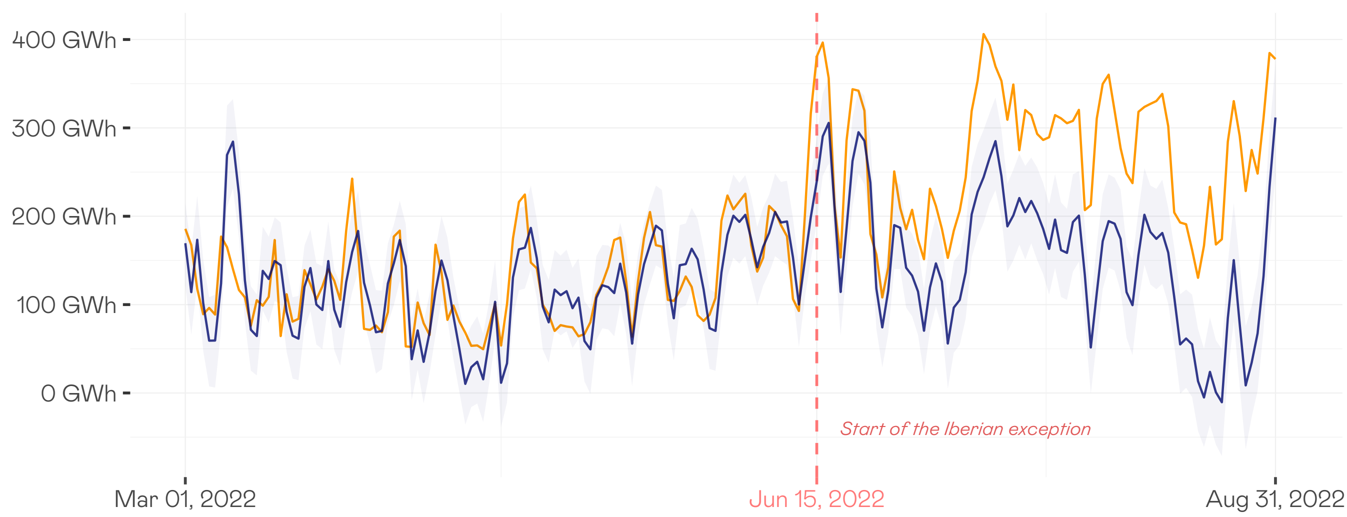
15 Data from the INE Household Budget Survey.

Indeed, the increase in combined cycle power generation has been identified as a possible effect of the cap. Intuitively, the use of the gas cap could incentivize the use of a combined cycle because of the opportunity it would generate to respond to a higher external demand for electricity from France and Portugal, probably due to the lower prices in the Spanish wholesale market favored by the "gas cap" and under the protection of the price safeguard provided by the compensation for combined cycle plants. In addition, another mechanism could be activated to incentivize the production of these generators. Before the cap came into effect, producers were exposed to rising gas prices and therefore needed to be more conservative in their production decisions. With the cap, consumers are exposed to the risk of gas price increases through compensation payments. Combined cycle plants have a greater incentive to bid into the market. This section aims to test the possible existence of this effect in the same way as has been done for the VPSC.

The following figures show the counterfactual series for the daily GWh output of the combined cycle plants, the observed (blue and orange lines in figure 7), and the differences between them (figure 8). The variables used to approximate the production in combined cycle plants have been the daily electricity demand, as well as others that could affect the decisions, such as the VPSC, the weighted natural gas price of a previous day, the production in these plants one day and seven days before, and the reforms implemented in 2021. The degree of approximation is high, with a coefficient of determination above 83%.

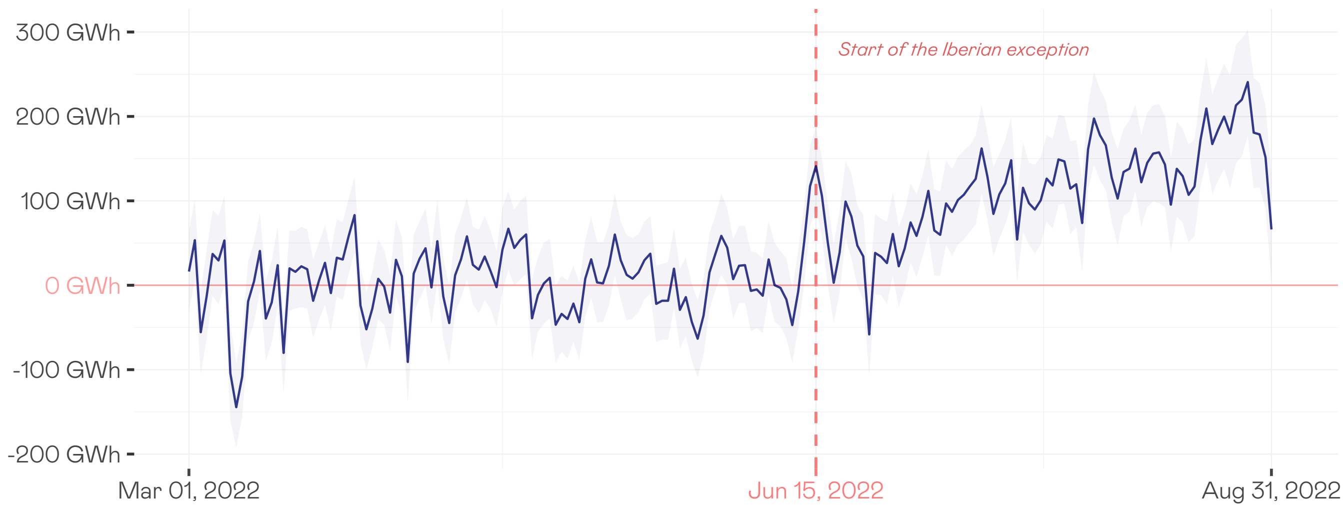
As seen in Figure 7, **introducing the gas cap could have led to a significant increase in the use of combined cycle plants in Spain.** Figure 8 thus shows that this increase would be substantial for the whole period since June 15, except for the first few days of June. From July onwards, the possible effect stabilizes between 100 and 200 GW per hour per day, with a peak on 25 and 26 August. On average, **the effect would be 139.0 GW per hour per day for the period as a whole.**

Figure 7. **Electricity generation in combined cycle power plants.**
Estimated without gas and actual



Source: Authors' own elaboration | EsadeEcPol

Figure 8. **Effect of the gas cap on combined cycle generation**



Source: Authors' own elaboration | EsadeEcPol

These results would fit with those advanced by Eicke et al. (2022) in their critical assessment of the export of the gas cap model to other EU countries: they note that gas-fired generation increased by up to 42% during the first weeks and highlight the tension between such increases and the savings and decarbonization objective.

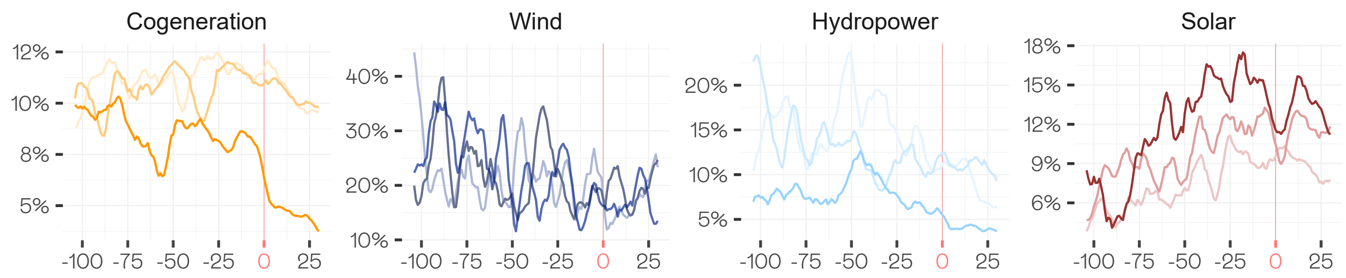
However, some questions arise from the above result. The counterfactual estimate assumes that electricity production by this technology only depends on exogenous factors, such as the total amount of energy demanded, the market price, or the gas price. However, the greater or lesser use of combined cycles in a marginalist electricity system such as Spain's depends on using the other technologies once they have supplied their optimal quantities. In other words, using gas-fired technologies to produce electricity depends on whether alternative technologies are available and capable of generating on a given day and time. Thus, the amount of GW per hour produced by combined cycles depends on the higher or lower production of the other technologies, except for hydro, which is closely related to gas[16]. For this reason, although our analysis above shows an apparent effect of the cap on the use of combined cycles, it is necessary to reflect on whether there could be other possible causes.

16 Hydroelectric power plants generate electricity from a scarce resource: water. Consequently, given the marginalist design of the market, their entry into the market is reserved for the times when it is most needed, i.e. when an even more expensive technology is about to enter the market: gas. Thus, hydroelectric generators use the combined cycle as a benchmark and bid according to the opportunity cost (they store water when the price is low and gas will not be needed to meet demand and use it when the price is high).

What has happened to the other technologies?

The first thing to say is that, with the information available, it is not possible to rule out that the lower use of some technologies, such as hydroelectric and, especially, cogeneration in favor of combined cycle, is due to the incentives created by the gas cap, nor that there may be other reasons for this. For example, in a year characterized by a persistent drought, the low use of hydropower during the summer months could explain part of the shift to combined cycle of the space left in electricity generation, independently of the introduction of the gas cap.

Figure 9. **Weight of the different technologies in the total amount generated For 2019, 2021 and 2022**



Source: Authors' own elaboration | EsadeEcPol

Note: The 7-day moving average is calculated from March 1 to August 31.

Figure 9 offers clues that may support this possible explanation. As can be seen, from June 15onwards there is a divergent behavior in the weight that each technology represents in the total daily energy generated. On the one hand, hydro and CHP show a significant drop, while wind and solar do not seem to show any particular reaction that cannot be attributed to mere seasonality. This divergence between groups would have a place among the expected effects of the different incentives created by the gas cap. For instance, for the drop in cogeneration, there are strong reasons to consider that its lower use since the start of the cap may indeed be due to a direct consequence of the design of the measure itself. In particular, the fact that cogeneration plants have been excluded from the compensation deriving from the gas cap has created incentives to divert part of the production previously generated by cogeneration towards combined cycle power plants. With the measure, part of these plants would operate in the new regulatory context at a loss, which has led to the paralysis of a significant portion of the cogeneration fleet.

The Spanish Cogeneration Association (ACOGEN) calls for cogeneration to be included in the compensatory mechanism. By early September, Prime Minister Pedro Sánchez announced a modification to the regulation of the cogeneration remuneration system to allow facilities that so wish to temporarily waive it and receive the adjustment resulting from the Iberian exceptionality.

The Council approved this regulatory change of Ministers on September 20, so there will likely be an upturn in the participation of these technologies in electricity generation. As for its effect on gas consumption, although it is true that these plants also use gas in production, they do so more efficiently: while combined cycle plants have an efficiency of 50-60%, cogeneration plants have an efficiency of 90%. Thus, and waiting for a proper evaluation once the data is in, it seems at least a priori could contribute to reducing gas consumption.

However, concerning hydropower, there are reasons to believe that we may be facing a combined effect of several factors operating in the same direction, making it impossible to differentiate the weight of each one. The cap and the drought could explain part of the reduction in generation by this technology during the summer, confusing both effects into one. This does not mean there were no incentives to reduce hydro generation in favor of combined cycle power plants. Still, it does mean that an undetermined part of the increase in the latter, observed in the previous estimate, is not due to the cap but to cyclical events such as the lack of rain.

The cost of diversion to combined cycles

The observed effect on electricity generation through the more intensive use of combined cycles has made the measure that introduced the gas cap less efficient. Thus, the excess production through gas flaring has been passed on to the final bill as a higher compensation surcharge for combined cycle plants. Indeed, these payments can be seen as a potential saving loss additional to those already estimated (24.4% of the counterfactual VPSC). In addition, this increased use of cycles suggests that the gas cap could affect, at least partially and permanently in the medium to long term, the original incentive of the marginalist system to transition to non-polluting sources. Gas becomes more attractive, making more frequent use of gas relatively inevitable, especially for those sources that are more easily replaceable (such as CHP) or that are not in good shape due to cyclical factors (such as hydropower during 2022). Thus, when considering market reforms, it is necessary to consider how they will interact with possible external factors that temporarily or permanently increase the cost of desirable energies in the long term. When, as has happened in recent months, a cap on the price of gas coincides with an increase in the price associated with these energies, the result may be an undesirable slowdown in savings and transition. However, it is impossible to discern the weight of each factor (the upper limit on gas and the new lower floor for the other technologies) in closing the gap between the two costs.

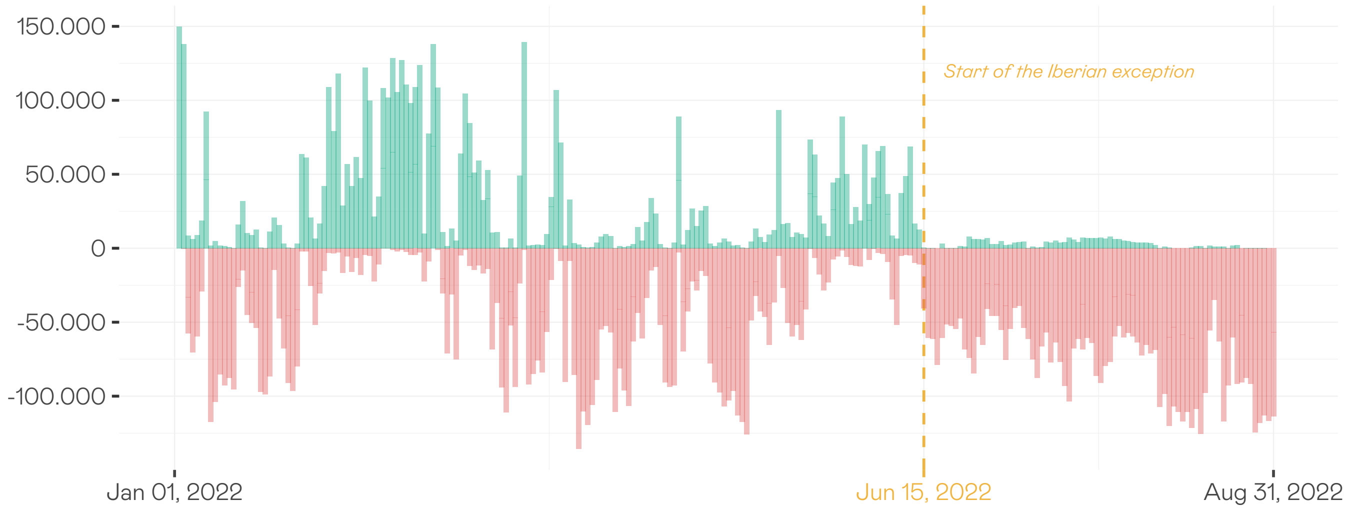
It is possible to counter-argue that this gap closing will be more remarkable in Spain, which can import from places other than Russia: in central, northern, and eastern Europe, non-Russian gas is a scarcer resource, so the market would not respond as quickly to the incentive. But, as Eicke et al. (2022) point out, this also implies caution when considering a generalization of the cap to the whole of Europe. If gas becomes more attractive but not easier to import, it is unclear whether the effect on price will be as desired or of a magnitude similar to that observed in Spain.

Current impact in other countries: possible leakage from the system

Beyond the impact of the mechanism on prices and the generation mix in Spain, its implementation has had a significant impact in France, which is of particular interest for the European dimension of the debate, as it serves as a clue as to how it could change regional (between the EU and its neighbors) energy dynamics. Although the proposal drafted by Spain and Portugal initially envisaged a different price for interconnections, the European Commission finally ruled out this possibility to not restrict cross-border trade or discriminate between consumers. Thus, the lower prices in the Iberian market, together with the unscheduled stoppages in the French nuclear fleet and hydroelectric production at a minimum due to the drought, increased the demand for exports to our French neighbor.

The following figure gives us an idea of the magnitude of the change in the trade balance between Spain and France. Since the entry into effect of the cap, Spain has become a net exporter. In particular, exports grew by 80 % between June and July. In August, they increased by 34 % compared to the previous month. Moreover, in the two and a half months[17] that the mechanism has been in place, exports have already reached 82 % of those made during the first six months of the year. If this trend continues, by the end of the year, exports will double those of 2021.

Figure 10. **Use of the interconnection between Spain and France in MWh**
Imports and exports



Source: Own elaboration based on data from Red Eléctrica | EsadeEcPol

17 Consideramos las exportaciones realizadas hasta el 31 de agosto de 2022

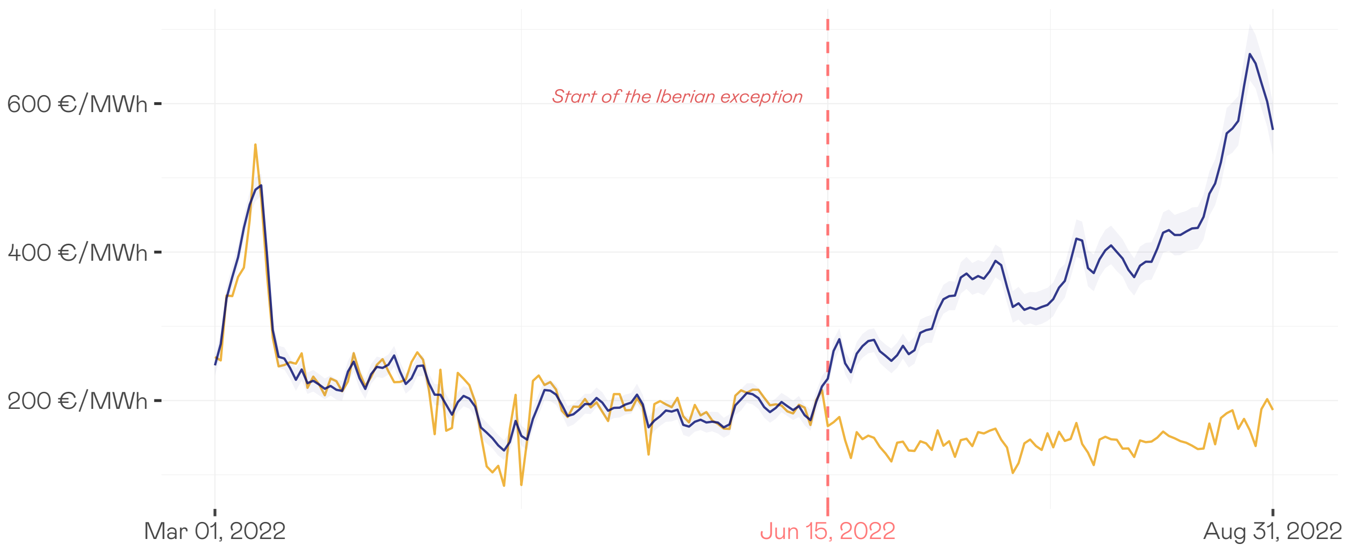
This effect could have been even greater had export capacity not been limited. Export capacity between France and Spain has been reduced by an average of 30% since June 15 compared to the average values recorded up to that date. Given that the available interconnections have been fully occupied since the mechanism became operational, exports would most likely have been even higher had they not been restricted.

To assess, in turn, the possible impact of the gas cap on exports to France, we adopt an indirect strategy. First, we estimate, in the same way as used in the previous cases, a model for the wholesale prices or spots (not VPSC) that would have prevailed in Spain in the absence of the cap and, once obtained, we contrast them with the French spots. Behind this exercise is the intuition of assuming that exports of electricity to France are due to a lower spot price in our country and, with the estimation of the counterfactual, the aim is to visualise whether, even without the existence of the cap, Spanish prices would have been cheaper or cheaper than French prices.

Let us not forget that the price difference may be due to two reasons or a combination of these. Firstly, it may be that this difference, which makes MWh relatively cheaper in Spain, is indeed be due to the cap or, secondly, it may be that the relative increase in the price of French MWh is also be due to cyclical reasons that have dominated the French electricity market in recent months.

Figure 11 shows the series of the spot price in Spain observed from March 1, 2022 to August 31, as well as the counterfactual estimated by a model that reproduces the one used for the VPSC. Once again, it can be seen that the cap clearly led to a reduction in the spot price in Spain. This reduction is greater than that of the VPSC because, as we know, the latter includes compensation for power plants that use gas for electricity generation.

Figure 11. **Observed wholesale price in Spain and estimated without the gas cap**

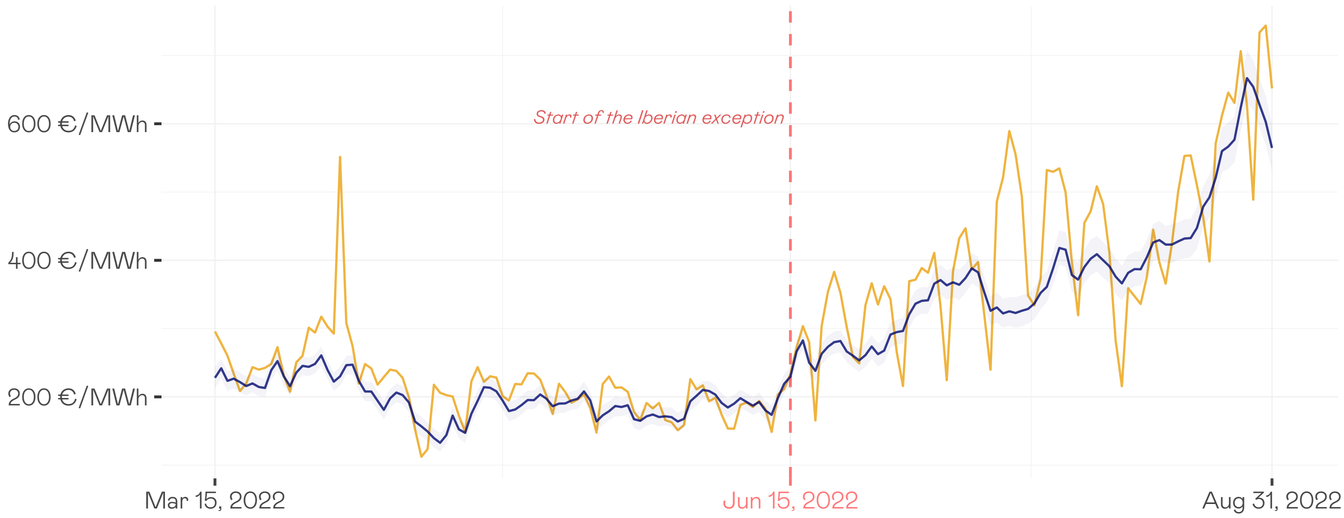


Source: Authors' own elaboration | EsadeEcPol

17 Consideramos las exportaciones realizadas hasta el 31 de agosto de 2022

The following figure compares the counterfactual series for the Spanish spot with the French spot. There are several issues that are worth explaining from what is observed. First, the French price would have been higher than the Spanish price most of the weeks since June 15. More precisely, 55 days out of the 78 analyzed, the French spot would almost certainly have been higher than the Spanish spot even without the cap. Of the remaining 22 days, 19 correspond to Saturdays and Sundays, days on which French demand falls sufficiently low for its system, with a still significant nuclear carryover, to be able to meet it at low prices.

Figure 12. **Comparison of the observed wholesale price in France and the estimated wholesale price without the gas cap in Spain**



Source: Authors' own elaboration | EsadeEcPol

Striking, however, is the pronounced change in the behavior of French prices, particularly since the introduction of the gas cap. Although it could be also due to other reasons that are difficult to observe, **we cannot rule out that the cap may have meant a strategic shift in the production of the French electricity system.** Let us not forget that the technical shutdown of quite a few nuclear power plants in France came into effect at the end of April, which would explain why, although the remaining ones in operation were able to more than meet the demand at weekends, they were unable to cover it adequately on other days. This would explain, both the change in the profile of the series and the increase in exports. It is therefore feasible to consider that the rise in exports to France was not only and exclusively a direct consequence of the increase in spot price differences between the two countries, since these incentives would most likely have existed without the cap, but also due to a French shift in response to the cap due to not financing the compensation. In any case, it should be kept in mind that the French system is highly interconnected and therefore does not set prices on its own.

It is certainly difficult to discern conclusively whether the gas cap has caused changes in export flows or not. But what is unquestionable (and mechanic) is that it has generated an economic benefit for French and Portuguese consumers. And, in any case, the result observed is that French imports and their price have clearly changed since the measure came into effect. This would support the fear expressed by Eicke et al (2022) of "leakage" to non-member states of the money spent on compensation. A leakage that may be significantly higher than that observed between Spain and France simply because the connections from EU countries to non-EU countries are more intense.

To this we must add that the Iberian energy island with its exceptional nature and the current mechanism (or others to replace it) will have to adapt to a new European energy context. Throughout 22-23 (and beyond) the EU will consider various measures to try to curb price escalation and limit its impact on the population: a cap on revenues from infra-marginal technologies, a cap on gas prices or reductions in demand are some actions that are on the table today. Analyzing how the gas cap interacts with all these policies and how its effectiveness can be maximised in the face of this new market configuration (if it can be maintained in its current form) are key tasks. In this sense, given that the interventions will take place at the European level, it may make sense to relax some of the restrictions that were imposed for their approval. For example, even if France applies the reduction in the remuneration of infra-marginal generators, the wholesale price will probably remain above the Spanish price, so that the incentives to import electricity from Spain will persist. Thus, from a perspective of European solidarity, it would make no sense to limit interconnections, but it would be necessary to implement cross-financing mechanisms to produce fairer and more equitable balances between countries. After all, both a possible extension of the gas price cap and other mechanisms being considered will generate significant cross-border flows, and therefore transfers between countries that should be recognised within the European economic and political balance in an explicit, supportive and permanent manner.

Conclusions

According to our estimates based on a causal identification model the exceptional gas cap for Spain and Portugal, the most drastic measure taken within Europe to manage the escalation of energy prices caused by Russia, has achieved its main objective: the prices of the regulated VPSC tariff were, on average, 24.6% lower than they would have been without the measure, for the period from its start on June 15 to August 31. This lower price, despite the compensation included in the bill, has resulted in average savings of around 113.9 €/MWh per day, or 8,881.1 €/MWh accumulated since June 15. Assuming a consumption of 8 kWh per household per day and 10 million households using the tariff, the savings could amount to almost 700 million euros, which could be amplified in the future as the effect of the cap is spread to the rest of the prices in the free market.

However, the introduction of the cap may have generated other unintended effects. First of these is that of a significant increase in the use of combined cycle power plants at the expense of a reduced use of (non-CO2 emitting) hydro and (more efficient) CHP plants. Although it is not so evident that, particularly in the case of hydro, the substitution of these technologies by CHP is exclusively caused by the cap, it is no less true that the introduction of the measure in a particular context that raises incentives to burn gas may be amplifying the undesired effects described above.

Finally, although the introduction of the cap has raised the incentives to export to France, these could have remained in place without its application. However, we cannot rule out that France's decisions on its electricity market production may have been equally strategic given the existence of an implicit subsidy, as the compensation to combined cycle plants is paid only by Spanish consumers. Therefore, it is feasible that the increase in exports to France is due both to a lower relative price created by the cap and to a change in the neighboring country's strategy to take advantage of this eventual situation.

This reflection inevitably leads to the confirmation that there is **an insurmountable dilemma between trying to reduce the price of gas in the short term and maintaining incentives for gas savings and decarbonisation.** Thus, when the European political objective of energy independence prioritises the former over the latter, it would be important to make explicit the cost that is assumed, and for what. In other words: it seems defensible to argue that without this erosion to the incentives to reduce the consumption of fossil fuels, the impact of a free escalating price on citizens would be excessive in socio-economic terms and, therefore, would damage the coalition in favor of energy savings and transition in the long term. However, to sustain this position it would be advisable to design credible commitments that exchange emergency measures today for solid transition and demand reduction measures tomorrow. Because, to conclude, it is important not to forget that this will be a game of several iterations: Spain and Europe have more than a winter ahead to finish aligning the objectives of decarbonisation and energy independence in a fair, balanced, and sustainable way.

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Methodological Annex

What is Causal Impact?

The causal impact method offers the possibility of implementing in a simple way for a structural model with time series the estimation of the effect of an intervention "designed" to affect the behaviour of one or several of the series included in the model. In simple terms, we can say that the effect is measured through the analysis of the differences between the behaviour that we should have expected in the time series and the behaviour observed. More technically, what the model used does is to generate a counterfactual series from the time of the intervention, which we could consider as observations that we should have expected if there had been no intervention versus those that have actually occurred.

In this case, the model that is fitted is a Bayesian structural time series (BSTS) model to a long target series and where this can be explained, in turn, by other exogenous variables. Thus, starting from the best possible model for the approximation of the series, an inference on the counterfactual is made from the date of the intervention.

The advantage of using a BSTS model over other models such as traditional time series analysis that estimate their coefficients through maximum likelihood estimation or other more advanced models such as the use of neural networks that learn from sequences of past data such as LSTMs lies in the ability to generate a posterior probability function with which not only to perform a forecast analysis, i.e. a point estimate of a data point, but also the probability resulting from the estimate for a given hypothesis. This fact allows us to know what will be the probability that the estimated counterfactual is significantly different from the observed data. By observing this probability, we can affirm, or not, whether the observed change is a chance result or, nevertheless, responds to an event that only the intervention itself could explain.

BSTS models, on the other hand, employ a probabilistic approach to modelling a time series problem, i.e. it returns a posterior predictive distribution which can be sampled to provide not only a forecast but also a means of quantifying model uncertainty, allowing for a wide variety of models, from simple ARIMA models to more complex ones.

Finally, the results allow us to infer the probability that the intervention is chance or random or, on the contrary, derived from a fortuitous event that can be associated with the treatment. In this way we can assess not only in quantitative terms the distance between the observed and expected series, but also the confidence interval for their difference and the probability that allows us to infer that we are observing a treatment and, therefore, its causality.