Basket risk assessment

In the context of the subsidy mechanism introduced in the Spanish Royal Decree, RD-L 413/2014.

KYOS Energy Analytics

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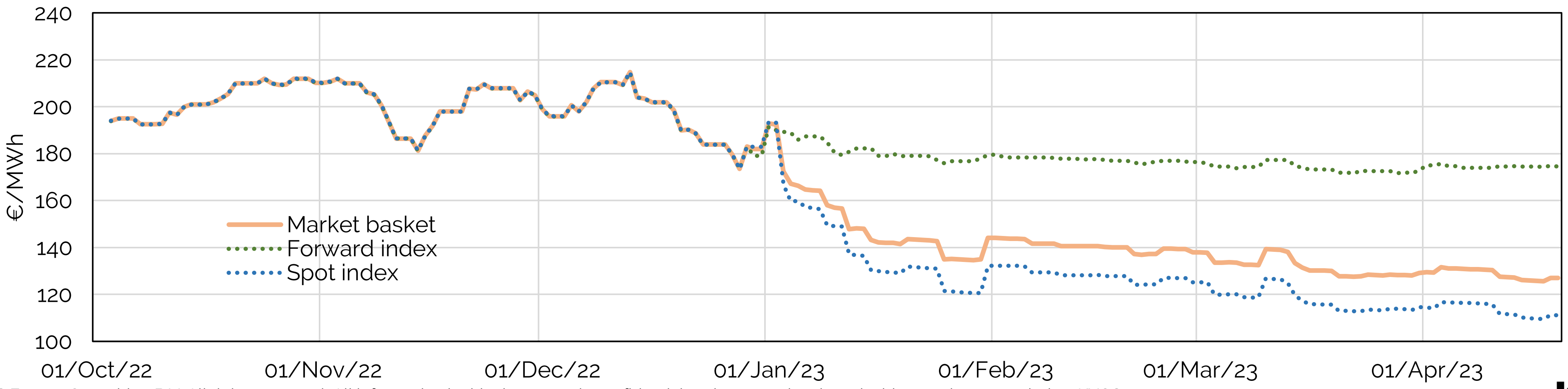
Expected market basket price in 2023

Below we provide insights into the realized and expected *Market* basket price in 2023, which eventually determine the cashflows of the assets within the subsidy scheme governed by the Spanish Royal Decree, RD-L 413/2014 (modified in RD-L 6/2022 and then in RD-L 10/2022). The Market basket price ('Market basket') is a weighted average of forward and spot prices, which in 2023 follows: **Market basket = 0.75 * Spot index + 0.25 * Forward index**. The Spot index is the average spot price in 2023, and the Forward index is a weighted average of Cal'23 and Q1/2/3/4 '23 forward prices. Each forward price is averaged over the three months prior to the first delivery day of the product.

From Oct. 1st, 2022 to Dec. 31st, 2022, the average Cal'23 and Q1'23 prices equaled 200.57 €/MWh and 164.98 €/MWh, respectively. The average Q2'23 price is calculated from Jan. 1st, 2023 to Mar. 31st, 2023 and it equaled 123.88 €/MWh.

Up to trading date Apr. 19th, 2023, the Q3'23 average price equaled 122.06 €/MWh, while it equals 121.50 €/MWh on the trading date itself. At the end of June 2023, the Q3'23 is expected to settle at an average of 121.62 €/MWh. This results in an expected **Forward index of 174.58 €/MWh**. See RD-L 413/2014 to know how each product is weighted within the Forward index.

Since Jan. 1st, 2023, the Spot index has been gradually forming as well, with a current average spot price of 90.74 €/MWh. Combining this with the average price of the KYOS OMIP-based Spanish price forward curve for the remainder of 2023 (119.86 €/MWh), the expected **Spot index is 111.17 €/MWh** and the expected **Market basket is 127.02 €/MWh**.



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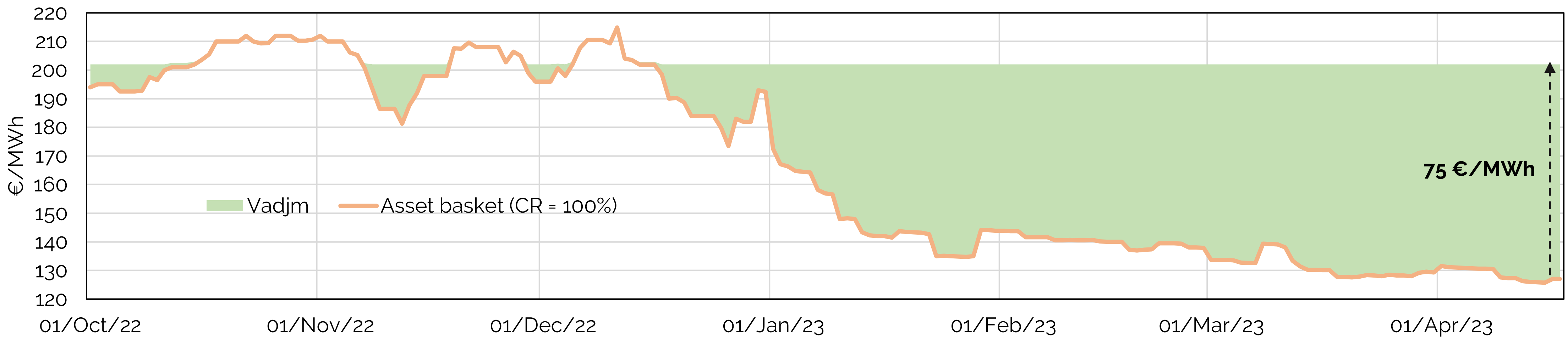
Expected basket adjustments in 2023

The *Market* basket price, as calculated before, is only a part of the final basket price reported under the subsidy scheme. The final basket price is in fact asset-specific ('Asset basket'), as it also includes the asset capture rate: **Asset basket = CR * Market basket**. CR is a capture rate estimated by the Spanish government based on the technology types and locations of all listed assets.

While the Asset basket is an indicator of the performance of the Spanish power market and the asset itself, the Spanish government has estimated that a Fair market price for regulated assets in 2023 is in fact **207.88 €/MWh**. This means that if the Asset basket is significantly below the Fair price, the government may partially make up for the difference between the two prices. But, if the asset basket is much higher than the Fair price, the government may request a partial reimbursement.

In either direction, the regulator refers to this as the *adjustments due to market deviations* (In Spanish: *Vajdm - ajustes por desviaciones de mercado*).

Adjustments are calculated depending on how much the Asset basket deviates from the Fair price. There are exactly five price ranges, defined by two lower bounds (LI2, LI1) and two upper bounds (LS2, LS1). With the current Market basket price at 127.02, and lower bounds of LI2 = 200.07 and LI1 = 203.97, the adjustment for an asset with 100% capture rate is as follows: **Vajdm = 200.07 – 127.02 + 0.50 * (203.97– 200.07) = 75 €/MWh**. The adjustment is positive (i.e. the government makes up for the difference), because the Market basket price is much lower than the Fair price and the lower bounds. See Appendix to understand how Vajdm is calculated for each of the price ranges.



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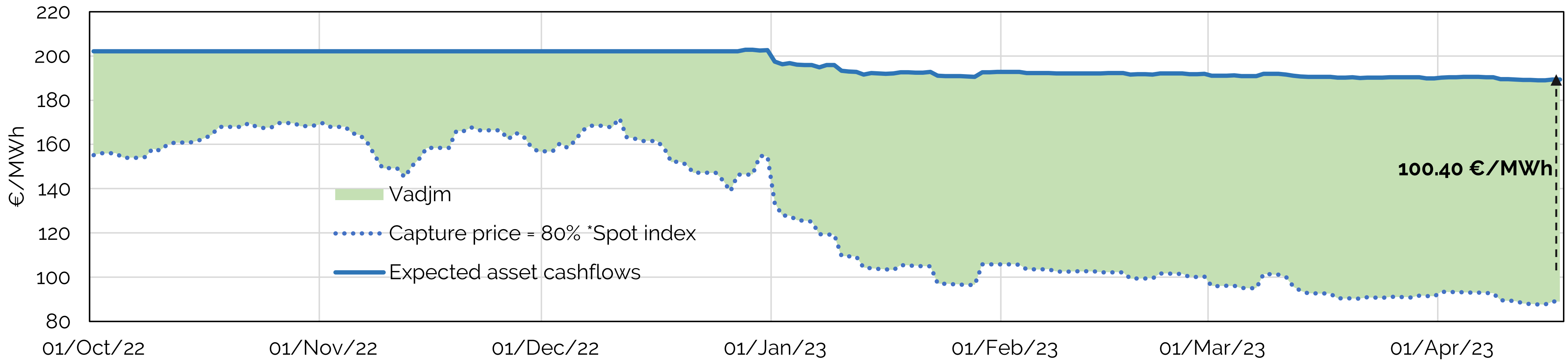
Expected asset cashflows in 2023 with 80% CR

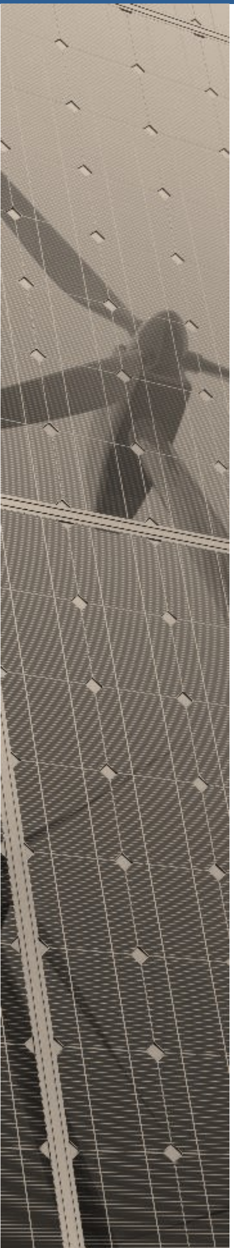
So far we have observed that an asset with a capture rate of 100% obtains an adjustment of Vajdm = 75 €/MWh. When the Market basket price (**127.02 €/MWh**) is well below the lowest bound LI2, finding the adjustment of an asset with a different capture rate (e.g. 80%) is straightforward: **Vajdm = (100% - 80%) * 127.02 + 75 = 100.40 €/MWh**.

The Vajdm adjustments are to be understood as subsidized cashflows for regulated assets. If we additionally assume that such assets sell their production in the spot market, the total cashflows of a given asset would thus be: **Total cashflows = market capture price + Vajdm**. For instance, with the current expected Spot index at **111.17** and an expected market basket at **127.02**, an asset with 80% capture rate would have the following total cashflows: **Total cashflows = 80% * 111.17 + 100.40 = 189.34 €/MWh**. Note that for simplicity, we have assumed Vajdm to be actual cashflows, but in fact the adjustments are only used in the calculation of the Net Asset Value (see RD-L 413/2014).

Interestingly, in the current context, cashflows turn out to be higher for assets with a lower capture rate, because adjustments become much higher than the loss in the market capture price: **100.40 – 75 > (100% - 80%) * 111.17 €/MWh**. In the figure below, we show the evolution of the expected asset cashflows for an asset with a 80% capture rate.



KYOS Analytical Platform for risk assessment

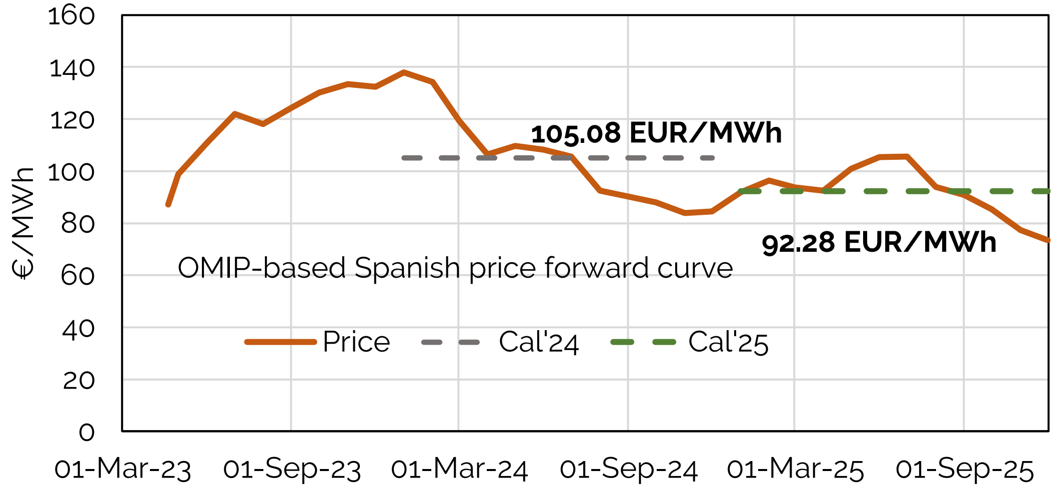


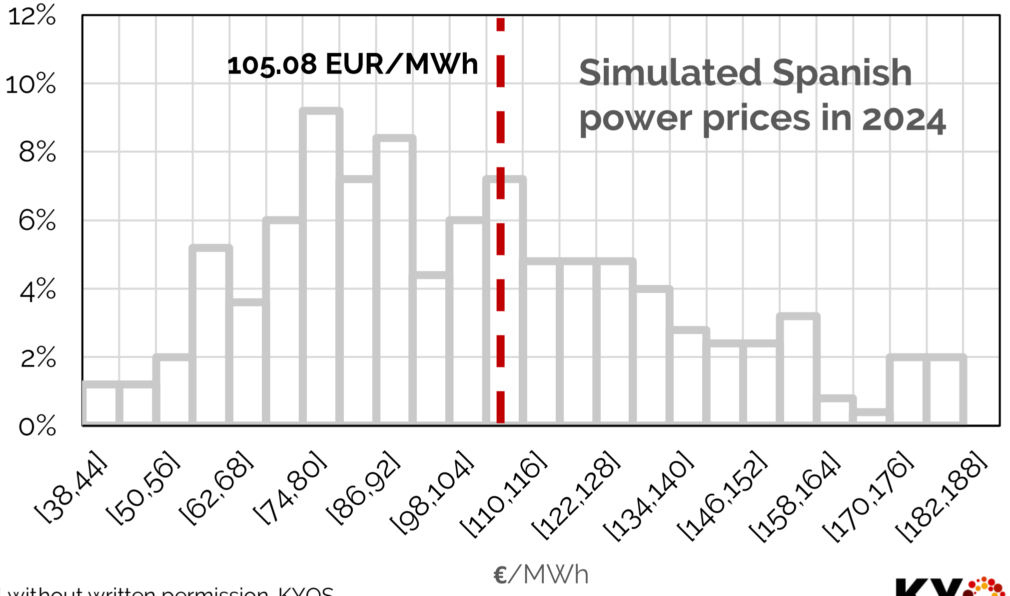
In this section, we describe the methodology to assess the price risks of regulated assets in the Spanish market, using the KYOS Analytical Platform, and especially the Monte Carlo price simulation engine, KySim. This model has been developed over a timespan of more than 15 years and it is in use at dozens of energy companies.

For the Spanish power market, KySim produces forward and spot price simulations, using volatilities and correlations observed in OMIP and OMEL. The result is a large number of simulation paths, which show realistic forward price levels and hourly shapes.

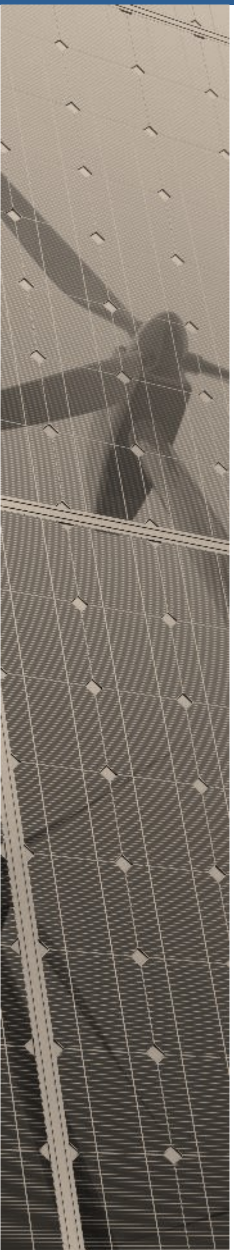
At the center of the simulations is the Spanish hourly price forward curve. The KYOS forward curve builder (KyCurve) shapes this curve using month, quarter, and year end-of-day settlement prices from OMIP. The model then refines the curve with seasonal, daily and hourly shapes.

The Monte Carlo simulations are arbitrage free with respect to the forward curve. For example, in the upper right plot we show the Spanish power monthly forward curve and its average in 2024 and 2025. In the lower right plot, we show the distribution of simulated prices in 2024 and its mean. Note that in both cases, the mean matches e.g. the Cal'24 = 105.08 €/MWh of the current trading date.





Market price risks



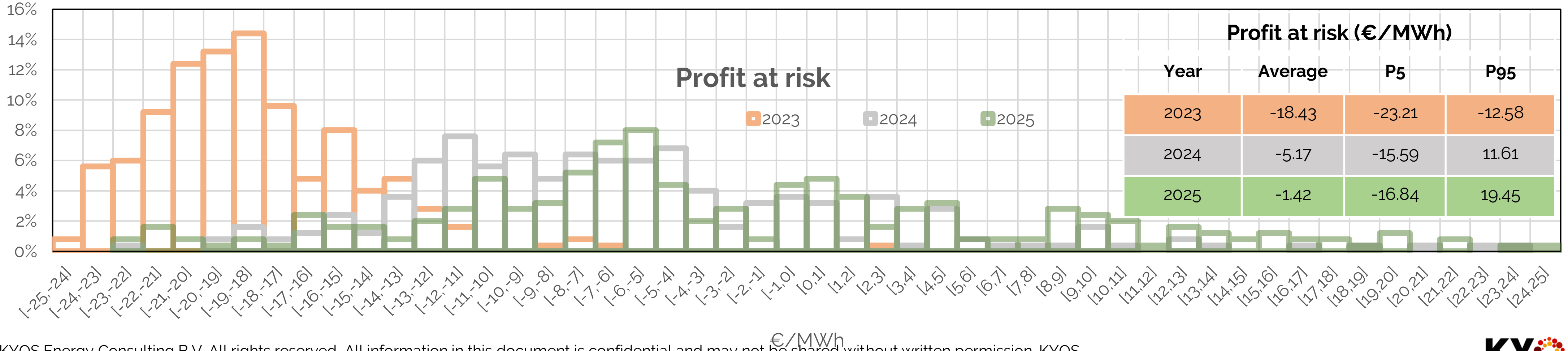
The total cashflows of regulated assets in the Spanish market are exposed to market price and volume risk. In this section, we assess the price risk.

We have defined that the price earned per MWh of production equals to: **Price = market capture price + Vajdm.** We consider this price to be fair when it matches the "Fair price" (or estimated price) set by the Spanish government, e.g. 207.88 €/MWh for 2023. We define the Profit as the difference between the Price and the Fair price. When the Profit is negative, it means there is a loss. **Profit = Price - Fair price.**

If the Asset basket price had been exactly equal to the Spot index, then the Profit would not be below -5.86 €/MWh. However, there is an additional price risk, because the asset basket combines the Spot index with a Forward index.

If the Forward index is above the Spot index, then the Price is further below the Fair price and the Profit more negative. That is the situation in 2023, and may also happen in 2024/2025, depending on how prices evolve.

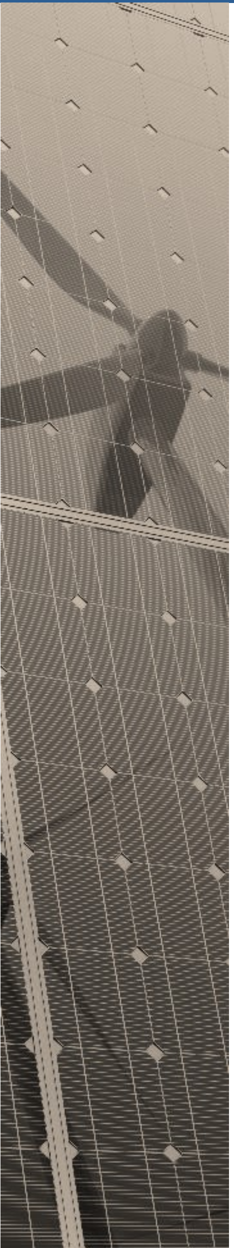
For each calendar year, we have therefore generated Monte Carlo price simulations of spot and forward prices to calculate many possible outcomes of the Asset basket price and the Profit for an asset with 80% capture rate. For 2023, the average Profit is -18.43, but with 5% probability, it will be below -23.21 €/MWh. For 2024 and 2025, the average Profit is not low yet, but in many simulation paths it can be quite negative. For example, the table shows that with 5% probability the loss in 2024 can be more than 15.59 and in 2025 more than 16.84 €/MWh.



Profit at risk (€/MWh)

Year	Average	P5	P95
2023	-18.43	-23.21	-12.58
2024	-5.17	-15.59	11.61
2025	-1.42	-16.84	19.45

Conclusion



The Spanish subsidy scheme we have described provides support to regulated renewable energy assets in the country. The changes to the scheme, however, expose asset owners to market prices, but also provide an increasing incentive to hedge price exposures on the OMIP futures market.

The design of the scheme is quite complex and exposes asset owners to risks that are not always well understood. For example, due to the evolution of prices, many asset owners are likely to earn much less than the estimated ("fair") price set by the Spanish government.

This report has shown that the expected loss in 2023, relative to the estimated price set by the Spanish government, is 18.43 €/MWh, and may become even worse. We have also shown that the years 2024 and 2025 may create losses of equal magnitude, depending on how market prices evolve.

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A large part of this exposure to market prices can be hedged in the market, either on the exchange or via OTC transactions. KYOS is an independent provider of software and advisory services to support market players with a thorough risk analysis and recommendations of how to manage the financial risks in energy markets.

KYOS also provides independent assessments of the fair value of risk management products. We combine sophisticated Monte Carlo simulation tools with a deep understanding of the Spanish market dynamics for the best advisory services.

Contact us on info@kyos.com for more information and plan a meeting with one of our energy market specialists.

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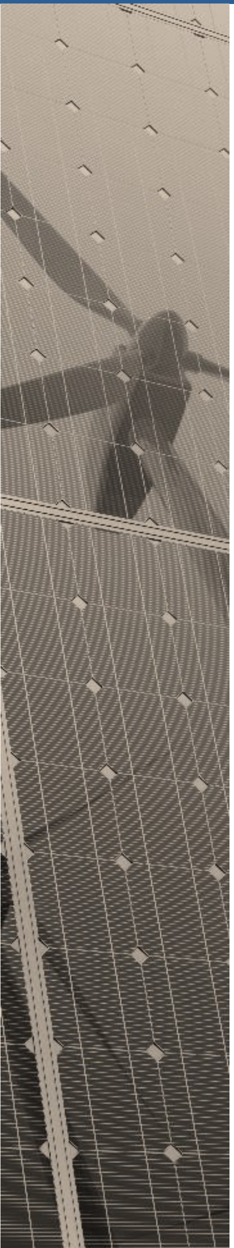
Appendix

Overview of the subsidy scheme



Financial subsidies for renewable energy assets in Spain are mainly regulated by the Royal Decree, RD-L 413/2014. After the publication of Royal Decrees, RD-L 6/2022 and RD-L 10/2022, these subsidies are calculated following a basket-based principle. The purpose of this note is to analyze the risk that this mechanism brings to regulated assets in the country.

To understand the risk, we first provide general insights into the subsidy scheme:

- Subsidies are provided every three-year semi-periods. The decision whether a subsidy is granted in a semi-period for any given asset is taken on the semi-period before, primarily based on the comparison between basket-related cashflows and estimated cashflows of the asset.
- Asset cashflows are a function of the asset's capture rate (C_{apunt}), its number of equivalent production hours per year (N_h), and a reference price (P). For every year i in the semi-period, the regulator assumes a given $C_{apunt,i}$ and Nh_i.
- The reference price ($P_{estimated}$) for the estimated asset cashflows is government-based, and it is published in a Royal Decree prior to the start of every new semi-period. On the other hand, the reference price for the basket-related asset cashflows is the basket price (P_{basket}), which is calculated as a weighted linear combination of market products: average yearly spot (P_m), calendar ($Pfannual$), quarter ($Pftrim$) and monthly ($Pfmen$). That is, for a year i in a semi-period and weights a, b, c and d:

$$P_{basket,i} = \left[a_i * P_{m,i} + b_i * Pfannual_i + \sum_{k=1}^{k=4} \left(c_{i,k} Pftrim_{i,k} \right) + \sum_{l=1}^{l=12} \left(d_{i,l} Pfmen_{i,l} \right) \right] C_{apunt,i}$$

- The relation between $P_{estimated}$ and P_{basket} , which directly determines whether the subsidy scheme is granted in the next semi-period, is calculated as per $V_{adjm} = \delta(P_{estimated}, N_h) + \alpha(N_h)\, P_{basket}$. The Royal Decree, RD-L 413/2014, refers to V_{adjm} as the *adjustment in the deviations from the market price*. The adjustment in the deviations from the market price, V_{adjm} , is a piece-wise function, which means that variables δ and α take different values depending on the level of P_{basket}.

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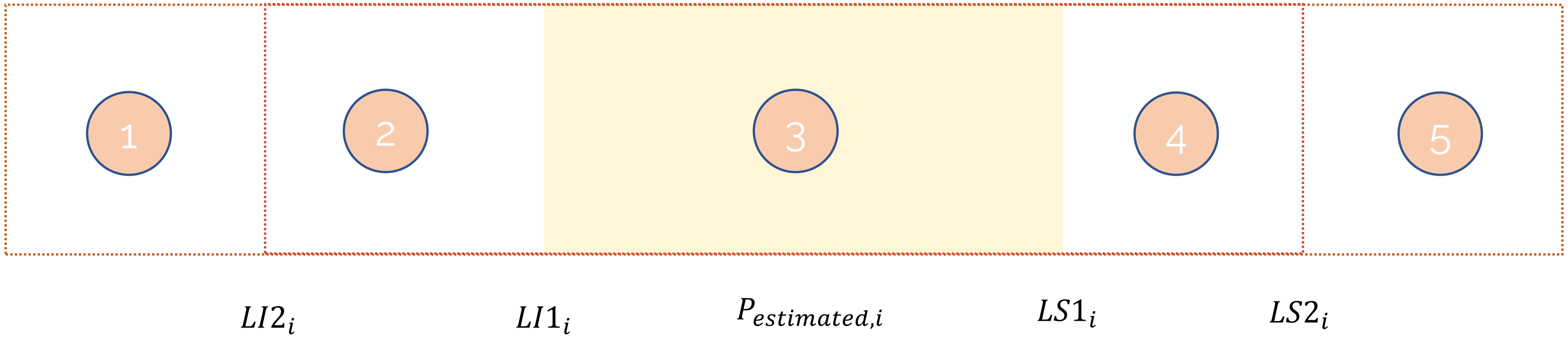
Overview of the subsidy scheme (cont'd)

The adjustment in the deviations from the market price, V_{ajdm} , is defined by the five regions shown below. In this formulation, LI represents a lower bound, while LS represents an upper bound. These bounds are symmetric to the estimated price, $P_{estimated}$: $LI2_i = P_{estimated,i} - \Delta$, $LI1_i = P_{estimated,i} - \frac{\Delta}{2}$, $LS1_i = P_{estimated,i} + \frac{\Delta}{2}$, $LS2_i = P_{estimated,i} + \Delta$. The deviation constant, Δ, is set up by the government to be: $\Delta = 7.81$ EUR/MWh.

1. $Vajdm_i = Nh_i * 0.5\ (LI1_i - LI2_i) + Nh_i * (LI2_i - P_{basket,i})$
2. $Vajdm_i = Nh_i * 0.5 * (LI1_i - P_{basket,i})$
3. $Vajdm_i = 0$
4. $Vajdm_i = Nh_i * 0.5 * (LS1_i - P_{basket,i})$
5. $Vajdm_i = Nh_i * 0.5\ (LS1_i - LS2_i) + Nh_i * (LS2_i - P_{basket,i})$



$V_{ajdm} = \delta(P_{estimated}, N_h) + \alpha(N_h)\ P_{basket}$.
For example, if $P_{basket,i} > LS2_i$, $\delta = Nh_i * 0.5 * (LS1_i - LS2_i) + Nh_i * LS2_i$ and $\alpha = -Nh_i * LS2_i$.

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