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# Construction of the calibration curve for the calibration of the Strike Price linked to the Delivery Period 2027-28

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# Abstract

This document presents the context and the results of the application of the methodology described in Article 27 §1 from the Royal Decree Methodology. This methodology aims to define the process followed to obtain a Strike Price calibration curve. This document is prepared for Elia in view of the development of its proposal for a Strike Price of the Delivery Period 2027-28.

The Strike Price of the Belgian Capacity Remuneration Mechanism (CRM) is determined in two steps:

1. The determination of the calibration curve that is used to determine the Strike Price interval according to the methodology presented in Article 27 §1 from the Royal Decree Methodology.

2. The final calibration of the strike price based on the calibration curve and on additional energy market considerations according to Article 27 §2 from the Royal Decree Methodology.

This report focuses on the first step of the calibration process of the strike price. The required data have been collected for the last three winter periods (2019-2020, 2020-2021 and 2021-2022) from both EPEX and Nord Pool Spot to build the curve according tot the methodology. E-CUBE Strategy Consultants has been working in close collaboration with both EPEX and Nord Pool Spot thereby ensuring a good and correct understanding of the received data.

Firstly, the report introduces the overall context and use of the strike price calibration curve. Secondly, a detailed description of the full steps leading to the final result for the calibration curve is provided. Finally, the results from the update of the calibration curve for the Y-4 auction for the Delivery Period 2027-28 are shared as well as an interpretation of the results.

The analysis of the calibration curve zooms on the range which will be targeted for the calibration of the strike price : the [75%, 85%] interval as put forward by the Royal Decree Methodology. For the Y-4 auction for the Delivery Period 2027-28, the interval is computed at [270; 417] €/MWh. This results is quite different from past results, but coherent with the steep increase in electricity prices since last November in all Europe. The high increase is due to several reasons (weather conditions, rebound of the economy after COVID-19, Ukrainian war) and is likely to stay for more than the past winter.

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# 1. Introduction

## 1.1 Context of the Capacity Remuneration Mechanism

In the context of Belgian future adequacy, Belgian Electricity Law foresees in a Capacity Remuneration Mechanism (CRM). This mechanism offers, through auctions, a complementary revenue to market revenues for Capacity Providers. However, episodes of scarcity in the energy market can result in events of very high prices, which might result in windfall profits for some Capacity Providers already benefitting from the CRM complementary revenues. The Strike Price is therefore set , in the context of the Reliability Option , as the upper price limit until which Capacity Providers from the CRM can earn energy market revenues.

## 1.2 Context of the methodology related to the calibration curve and to the calibration of the strike price

On April 28th 2021, the Royal Decree defining, among others, the steps to be fulfilled for the computation of the calibration curve leading afterwards to the determination of the strike price was published (hereinafter referred to as "Royal Decree Methodology")[1]. The methodology therein described is identical to the methodology proposed in draft Royal Decree Methodology and applied for the computation of the calibration curve of the strike price for the Y-4 auction related to the Delivery Period 2025-2026 (conducted two years ago).

The analysis applied in this report for the update of the strike price calibration range for the Y-4 auction related to the Delivery Period 2027-2028 (hereinafter referred to as "Y-4 auction") is similar to the analysis conducted for the first calibration report and fully complies with the methodology as put forward in the above mentioned Royal Decree.

## 1.3 Overview of the Royal Decree methodology for the strike price determination

### 1.3.1 Definition of the strike price in the CRM

The strike price is defined as "*the predefined price that determines the threshold above which the Capacity Provider has to pay back the difference with the Reference Price*"[2].

The strike price is set to define a cap price on energy market revenues for capacity providers benefitting from CRM complementary revenues. If the reference price (based on the price observed in the day-ahead market for a NEMO active in the Belgian Bidding Zone) exceeds the strike price, then all additional revenues made on the energy market from the capacity provider above the strike price are to be paid back by the capacity provider.

### 1.3.2 Brief reminder of the methodology used for the construction of the strike price calibration curve

The Royal Decree Methodology provides detailed specifications for the strike price determination. It must be determined through:

- **The construction of a strike price calibration curve providing price and volume couples computed through the processing of historical day-ahead market data (Article 27 §1)**

[1] Accessible through ejustice.just.fgov.be:
http://www.ejustice.just.fgov.be/eli/arrete/2021/04/28/2021041351/justel#LNK0008
[2] *Law on the Organisation of the Electricity Market, Article 2 §1 80°,* April 1999

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The relevant thresholds of the range of the strike price calibration curve are defined as the price levels for which 75% and 85% of the bidden volumes[3] have been offered (supply side) or withdrawn (demand side) from the market. For each year, the bidden volumes and their corresponding price level are extracted from historical market data. The calibration curve used for the determination of the price interval is based on the prices observed for the last three winters.

- **The calibration of the strike price taking place within the calibration range defined in the first step above by taking into account the criteria listed at the article 27 of the Royal Decree Methodology the calibrated strike price has to comply with:**

  1) The variable costs of the units with a daily schedule (determined based on a simulation of the electricity market) must be covered by the calibrated strike price ;
  2) The shape of the calibration curve ;
  3) The evolutions of the electricity markets ;
  4) The stability of the strike price in time ;
  5) A reasonable chance for the strike price to be reached by the reference price.

However, it is important to insist on the fact that this report only focuses on the construction of the calibration curve of the strike price. The further calibration of the strike price based on the range provided in this report is done apart by applying the 5 criteria from the Royal Decree.

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*  *

[3] Specific criteria are further detailed

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# 2. Description of the methodology

## 2.1 General methodology used for strike price determination

The methodology used to determine the calibration curve of the strike price is described in article 27 of the Royal Decree Methodology.

The strike price calibration range is the price range for which 75% up to 85% (included) of the "elastic volumes" are offered on the Belgian day-ahead market. According to the Royal Decree Methodology, a volume is considered as "elastic" when it is offered at a price strictly above 0 €/MWh and strictly below the maximum authorized price on the market.

These volumes are sensitive to price variations in scarcity periods and may provide the electric system part of its flexibility. For instance, when the price rises, the reaction of elastic volumes can either be an increase in the supplied volumes or a decrease in the demanded volumes. The new volumes proposed in the supply side and the volumes that are no longer demanded in the demand side are equivalent from a system adequacy perspective.

The methodology first aims at building the calibration curve based on elastic volumes according to the price they are offered at in the Belgian day-ahead market. This calibration curve is built considering the different order types (aggregated curves, simple and complex block orders…) from the different Nominated Electricity Market Operators (EPEX and Nord Pool) present in the Belgian Bidding Zone.

The strike price calibration range is then directly determined from this curve.

## 2.2 Step-by-step description of the applied methodology

### 2.2.1 The different steps used to calibrate the strike price interval

The steps of the methodology are described in the article 27 of the Royal Decree Methodology. The applied methodology is presented in Figure 1 and matches the 6 steps detailed in the Royal Decree Methodology.

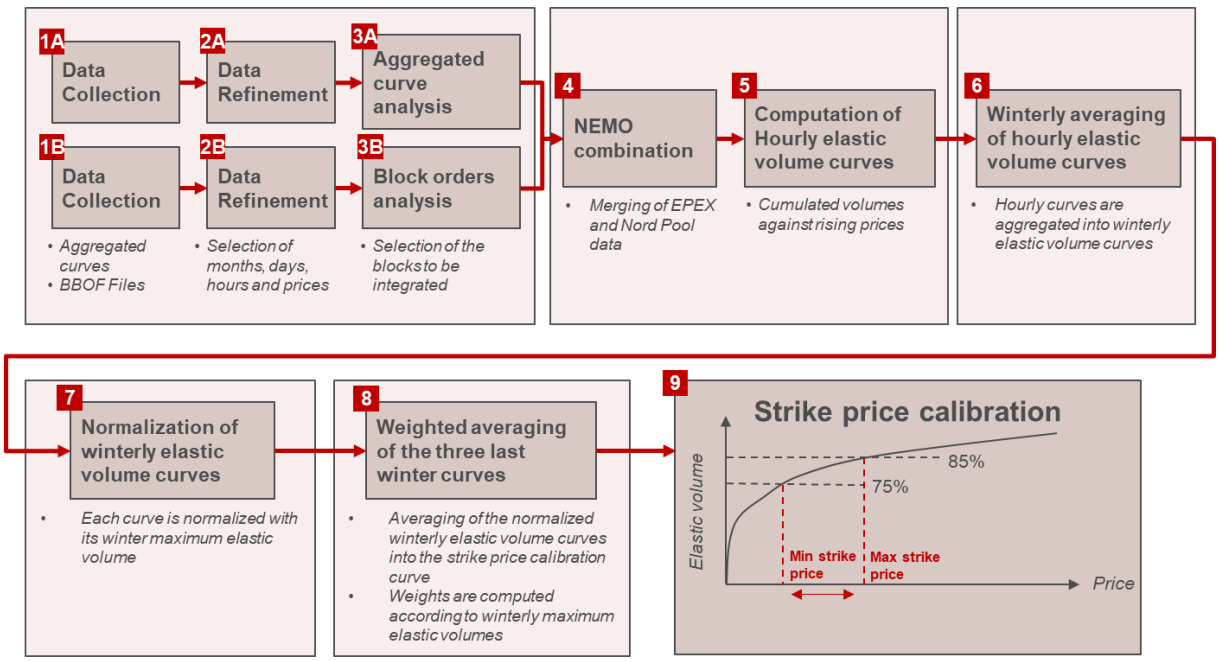


*Figure 1 - Steps applied in the methodology and in accordance with the Royal Decree Methodology*

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- **STEP 1 - 3: Data collection – Data refinement – Elastic Volume Determination**

The two first steps have three main objectives: collect and load the data from the different NEMOs considered, refine them to meet different criteria established in the Royal Decree Methodology (see Figure 2) and finally determine the volumes considered as elastic in accordance with the rules specified in section 2.3.

According to the Royal Decree Methodology, the analysis focuses on data from weekly peak hours (8AM-8PM) during winter months (November to March). Moreover, the volumes offered at prices equal or inferior to zero are not considered, just like those offered at a price equal to the maximum authorized price.

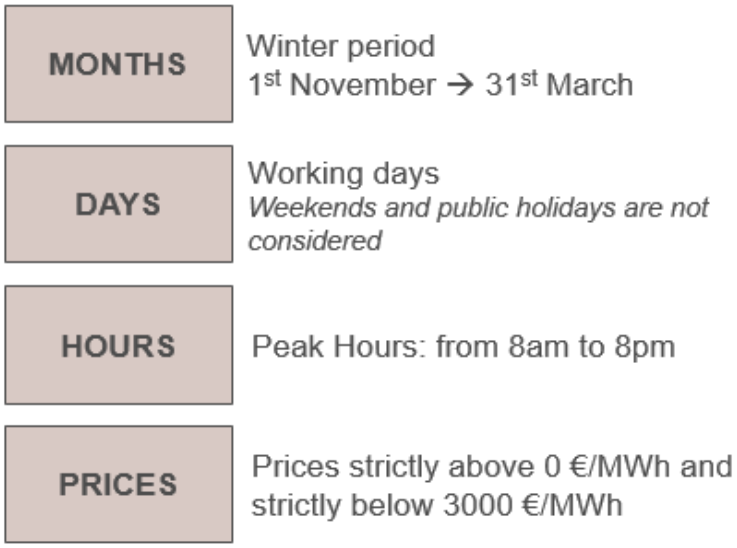


*Figure 2 - Refinement rules applied to all data sources*

The objective of these steps is to process the different data sources to **get all hourly elastic orders**[4] offered in the day-ahead market during the last three winter periods.

- **STEP 4-5: Compilation of data from different NEMOs into hourly elastic volume curves**

In the strike price calibration for the Y-4 auction, data are collected under the form of aggregated curves from EPEX and Nord Pool Spot and block orders from EPEX and Nord Pool (see 2.2.2). At the end of STEP 1-3, all elastic hourly orders from the different sources have been determined.

These volumes are cumulated, on an hourly basis, with increasing prices to build the **hourly elastic volume curve** corresponding to a certain hour. For every price level between 0 and the maximum authorized price on the market (both excluded), the hourly elastic volume curve represents the sum of elastic volumes coming from the supply and demand sides and offered at this given hour from both EPEX and Nord Pool Spot.

[4] An hourly order is a certain volume (MWh) proposed at a certain price which might come from the demand and/or the supply side. According to the Royal Decree Methodology, it is considered as elastic if its price is not strictly above 0 €/MWh and strictly below the maximum price authorized on the market.

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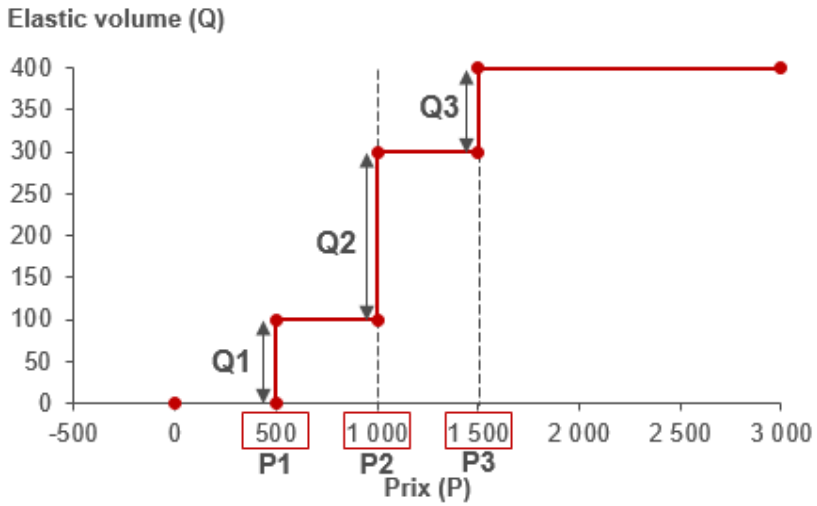


*Figure 3 - Construction of the hourly elastic volume curve from hourly orders (STEP 4-5)*

The Figure 3 illustrates this construction in a theoretical case. In this case:

- The volume Q1 is offered at price P1 (500)
  - If Q1 is from the supply side, Q1 is a production volume proposed on the market for prices above P1
  - If Q1 is from the demand side, Q1 is a consumption volume that is no longer demanded for prices above P1
- The volume Q2 is offered at price P2 (1000)
- The volume Q3 is offered at price P3 (1500)

**All elastic volumes are considered on an equal basis**. (Q1; P1), (Q2; P2) and (Q3; P3) can be from any of the data sources (Nord Pool Spot or EPEX Spot) and from the supply or the demand sides.

In the construction of the hourly elastic volume curve in Figure 3:

- at a price P1, the cumulated elastic volume is Q1
- at a price P2, the cumulated elastic volume is Q1+Q2
- at a price P3, the cumulated elastic volume is Q1+Q2+Q3

At the end of STEP 4-5, the data from the different NEMOs are combined and an hourly elastic volume curve is computed for every hour in the dataset.

- **STEP 6: Winterly averaging of the hourly elastic volume curves**

All relevant hourly elastic volume curves belonging to a single winter period are grouped and averaged. It means that for each price level, the cumulated elastic volumes of all relevant hourly elastic curves from one winter are summed and divided by the number of relevant hours from that winter.

- **STEP 7: Normalization by winterly maximum**

At the end of STEP 6, three curves are computed, one by winter period. These curves are now normalized: meaning that, for each winter, all averaged cumulated volumes are divided by the maximum volume of the winter curve. Consequently, the three winter curves have a normalized elastic volume starting at 0% and ending at 100% and that is expressed in function of that winter maximum elastic volume.

STEP 6 & 7 are illustrated in Figure 4.

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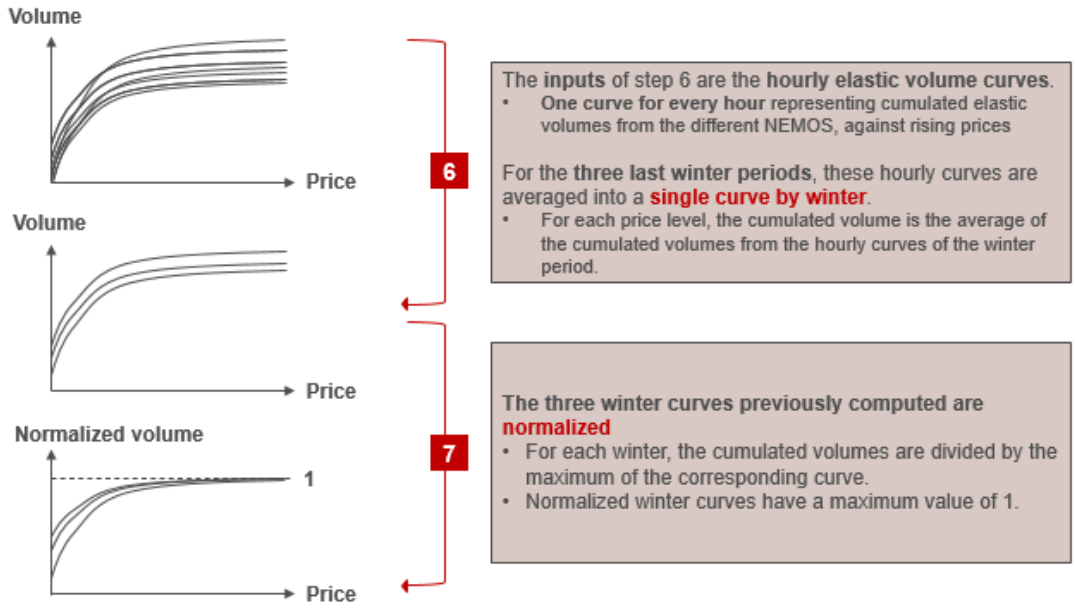


*Figure 4 - Illustration of the averaging of hourly elastic volume curves by winter and the following normalization (STEP 6 & 7 from the Royal Decree Methodology)*

- **STEP 8 & 9: Construction of the strike price calibration curve**

The strike price calibration curve (represented in red in Figure 5) is computed through a weighted averaging of the normalized winter curves from STEP 7. According to the Royal Decree Methodology, the weights used for the ponderation are the maximum volumes of each winter curve before their normalization.

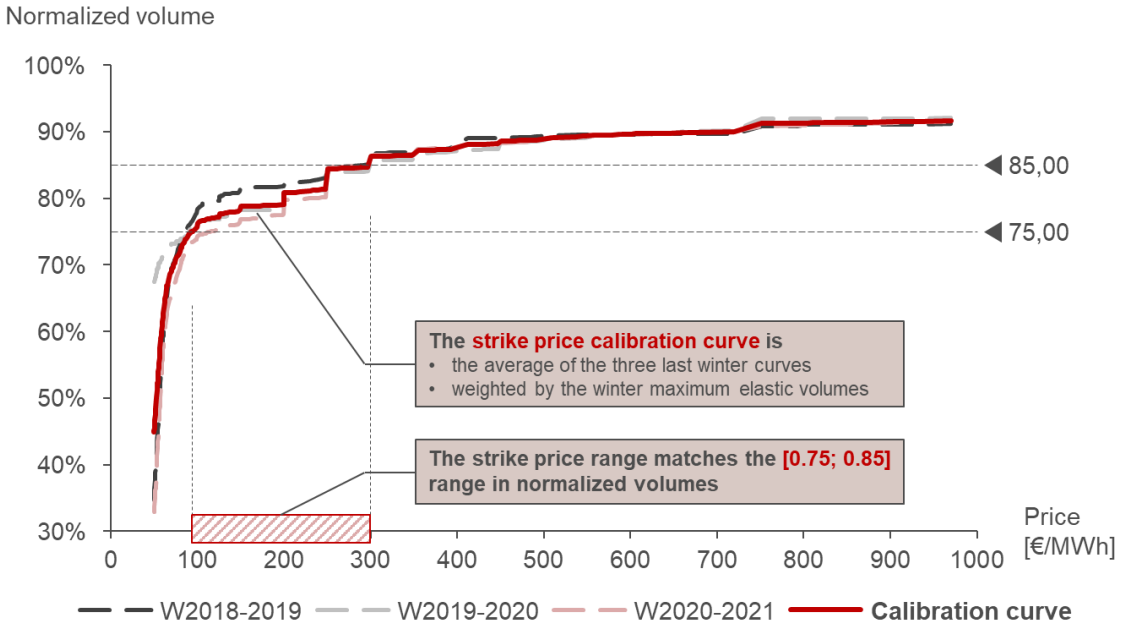


*Figure 5 – Computation of the strike price calibration curve and the reading of the strike price interval (STEP 8 from the Royal Decree Methodology) 2019-2021*

Since the calibration curve is the weighted average of three normalized curves, it is a normalized curve as well. The strike price calibration range is the price range corresponding to a [0.75, 0,85] normalized volume interval. This interval is clearly indicated on the calibration curve in Figure 5 above.

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### 2.2.2 Data sources used

The data used were made available by EPEX and Nord Pool Spot, as hourly aggregated curves and individual block orders. These data were collected for weekdays, peak hours for the entire period November 1st – March 31st.

#### *2.2.2.1 Hourly aggregated curves*

The data from aggregated curves are hourly data files, containing pairs of prices and associated aggregated volumes for a given hour. A file typically contains, on an hourly basis:

- cumulated volumes associated to descending prices on the buy side
- cumulated volumes associated to ascending prices on the sell side

The corresponding curves are represented on Figure 6 below. The hatched areas are the volumes that are not considered in the aggregated curve analysis either because they are:

- offered at null/negative prices
- offered at the maximum authorized price

These volumes are thus not considered as elastic neither taken into account for the construction of the calibration curve of the strike price. Only volumes associated with executed block orders are integrated in the aggregated curves files and are stored at the maximum price (demand side) or at the minimum price (supply side). However, the volumes are excluded from the aggregated curve analysis as they appear at any price. They are thus collected via BBOF files and treated distinctly. These volumes are hatched on Figure 6 below. Still the construction of the strike price calibration curve relies as well on the block orders that were submitted but not executed and which cannot be found back at the minimum/maximum price of the aggregated curves: this explains once again why block orders are treated separately via BBOF files.

Furthermore, it is important to remind that no block orders were observed on Nord Pool Spot and all came from EPEX Spot for the winters considered for the construction of this calibration curve.

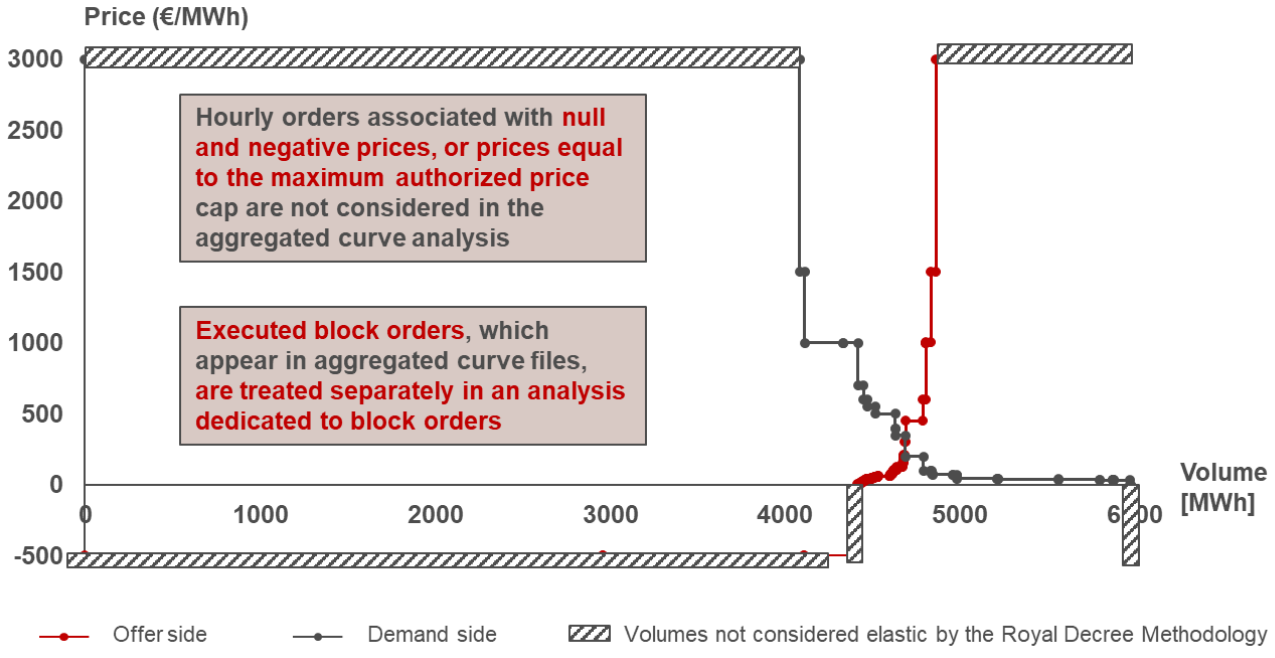


*Figure 6 - Example of a Belgian Day-Ahead-Market hourly aggregated curve*

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Volumes offered in the aggregated curves and meeting the already mentioned price[5] and time[6] criteria are integrated as elastic volumes in the analysis of the strike price calibration. A theoretical example is provided in the left part of Figure 7 for the integration of volumes from a theoretical aggregated supply curve. In this example, volume Q1 is offered at price P1 (500), volume Q2 at price P2 (1000) and volume Q3 at price P3 (1500). By contrast, volume Q4, offered at a negative price, and volume Q5, offered at the maximum authorized price are not considered as elastic volumes and are not kept in the following steps.

The right part of Figure 7 illustrates that the volumes from the demand side are integrated in a symmetrical way. In the demand side, the elastic volumes are equal to a reduction of the consumption when the price increases.

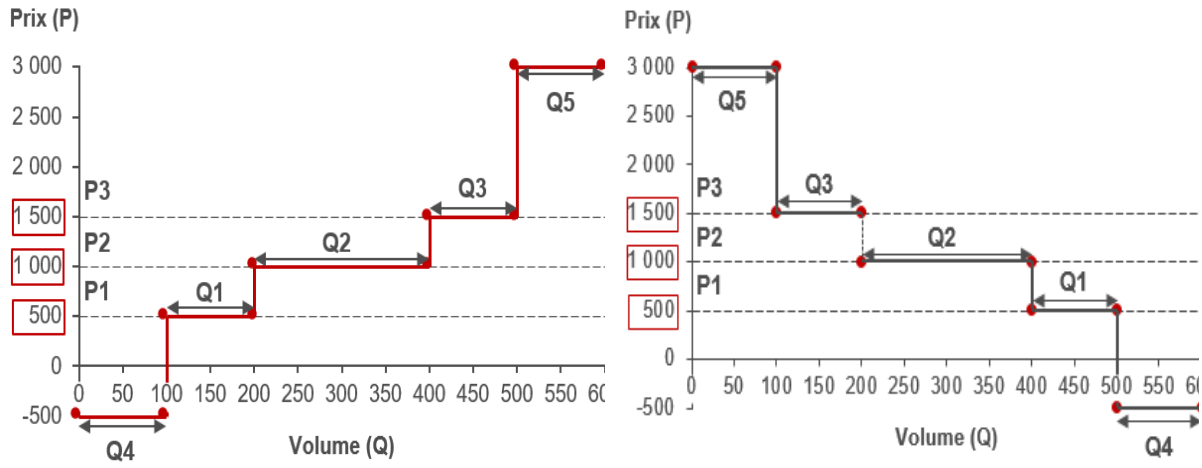


*Figure 7 - Integration of volumes from the aggregated curves from supply side (left) and demand side (right)*

#### 2.2.2.2 Block orders

This data consists of daily data files named BBOF, containing block orders for a given day. A block order is defined thanks to a type, a price, and volumes for each hour of the day. All the volumes of a daily block order are offered at the same price. Negative volumes are associated with orders from the supply side (or sell side) while positive volumes are associated with orders from the demand side (or buy side). Block orders were only observed on EPEX Spot and not on Nord Pool Spot.

Each type of the block order is associated with specific rules of acceptance described on Figure 8 below.

[5] Only prices strictly superior to 0 and strictly inferior to the maximum authorized price on the market
[6] Winter peak hours from weekdays, excluding bank holidays

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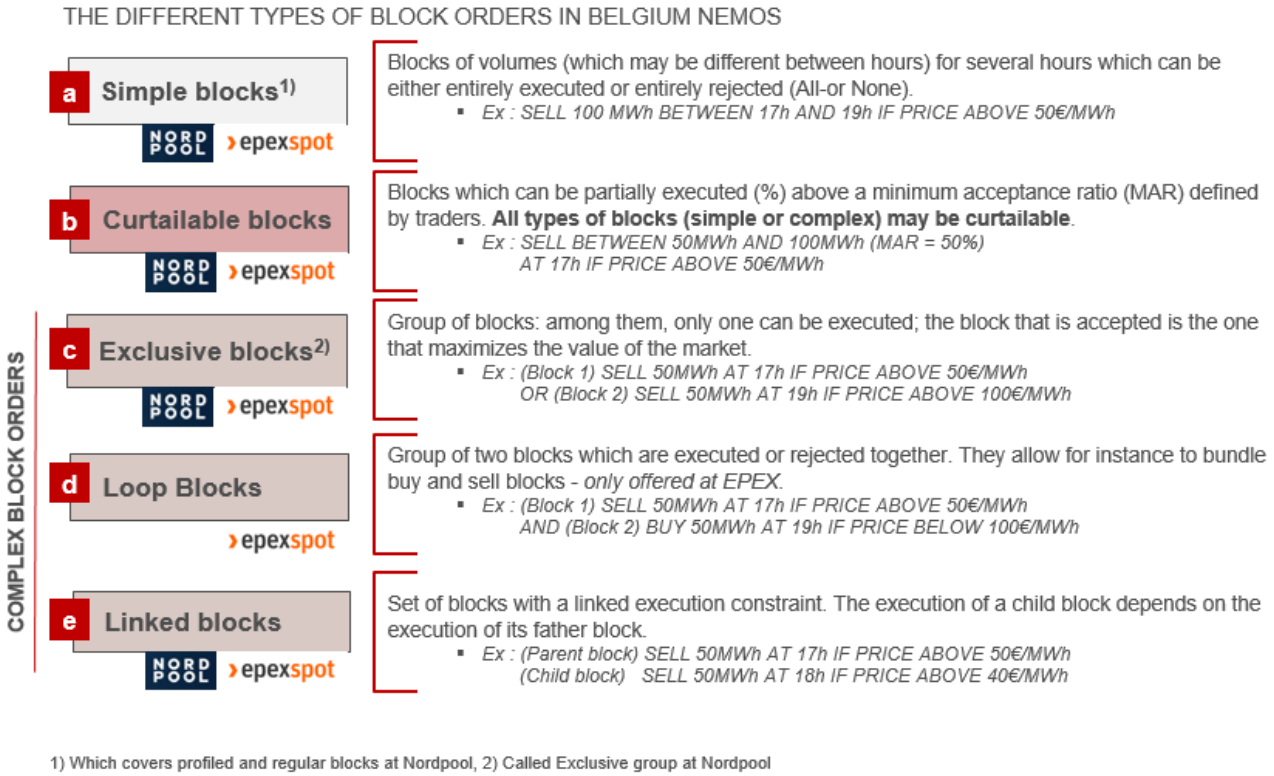


*Figure 8 - Different types of block orders and their specific rules of acceptance*

Hourly orders are not directly accessible from the BBOF files as the block orders are offered daily and not hourly: various volumes may be offered during various hours in a day.

## 2.3 Integration rules of block orders

The integration rules for block orders depend on the type of block orders considered. No changes were made to the block orders' integration rules compared to last year, exactly the same approach was followed.

On the one hand, simple, curtailable, linked or loop blocks (see Figure 8) can be fully integrated because all the volumes offered in these orders can be executed if needed and be considered as elastic volumes.

On the other hand, exclusive block orders need a specific rule of integration because at most only one block order per group can be executed on the market. It means all the volumes offered should not be considered as elastic but only the volumes from one block order per group. The specific rule aims at selecting one block order per group of exclusive block orders to maximize the volumes offered. If all block orders offer the same volumes for the same price, then one block order is randomly selected to be integrated as elastic volume.

The rule on the integration of each type of block is described in Figure 9.

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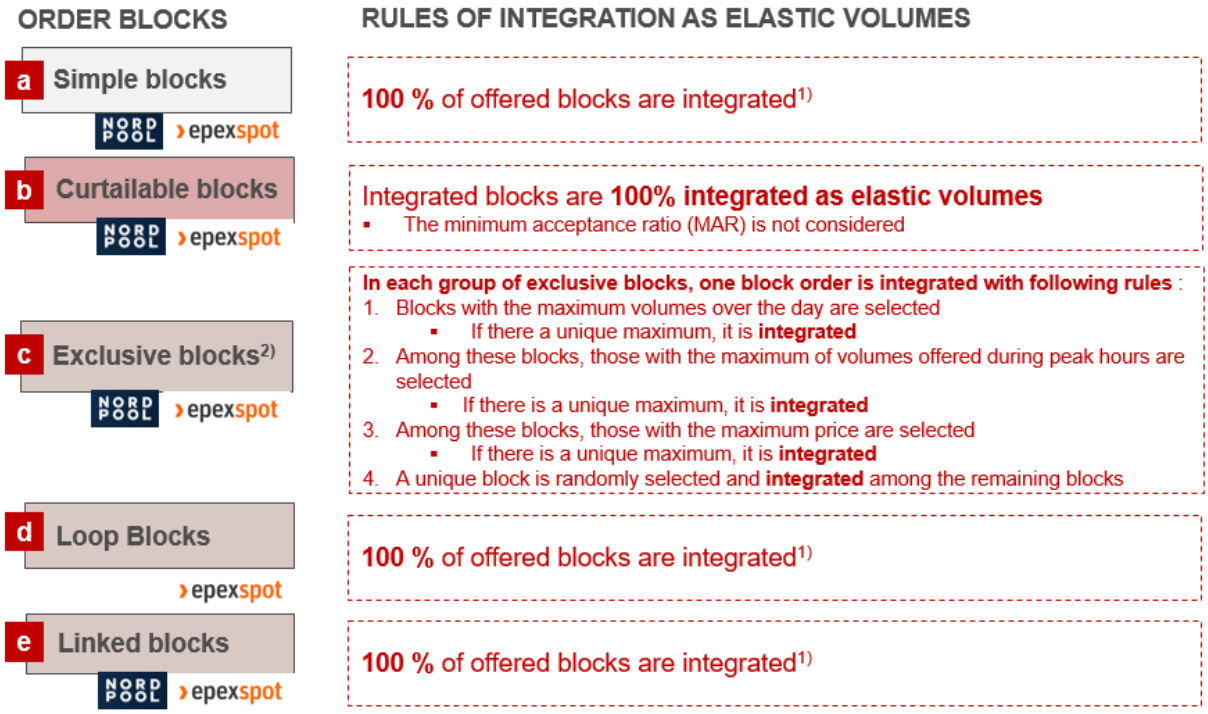


*Figure 9 - Rules of integration of block orders as elastic volumes depending on the block order type*

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# 3. Update, analysis and interpretation of the calibration curve

## 3.1 Overview of results

The application of the Royal Decree Methodology for the Y-4 auction for the Delivery Period 2027-28 leads to the calibration curve represented in red on Figure 10 below. The [P75, P85] interval corresponding to the threshold values of the calibration range of the strike price were computed at [270; 417] €/MWh.

The strike price calibration curve (red) is based on a weighted average of the curves computed for the three last winter periods (winters 2019-2020, 2020-2021 and 2021-2022). Its construction is explained in a more detailed way step by step in section 2.2 and follows the steps foreseen in the Royal Decree.

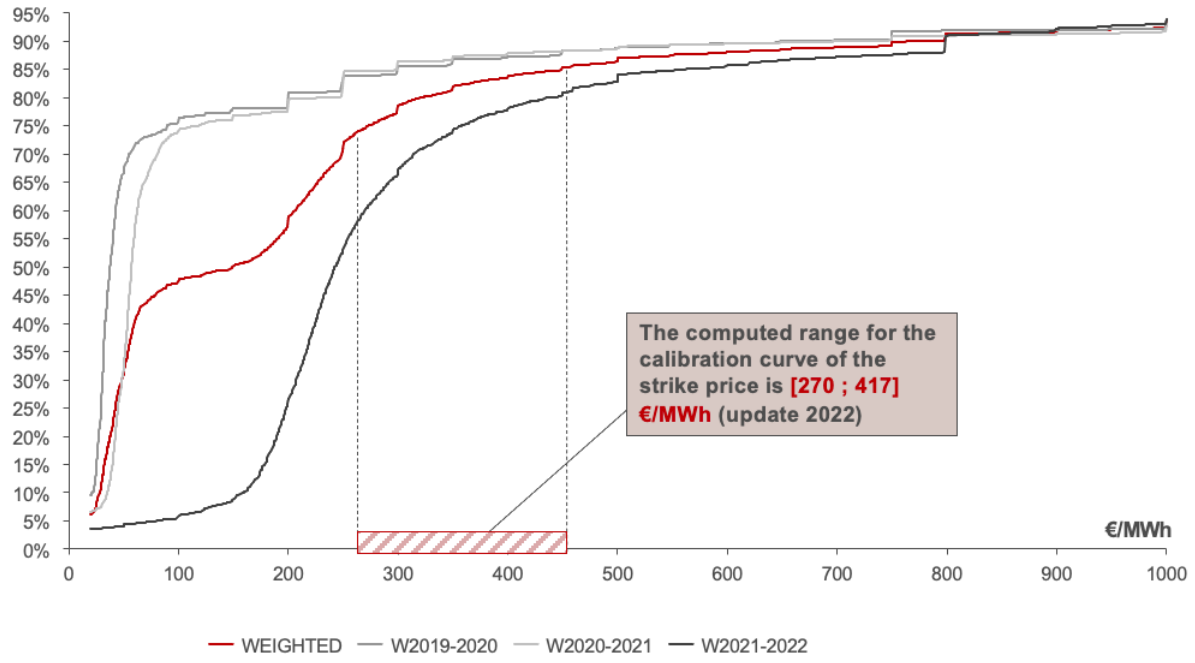


*Figure 10- Strike price calibration curve and computation of the strike price interval for 2022*

## 3.2 Analysis of the calibration curve

### 3.2.1 Year-on-year calibration curve stability

On mid-March 2020, Belgium witnessed a lock-down following the spread of covid-19 disease. This unique situation occurred again during the winter period of 2020-2021. . As shown in Figure 11, the sanitary conditions led to few changes in the couple elastic volumes and equivalent prices on the day-ahead market and therefore did not modify the calibration curve compared to the previous year.

Since November 2021, Belgium also witnessed a steep increase in electricity prices on the market due to several conjunctural situations. The prices are still not back to what they were before, and they could stay high until next winter. This time, the increase in electricity prices has lead to a big impact on the overall strike price calibration curve, especially as bigger volumes have been exchanged for high prices on the market this past winter.

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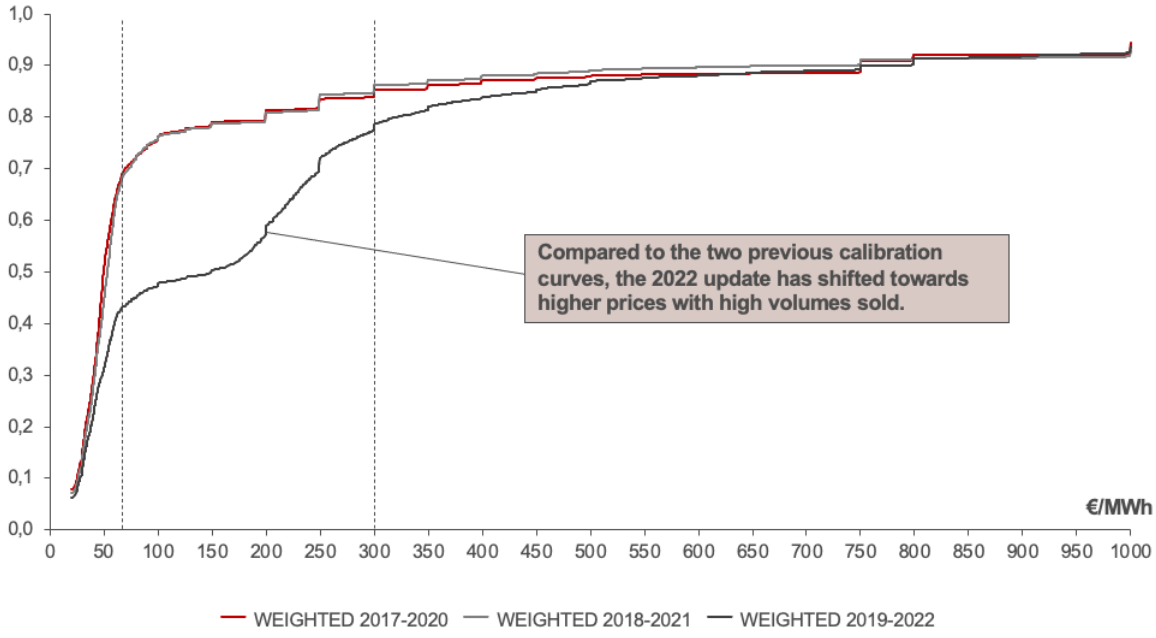


*Figure 11 - Sensibility analysis of the calibration curve shapes*

## 3.3 Curve interpretation

### 3.3.1 Reading of the calibration curve

The normalized volume associated to a price level is the percentage of elastic volumes offered at a price equal or inferior to this price level. For instance, in the Y-4 auction calibration curve, more than 85% of elastic volumes were offered below 417 €/MWh. These volumes were either proposed on the offer side (production) or on the demand side (no longer demanded for consumption).

### 3.3.2 General shape of the strike price calibration curve

The strike price calibration curve is characterized by three main features illustrated on Figure 12:

- At low prices, a steep slope: most volumes are offered at relatively low prices compared to the maximum authorized price
- At high prices, a flattened curve converging to the maximum of the curve (100%): volumes are rarely offered at very high prices
- At intermediary prices, an elbow with a decreasing slope: for the same increase in price, less volumes are offered

Before the elbow, a small increase in price leads to an important increase in normalized elastic volume. Bidders are willing to offer more volumes (supply side) or to give up some consumption (demand side). After the elbow, an increase in price leads to a lower additional level of normalized elastic volume.

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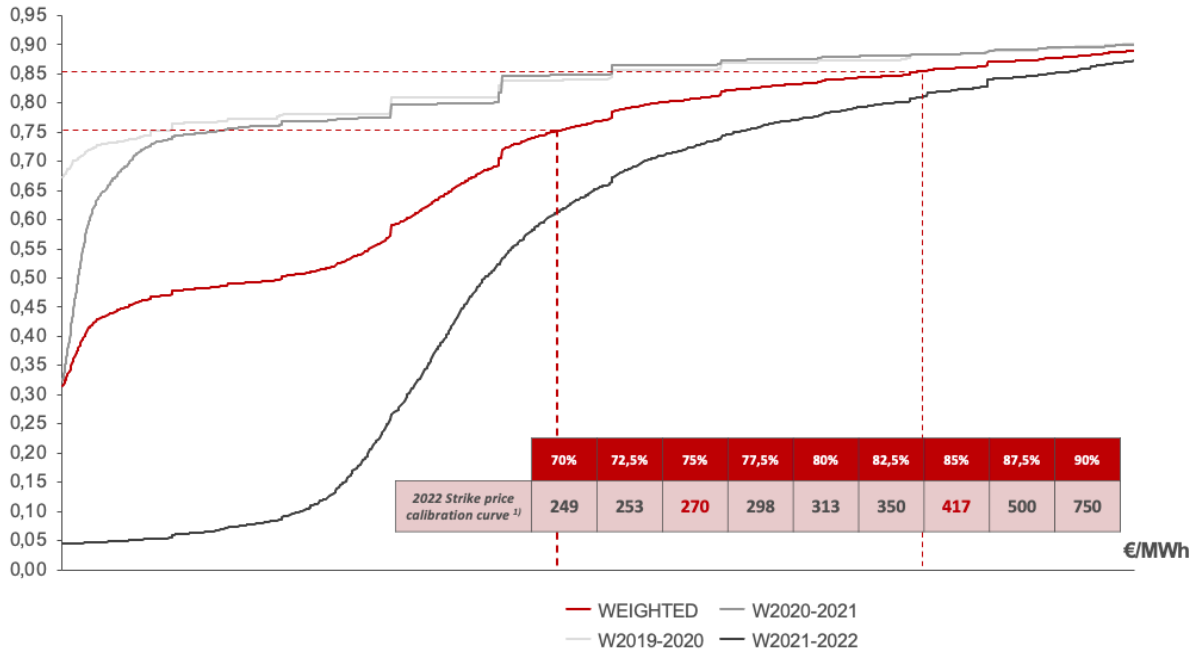


*Figure 12 – Zoom on 70% to 90% elastic volume normalized for the last three winters and the calibration curve*

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# 4. Appendix

## 4.1 Price table for the 70 – 90% percentile range with a 2.5% normalized hourly elastic volume curve interval

When considering the full range of winter periods and the resulting Y-4 auction calibration curves, no historical trend can be highlighted. A detailed analysis of the [P70, P90] interval is shown in Table 1.

| | 70% | 72,5% | 75% | 77,5% | 80% | 82,5% | 85% | 87,5% | 90% |
|---|---|---|---|---|---|---|---|---|---|
| ***Delivery period 2027-2028*** [1] | 249 | 253 | 270 | 298 | 313 | 350 | 417 | 500 | 750 |
| *Delivery period 2026-2027* [2] | 73 | 81 | 94 | 125 | 200 | 249 | 300 | 399 | 700 |
| *Delivery period 2025-2026* [3] | 70 | 80 | 95 | 125 | 200 | 249 | 300 | 450 | 750 |
| *Winter 2021-2022* | 300 | 313 | 335 | 355 | 391 | 434 | 494 | 591 | 799 |
| *Winter 2020-2021* | 80 | 89 | 116 | 198 | 230 | 250 | 299 | 385 | 699 |
| *Winter 2019-2020* [4] | 55 | 64 | 90 | 148 | 200 | 249 | 300 | 399 | 648 |
| *Winter 2018-2019* | 72 | 78 | 85 | 97 | 125 | 215 | 280 | 379 | 750 |
| *Winter 2017-2018* | *80* | *96* | *115* | *158* | *200* | *300* | *450* | *750* | *799* |
| *Winter 2016-2017* | 54 | 61 | 72 | 90 | 180 | 250 | 300 | 300 | 600 |

1) Computed from winters 2019-2020, 2020-2021 and 2021-2022, first integration of block orders from Nord Pool Spot
2) Computed from winters 2018-2019, 2019-2020 and 2020-2021
3) Computed from winters 2017-2018, 2018-2019 and 2019-2020
4) First integration of Nord Pool Spot's aggregated curves

*Table 13 - Prices associated to different percentages of elastic volumes of the Y-4 auction calibration curves and for the five winter periods [€/MWh, 2016-2022]*

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## 4.2 Volume jumps in the strike price calibration curve

The strike price calibration curve is characterized by small jumps (see Figure 14) of normalized volumes for certain price levels. This strike price calibration curve is not smooth because volumes are more frequently offered at "rounded" prices like multiples of 50 €/MWh (200 €/MWh, 250 €/MWh, 300 €/MWh …).

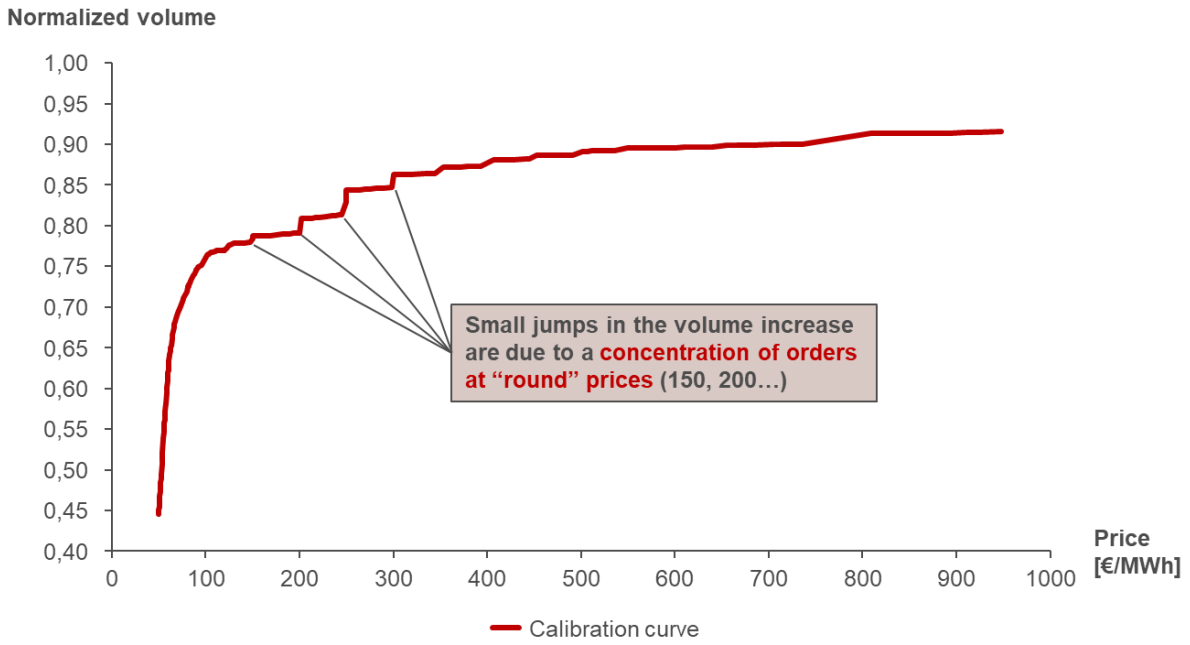


*Figure 14 - Illustration of breaks in the strike price calibration curve*

## 4.3 IT Tools

The data was processed by a script written in the programming language R. It is a free software environment, commonly used for statistical computing.

The use of a dedicated software instead of more widely used spreadsheets was made necessary by the amount of data files to be processed. The aggregated curves are for instance stored in individual hourly files and tens of thousands of these files must be loaded.

The R script processes raw data made available by EPEX and Nord Pool and are applied for each step of the methodology consecutively. Intermediary results and graphics are provided through the use of a Jupyter notebook to monitor the run of the script.