Market Response study 2017 – 2nd phase report

July 2017

I. Executive summary

The first phase of this study aimed at designing a methodology to assess the volumes of Market Response[1] (MR), which are not already included in the Adequacy Study[2] by means of the demand profiles used, or contracted as Ancillary Services. The methodology designed is based 1) on the analysis of the aggregated demand and supply curves of the day-ahead market of EPEX Belgium (EPEX DAM Belgium), 2) complemented with a qualitative questionnaire sent to stakeholders (BRP, aggregators, TSO grid users) to assess the activation constraints (e.g. number of weekly activations and maximum activation duration) and finally 3) verified with a sanity check. This three-fold methodology will lead to the inputs required by Elia to perform its Adequacy Study. As the presented methodology is mainly based on a robust quantitative part, the output can be considered to be objective. This robustness also stands in the historical data, used as input of the methodology, but then requiring making some hypothesis for the future evolutions (1 to 3 years). Furthermore, the quantitative part can be updated with the most recent market data, facilitating a yearly re-calculation. In contrast, a yearly update of the qualitative questionnaire is not required as the activation constraints are not expected to change from year to year, while conducting the questionnaire itself is very resourceful.

The aggregated curves analysis firstly enabled to obtain an estimation of the volumes of Market Response. The volumes had to be extracted first from the EPEX DAM Belgium aggregated curves so as to obtain a treatable dataset of 29 207 hourly values of Market Response from 01/01/2014 00:00 to 01/05/2017 23:00. On the demand side, volumes of Market Response can be directly found in the aggregated demand curve, by studying the decrease of volume when price increases from 150€/MWh to 3000€/MWh (excluding the “at any price” bids). In the supply curves, the Market Response are represented by two volumes: Market Response offered above 150€/MWh (high bound) and above 500€/MWh (low bound).

The raw dataset was then refined, firstly by excluding the national strike and treating the national holidays as Sundays in terms of day type. Secondly, the year 2014 was excluded from the dataset due to a specific bidding behavior in the offer curves, not corresponding to the current reality of the market. This refined dataset is therefore more accurate while maintaining a satisfying amount of data of 20 375 hourly values.

The refined dataset was then analyzed to assess the impact of various parameters on the Market Response volumes, including temperature, price and Elia grid load. Although the regressions did not reveal statistical correlations between the Market Response volumes and these parameters, another analysis enabled to assess that the Elia grid load impacts the most the volumes of Market Response. Indeed, in periods of important load, the standard deviation of the dataset is reduced and the average volume is increased. Consequently, the volumes were separated into two categories so as to study

[1] DSR is seen as the reduction of consumption (not including distributed generation or storage technologies), while MR should be understood in a broader sense making abstraction of the technology (including distributed generation or storage technologies). In such sense, it is the Market Response which is investigated as input for the Adequacy Study.

[2] Adequacy study for Belgium used to determine the need for strategic reserve. www.elia.be > products and services > strategic reserve > volume assessment

separately the hours of important load: the peak hours of the winter. The average volume during the peak hours of the winter for the refined dataset (01/01/2015 to 01/05/2017) reaches 637 MW.

Finally, the output was extrapolated to the 3 future winters of implementation (i.e. winter 2018/2019, 2019/2020 and 2020/2021). A choice for an extrapolation factor evolution of the Market Response volumes during the following years was discussed during the Task Force. An extrapolation factor of 1% growth per year, based on the historical analysis, together with two alternative extrapolation scenarios of 3% and 5%, were presented. Based on a discussion during the Task Force, a 5% yearly growth was put forward, subject to a yearly re-assessment based on an update of the quantitative analysis.

To be useful for the Adequacy Study, the output of the aggregated curves analysis was complemented with the activation constraints: number of weekly activations and maximum activation duration. This qualitative information was provided by the questionnaire sent to all relevant market players, i.e. TSO grid users, BRPs (non-grid users) and aggregators. A satisfying response rate (81 out of 162 questionnaires sent) enabled to differentiate 7 categories of activation constraints: the majority of the volumes is estimated to provide between 2 to 28 activations per week, and between 1 to 4 hours of maximum activation duration, while 5% of the volumes have no constraints regarding both the number of activation per week and the activation duration. This categorization, based on answers from the TSO grid users, was broadly validated by answers from BRPs (non-grid users) and aggregators.

The third part of the methodology consisted in verifying the coherence of the results with a sanity check. Firstly, in addition to the qualitative information, the respondent of the questionnaire also provided a quantitative feedback on the volume of Market Response available. This volume is to be treated very carefully since the individual estimations cannot be extrapolated as such to provide an objective quantification of the total Market Response volume. Though, this sanity check enabled to validate the order of magnitude of the volumes with an estimated range of Market Response of [560 – 690] MW. The qualitative feedback from the questionnaire also enabled to validate the categorization of the winter peak hours categorization. Secondly, the volumes were compared to the information available regarding Market Response in the benchmarked countries. In the UK, an estimation of the Market Response is provided by the Triad Avoidance mechanism: these volumes represent 4% of the peak load of the UK, which is coherent with the 5% found for Belgium (MR excluding AS). Similarly, a coherence check was conducted for France and PJM, yet on a total Market Response level (including AS). The total MR estimate for Belgium is above the values for France and PJM.

So as to take into account the future evolutions of the Market Response volumes, its implementation in order to obtain representative results could be updated regularly. However, the methodological framework itself, defined together with the market parties, could be considered stable. The quantitative method facilitates a yearly re-calculation, with an update of the data and the parameters without any need to re-design the methodology on a yearly basis. The EPEX DAM Belgium aggregated curves are to be updated with recent data every year, along with price thresholds, extrapolation factor and ancillary service evolutions. The qualitative methodology, however, is less sensitive to yearly evolutions while being more resource intensive for Elia and market parties. An update of the qualitative aspects could be foreseen after a few years or whenever the need would become apparent.

Finally, regarding the process, the objective of the subgroup is achieved: the most adequate methodology was designed and implemented in close cooperation with stakeholders, through 6 workshops in total, all of this in full transparency with the subgroup and the Task Force iSR.

II. Context & Objectives of Market Response – *Reminder*

The response of electricity consumers in periods of possible tightness to meet electricity demand, i.e. Market Response, is a crucial market dynamic when adequacy issues arise. In conditions of high prices, the market will indeed react and some players will reduce their load due to the price increase. The Adequacy Study conducted by Elia in the framework of strategic reserves has to take into account all Market Response (MR) in the market. A certain share of this volume is reserved as Ancillary Services and another share is already included in the demand profile. Indeed, market reactions under 150€/MWh (Day-ahead (DA) prices) are already implicitly taken into account in the load forecast used by Elia in its Adequacy Study[1].

Therefore, this study aims at assessing all Market Response[2] (MR) volumes, which are not already included in the Adequacy Study, as explained above.

When European (2009/72/CE and 2012/27/CE) and national policy makers, as well as European regulators, are pushing for an increased development of demand side response (DSR) and Market Response (MR), reflections around the estimation of the volumes associated become more and more essential. The global effort is mirrored by market stakeholders' (Flexibility Service Provider (FSP), Balance Responsible Parties (BRP), producers, suppliers, third party aggregators and customers) demand to fine-tune the methodology used to grasp the potential of Market Response in Belgium.

In Belgium, the estimation of Market Response is even more essential as it is carried out in context of the volume determination of strategic reserves. The strategic reserve is handled by Elia to solve shortage situations during the winter period. The volumes of Market Response are taken into account in the Adequacy Study, which then sizes the volumes of strategic reserves required. Indeed, a correct Market Response estimation is essential to obtain an accurate sizing of the strategic reserves.

In 2015, Elia has launched a questionnaire to the BRPs, the consumers and the aggregators to estimate the Market Response in moments of grid stress. After 2 years of implementation, key stakeholders of the market have expressed[3] their willingness to contribute to the development of a new methodology to determine the volumes of Market Response in Belgium.

In this context, E-CUBE was mandated to design and implement the methodology or methodologies to determine the volume of Market Response in the context of volume determination of the strategic reserves, for the winter 2018-2019, 2019-2020 and 2020-2021. In this context, a task force subgroup "Market Response Study" was created in January 2017 to design the **most adequate methodology**

[1] The hours above 150€/MWh are flagged from the input data used for the adequacy, while the hours below 150€/MWh are used as inputs for the Adequacy Study. Indeed, the volume variations according to the prices below this threshold are already taken into account in the Adequacy Study.

[2] In this text, the scope is referred to as both Market Response or Demand Response. However, in general, DSR is seen as the reduction of consumption (not including distributed generation or storage technologies), while MR should be understood in a broader sense making abstraction of the technology (including distributed generation or storage technologies). In such sense, it is the Market Response which is investigated as input for the Adequacy Study.

[3] Task Force « Implementation Strategic Reserves » 2017/2018, September 19, 2016; www.elia.be > users groups > working group balancing > task force iSR > Agenda

to determine the volumes of Market Response. The methodology was designed based on interactions with stakeholders, over the course of four workshops and several bilateral interviews[1].

The Market Response volume assessment methodology indeed targets the types of flexibility able to respond to periods of high prices, when there is possible tightness to meet electricity demand. Globally, **four categories** can be distinguished:

- Contract with the Transmission System Operator (TSO);
- Contracts with the Balancing Responsible Parties (BRPs);
- Price based MR;
- Voluntary MR.

Knowing that market reactions under 150€/MWh (Day-Ahead (DA) prices) are already implicitly taken into account in the Adequacy Study, **the perimeter of the study is restricted to three categories: Contract based with BRPs, Price based MR and voluntary MR, with prices above normal conditions, i.e. above 150€/MWh.**

The final methodology was established after the criteria confrontation and various group discussions with stakeholders, to fine-tune the methodology proposal. The global Market Response volumes in the framework of the volume determination of SR will be estimated based 1) on the analysis of the aggregated demand and supply curves[2] of the day-ahead market of EPEX Belgium (EPEX DAM Belgium), 2) complemented with a qualitative questionnaire sent to stakeholders (BRP, aggregators, customers) to assess the activation constraints (e.g. number of weekly activations and maximum activation duration) and finally 3) verified with a sanity check. This will lead to a robust result and takes into account the feedback and the remarks from stakeholders.

This report describes the results of the second phase of the study: the implementation of the methodology.

[1] All material presented to the stakeholders can be found on the website of the Task Force (User's Group > Working Group Balancing > Task Force iSR > Agenda), including the Minutes of Meeting.

[2] In the EPEX DAM Belgium aggregated curves, Market Response volumes are reflected in both the offer and demand aggregated curves

III. Approach followed with the stakeholders

In the context of the task force “Implementation Strategic Reserve”, a subgroup “Demand Response Study”, open to all interested stakeholders, was created with key stakeholders to design the new methodology.

Besides Elia, this subgroup was composed of:

- Michael Van Bossuyt, *Febeliec*
- Peter Schell, *Restore*
- Bénédicte Vignoboul, *Energy Pool*
- Alain Vandevenne, *Energy Pool*
- Steven Harlem, *FEBEG*
- Dieter Jong, *Anode*
- Valentijn Demeyer, *Engie*
- Aurélie Gillieaux, *Engie*
- Mattijs Van Bruwaene, *EDF Luminus*
- Bram De Wispelaere, *EDF Luminus*
- Jean-Francois Williame, *Uniper*
- Francois Brasseur, *Direction Générale Energie*
- Sylvie Tarnai, *EPEXSpot*

During the first phase of the study, the stakeholders were invited to participate to 4 interactive workshops which successfully led to the design of a robust methodology. The methodology was then presented during the Task Force “Implementation Strategic Reserve”, and brought to formal public consultation[1].

So as to continue in the same direction, the implementation of the methodology was also organized around strong interactions with the subgroup participants to maintain positive dynamics of the first phase.

Two workshops were organized:

- **Workshop 5 (May 24)**: Intermediary results presentation
- **Workshop 6 (June 26)**: Final results presentation

The fifth workshop aimed at presenting to the stakeholders the first results of the aggregated curves analysis, so as to be transparent with the stakeholders regarding the analyses computed and the possible assumptions. During this fifth workshop, stakeholders could suggest additional analyses to conduct.

The last workshop enabled to present the final results, taking into account the remarks previously raised by the stakeholders and also present the final results of the questionnaire, which was conducted until June. This last workshop was also the opportunity to have various interactive

[1] See minutes of the Task Force of the 20th of April 2017 and the consultation document (§ 5.6), both available on the website of the Task Force Implementation Strategic Reserves; www.elia.be > users groups > working group balancing > task force iSR > Agenda

discussions with the stakeholders regarding some extra matters of implementation: extrapolation of the results, categorization of the activation constraints and update frequency of the calculation and methodology.

In addition to the workshop participation, the stakeholders participated in the elaboration of the questionnaire: a consultation on the Q&A was organized during 3 weeks April – May so as to gather the feedback of the subgroup members and design the best possible questionnaire.

As presented in the following calendar of implementation, the results of the methodology were then presented to the Task Force "Implementation Strategic Reserve" on the 12th of July 2017. The results of the implementation will be included in the public consultation on the input data for the Adequacy Study.

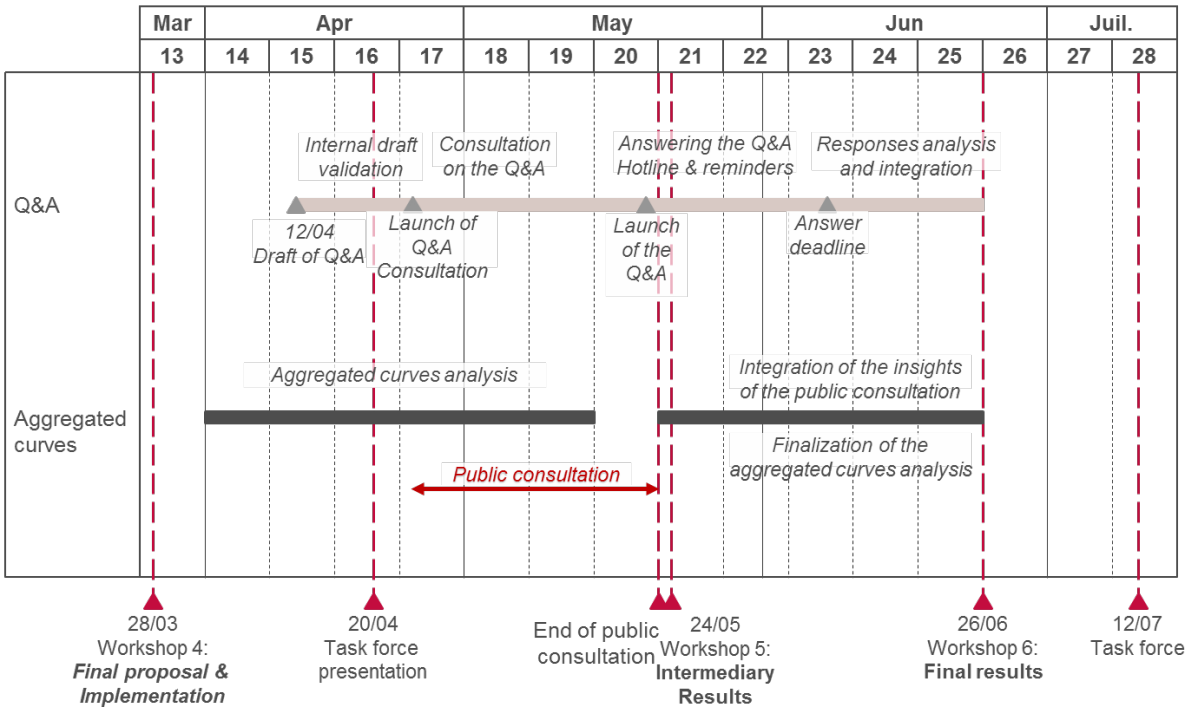

Figure 1: Market Response study phase 2 calendar

IV. Aggregated curves analysis

The first part of the analysis consisted in analyzing the aggregated demand and supply curves of the day-ahead market of EPEX Belgium (EPEX DAM Belgium). This analysis was divided into four steps:

1) **Extraction of the Market Response volumes:** knowing the important amount of data, a specific model was designed to extract these volumes from the EPEX DAM Belgium aggregated curves

2) **Refinement of the dataset**: the dataset, composed of the hourly volumes of Market Response, was then refined so as to reveal outliers, possibly impacting the analysis and misrepresenting the actual bidding behaviors of the participants

3) **Statistical analysis**: on the refined dataset, various analyses were conducted so as to assess the impact of some parameters on the volumes of Market Response (price, temperature, load…)

4) **Implementation**: finally, based on the statistical analysis, the final implementation proposal will be formalized. It has to take into account the need for accuracy of the results while maintaining a realistic complexity of implementation in the Adequacy Study

The following section reviews these four steps in more detail.

1) Extraction of the Market Response volumes

EPEX DAM Belgium provides hourly aggregated curves of the purchase and sale orders, which enable to determine the clearing price: at the intersection of the demand and supply curve. From the curves, we can deduce the load variation corresponding to a given price increase. This load variation corresponds to the perimeter of Market Response with contract based and price based MR but also voluntary DR. Indeed, if there are some volumes in the voluntary DR category, BRPs will anticipate voluntary DR events: it will impact their bidding behaviors and hence be reflected in the aggregated curves.

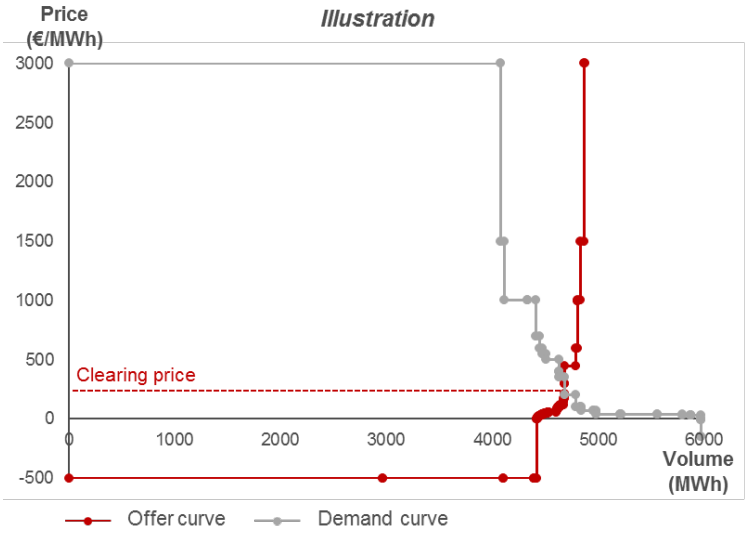

Figure 2 : Illustration of the aggregated curves for a given hour

On the demand side, volumes of Market Response can be directly found in the aggregated demand curve, by studying the decrease of volume when price increases from 150€/MWh to 3000€/MWh (excluding the "at any price" bids).

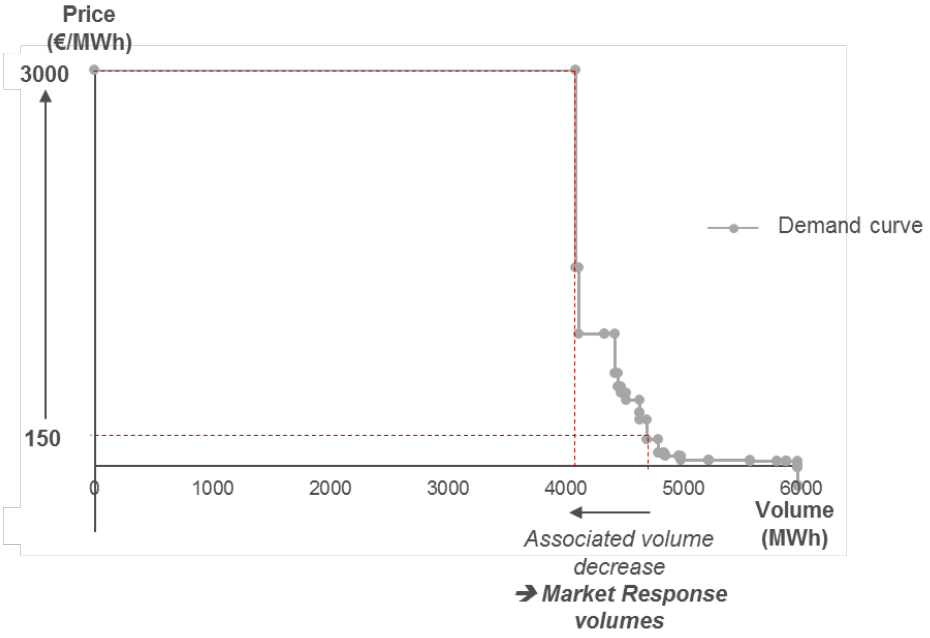

Figure 3: Market Response volumes on the demand side – *Illustration*

In the supply curves, the response of generation assets can be present so two volumes were extracted from the supply curves: Market Response above 150€/MWh (high bound) and 500€/MWh (low bound).

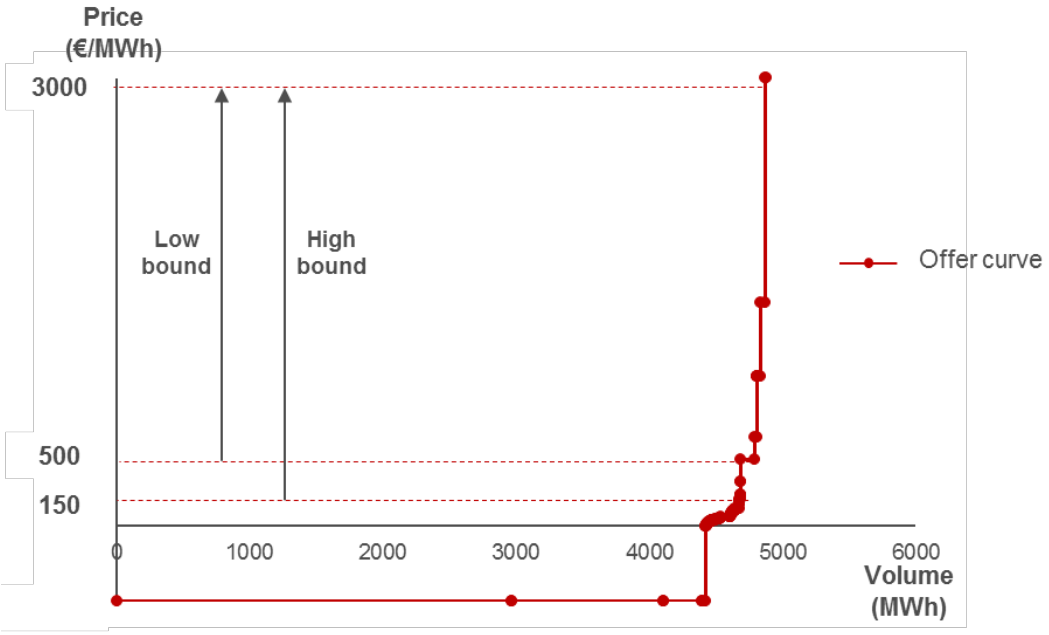

Figure 4: Market Response volumes on the offer side – *Illustration*

The aggregated curves are given for each hour from 01/01/2014 00:00 to 01/05/2017 23:00, representing a total of 29 207 excel files, gathering ~150 to 250 rows each. The first step was indeed to extract the three values of Market Response from each curve: one value on the demand side

(above 150€/MWh) and two values on the offer side (above 150€/MWh and 500€/MWh). Finally, the sum enables to obtain two values: a high bound and a low bound of Market Response.

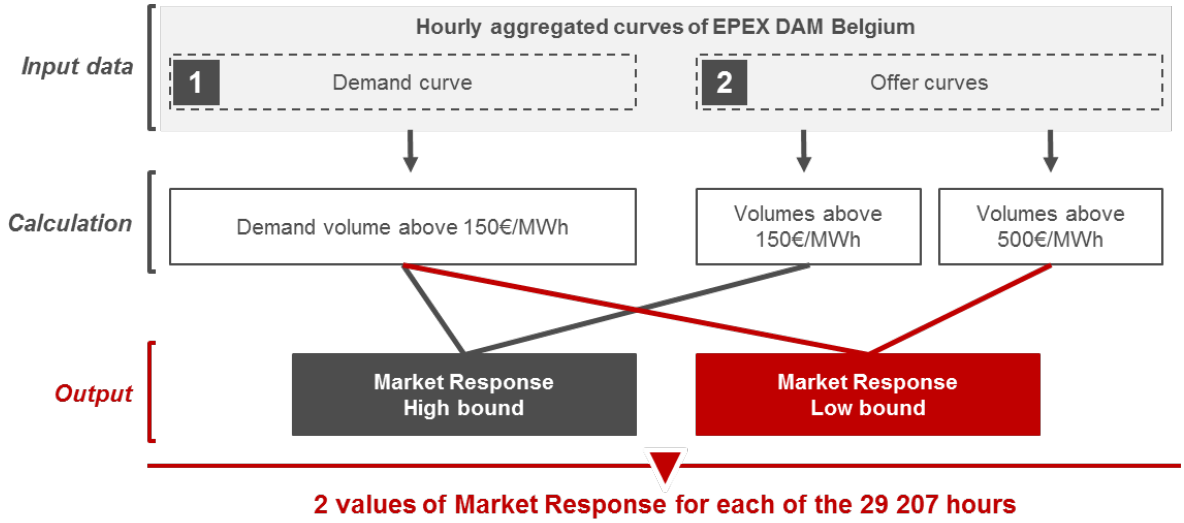

Figure 5: principle of the extraction of the volumes of Market Response

In the following, the high bound[1] volume (sum of demand and offer volume both with the 150€/MWh threshold) is referred to as "150€/MWh" while the low bound (sum of the demand volume with the 150€/MWh threshold and the offer volume with the 500€/MWh threshold) is referred to as "500€/MWh".

2) Refinement of the dataset

The entire dataset, gathering 29 207 hourly values, has an average Market Response volume of 454 MW for the low bound and 577MW for the high bound.

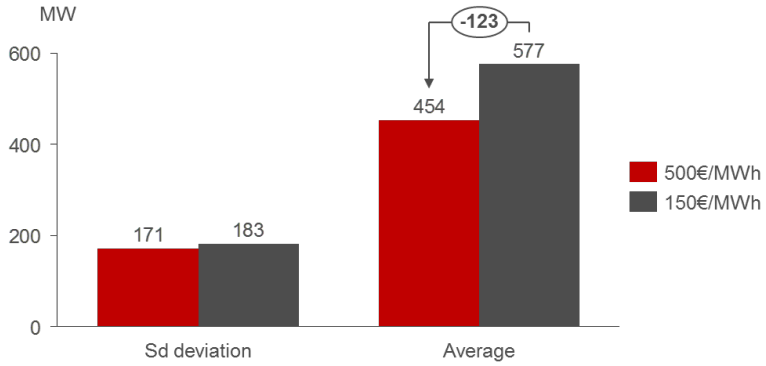

Figure 6 : key statistics of the raw dataset

The Standard deviation indicates the dispersion of the values of the dataset: whether the values are spread over a wide range of values. The dataset presents a rather important standard deviation which justifies a refinement and a statistical analysis of the dataset.

As a first refinement of the raw results, the days of general strikes were excluded and the days of holidays were considered as Sundays. Indeed, in the Adequacy Study, the days of general strikes in

[1] This volume is referred to as high bound as it will result in a higher Market Response capacity

Belgium are flagged since they do not correspond to a rational behavior of the players. They are not to take into account in an adequacy simulation. From 2014, the days of general strikes were, the 15/12/2014, 07/10/2015, 24/06/2016, 07/10/2016.

Secondly, when looking for pattern, the utilization of the day types (weekdays, weekends etc.) would be biased without applying a specific treatment to the holidays. Indeed, the national holidays of Belgium are closer in terms of day type to Sundays than Weekdays, and should be treated as such for the Day Type categorization.

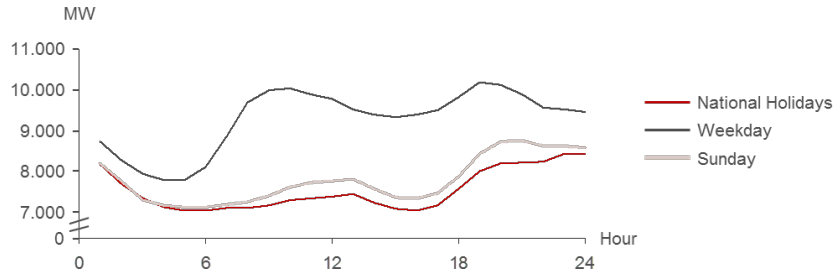

Figure 7: daily evolution of total load – year 2014 to 2017 (ytd.)

The third and last topic of refinement was the specific study of the year 2014. Indeed, in 2014, compared to the following years, a different behavior is observed on the offer side.

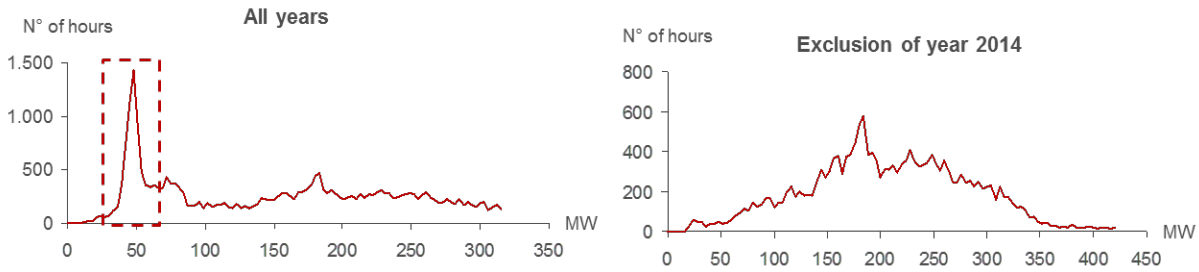

Figure 8: offer side volume distribution (150€/MWh threshold)

This behavior is not present in the volumes of 2015, 2016 and 2017. **Indeed, the volumes of 2014[1] do not represent the current bidding behaviors of the market participants: therefore, the decision was made to exclude them from the dataset.**

The refinement can be summarized in the graph bellow. We indeed notice a decrease of the standard deviation, along with an increase of the average value of Market Response, while maintaining a satisfying amount a data in the dataset with 20 375 values.

[1] To confirm this exclusion, the volumes of 2013 were also analyzed: see details of the analysis in appendix

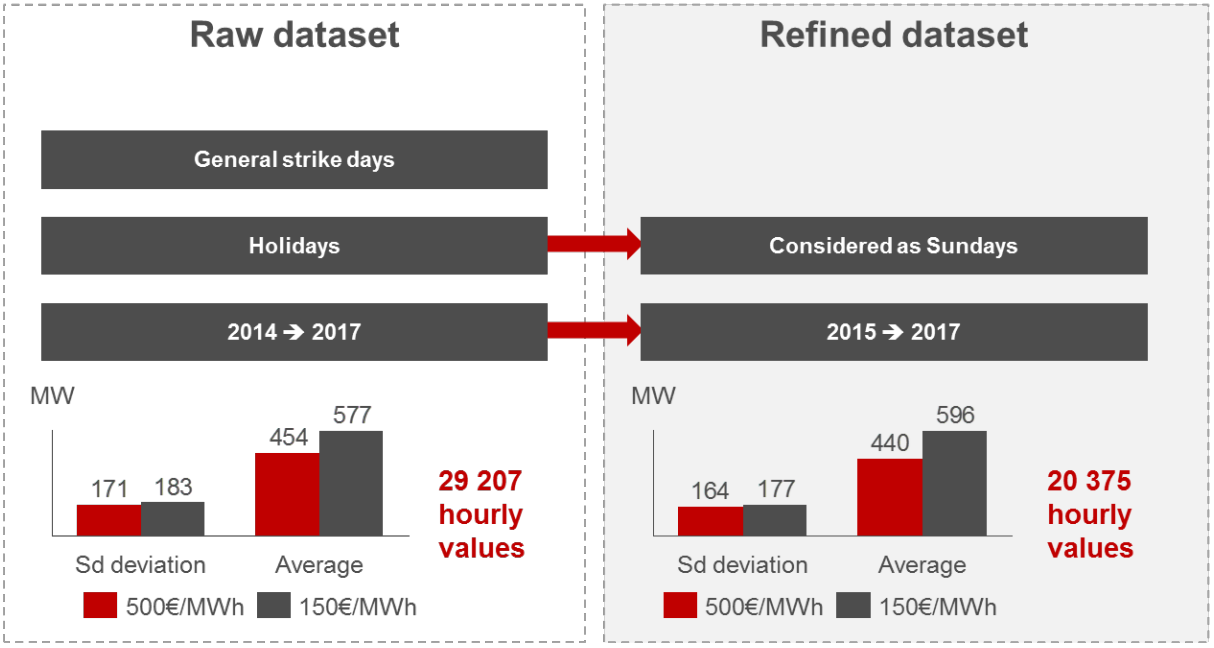

Figure 9: refinement of the dataset

Nevertheless, the standard deviation of the refined results is still rather important. This can be shown in the distribution of the results (Figure 10).

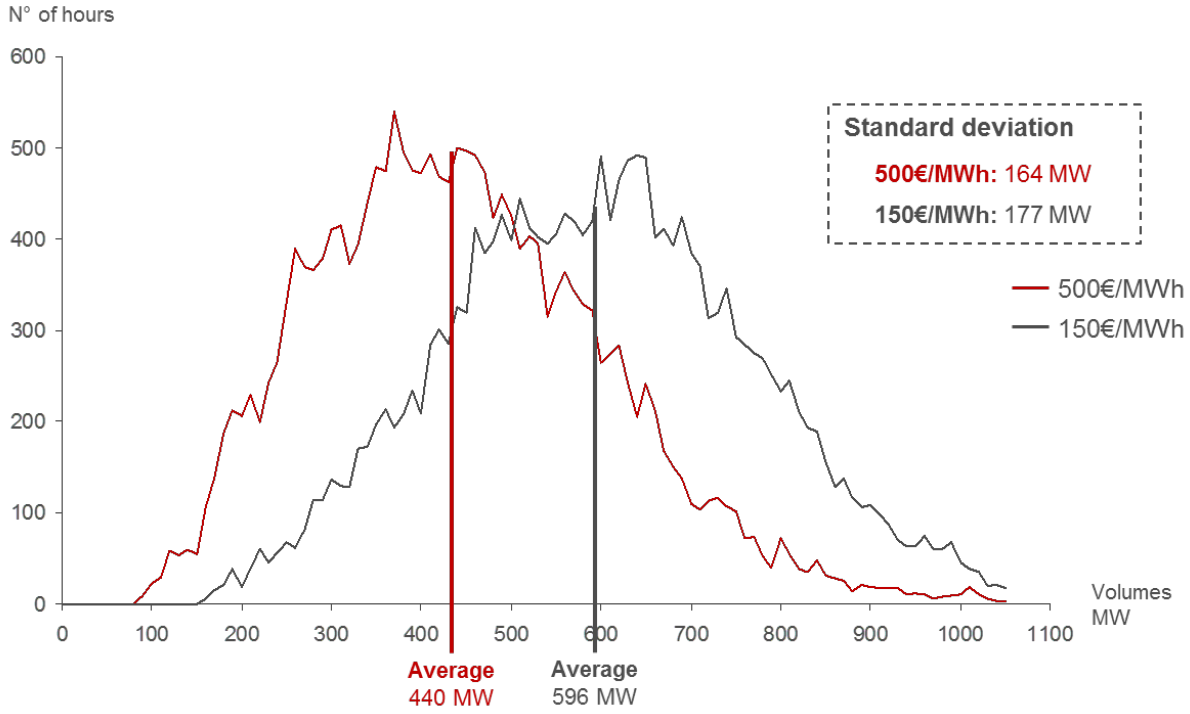

Figure 10: volume distribution of the refined dataset

3) Analysis of the Market Response volumes

The analysis process was divided into two parts. The first part was conducted before the first workshop, with the conduction of a large amount of analyses to assess the impact of various parameters on the dataset (load, price, temperature…) and try to find some correlations. These results

were presented during the Workshop V, where the subgroup members suggested additional analyses to conduct. These analyses were computed by E-CUBE and presented during the last workshop.

The first analyses computed were regressions (simple and multivariate) between different variables. Various correlations were computed (Day-ahead (DA) prices, temperature, normal temperature, daily maximum price, load, gas prices), without any satisfying results[1] (very low R^2: all R^2 are bellow 10^{-2}).
An analysis of the tail of the distribution (volumes above 1000MW) was also computed to assess if specific behaviors were present: this analysis did not reveal any specific pattern at the tail (see detailed analysis in appendix).

So as to overcome the poor results of the regressions, the impact of various parameters (price, temperature and grid load) on the dataset was assessed by a different analysis. The principle of the analysis is to restrict the dataset to the hours when the parameter is above (or below) a threshold. For each value of the threshold, the standard deviation is calculated, along with the number of data in the dataset and the average volume.

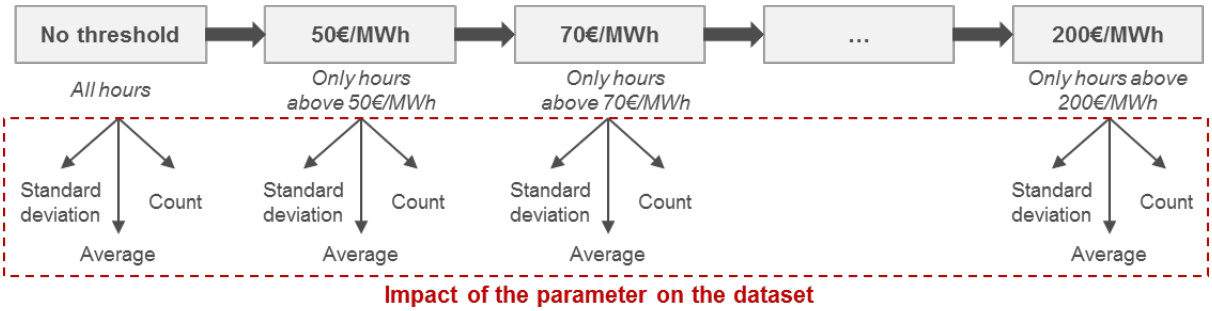

Figure 11: principle of the analysis of impact

Impact of the Elia grid load

The first analysis was computed with the Elia grid load: the dataset was restricted to the hours of important load on the network to assess the evolution of three key parameters: the standard deviation, the average and the number of values in the dataset.

[1] When computing regressions, R^2, the coefficient of determination, enables to assess the quality of the prediction of a linear regression. When variables are correlated, the R^2 is close to 1. If this coefficient is equal to 0, there is no correlation between both variables

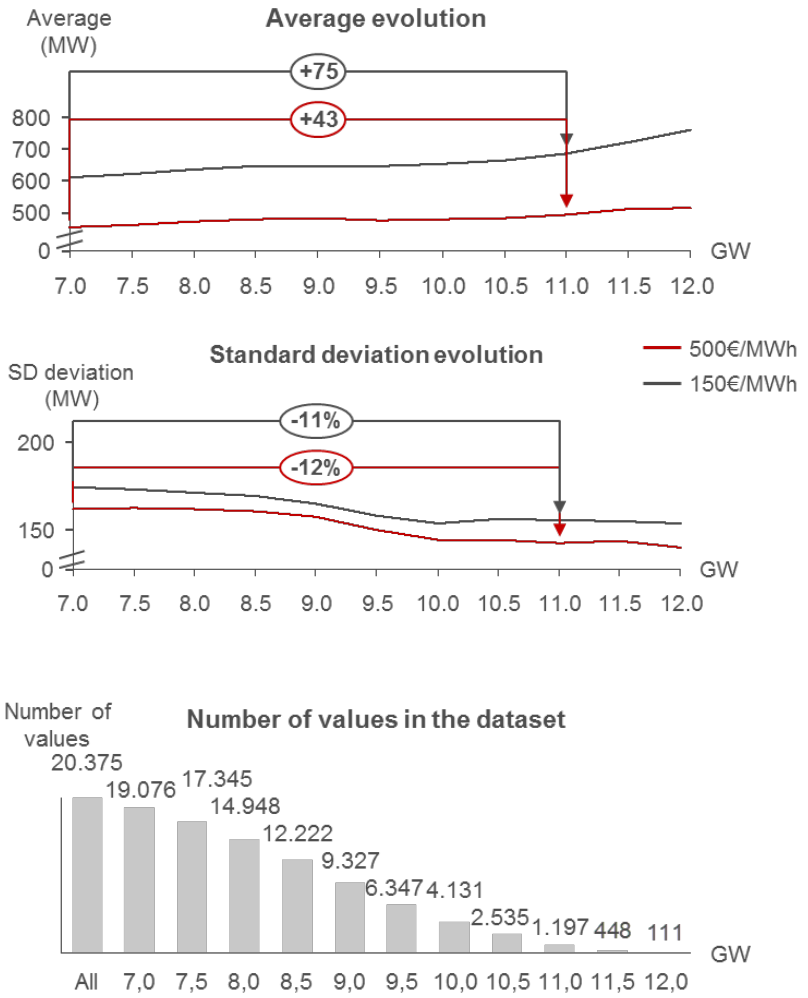

Figure 12: evolution of the key statistics with the Elia grid load

The Elia grid load impacts the standard deviation of the dataset with a ~11%-12% decrease when restricting the dataset to important loads. The impact of the Elia grid load is therefore further investigated to integrate it in the results, see the following paragraphs for more details.

Impact of the DA prices

The exact same analysis was computed for the DA prices. Compared to the previous analysis, the price threshold presents a similar impact in terms of average increase but the evolution of the standard deviation does not follow the same trend: there is a strong increase of the standard deviation after 100€/MWh. The impact of the price seems less pertinent than the impact of the Elia grid load. This analysis is detailed in appendix.

Impact of the temperature[1]

This analysis for the temperature threshold provides an even less interesting trend with an increase of the standard deviation with the decrease of the temperature threshold. A temperature threshold should not be established to refine the dataset. This analysis is detailed in appendix.

[1] For this analysis, the hourly values of the reference temperature of the Uccle station were used.

Among the previous parameters, the load has the most important impact on the dataset: in periods of important load, the Market Response volumes are more pertinent (there is a decrease of the standard deviation, along with a variation in the average). Though, the load varies strongly according to the period: as shown in the graphs below, during the winter and the peak hours, the average load on the Elia grid is more important.

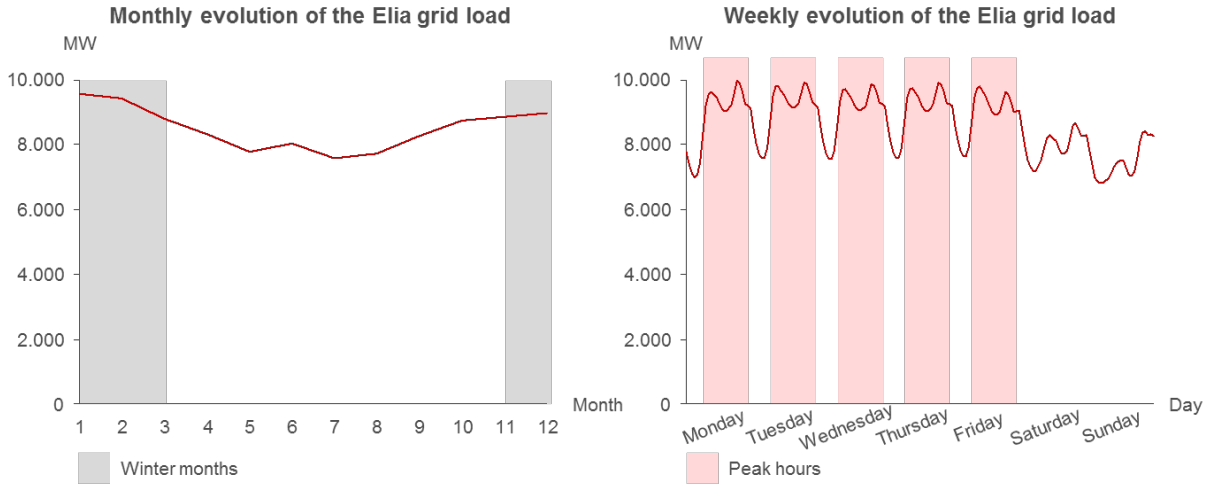

Figure 13: Monthly and weekly evolution of the Elia grid load[1]

In the graphs above, the winter is considered from the 1st of November to the 31st of March, the months: this is also the period of contract of the Strategic Reserve. The monthly load is more important during these months. The peak hours are defined as the weekdays hours between 8 AM and 8 PM and correspond to hours of important load in the Elia grid.

Indeed, Market Response should be studied during the hours of important load on the Elia grid: the peak hours of the winter.

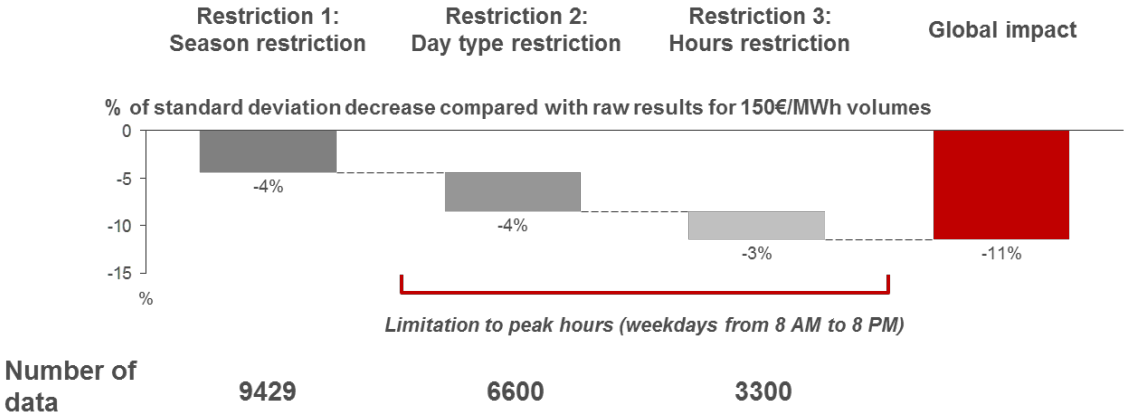

Figure 14: standard deviation reduction due to the dataset restriction – 150€/MWh volumes

- **Restriction 1:** days from the 1st of November to 31st of march. The dataset is restricted to winter months, according to the definition of the Belgian Electricity Law (and considered by Elia in the Adequacy Study)
- **Restriction 2:** restriction to weekdays

[1] The Elia grid load was studied on the timeframe of the refined dataset: from the 1st of January 2015 to the 1st of May 2017

- **Restriction 3:** the dataset is restricted to 8 AM to 8 PM

Restrictions 2 and 3 enable to constitute the peak load hours (weekdays from 8 AM to 8 PM). The restriction of the hours from 5 PM to 8 PM was also analyzed upon stakeholder request, without any additional results (see details in appendix).

The focus on the most relevant hours in the context of the Adequacy Study (peak hours of the winter period) enables to reduce the standard deviation by 11% compared to the refined dataset. In the same time, the size of the dataset is still relevant in a statistical assessment. The same analysis conducted on the 500€/MWh volumes gives the same impact of standard deviation, i.e. 11% of decrease.

Therefore, two categories will be implemented in the Adequacy Study:

- One category for the peak hours of the winter
- Another one for the other hours

The categorization leads to an increase of the volumes along with a decrease of the standard deviation during the peak hours of the winter to reach 637 MW for the high bound. Indeed, with this categorization, the most important hours for Elia: the peak hours (8 AM to 8 PM during weekdays) in the winter are treated as a separate category. The creation of this separate category leads to a non-negligible decrease of the standard deviation: -11%.

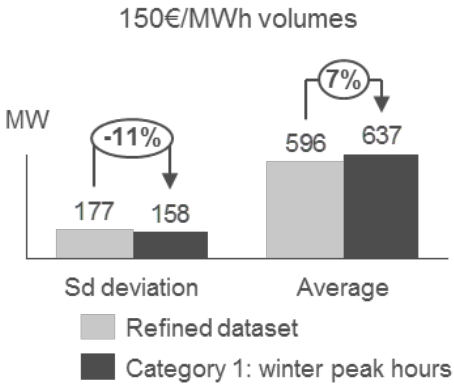

Figure 15: category 1 – Winter peak hours

As these hours are the most interesting hours for the Adequacy Study of Elia, the 637MW volume is the main output of the Market Response Study.

The other hours are treated as a single category: non-peak hours of winter and all hours in the summer period. The creation of this category leads to very limited evolutions both for the standard deviation and the average.

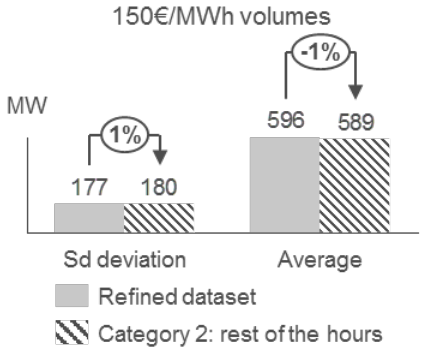

Figure 16: category 2 – other hours

The 500€/MWh volumes follow the same type of evolution with this restriction: 11% of decrease of the standard deviation and 7% increase of the average for the restriction to peak hours of the winter and limited impact for the remaining hours.

4) Volume implementation in the Adequacy Study

When re-conducting the methodology, three main parameters are to be re-assessed:

- **The price thresholds**: the impact of certain parameters such as the gas prices on the thresholds are to be studied, to conclude the possible evolution of these thresholds
- **The extrapolation of the results towards the relevant winter periods**: the extrapolation of the results are to be studied taking into account the evolving framework for Market Response (legislation, Elia products, industrial readiness)
- **The market response in ancillary services**: the observed and projected Market Response in contracted Ancillary Services have an impact on the extrapolation of the results, as both are considered as communicating vessels. These figures have to be updated with the latest information available.

On the contrary, the data refinement, also based on the analysis of the current dataset, does not need to be re-assessed yearly: the national strike days should be excluded, and the holidays should considered as Sundays.

The data set representing the aggregated curves is the main updated parameter. The update should happen with the most recent relevant data (i.e. last winter period). Indeed, the methodology assumes that new Market Response following will be observed in the EPEX DAM aggregated curves.

a) Price thresholds

The selection of the two thresholds (150€/MWh and 500€/MWh) should not be carved in stone. Indeed, towards the future, they could vary according to external parameters. One important parameter influencing the generation bids is the gas price, as indicated by stakeholders. Indeed, an increase of gas prices may change the bidding behaviors and hence the Market Response volumes.

To analyze the impact of the gas prices on the Market Responses volume thresholds, the average volume of Market Response, on the offer side only, which is present between 150€/MWh and 500€/MWh was analyzed in situations of important gas prices. A significant change of this volume would indicate the need to provide a new estimation of the thresholds. The graph bellow shows this

analysis: the delta between 150€/MWh and 500€MWh volumes on the offer side was calculated in three different situations:

- for the entire dataset;
- during hours of gas prices above 15€/MWh;
- during hours of gas prices above 20€/MWh.

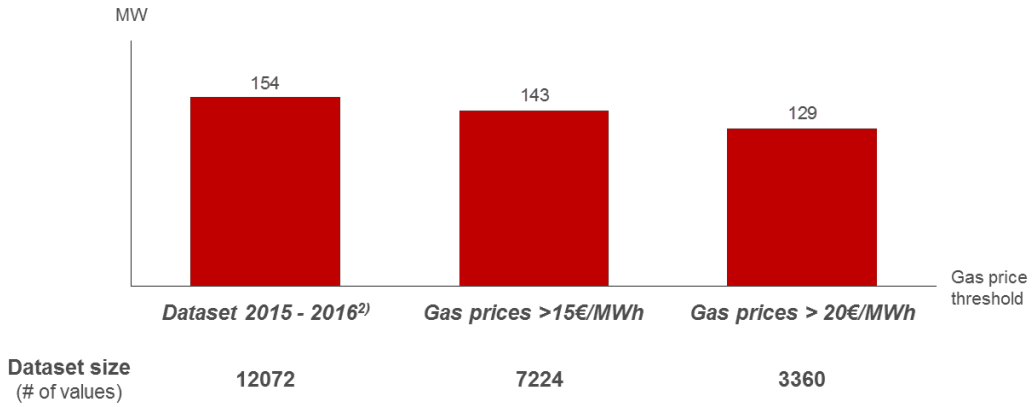

Figure 17: evolution of the Market Response delta [150-500 €/MWh] on the offer side according to the gas price[1] threshold

The increase of gas prices does not have a significant impact on the Market response thresholds. **Though, these thresholds may evolve in the future, when updating the analysis: if different behavior appears concerning the gas prices, they should be noticed in the analysis above.**

b) Ancillary services

The volumes of Market Response in the Ancillary Services have an impact of the possible volumes of Market Response excluding the Ancillary Services (see detailed volumes in appendix):

- A decreasing Demand Response (DR) in the ancillary services will increase Market Response, assuming that the total DR is not reduced.
- An increasing DR in the ancillary services will decrease Market Response, assuming that this increase exceeds the total DR growth.

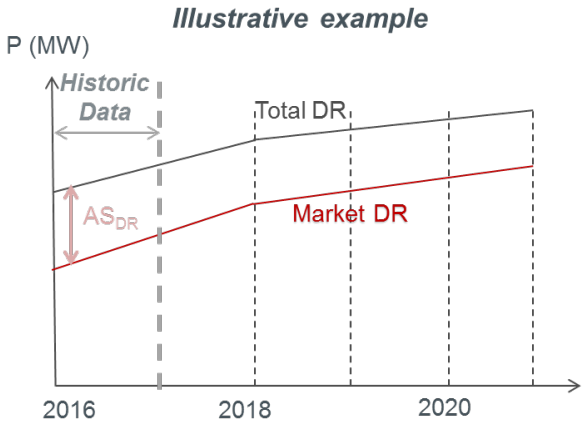

Figure 18: link between the different types of DR

[1] The gas prices used for this analysis are the Day-ahead prices for the ZTP. These index is quoted in €/MWh

The volumes of Ancillary Services are provided in appendix to this report. The figures used in our analysis are rough estimations and do not represent any targets or ambitions. The final share of DR is determined by the market as products (R1, R3) are open for the offers of different technologies.

When re-conducting the analysis, this volume of Market Response in the Ancillary services will indeed need to be re-assessed, so as to analyze its possible impact of the evolution of the volumes. This will be part of the extrapolation of the results of Market Response

c) Extrapolation of the results

For their integration into the Adequacy Study, the volumes of Market Response needed to be provided for 3 winters: 2018/2019, 2019/2020, 2020/2021. Though, the output provided by the aggregated curves analysis can be used for the following winter but then needs to be extrapolated.

Based on discussions with stakeholders, three scenarios were envisaged: one based on historical growth rates and two based on a more sustained growth rate of Market Response volumes.

The study of the extrapolation started by analyzing the past evolutions of the Market Response volumes. Over the last winters, the figure bellow reveals that the volume decrease is compensated by an increase of the volumes valued in the Ancillary Services[1].

Indeed, the historical extrapolation is based on three separated steps to obtain the past evolution of the Market Response volumes, as discussed in the subgroup:

1. Firstly, the aggregated curves analysis enables to extract the volumes of Market Response excluding the Ancillary Services per winter (in red in the figure below). These volumes are indeed the average Market Response volumes for the peak hours of the previous winters
2. Then, the Ancillary Services volumes are observed for the past periods (see detailed volumes in appendix). Since the volumes of Ancillary Services are contracted for yearly periods, the yearly volumes have been weighted according to the number of months (November and December vs. January, February and March) to obtain “winter” volumes
3. The sum of both volumes gives a total volume for each winter, enabling to obtain a total MR average growth of +1% per year for the past 3 winter periods

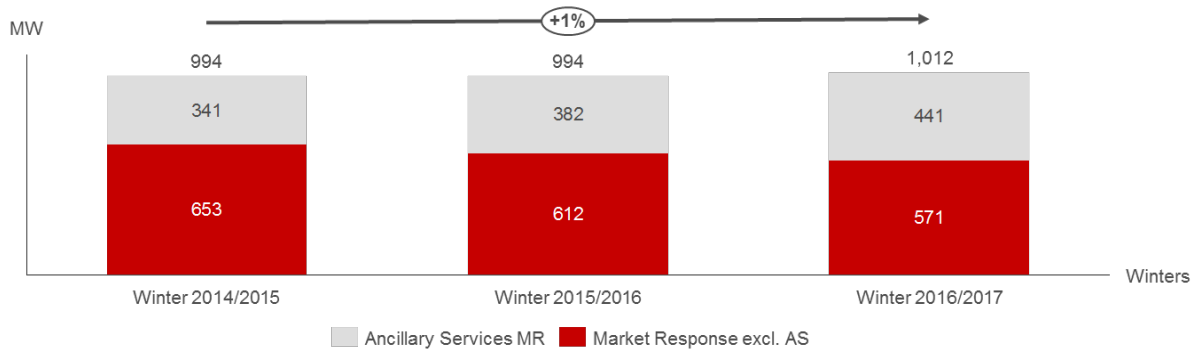

Figure 19: evolution of the volumes of Market Response – Winter months[2]

[1] The volumes of DR in the Ancillary Services gathers: up to 2016, the volumes ICH, R3DP and R1Up and for the year 2016, the volumes are ICH, R3Flex and R1Up.

[2] Winter months: from the 1st of November to the 31st of March

This results in a Market Response volume of 637 MW, starting point of the extrapolation. Note that this is the average value following the statistical analysis of the aggregated curves over the last 3 winter periods (peak hours, week days). A period of 3 year was deemed more robust in terms of statistical relevance in comparison to only taking the last winter period. The value for the MR in Ancillary Service is 441 MW for winter 2016/2017. Note that this value represents the last available data, weighted to get the last winter period, as these are based on observations and therefore represent the last known and most accurate value.

Then, the past average growth of 1% per year was leveraged to extrapolate the future volumes of Market Response:

1. The total MR volumes (thus including MR in Ancillary Services) are observed to follow this +1% increase per year. For the extrapolation, the total MR volume is obtained by summing up the output of the methodology's result (637 MW, based on the whole analysis of the aggregated curves, see above) and the actual and observed volumes of Ancillary Services MR
2. Elia provided the projections of Ancillary Services Market Response, which are assumed to further increase in the coming years (see appendix for details). These AS volumes are subtracted from the total MR volumes
3. The subtraction of this AS volume from the total volume enables to obtain the volumes of Market Response excluding AS (hatched in the graph in Figure 20)

These extrapolated volumes follow a +0.6% increase, which was rounded at +1%. The yearly volumes are calculated by subtracting the volumes of AS from the total MR, hence the non-linear growth rate for MR volumes excluding AS.

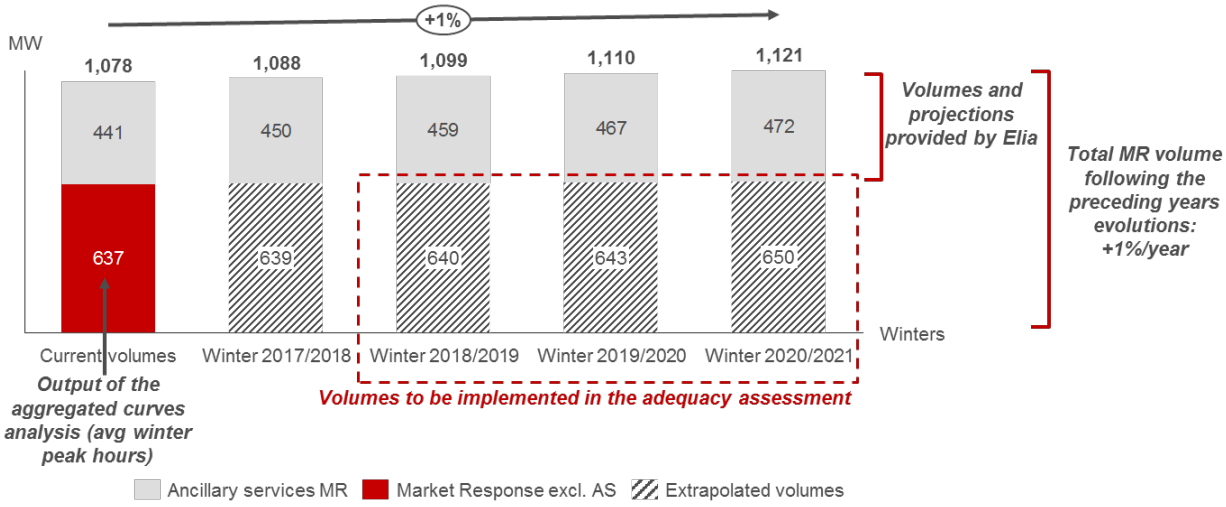

Figure 20: extrapolation of the Market Response volumes

This scenario is the rather conservative, based on an analysis of the past, and consequently leads to Market Response growth that is rather limited.

Therefore, two other scenarios representing a 3% and 5% were elaborated and discussed with stakeholders and within the Task Force. These are based on comments from the questionnaires and from the discussions within the subgroup and the Task Force.

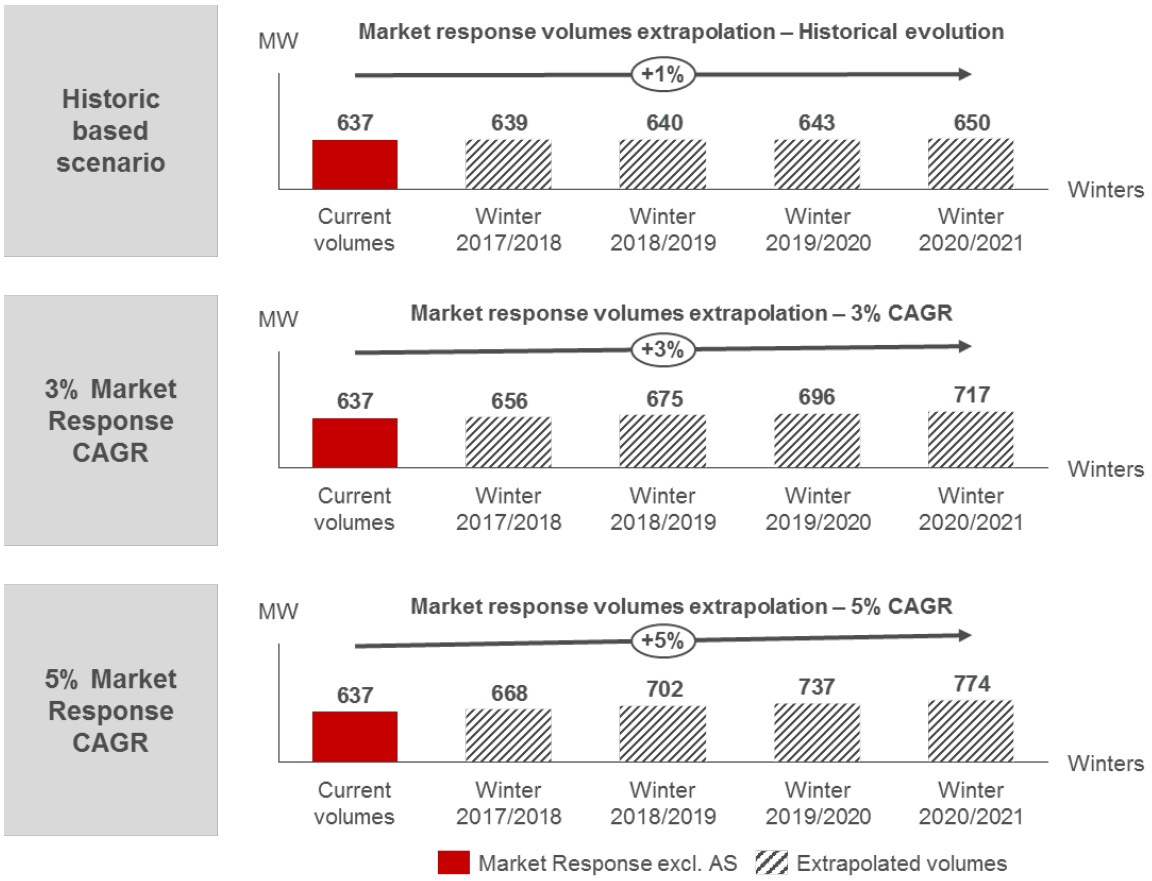

Figure 21: extrapolation scenarios presented during the TF

The Market parties mentioned in the questionnaire a higher evolution of the Market Response volumes in the following years:

- BRPs estimate that the **flexibility currently managed will increase**. Part of this increase is estimated to be done by unlocking new flexibility
- Globally Aggregators consider that **the global amount of Market Response (incl AS Market Response) will increase in the following years** as the saturation level has not been reached yet. **The increase of Market Response excl. AS MR depends on the profitability of Explicit MR products, which is still more important for now.** The increase is possible by responding in **the most pertinent manner to the needs**: with **innovation**, with the **opening of new products**, with favorable **market conditions**
- Among the answers of TSOs gathered, two different categories can be separated:
    - Most of the interviewed TSO grid users consider that their potential will remain flat in the following years since it is already fully exploited
    - Some other TSO grid users are currently **working on the different means to value their flexibility**. They also become more and more **aware of the flexibility potential** and possibilities: they try to take this new topic into account in the evolution of their processes. For them the global volume of flexibility will slowly increase.

Discussions in the subgroup and in the Task Force added elements such as the general ambition to grow Market Response in Belgium, all the efforts put forward by all market players should lead to a higher growth than the historical approach (a few MW per year) or the future possible change of legislation. On the other hand, some reservations were made regarding a high growth scenario based on the current market context with low price volatility, which is not expected to increase in the next years.

Despite the recognized difficulty to assess future growth of volumes, a preference was given during the Task Force meeting of the 12th of July, **to implement a Market Response at 5% yearly growth, during the following years, if this is subject to re-analysis during the yearly re-calculation of the volumes.**

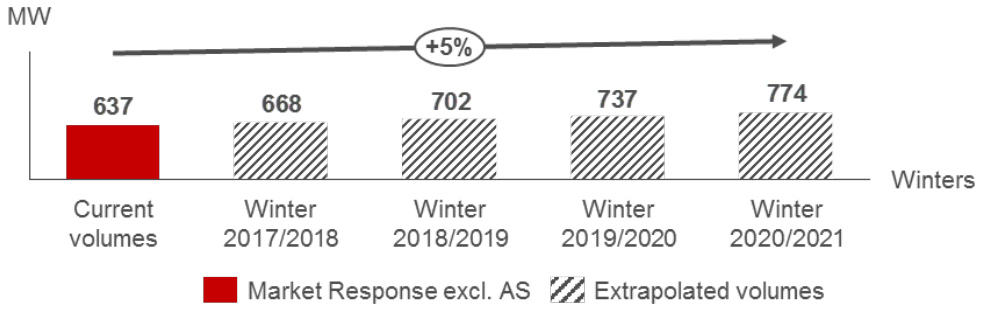

Figure 22 : Market Response volumes extrapolation

Indeed, given the methodology, the volumes of Market Response can be easily updated on a yearly basis. We recommend therefore that the extrapolation should be re-estimated during the re-calculation of the quantitative part of the Analysis in the following years. This calculation might lead to discussion with stakeholders on the volumes of Market Response.

V. Qualitative questionnaire

The second part of the study consists in a qualitative questionnaire sent to all players related to the Elia grid, i.e. grid users, balancing responsible parties and aggregators. The following part will detail the process of implementation of this questionnaire, taking into account the feedback of the subgroup members, and the results associated in terms of activation constraints.

1) Implementation of the questionnaire

To be implemented in the Adequacy Study, the volume of the aggregated curves analysis needs to be complemented by the activation constraints. This information was gathered by a qualitative questionnaire. This questionnaire is to be used firstly for the activation constraints and secondly to conduct a sanity check on the volumes of Market Response as described in the Figure 23.

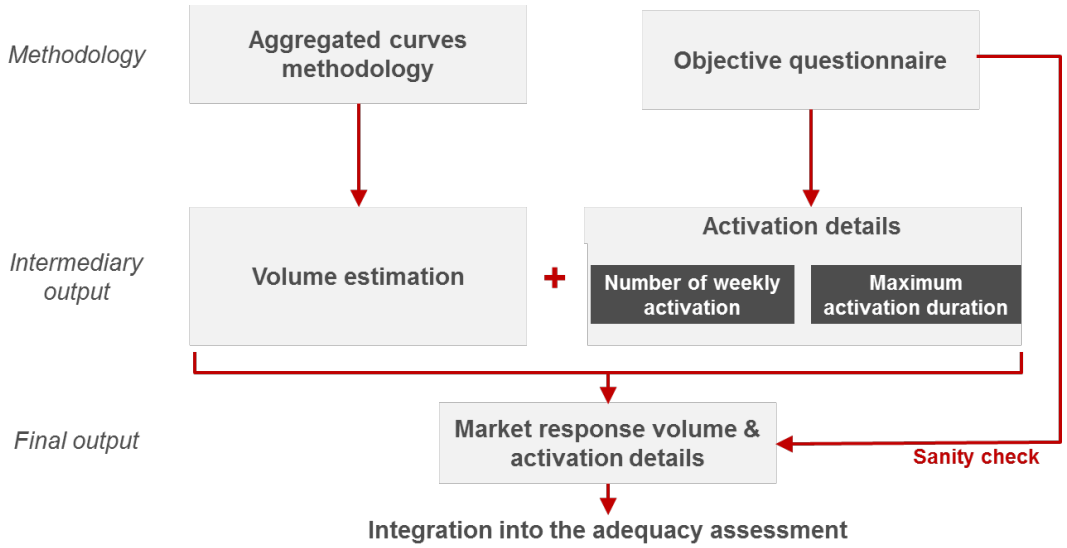

Figure 23: integration of the output of the questionnaire

The questionnaire was implemented in 4 steps: after the decision of implementation at the end of the first phase of the study, a first draft of a Q&A was designed and sent to the subgroup members. During a period of 3 weeks, the subgroup members provided their feedback on this first draft. Their remarks were integrated so as to come to a final version of the Q&A.

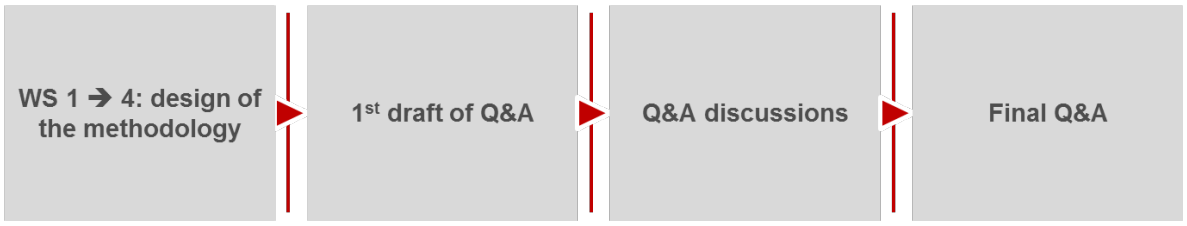

Figure 24: implementation process of the Q&A

This final version was then sent to all players: BRPs, Elia grid users and aggregators. Among a total of 162 questionnaires sent, 81 answers have been gathered, after intensive follow-up and chasing by the project team. The questionnaire was conducted in full confidentiality: the respondents had the possibility to sign an additional NDA with E-CUBE so as to guarantee the confidentiality of their

responses between them and E-CUBE. Elia has not had, and will not have, access to the individual responses.

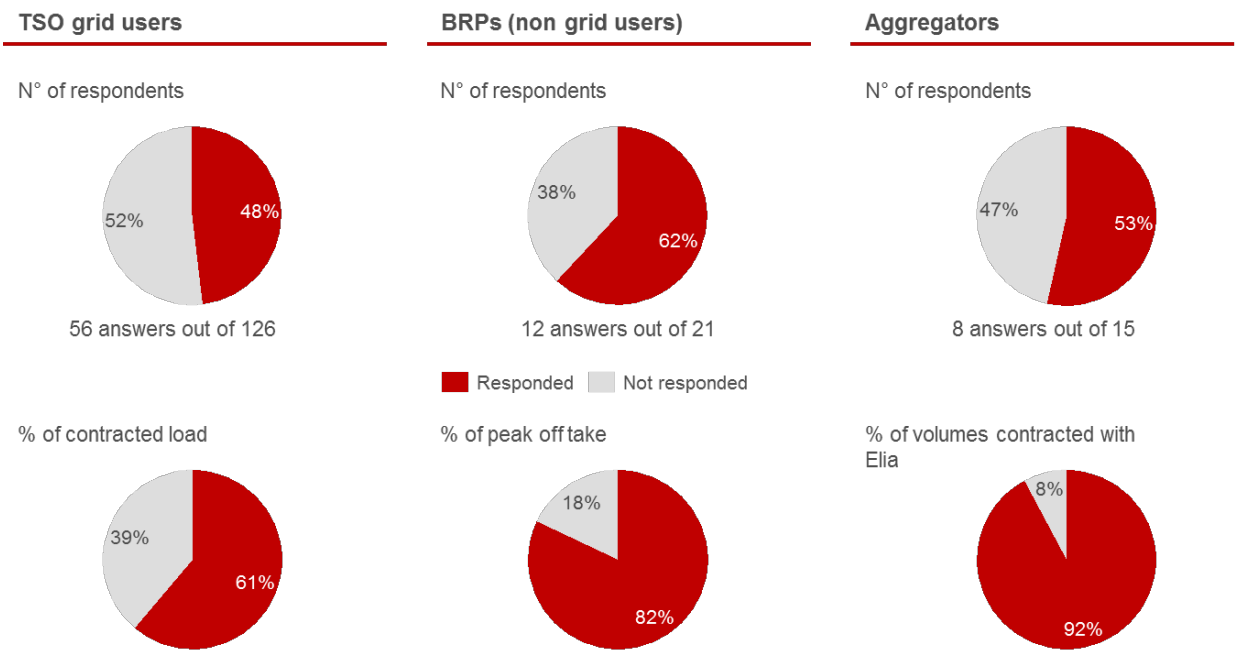

Figure 25: responses to the questionnaire

The response rates in terms of load are all above 60% and even above 80% for BRPs and aggregators which is satisfying and enables to have a good qualitative feedback on the activation constraints.

2) Qualitative results of the questionnaire

The responses gathered from the TSO grid users enable to differentiate 7 different categories of activation constraints.

Number of activations per week	**2**	**4**	**7**	**14**	**14**	**28**	No limits
Activation duration (hours)	**1**	**4**	**2**	**2**	**4**	**4**	No limits
% of MR volumes	~10%	~10%	~25%	~10%	~30%	~10%	~5%

The number of activations is also limited by a maximum number of activations per year. This number varies between 10 and 100 according to some TSO grid users. The categorization of the results is based on 13 answers from the grid users: indeed, in some cases, the respondent did not provide a pertinent answer. For example, some TSO grid users consume at any price and would not reduce their load even with DA prices at 3000€/MWh. This independence towards DA prices can be due to various reasons: electricity is considered as a marginal cost, the electricity supply is managed on a yearly basis, the electricity price is billed to the client…

Information regarding the activation constraints was also provided by the BRPs (non-grid users) and the Aggregators. The answers from the BRPs reveal the presence of a category of customer without any activation constraints, hence confirming the presence of the “no limits” category of the table above. For customers with activation constraints, the most recurrent activation constraints are 14 times a week for a maximum duration of 4 hours and 7 times a week for a maximum duration of 1 to 2 hours.

➔ **Answers from the BRPs broadly confirm the categories from the TSO grid users’ answers**

For aggregators, the answers are slightly different: they estimated volumes that could potentially be contracted in a near future (except for small volumes already contracted). The activation constraints estimated reveal between 1 to 7 activations per week for durations between 2 and 8 hours maximum. These activations constraints are complemented with a maximum number of activation per year varying from 10 to 100.

➔ **The activations constraints presented by the aggregators are globally coherent with the response provided by the TSO Grid Users**

VI. Cross check of the results

The last part of the methodology aims at verifying the results provided by the aggregated curves analysis with a sanity check. This section presents the two sanity checks conducted:

- The first cross check was based on the quantitative volumes obtained from the questionnaire. A very cautious approach is to be adapted regarding these volumes knowing the difficulties of the respondent to answer objectively to quantitative questions regarding Market Response. This explains the use of this volume only as a cross check.

- The second cross check conducted compares the volume obtained to the Market Response present in the countries benchmarked for the 2nd workshop.

Both cross checks enable to verify the overall coherence of the results provided by the aggregated curves analysis.

1) Questionnaire cross check

Disclaimer: the quantitative results from the questionnaire are not to be used without great caution They give orders of magnitude of the market response volumes and are just used in this study as sanity checks of the aggregated curves volumes.

From the questionnaire sent to grid users, we were able to find a range of Market Response volumes for the 61% of the respondents (in terms of contracted load) which can be then extrapolated to the entire market. This extrapolation leads to a range of market response of [560 – 690] MW, which is coherent with the number of 637MW found with the analysis.

Figure 26 : extrapolation of the TSO grid users volume

From the questionnaire sent to BRPs, the overall volume of contracts indexed on prices reaches 705 MW. The fact that this volume is higher than the volume of Market Response confirms the global coherence of the Market Response volumes provided by the aggregated curves.

The questionnaire sent to aggregators enabled to extract the potential volume of Market Response that aggregators estimate to value in the next years, when being able to do so. This volume amounts 255 MW which reveals their goal to get involved in Market Response. Their contracted volumes will indeed increase and will need to be followed for this assessment in future years.

The quantitative part of the questionnaire enables to broadly validate the coherence of the results of the aggregated curves analysis.

Also in the questionnaire, various responses go in the same direction as the categorization conducted when analyzing the EPEX DAM Belgium curves. The winter peak hours have to be separated from the other hours. According to a respondent, the potential of Market Response is correlated with the total demand, so there should be "less [Market Response] in the weekends than during weekdays, although some of the large flex providers are 24/7". Among the answers of the TSO grid users, when comparing winter peak hours and the remaining hours, respondents noted an increase of their volumes: the answers reveal ~38 MW of additional volumes during those periods. This is coherent with the increase of volume of our categorization: the difference between the peak hours of the winter category and the other hours equals 48MW.

This qualitative feedback confirms the categorization established during the first part of the methodology.

2) Benchmarked markets

During the first phase of the study, a benchmark of the Market Response methodologies was conducted. Among the most advanced countries, the UK does estimates of the Market Response thanks to a very specific product: the Triad avoidance[1]. They are able to estimate a maximum amount of Triad avoidance of 2GW, which can be compared to their total peak load of 57 GW. In this analysis, we look for the order of magnitude to verify the results. Indeed, for example, the Triad Avoidance are not exactly similar to Market Response, this product is activated 3 times a year with a much more structured and defined environment.

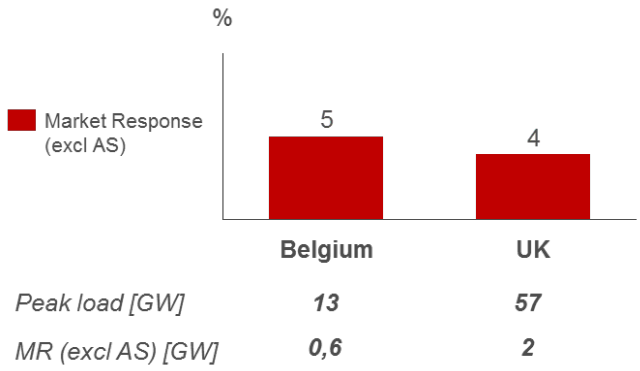

Figure 27: Market Response (excl. AS) as a % of peak load[2]

The comparison shows that the percentages of peak load are in the same order of magnitude.

In the other most advanced markets, like France and PJM, the market response volumes are not estimated. The comparison was indeed made with the total volume.

[1] Triad Avoidance consists in distributing the charges of the transmission network based on customers consumption during periods of peak load – See report of the phase 1 for the detailed benchmark

[2] National Grid – 2016 - "Winter Outlook Report 2016 – 2017"

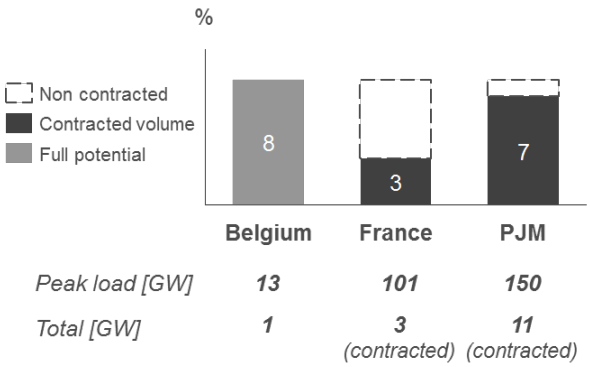

Figure 28: Market Response as a % of peak load [1]

In France, we only have access to the contracted DR. No estimation of Market Response is conducted. The % of peak load is then naturally less important since it does not represent the full potential.

PJM is more advanced regarding the contracted DR capacities. This 7% still does not represent the full potential of PJM but it is coherent with the value of 8% found for Belgium.

[1] RTE – 2016 - "Bilan prévisionnel 2016", PJM – 2016 - "Load forecast report"

VII. Update of the methodology

So as to take into account the future evolutions of the Market Response volumes, its implementation in order to obtain representative results could be updated regularly. The quantitative method is adapted to a yearly update, since there is no need to re-design the entire methodology. The EPEX DAM Belgium aggregated curves can be updated with recent data every year along with price thresholds, extrapolation factor and ancillary services volumes (detailed in part IV.4).

The qualitative methodology is less sensitive to yearly evolutions while being more resource intensive for Elia and market parties. Indeed, the questionnaire will have to be re-sent to all market parties, who will have to be solicited for their answer: this mobilizes resources from Elia's side but also for market parties, who will not necessarily grant us some time to respond every year. The qualitative methodology, however, is less sensitive to yearly evolutions while being more resource intensive for Elia and market parties. An update of the qualitative aspects could be foreseen after a few years or whenever the need would become apparent

VIII. Appendices

1) Glossary

- MR: Market Response
- DR/DSR: Demand Response / Demand Side Response
- DAM: Day-ahead Market
- FSP: Flexibility Service Provider
- BRP: Balance Responsible Party
- TSO: Transmission System Operator
- SDR: Strategic Demand Reserve
- DA: day-ahead
- ID: Intraday
- AS: Ancillary Services

2) Additional analyses as requested by subgroup stakeholders

Various analyses were conducted:

- **Analysis of the offer volumes of 2013:** finally, the market response volume distribution of year 2013 was also analyzed to confirm the exclusion of year 2014
- **Restriction of the dataset from 5 PM to 8 PM:** the objective of this analysis is to assess if this restriction has a more important impact on the dataset than the previously presented categorization
- **Tail analysis:** this analysis was conducted to assess if specific patterns are present at the tail of the distribution
- **Multivariate regressions and addition of P-values:** this analysis was conducted to assess the impact of various factors at the same time
- **Impact of gas prices:** gas prices were analyzed in two different ways. They were integrated in the regressions and their impact on the price thresholds (150€/MWh and 500€/MWh) was analyzed

3) Analysis of the offer volumes of 2013

So as to complement and validate the exclusion of year 2014, the analysis of the distribution of the offer volumes of 2013 was also analyzed

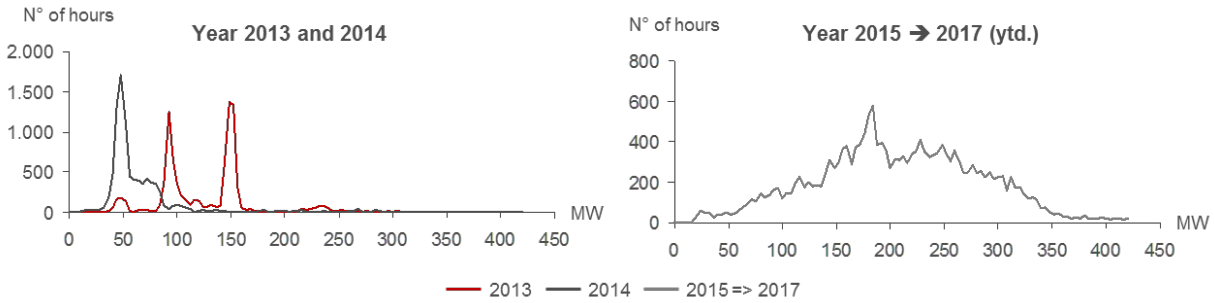

Figure 29: distribution of the volumes on the offer side (150€/MWh volumes)

The Market Response volumes of 2013 also show a specific pattern of distribution with two peaks. This behavior does not correspond to the current bidding behaviors (2015 – 2017 (ytd)) as the distribution is very different. This analysis also confirms that the restriction of the analysis to 2015 – 2017 (ytd) is more pertinent: previous data does not describe the current bidding behaviors.

4) Restriction of the dataset from 5 PM to 8 PM

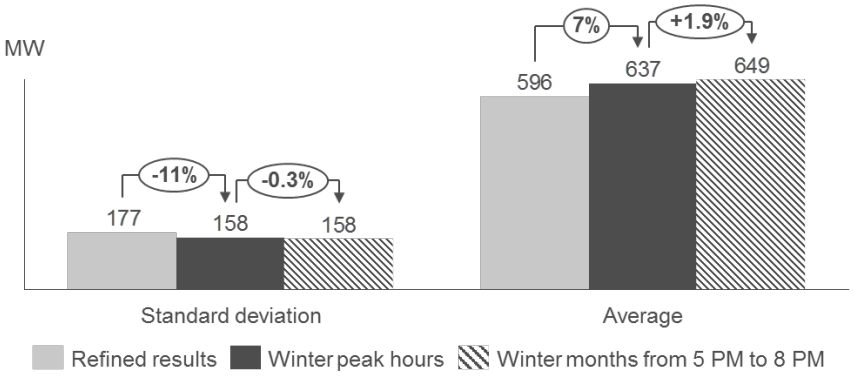

Figure 30: key statistics of the 5 PM to 8 PM restricted dataset – 150€/MWh volumes

The impact of the restriction to the hours from 5 PM to 8 PM is not very significant regarding both the standard deviation and the average. If we consider the volumes with the 500€/MWh threshold, the standard deviation follows a -1.3% decrease (from 145 MW to 143 MW) and the average a +0.7% (from 472 MW to 475 MW). These evolutions are in the same order of magnitude as the one of the 150€/MWh volumes.

In addition, the number of data in the restricted dataset is 825. **Knowing the limited impact, along with the low number of data in the refined dataset, we suggest not to implement this restriction.**

5) Tail analysis

The analysis of the tail was conducted on the values over 1000 MW, representing a total of 298 values for our dataset.

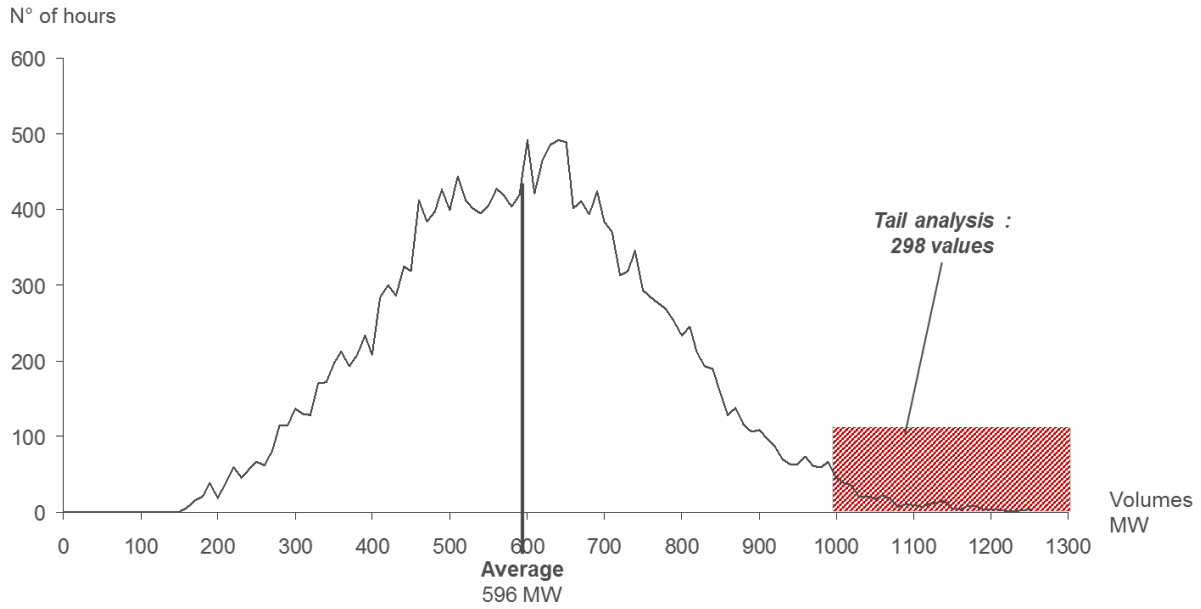

Figure 31: volume distribution of the refined results – 150€/MWh volumes

The objective of the analysis was to assess if some pattern were present at the tail of the distribution. In this perspective, analyses of the temperature, the load and the different period patterns were conducted.

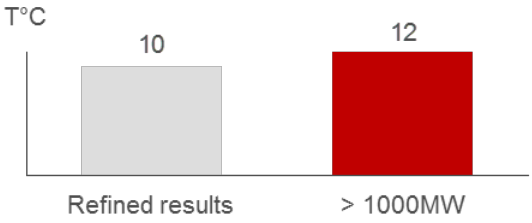

Figure 32: average temperature at the tail of the distribution

Contrary to what could be excepted, the average temperature is slightly higher at the tail of the distribution.

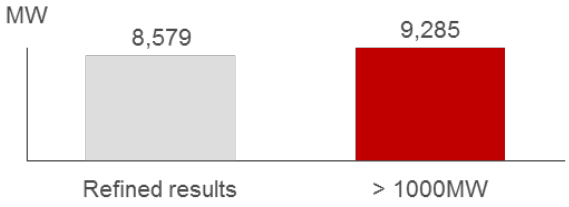

Figure 33: Elia grid load at the tail of the distribution

The load is on average higher at the tail of the distribution, but the difference is not very significant.

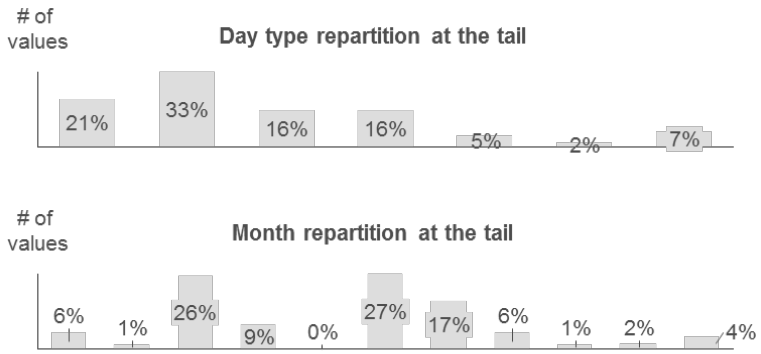

Figure 34: day and month repartition at the tail of the distribution

Regarding the day type repartition, the majority of the values are within the week, and more than 50% during the beginning of the week. Though, there are no clear patterns since we also notice values on Sundays and Saturdays. Regarding the month repartition, this type of value happens during all the months, except during May. It is indeed not possible to conclude on clear pattern at the tail regarding both the Month and the day types repartition.

➔ No specific behavior was noticed at the tail of the distribution. Though, the observed results do not contradict the proposed refinement concerning the winter peak hours.

6) Multivariate regressions and addition of P-values

Two multivariate regressions were computed: one with the daily averaged volumes and one with the hourly volumes. The variables integrated in the multivariate regression were the gas prices (ZTP prices), the DA prices, the temperatures and the Elia grid load. So as to compute these analyses, the Market Response volumes were restricted to weekdays because of a lack of ZTP prices data for the weekends and holidays.

The results of the two regressions are in the same order of magnitude and does not reveal any correlations with the selected variables:

- **Daily averaged regression**: the R^2 is 0.06, showing that 6% of the variance is explained by this model. The standard deviation is also high (157MW) with a P-value bellow 0.05 only for temperature and load[1]
  ➔ This regression model does not seem to be a good fit for the Market Response volumes, though, the load and temperature should be further investigated

- **Hourly regression:** the R2 is 0.07, showing that 7% of the variance is explained by this model. The standard deviation is high (166 MW) and the P-value is bellow 0.05 only for the Elia grid load
  ➔ This regression model does not seem to be a good fit for our dataset but the P-values reveal that the Elia grid load should be further investigated

[1] The P-value is bigger than 0.05 for gas prices and DA prices, meaning it is not possible to reject the hypothesis that they are 0: they can be eliminated from the model

7) Impact of the DA prices on the dataset

As shown in the graph bellow, the set-up of a price threshold leads to an increase in the average volume of Market Reponses, which could be pertinent for our study. Though, this observation is strongly moderated by a very limited evolution of the standard deviation, and even an increase of this standard deviation after 100€/MWh. Also, the number of values in the dataset is too limited to conduct a robust statistical analysis: the periods of important prices are too limited.

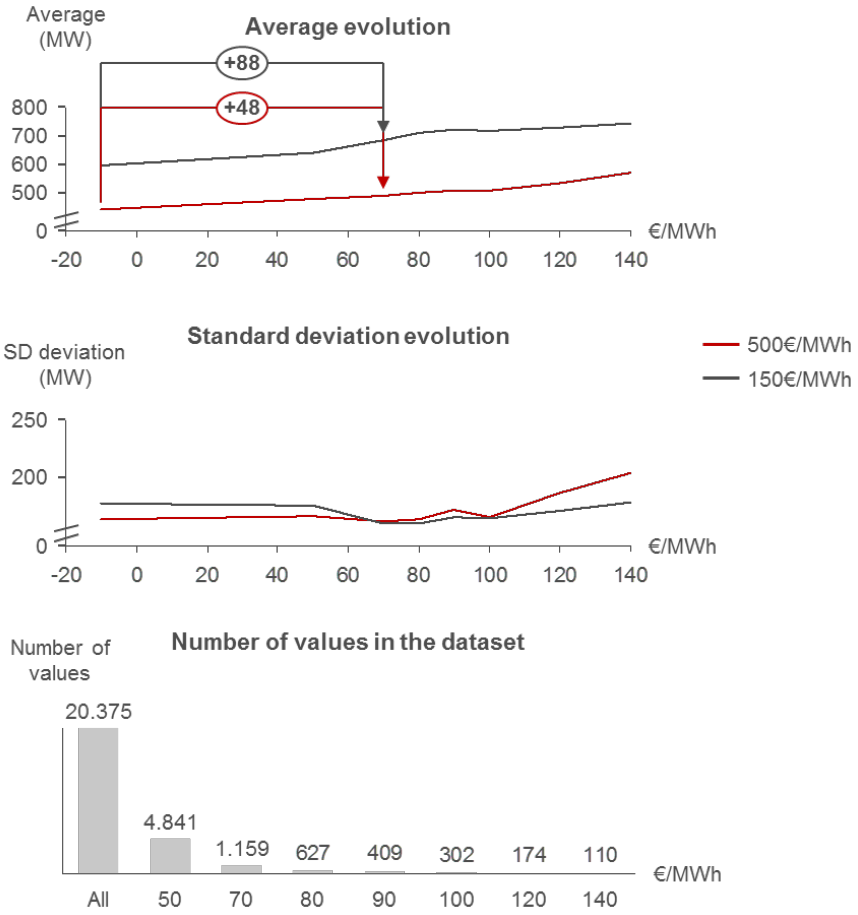

Figure 35 : evolution of key statistics with the price threshold (DA prices)

8) Impact of the temperature on the dataset

For the temperature, the threshold was decreased since we try to assess a pattern in the volumes of Market Response in situations of possible tightness to meet electricity demand, indeed when the temperature is low. This analysis shows that when we decrease the price threshold, there is a limited impact on the average value but particularly there is an increase of the standard deviation. This shows that a temperature restriction should not be established, the temperature has no impact on the Market Response volumes.

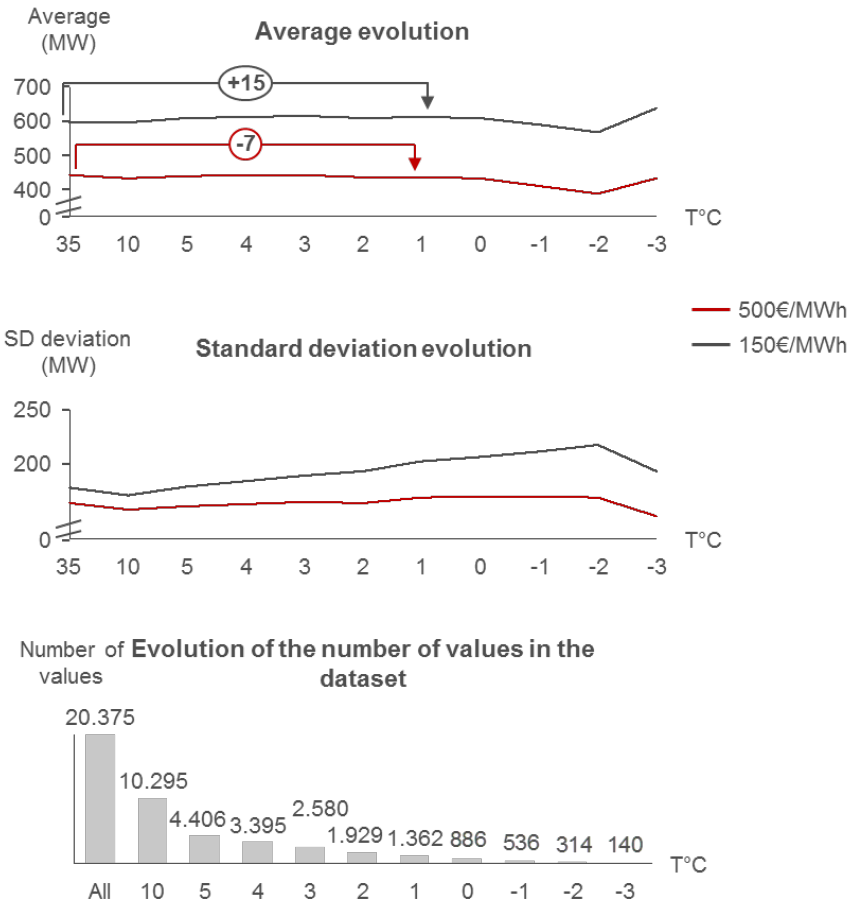

Figure 36 : evolution of key statistics with the temperature[1]

9) Historical values and extrapolation of the Ancillary services volumes

		FRR need	R1 Total	R1 DR (Average)	R2 Total	R2 DR	R3 Total (inc. XB)	R3+DR (Average)
	2015	1240[1a]	83[1a]	**23[1b]**	140[1a]	**0**	911[1a]	**321[1b]**
	2016	1203[1a]	73[1a]	**14[1b]**	140[1a]	**0**	1020[1a]	**424[1b]**
	2017[1c]	1183[1a]	68[1a]	**18[1b]**	144[1a]	**0**	1030[1a]	**428[1b]**
	2018	Dossier Volume 2018						
Scope	**2019**	1212[3]	90	**25.2**	155[3]	**0**	1048[3]	**440**
Scope	**2020**	1226[3]	90	**26.1**	165[3]	**0**	1057[3]	**444**
Scope	**2021**	1240[2]	90[2]	**27.0**	175[2]	**0**	1065[2]	**447**

Figure 37: Ancillary Services volumes historical values and extrapolation

[1a]Historic values of FRR need, R1, R2, R3 (dossier volume), [1b]R1up, ICH, R3DP and R3flex (website); [1c] Until week 25; [2]mFRR+ presented in Adequacy Study 2027; [3]Linear extrapolation

This calculation is based on several assumptions concerning the calculations (cells in red):

- For R1: increase of share and capacity towards 2021

[1] For this analysis, the hourly values of the reference temperature of the Uccle station were used.

- For R2: no contribution of DR (but under investigation towards 2020)
- For R3: capacity growth following a constant share of DR in R3

The figures shown are rough estimations and do not represent any targets or ambitions. The final share of DR is determined by the market as products (R1, R3) are open for the offers of different technologies. The participation of DR in R2 is under investigation but in this preliminary phase, no capacity can be taken into account.