APPENDIX ON THE ECONOMIC VIABILITY ASSESSMENT

Version submitted to public consultation for the next Adequacy & Flexibility study 2024-34

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1. INTRODUCTION

The economic viability assessment (EVA) is a crucial but complex analysis which allows the assessment of the economic viability (under certain conditions) of existing or new capacity in the electricity market. The ERAA methodology (see [ACER-1] Article 6) indicates that the EVA shall either assess the viability for each capacity iteratively or by minimising the overall system costs, where all capacities are optimised at once. This second method, minimization of overall system costs, is considered in the ERAA methodology as a simplification of the EVA methodology. In this study, as in previous studies, the first method referred in the ERAA methodology, i.e. *the assessment of the viability for each capacity resources*, is considered. A full iterative approach is thus applied. For each iteration, the economic viability of all monitored capacities (or 'candidates') is evaluated following the criterion or metric. The details of this approach are presented in this appendix.

Elia has performed economic viability assessments in recent and past studies. In the previous Adequacy and Flexibility study of June 2021 [ELIA-1], based on the introduction of the ERAA methodology as well as on the feedbacks received after the Adequacy and Flexibility study of June 2019 [ELIA-2], several major improvements were introduced to make the EVA metric compliant with the ERAA methodogy. These improvement include an extention of the perimeter to other countries than Belgium and the inclusion of additional capacity types to be considered in the assessment.

In the present study the methodological development of the method is proposed to be further improved starting from the previous approach but with the novelty of making it a multi-year approach. In addition, the hurdle rates were also updated based on the latest study done by Prof. Boudt of which a draft version is shared along with the public consultation.

2. METHODOLOGY FOR THE EVA METRIC – UPDATE OF THE HURDLE RATES

Basic principle

The methodology for the EVA metric is fully in line with the methodology presented as part of Elia's Adequacy & Flexibility Study 2021. This methodology was based on an academic study published by Professor K. Boudt in 2020, which provides a theoretical and academic framework for investor behaviour [BOU-1] and which was further refined in a 2021 publication [BOU-2] by the same professor as part of the public consultation process of Elia's Adequacy & Flexibility Study 2021.

According to the methodology, a capacity is considered as viable if the average simulated internal rate of return on a project exceeds the so-called hurdle rate:

$$Economically\ viable\ \Leftrightarrow\ Average\ internal\ rate\ of\ return \geq hurdle\ rate$$

The average internal rate of return (IRR) and the way it is calculated as part of the overall process is further explained in Section 3.

The hurdle rate is the threshold that the average project internal rate of return needs to equal or exceed for the project to be economically viable. The hurdle rate equals the sum of an industry-wide reference WACC and a hurdle premium. All capacity (of any technology) is subject to the same WACC, whereas the hurdle premium differentiates between the technologies in accordance with the identified risks and uncertainties.

As part of this public consultation process, Professor K. Boudt has again provided an update of the study to propose a new reference WACC and a new hurdle premium for each technology. The proposed hurdle rates take into account recent market events and up to date data. The exact values for the reference WACC and the hurdle premium per technology can be found in the Excel with input data shared in the public consultation in sheet "3.2 Investment costs".

3. DESCRIPTION OF THE EVA PROCESS

Starting from a given scenario, the economic viability assessment of capacity (under different assumptions) is performed on a given scenario.

The process, which is illustrated in Figure 1, is computationally intensive. For each iteration, the results of an ANTARES simulation are combined with simulation-independent economic parameters to generate a set of possible investment outcomes over the lifetime of a candidate. The set of returns is then used to calculate the Internal Rate of Return (IRR), a metric that can be used to gauge the profitability of the candidate. Following the approach proposed by Professor Boudt (see Section 2) investments decisions are made and the model is updated.

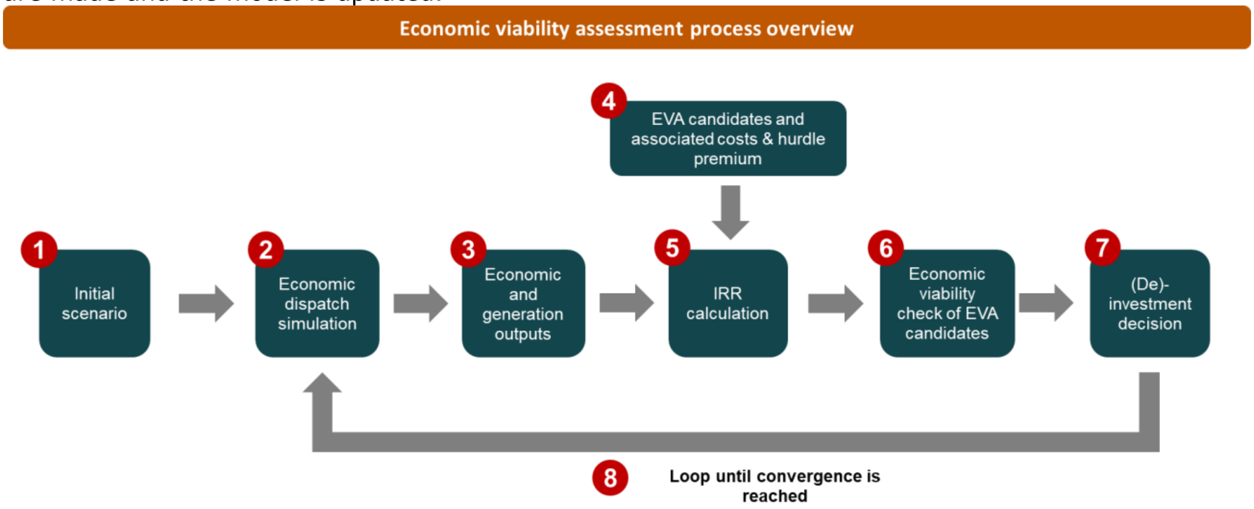

Figure 1: Overview of the EVA loop

1. The process begins with the adoption of a starting situation (= given scenario).
2. An economic dispatch simulation is performed. A full year market simulation (on an hourly basis) is performed for a large amount of 'Monte Carlo' years. The amount used is further elaborated in Section 8 (or step 8).
3. For each 'Monte Carlo' year, several indicators were calculated for each capacity type/unit. Those are needed to calculate the IRR metric that determined the economic viability of a given capacity type or unit. In addition, other revenue streams are also taken into account if relevant.
4. For each scenario and case, candidates for (de)-investment needed to be defined. Depending on the scenario framework or analysis to be performed, a list of candidates is defined (for instance, the perimeter or the type of units and/or candidate investment decisions (existing, new, refurbishments…) that are part of the EVA). Each capacity type is also associated with costs that need to be covered. The study (including a calibration of the hurdle premium) performed by Professor Boudt published in 2021 is used to determine the hurdle premium needed to assess the viability of each capacity type.
5. Based on the different simulation outputs and candidate parameters, the IRR (Internal Rate of Return) is calculated for each candidate. To calculate the IRR of a candidate, first a large amount of sequences of cashflows that each candidate could obtain for their entire economic lifetime is simulated. For each sequence of cashflows, the IRR is calculated. The average of the sampled IRR's is then used in the economic decision-making process.
6. The average of the IRR over the large amount of draws is then compared to the hurdle rate (i.e. the sum of the WACC and the technology-specific hurdle premium) for each candidate.
7. The candidates where the average of the IRR's is below the hurdle rate are removed from the model as these are not economically viable. On the contrary, if the IRR is above the hurdle rate, the candidate remains in the market or is invested in (if not yet in the market). Given the non-linearity of the evolution of revenues (when removing or adding capacity), the amount of capacity to be removed or added in each iteration is limited.
8. The process (from 2 to 8) is repeated a large amount of times until convergence of the results is reached.

4. ECONOMIC AND GENERATION OUTPUTS (step 3)

The market clearing price and generation (as well as consumption in case of storage) of each candidate are extracted from the simulation. Then, the revenues generated on the market as the product between the market clearing price and the amount of energy delivered/consumed is computed. Assuming that the capacities bid at marginal cost, the market bids are subtracted. In case of storage, no variable costs are assumed. For demand side response, a certain activation price is assumed. Finally, inframarginal rents are computed. In this calculation, startup costs are not taken into account, resulting in a possible over-estimation of the inframarginal rents.
For a week in the simulation and for a given unit, this process is presented in Figure 2. This can be presented in a simplified way on a yearly level as shown in Figure 3

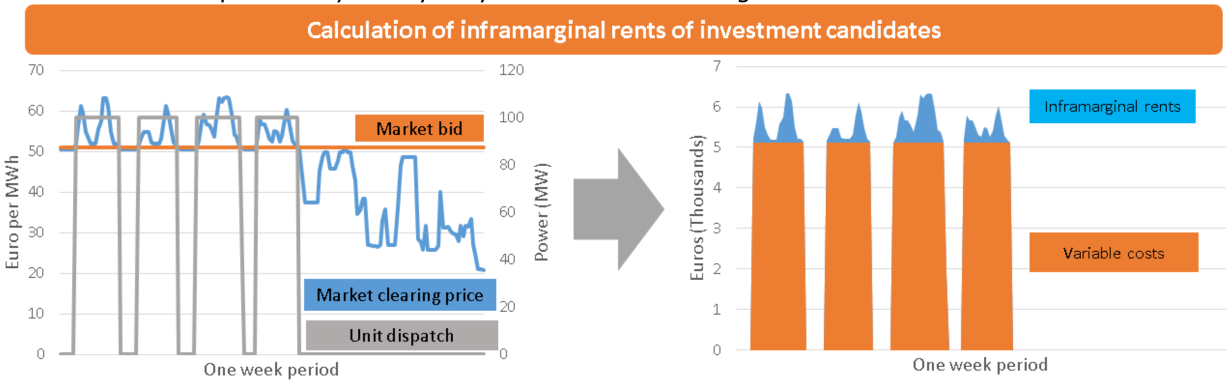

Figure 2: calculation of inframarginal rents of investment candidates: one week period

One can understand the inframarginal rents on a yearly level as schematically represented in Figure 3.

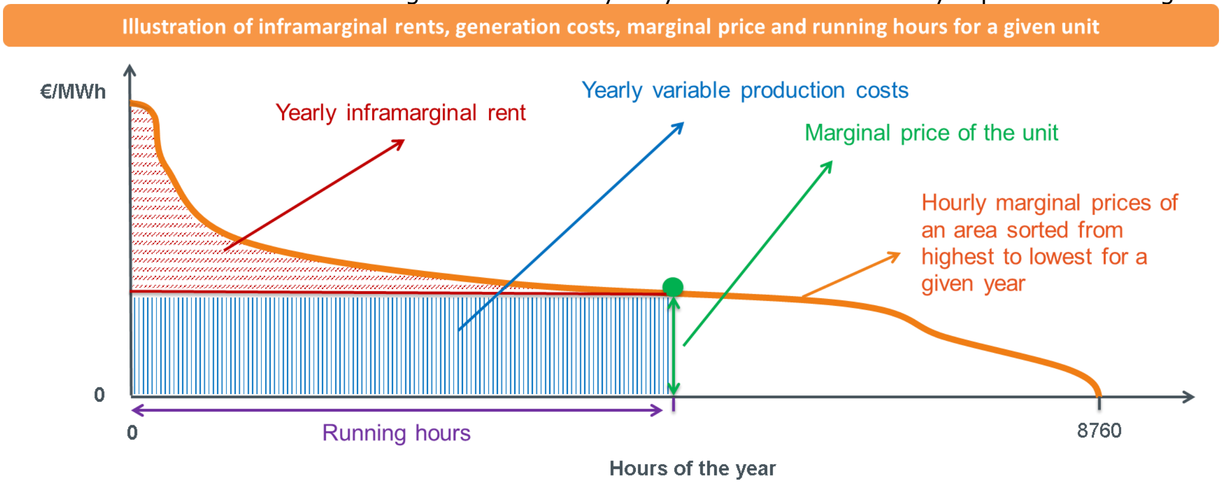

Figure 3: calculation of inframarginal rents of investment candidates: simplified overview of a one year period

To take into account possible increases in the market price cap, two additional indicators are extracted from the market simulation. On one hand, the amount of energy delivered by the candidates during times when the price is at the price cap of the simulations is extracted. On the other hand, for each possible future price cap, the amount of times this price cap would be increased during a given 'Monte Carlo' year is analysed. To mimic future price cap evolutions, the latest regulatory evolutions will be monitored and taken as best as possible into account.

With the current high prices situation on electricity markets, ACER has urged for a review of the methodology for the automatic increase of the price (-cap-)limit [ACER-2]. ACER states *'The aim of the review is to limit the frequency of increases of the maximum clearing price in the spot markets, allowing consumers and market participants to gradually and better adapt to the scarcity situation in the market'* ACER launched a public consultation on the review of this methodology from 19 September to 9 October 2022 and formally has six months to reach a decision.

5. EVA PARAMETERS (step 4)

To determine the economic viability of an investment candidate, an estimation of the costs incurred and revenues generated from the moment the decision to invest is made until after its (de-) commissioning needs to be performed. Some of these costs and revenues, like the revenues on the electricity market, depend on the market situation that will actually materialise. It is these uncertain revenues and costs that are estimated using a detailed simulation of the electricity market as explained in Section 4. Cashflows like the investment costs and fixed operational and maintenance costs, are assumed as 'known' at the start of the candidates' lifetime.
Other revenues (other than electricity market revenues) are also taken into account in this assessment. These are described in the sections below.

Net Ancillary services revenues

Capacities in the energy market can potentially earn net additional revenues by participating to ancillary services. However, these (net) revenues are not modelled within ANTARES. Hence, Elia has to estimate these net revenues that market actors may potentially earn on top of the simulated energy market revenues.

In order to perform such an estimation, Elia relies on the existing methodology used for each calibration cycle of the Capacity Remuneration Mechanism that calculates net balancing revenues based on reservation costs for the latest 36 months for these revenues. When doing so, Elia is of the opinion that market actors must consider additional aspects to account for potential arbitrage between energy and balancing market and the associated opportunity cost.

Therefore, Elia's proposal is to consider the same approach than the one considered for the CRM Calibration to calculate **net revenues** starting from the revenues earned from the provision of balancing services, while considering some differences highlighted below :

- Elia proposes to look at reservation costs for the latest 36 months for balancing services.
- Elia proposes to consider the following principles for the different balancing products when going from balancing revenues to **net** balancing revenues:
  - For FCR & aFRR, Elia considers that the estimation made should :
    - take into account the foreseen trend regarding the volume of capacity and the mix of technologies able to provide such services and the potential evolutions of the prices of these products;
    - consider applying a limiting percentage to these revenues to account for activation and maintenance costs linked to the provision of such services.
    - consider applying a limiting percentage in order to take into account the arbitrage made by technologies participating potentially to such services including their opportunity costs.
  - For mFRR, Elia considers that the estimation should :
    - consider applying a limiting percentage in order to take into account the arbitrage made by technologies participating potentially to such services including their opportunity costs.

Generation from heat or steam.

In order to assess the additional revenues that CHP units could generate from combined heat and power generation, the method applied by Fichtner in their study entitled 'Cost of Capacity for Calibration of the Belgian Capacity Remuneration Mechanism' published in April 2020 [FIC-1] is applied. Such a method - which is called 'CHP credit' - considers a reduction of the variable costs of the CHP units for their dispatch decision in the electricity market. By reducing the variable cost at which the unit is dispatched, it increases the margin that such units would make (based on electricity market revenues and the decreased variable costs), which mimics the additional revenues they would get from selling heat or steam.
The CHP credit is built upon the reasoning that heat needs to be generated for a certain process and that if not provided by the CHP, it would be provided by a gas boiler. The benefit in marginal cost for the CHP is therefore the 'avoided' cost of generating the same amount of heat with a gas boiler. In order to calculate these avoided costs, the following assumptions are made:

- boiler efficiency: 99%;
- heat generated per MWh electric produced by the CHP: 1.6 MWhth/MWhel.

Depending on the gas and carbon prices, the 'CHP credit' is calculated and then subtracted from the CHP marginal cost. The heat and steam revenues are therefore taken directly into account in the 'electricity market' revenues calculated by the model.
Even if such an approach takes into account the benefits of combining heat and power generation, the detailed gains will greatly depend on the supplied process (heat generation, steam generation, industrial process, heat/steam profile required…) and on a case by case basis, the resulting benefits could greatly vary.
As also observed when analysing historical dispatch decisions made by CHP units, there is quite a number of CHPs still running when electricity prices are low (below their variable costs). During such moments, it is possible that those units might not make any profit or even present losses.

Finally, it is important to note that no other subsidies are taken into account and hence all units that are 'policy driven' or that are expected to get subsidies are outside the scope of the economic viability assessment. This concerns:

- coal and lignite generation (as they are mostly policy driven): although their profitability is under pressure, their economic viability is not assessed.
- nuclear units which are assumed to be policy driven;
- RES generation (biomass, wind, PV, hydro), as they get subsidies and it is assumed that the authorities will put in place a framework to achieve the targeted capacities set in the NECP.

6. IRR CALCULATION (step 5)

The methodology to determine the metric on which each technology/capacity would be assessed is developed by Professor Boudt. In accordance with this methodology, a technology is considered economically viable if the average projects' internal rate of return exceeded the hurdle rate. This section further elaborates on the IRR (Internal Rate or Return) calculation based on the costs, the revenues and the economic lifetime of the asset.

For each simulation result in the dataset, the **internal rate of return** is calculated as the rate R for which the net present value of the sequence of cash flows equals zero:

$$NPV = -I + \sum_{t=1}^{K} \frac{IR(t)}{(1+R)^t} = 0$$

As the formula above illustrates, the main drivers for the expected internal rate of return are:

- **Costs I,** which represents the outflow of cashflows to **cover all fixed costs** foreseen over the economic lifetime of the asset:

$$I = CAPEX + \sum_{t=1}^{K} \frac{FOM}{(1 + risk - free\ rate)^{t-1}}$$

  These include the fixed costs in terms of capex and FOM, which are known at the moment of the investment decision. These input parameters are detailed in the excel with input data sheet "3.2 Investment costs" shared in the public consultation.

- **Inframarginal Rents** (t) : The inframarginal rents over the lifetime of the asset are taken into account. These are a result of the economic dispatch simulations. No simulations for every year of the economic lifetime could be available, so results for the simulated year(s) are extrapolated over the asset's lifetime.
- **Economic lifetime of the asset K**: The time (in years) the unit will be active in the market following the decision to invest.

The project IRR is calculated for each sampled lifetime, after which the average value of the simulated project IRRs over the different sampled lifetimes is applied in the decision rule.

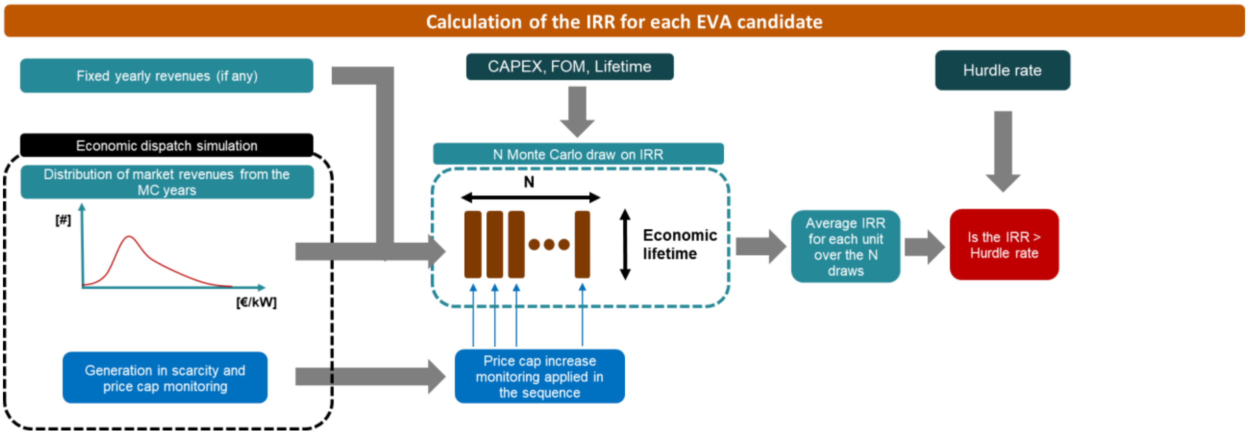

Figure 4: calculation of the IRR for each EVA candidate.

The starting value for price cap of the European day-ahead market will be assumed to be at the current value of €4 000 /MWh. However the review of the methodology for the automatic increase of the price (-cap-) limit proposed by [ACER-2], will be closely followed. Therefore, a modification of both, the assumed starting value, as well as of the rules for the increase and decrease of the price cap limit, might be necessary, according to the proposal put forward for consultation by ACER and ACER's final decision [ACER-2]. This price cap limits the profit energy producers can make at times of scarcity. When considering an investment in the energy market, investors might want to take into account the possibility that this price cap increases during its lifetime. Since it is impossible to know in advance which of the climate years will occur and in what order, the simulations are first performed with a higher market cap (€10 000 /MWh) and the correction for the over- or under- estimation of revenues is performed in a second step. To estimate what correction is needed for a given year, the number of MWh generated in scarcity are counted. Those are multiplied by the difference between the actual price cap (taking into account price cap increases due to scarcity events) and the price cap set in the model. While the maximal price cap is in theory unlimited, the market bids of load will at a certain point be lower than the price cap. By removing the profits higher than this market bid, overcompensation of unit revenues due to price cap increases is avoided. In this study, this "market bid limit" is kept at €20 000 /MWh.

7. ECONOMIC VIABILITY CHECK OF EVA CANDIDATES AND (DE-) INVESTMENT DECISION (step 6 and 7)

According to the methodology, a capacity is considered viable if the average simulated internal rate of return of a project equals or exceeds the hurdle rate of the technology:

$$Economically\ viable \Leftrightarrow Average\ internal\ rate\ of\ return \geq hurdle\ rate$$

The average internal rate of return is calculated as the output of step 6. The hurdle rate is set in accordance with the methodology developed by Prof. K. Boudt, as presented in Section 2.

Such a check is performed for all candidates considered in the EVA loop and during each iteration of the loop. At each iteration, the decision to add or remove a capacity to/from the market is undertaken as follows (see Figure 5 for an illustration of the process):

- For a capacity that is assumed 'in the market' in a given iteration:
  - if economically viable, then it remains in the market;
  - if not economically viable, then it is considered for possible removal from the market in the next iteration.
- For a capacity that is assumed 'out-of-the-market' in a given iteration (including any new capacity):
  - if not economically viable, then it remains 'out-of-the-market' (or it is not invested in, in the case of new capacity);
  - if economically viable, then it is considered for possible inclusion in the next iteration.

The investment and de-investment candidates are sorted from the most profitable to the least profitable. The investment decision for the next simulation step consists of adding the more profitable capacities (back) 'in the market' and removing the ones that are 'in the market' but are the least profitable.

In order to ensure the convergence of the results, only a limited amount of candidates is moved from 'in-the-market' to 'out-of-the-market' status at each iteration.

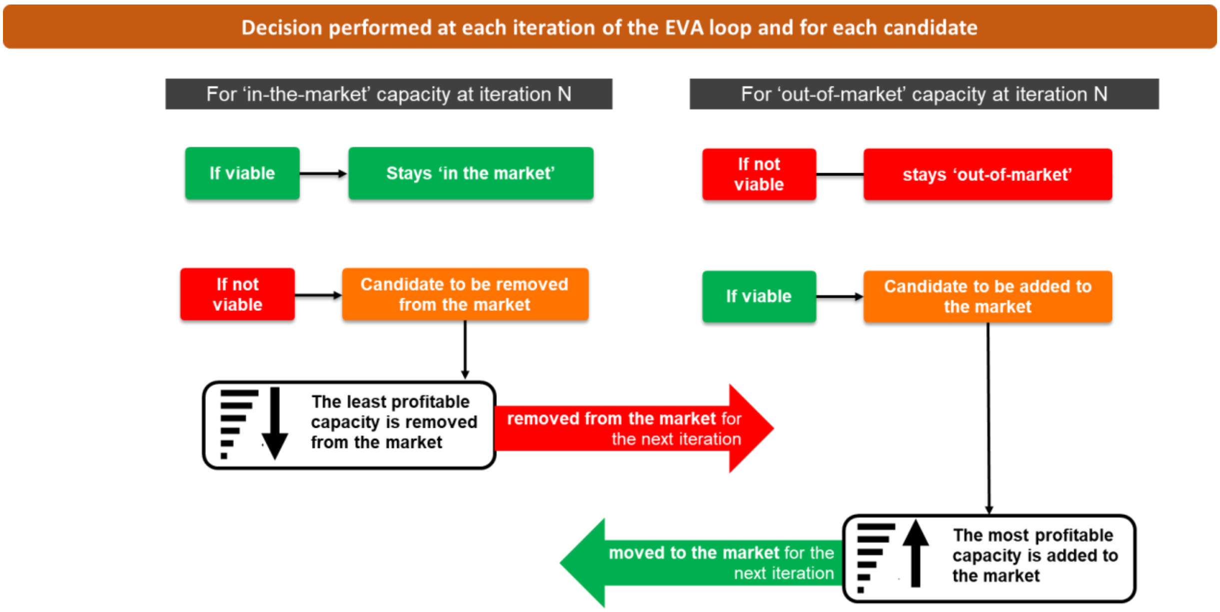

Figure 5: Decision performed at each iteration of the EVA loop for each candidate

8. PROCESS/LOOP ITERATION (step 8)

Tens of such iterations are needed to end up in a situation where all viable capacity is in the market and all non-viable capacity is out of the market. Given that these simulations are very computationally intensive, reducing the computational expense of each simulation (by for example limiting the number of Monte Carlo years simulated) significantly reduces the time needed to get a final result. To minimise the loss of information when selecting Monte Carlo Years, these are clustered based on the revenues generated by capacities in a 200 'Monte Carlo' year simulation. This clustering is performed using the k-medoids method. For each of the clusters, only the medoids are then simulated in subsequent simulations. Each of the medoids has a weight applied to it in proportion to the size of the cluster it represents, which is then used in the calculation of indicators. As the situation changes at each iteration, the original clustering could lose its relevance after several steps. To avoid this from happening, a full set of 'Monte Carlo' years is re-simulated after a given number of iterations (k). The clusters are then recreated based on the outcomes of this simulation.

Finally, to ensure that the final results are robust to the full set of 'Monte Carlo' years, the iterative approach is concluded with a 200 'Monte Carlo' year simulation. While some small changes in economic viability could still have occurred at this point, those are limited and are usually resolved after two or three additional full simulations.

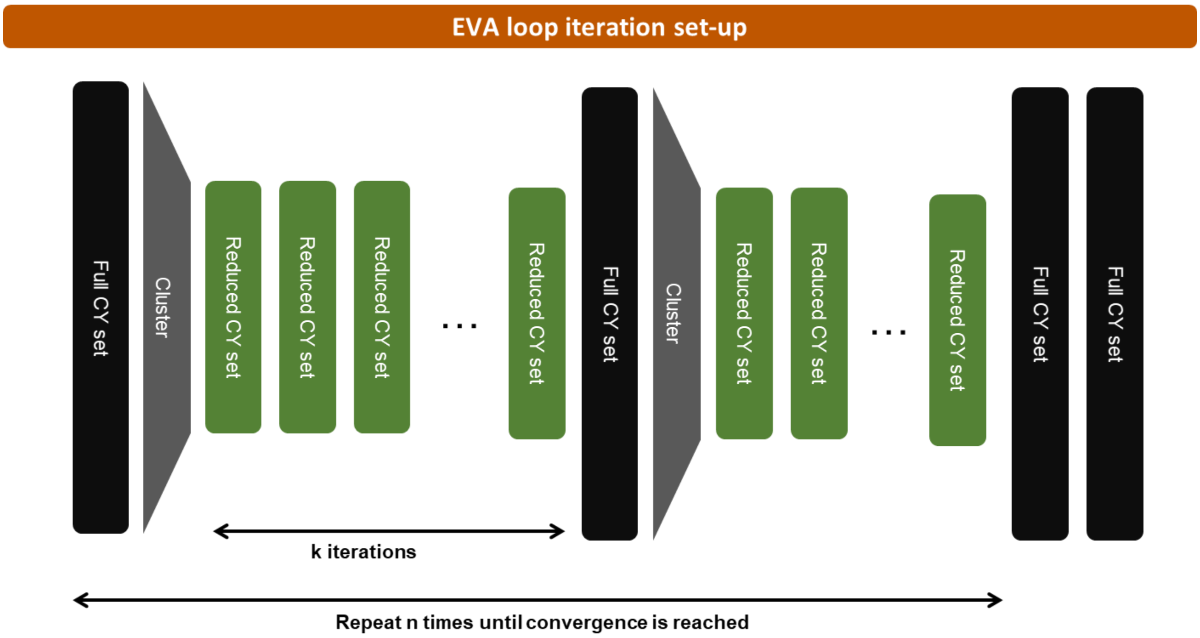

Figure 6: EVA loop: set-up of the iterations

In case of oscillations at the end of the full EVA loop, the one that maximises the 'in-the-market' capacity is chosen.

9. IMPROVEMENTS IN MULTI-YEAR REVENUE CALCULATIONS

A significant refinement is made with regards to the previous methodology concerning the estimation of costs throughout the lifetime of the unit. Where the approach used in previous Adequacy & Flexibility study published in 2021 simulated the evolution of profits throughout the lifetime of the unit through the evolution of price caps, the method that will be used for the next Adequacy & Flexibility study will explicitly take into account the future energy mixes that may occur during the lifetime of the unit. To achieve this improvement, the economic lifetime of each candidate is assessed based on a sequence of economic dispatch simulations in a multiyear approach. In case no simulation is available for a future year in the lifetime of the unit, the year is drawn randomly from the two closest years for which simulation data is available with a weight proportional to their "closeness" to the target year.
This improvement will have a major consequence on the computation time of the EVA process and some additional simplifications might be required but are not known at this stage given that the method is still being developed.

REFERENCES

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