FlexPlan

Advanced methodology and tools taking advantage of storage and FLEXibility in transmission and distribution grid PLANning

Impact assessment of the results of the FlexPlan project

D7.6

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About FlexPlan

The FlexPlan project aims at establishing a new grid planning methodology considering the opportunity to introduce new storage and flexibility resources in electricity transmission and distribution grids as an alternative to building new grid elements. This is in line with the goals and principles of the new EC package *Clean Energy for all Europeans,* which emphasizes the potential usage of flexibility sources in the phases of grid planning and operation as alternative to grid expansion. In sight of this, FlexPlan creates a new innovative grid planning tool whose ambition is to go beyond the state of the art of planning methodologies, by including the following innovative features: integrated T&D planning, full inclusion of environmental analysis, probabilistic contingency methodologies replacing the N-1 criterion as well as optimal planning decision over several decades. However, FlexPlan is not limited to building a new tool but it also uses it to analyse six regional cases covering nearly the whole European continent, aimed at demonstrating the application of the tool on real scenarios as well as at casting a view on grid planning in Europe till 2050. In this way, the FlexPlan project tries to answer the question of which role flexibility could play and how its usage can contribute to reduce planning investments yet maintaining (at least) the current system security levels. The project ends up formulating guidelines for regulators and for the planning offices of TSOs and DSOs. The consortium includes three European TSOs, one of the most important European DSO group, several R&D companies and universities from 8 European Countries (among which the Italian RSE acting as project coordinator) and N-SIDE, the developer of the European market coupling platform EUPHEMIA.

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List of Abbreviations and Acronyms

Abbreviation/Acronym	Meaning
DSO	Distribution System Operator
FES	Flexibility Energy Sources
NDP	Network Development Plan
SO	System Operator
T&D	Transmission And Distribution
TSO	Transmission System Operator

Executive Summary

The FlexPlan methodology proposes to enable getting grid services from flexible resources by including such resources as full-fledged participants of ancillary services markets as well as, in the long term, to consider these resources in TSO and DSO planning procedures.

Grid planning procedures, both at national and European level, should consider the possibility to deploy flexibility where it could provide a synergic action with traditional grid expansion, as already requested by Directive (EU) 2019/944 (Art. 32, Art. 40) and Regulation (EU) 2022/869 (Art. 13).

The success of this kind of initiative depends to a large extent on the European and the national regulation in force, in relationship to which barriers can emerge.

The present report is dedicated to the impact assessment of the concepts and the methodologies foreseen by the FlexPlan project, i.e an analysis of barriers and of possible enablers that could help or hinder a seamless implementation of it.

To this aim, three regulatory contexts are considered:

Regulatory framework 1: "Status quo" regulation	
Key impact	**Enablers**
This scenario proposes to apply the FlexPlan methodology and provide flexible resources (new storage devices and flexibilization of existing loa d) with the possibility to bid in ancillary services markets without modifying the current European and national regulations.	No enablers are requested, as the regulation would stay as it is. However, this scenario would highlight several barriers for an efficient deployment of the flexibility from storage and demand-side management, as highlighted in the relevant chapter.

Regulatory framework 2: Capacity Markets become open for flexible resources	
Key impact	**Enablers**
This scenario resolves the limited availability of flexible resources e.g. demand response and electric storage in specific well-defined places, where they will be needed for provision of services for network operation.	The existing technical requirements for participation in capacity mechanisms, should be redesigned in order to accommodate flexible resources. Considering experience from the existing markets, FlexPlan suggests:

The scenario proposes modifications to the existing capacity mechanisms to incentivise investments into flexible assets in the right place and period of time by facilitating investment recovery. This will make flexible assets a more reliable and attractive alternative for a more efficient planning of transmission and distribution grids.	(i) Reduction of min bid size. The forthcoming Demand Response Guideline indicates reduction of min bid size granularity for balancing energy products to 0.1 MW, the figure could be adapted for capacity mechanisms as well. (ii) Minimum duration of the bid, with timeframes allowing participation of flexible resources. (iii) Ramp requirements, meaning resources that can ramp up and down quickly. (iv) Compulsory inclusion of locational information into the bids to ensure correct allocation of the resources. These terms should be considered for specification of detailed demand response pre-qualification requirements, which are suggested in the above-mentioned Guideline.

Regulatory framework 3: Full integration of all technologies	
Key impact	**Enablers**
By assuming a removal of barriers for the participation on ancillary services markets, this scenario facilitates the implementation of the FlexPlan methodology. The access to these markets opens the potential for obtaining additional revenue streams that will increase the potential profitability of new investments. Furthermore, since congestion products include a location component, investors will face a local price which would facilitate the delivery of the FlexPlan methodology.	To enable this scenario, it will be crucial to remove any barrier still in place in the current procurement process for other flexibility providers providing these products (e.g. reduction on bidding size or information requirements) Furthermore, incentivising the provision of aggregation services will improve the overall performance as it will allow smaller producers of flexibility to participate in these markets.

1 Introduction

The International Association for Impact Assessment (IAIA: https://www.iaia.org/) provides the following definition for impact assessment: "*impact assessment (IA) is a structured a process for considering the implications, for people and their environment, of proposed actions while there is still an opportunity to modify (or even, if appropriate, abandon) the proposals. It is applied at all levels of decision-making, from policies to specific projects*".

In another more business-oriented definition, IA is a means of measuring the effectiveness of organizational activities and judging the significance of changes brought about by those activities. Impact assessment focuses on the effects of the intervention, whereas evaluation is likely to cover a wider range of issues such as the appropriateness of the intervention design, the cost and efficiency of the intervention, its unintended effects and how to use the experience from this intervention to improve the processes.

An IA assessment can be led in two ways:

- **qualitatively** – by analysing what positive/negative effects employing a new methodology could bring to the society: from the economic, social, environmental… points of view and what barriers are there and what "enabling factors" could facilitate reaching full impact (contact points with WP6)
- **quantitatively** – by assessing the economic advantage for the society when using the new methodology (difference with/without)

Whereas a quantitative appraisal would provide a clear and measurable assessment of the potential benefits of an activity (process, study…), this is very difficult to carry out in an objective way because the quantitative typically heavily depend on input data and scenario. Thus, very often, a qualitative assessment has to be preferred.

Coming to the specificities of the FlexPlan project results (methodology and tools), the potential impact deriving from their implementation into the grid planning procedures carried out by the system operators heavily depend on the regulatory context which is taken as a reference for this kind of analysis.

Similar to other deliverables in the project (e.g. [1]), by the FlexPlan methodology the study means a combination of different methods and techniques assembled together in the project, allowing to make estimations of the optimal system expansion considering use of flexible resources.

As highlighted in deliverable D6.3 of the FlexPlan project and, in particular in the final conclusion chapter which provides the regulatory guidelines summarizing the regulatory thought of the project, the present regulatory context, yet prompting to considering flexibility in the grid planning procedures (according to Directive (EU) 2019/944 (Art. 32, Art. 40) storage and DSM should become full-fledged grid planning candidates; according to Regulation (EU) 2022/869 (Art. 13) ENTSO-E's infrastructure gap analysis must consider with priority "all relevant alternatives to new infrastructure"), yet present some barriers to this process. In order to clarify that, the present report is organized into three chapters analysing each the potential impact of the FlexPlan methodology in a different regulatory context. In the chapter 2, the present regulatory context is considered (status quo). In the chapter 3, in addition to the status quo regulation, some long-term mechanisms are also considered capable to provide locational signals to drive new investments in flexibility assets (new storage and flexibilization of existing loads) to be carried out where system operators' studies indicate the maximum profitability for the system be. In chapter 4, on top of the long-term mechanisms, a real-time-markets reform is also hypothesized so as to create new products and to modify architectures to promote a "level playing field" participation in real-time markets by flexibility providers, for which such markets were not created.

For each of the three regulatory frameworks explained above, a complete impact analysis is carried out by highlighting the following aspects:

- overview: outline of the reference regulatory context,
- advantages and drawbacks of the FlexPlan methodology in this context,
- technical issues and barriers encountered in applying the FlexPlan methodology,
- enabling factors to overcome the barriers,
- as set final recommendations.

The report in closed by a conclusive chapter depicting the final considerations which can be extracted by the whole impact assessment study.

2 Regulatory framework 1: “status quo”

2.1 Overview

The current European regulatory framework is undergoing major changes to counteract the potential reduction of security of supply caused by the connection to the grid of steadily increasing amounts of Renewable Energy Sources (RES), characterised by a variable generation pattern, and to cope with the challenge of the electrification of consumption. Flexibility Energy Sources (FES), which can actively contribute to cope with these challenges, are indeed one of the subjects targeted by EU Regulation 2019/943 [2], EU Directive 2019/944 [3] and Framework Guideline of Demand Response [4] (hereafter called: Guideline of DR). For the scope of the developed FlexPlan tool, it is important to recall that new EU Directives support the use of FES during planning procedures. Deepening the development of the European regulations, a clear position is taken concerning different key aspects. Firstly, storage assets and demand side management are presently explicitly allowed to participate in every electricity market together with conventional power plants. Storage ownership, development and operation are not allowed to System Operators (SOs) with the exclusion of very particular and extreme conditions. Anyway, SOs are entitled for guiding private investors for the deployment of flexibility resources because of their knowledge in the system needs. To facilitate the coordination between planning procedures, the cooperation of TSO and DSOs to define next years’ Network Development Plans (NDPs) is becoming essential, and both TSOs and DSOs should take into consideration the use of storage facilities, demand response and other FES in synergy to traditional grid expansion.

The FlexPlan approach, applied in six regional cases discussed in Deliverable 5.2 [5], shows that grid planning strategies based on network investments can synergically take profit from the deployment of flexibility assets, strengthening the motivations why flexibility deployment should be accelerated thanks to a suitable regulatory framework. The FlexPlan planning toolbox represents an innovative and advanced approach for network planning able to incorporate storage and demand flexibility in synergy with classical grid expansion or reinforcement, according to what was requested in EU Directive 2019/944.

The FlexPlan optimization model takes as inputs:

- generation and demand time series,
- Transmission and Distribution (T&D) grid data,
- a set of grid expansion candidates (possibly provided by the “pre-processor” tool), considering both lines investments and flexibility assets.

Intermittent generation from RES, uncertainty on generation capabilities by solar and wind power plants and temperature-dependent demand are considered as stochastic inputs by the FlexPlan methodology: a large variety of nodal generation and demand scenarios are generated and then reduced to a representative set of time series which are used as inputs for the planning tool. The coordination of T&D Network Development Plans (NDPs), which generally increases the computational effort required, is managed thanks to the Benders’ decomposition, allowing to carry out a decomposition of planning and operational problems. Additionally, a decoupling between TSO and DSOs planning decisions is considered too. In this way, the exchange of data occurs only at the border between SOs and the optimisation models are solved sequentially for each SO responsibility region. Flexible loads are modelled as continuous variables (there is no discretization of the load curve, so there is no limitation on the minimum bid). The target function is designed so that a multi-decade optimization can be performed, meaning that it accounts for a long planning horizon covering multiple decades (2030,2040,2050) and considers the effects of both new installations and operational costs (i.e. dispatching costs) [6]. Three types of environmental impact are analysed and included into the target function : 1) air quality, 2) carbon footprint, and 3) landscape constraints.

The results of the simulations have shown that flexibility resources can be profitably deployed also for congestion management purposes and that investments in new flexible assets may sometimes compete with grid investments. Furthermore, the proposed coordination mechanism between TSO and DSOs proved efficient in optimising the overall system costs: indeed, investments in distribution grids sometimes contribute to removing congestion in the transmission grid, avoiding unnecessary investments.

Finally, the results of the FlexPlan simulations, have shown that it would be quite opportune to develop an efficient and adequate regulatory framework in order to fully exploit the potential of the flexibility resources. Regarding many regulatory aspects that have been described in this section, FlexPlan identified limitations and proposed recommendations (see Deliverable 6.3 [7]). In the following, the suggested recommendations are briefly summarised and described in terms of advantages and disadvantages, according to different criteria, concerning technological feasibility and economic efficiency.

2.2 Impact assessment

This section summarises the main aspects of the FlexPlan methodology which could fill specific gaps of the *status quo* regulation introduced in the Section 2.1:

- Flexibility resources (storage batteries and demand response management) should be taken into account during future planning procedures. In particular, a synergy should be established between flexibility resources and grid investments in order to provide an optimized network development plan.
- A coordinated approach between TSO and DSOs is key for the future. Anyway, a really integrated planning strategy could not be feasible due to computational complexity and due to data privacy reasons. A T&D decomposition approach is suggested by FlexPlan where data exchange concerns only data at the border between SO areas.
- Real time markets should not include any constraints to the participation of storage facilities and demand side response. Thus, flexibility resources are allowed to participate in wholesale and spot markets as well as in ancillary services and balancing markets in competition with other conventional or traditional resources.
- A regulatory framework dedicated to demand response management is still missing. However, FlexPlan acknowledges that a big improvement has been brought by Guideline of DR where considerations are made on the use of demand side management during the analyses of NDPs.

2.2.1 Advantages

The use of flexibility resources as investment candidates assures the possibility to find a solution which is optimal with respect to a solution found considering only grid investments. Indeed, the possibility of choosing among a bigger number of candidates potentially useful in solving network congestion, is a mathematical problem with more possible solutions to be analysed. Furthermore, by running FlexPlan regional cases, it has been observed that without the use of flexibility resources as candidates, overall system costs would be higher. Overall, the innovative approach developed by FlexPlan shows an advantage from the point of view of overall system costs.

An algorithm allowing TSO and DSOs coordination during the planning procedure is also included into the FlexPlan model. It is possible to observe how some congestion in transmission networks can be solved by means of candidates connected to distribution networks. This indicates that a coordinated TSO-DSO planning approach could be very profitable.

Looking at the regulatory aspects, the European Regulation 2019/943 and European Directive 2019/944 can be considered as the starting point for defining a regulatory framework which allows flexibility resources to compete at a level-playing field. Indeed, demand response and storage facilities are always mentioned explicitly when market participation is discussed.

2.2.2 Drawbacks

The computational effort required to solve the optimization problem can be considered as the main challenge in using such a complex model. Even if the combination of T&D decomposition and Benders's decomposition helps in reducing the complexity of the problem, the presence of units that define integral constraints connecting different timestamps (such as storage units and pumped hydro) generates a significant optimization complexity, which increases exponentially with the number of nodes of the system. However, an implementation allowing the parallelization of the solution of the optimizations on different machines/processors could significatively alleviate this problem.

Looking at the regulatory aspect, it is important to highlight how it is not sufficient to assure a level-playing field for storage assets and demand response with respect to conventional resources, in particular because of lack of know-how which characterises these technologies. Flexibility resources are not completely integrated in balancing services and wholesale markets mostly because of lack of statistical data (demand response is still in a testing phase thus their potential is still investigated in most Member States) or market regulatory requirements (minimum bid capacity limits) In support of the above, the deployment of new technologies is not made attractive by the present regulatory framework that, in order to remain totally technology neutral, does not consider that potential investors should be pushed towards the direction of investing in flexibility assets different from the conventional ones. Furthermore, the national regulations and networks code are still not considering flexibility with the necessary attention and new directives are still being transposed, thus still a lot of work is required so to fully integrate storage facilities and demand response in electricity markets.

2.2.3 Technical issues and barriers

The most relevant barrier to be overcome for the deployment of flexibility resources is represented by the lack of a proper regulatory framework. Indeed, even if great steps forward have been made by means of the publication of EU Regulation 943/2019 and EU Directive 944/2019, the integration of these resources is still proceeding slowly. Indeed, the participation of demand response by means of aggregations in electricity markets is not yet fully allowed in all EU countries and still investigated by means of pilot projects [6]. Precise roles and responsibilities of an "Aggregator" are still to be defined even at the European level; thus, difficulties are encountered in developing national regulatory frameworks.

Furthermore, the coordination of TSO and DSOs require the exchange of a big amount of data which are often covered by privacy policies. It is still missing the definition of which are the data to be exchanged and in which way they should be exchanged in order to respect the confidentiality of the information.

Some technical aspects can also be highlighted. Many national regulatory frameworks still present obligations concerning the minimum bid size. Indeed, given that demand response assets generally represent small-scale flexibility, the majority of these assets are not allowed to procure possible services, if not participating in aggregations. The same occurs with other distributed energy resources, generally connected to the distribution grid, which could provide services to both the transmission and the distribution grids.

2.2.4 Enablers

A proper system flexibility management is essential in order to exploit the potential of FES resources. Given that SOs are the legal entity in charge for the operation of the grid, their contribution in the definition of the regulatory framework for flexibility management will be essential. TSOs and DSOs analyses, concerning system bottlenecks and other weaknesses, should be used to determine appropriate remunerations for investments in critical nodes. This would foster the development of flexibility resources where the system mostly needs them and avoid unnecessary expenses. The T&D decomposition, developed in FlexPlan approach, can be identified as a possible solution in order to develop a coordinated approach, fulfilling all requirements concerning privacy aspects. Thanks to a data exchange limited at the border of the observability region of each SO, internal data privacy can be retained for each operator and computational efforts can be reduced.

The presence of a regulatory framework ensuring flexibility resources to be competitive, could create a favourable environment for their integration into the electricity markets. In particular, FlexPlan suggests some strategies which could be helpful in fostering the deployment of FES:

- the definition of capacity remuneration mechanisms which make investment in flexibility resources more attractive and reduce the risk of the investments. Local capacity markets are introduced and analysed in Scenario 2.
- the definition of tailored products for flexibility resources which are defined in accordance with the system requirements and how a particular kind of technology could be helpful in supporting the grid management. The participation of flexibility resources in ancillary services market is analysed in Scenario 3.
- In accordance with Guideline of DR, FlexPlan considers the possibility of introducing local markets for SOs or locationally tagged bids for the procurement of SO services and, indeed, stresses that a proper definition of products and pricing mechanisms should be developed.
- the definition of the roles and responsibilities of Aggregators should be clarified even at a common European level.

3 Regulatory framework 2: Capacity Markets become open for flexible resources

3.1 Overview

The second scenario addresses one of the key issues preventing wide use of flexibility resources for network services, namely limited availability of flexible resources e.g. demand response and energy storage in well-defined places, where they are required for the provision of the services for network operation. As it has been mentioned earlier, the initial assumption is that the present requirements not allowing SOs to own and operate energy storage (see [3]) will still subsist in the future, meaning that these services have to be procured in a market-based way from external actors. Considering substantial CAPEX requirements for energy storage this immediately raises the issue of incentivising these investments and ensuring a reasonable return on invested capital.

One of the possible solutions, which has been discussed during the recent years was using the existing capacity mechanisms as efficient means to increase flexibility in power systems (see [8] and [9]).

There is great variation in configuration of national capacity markets across Europe, but in broader terms capacity markets are a mechanism, which is intended to ensure the adequate medium-term and long-term security of supply by remunerating generators for the availability of their resources. The creation of these mechanisms has been justified on the basis of the so-called "missing money" market distortion (see [9] and [10] for details). The capacity prices are either set in advance administratively or they are the result of market-based principles (i.e. auctions) and are independent of the cost of the energy produced. Such capacity prices are based on the cost of providing the required capacity whenever needed.

The creation of capacity markets has been considered as somewhat controversial issue, essentially due to trend to overinvest into national generation capacities. The existing European regulatory framework, more specifically Regulation 2019/943 [2] stipulates the main principle for establishing capacity mechanisms and defines it explicitly as a temporary measure (up to 10 years) "to ensure the achievement of the necessary level of resource adequacy by remunerating resources for their availability, excluding measures relating to ancillary services or congestion management". The same document specifies the main principles in dedicated Art. 21. This means in principle that for the time being the legally defined capacity mechanisms in EU are decoupled from ancillary services and congestion management. In the most recent publication [11] the Commission underlines again that "capacity mechanisms should only be introduced to address residual concerns, such as problems or circumstances that cannot be resolved by market reforms alone". For the time being, the existing capacity markets operate on national levels and do not require inclusion of localisation information into the bids.

3.2 Impact assessment

3.2.1 Advantages

The main and most important advantage of introducing capacity markets is the possibility to incentivise investments into flexible assets in the right place and period of time by facilitating investment recovery.

This will make flexible assets a more reliable and attractive alternative for a more efficient planning of transmission and distribution grids.

Another positive effect of this will be establishing of a healthy competition between different resources, allowing and incentivising the combination of several complementary technologies and aggregation techniques for improving reliability of the services and overall cost reduction.

3.2.2 Drawbacks

The main shortcomings of capacity markets are often related to their nature, i.e., combination of regulatory mandates and market forces to produce a good that otherwise would be undersupplied in the market. Limitations associated with capacity markets in general can be found in several recent publication, while the main challenges, which have been observed are over-pricing and over-procuring the capacity (see [12] and [13]). This raises the issue of correct price definitions and construction of efficient and operational mechanisms to do this i.e. administrative or regulative vs. auctions.

3.2.3 Technical issues and barriers

From the technical point of view and apart from the obvious necessity to have Advanced Metering Infrastructure (AMI) deployed, there may be a need for installing additional communication and control devices.

From the business point of view, establishing a formal role of aggregator, which will define a set of related skills, competencies, and responsibilities. This is essential for a successful deployment of flexible resources in the future (for more details see conclusions from D6.3 [7]). It is necessary to underline that this has to be defined as a role (see Conclusions in [7]), which can be taken by or assigned to different actors.

Introduction of flexible resources into the capacity mechanisms does not necessarily mean abandoning the principles of technology neutrality, which have been reaffirmed in several recent documents including [2] and [4]. On the contrary, FlexPlan Consortium supports the technology neutrality principle, especially considering that aggregators may combine different technologies in order to meet the pre-qualification and bid requirements as they are outlined in [4].

3.2.4 Enablers

In general, it is necessary to mention that even though several of the existing national capacity mechanisms do not directly prohibit flexible resources (energy storage and demand response) to participate, the existing technical requirement e.g. the minimum bid size of several megawatts put important limits on it. This raises the necessity to modify the existing capacity market provisions, so that it can efficiently accommodate flexible resources as well. Design of specific configuration for capacity markets for trading flexible resources is not in the scope of FlexPlan, but considering experiences from the existing markets, one can suggest:

- Reduction of min bid size. The Alberta Capacity market uses 1 MW as min size [8]. The forthcoming Demand Response Guideline indicates reduction of min bid size granularity for balancing energy products to 0.1 MW, the figure could be adapted for capacity mechanisms as well.
- Minimum duration of the bid, with timeframes allowing participation of flexible resources.

- Ramp requirements, meaning resources that can ramp up and down quickly.
- Compulsory inclusion of locational information into the bids to ensure correct allocation of the resources. This requirement also complies with indications given towards the Demand Response Guideline (see (63) in [4]).

These terms should be considered for specification of detailed demand response pre-qualification requirements, which are suggested in the above-mentioned Guideline. Referring again to capacity market in Alberta, resources as storage have to sustain activation tests with certain duration to be pre-qualified.

4 Regulatory framework 3: Full integration of all technologies

4.1 Overview

This scenario builds on the previous ones and evaluates the effects on the possibility to successfully apply the FlexPlan methodology in Europe by removing the barriers faced by flexibility providers (e.g. batteries and demand response) for the provision of balancing and (short-term) congestion management services. One example of these barriers would be the minimum bid size in many of the balancing and congestion products. Standardised balancing products being developed by ENTSO-E include a minimum size of the bids of 1 MW.[1] However, Horizon 2020 projects such as OneNet [14] have identified this as a potential entry barrier for the provision of these products by some providers of flexibility (including batteries and demand response). To mitigate this barrier, the draft of the Network Code for Demand Response [4] proposes to reduce this minimum quantity to 0.1 MW. Furthermore, as DSOs develop local congestion management markets, they could decide to go even further to ensure they can address their local needs.

The same document also reflects the objective that other flexibility providers enter these markets facing a level playing field: "The principles set out in the new rules shall aim at allowing access of all resources to all electricity markets in accordance with the principles regarding its operation pursuant to Article 3 of the Electricity Regulation and allow the use of all resources by the SOs for operation and planning of the grid. [...] electricity markets is a broad term covering all market-based processes related to electricity, including both retail and wholesale markets as well as the market-based procurement of balancing, voltage control and congestion management…" Paragraph 4 in [4].

In addition, this option has also been included in legislation with Commission Regulation (EU) 2017/2195 [15] establishing a guideline on electricity balancing aiming at facilitating the participation of demand response including aggregation facilities and energy storage while ensuring they compete with other balancing services at a level playing field and, where necessary, act independently when serving a single demand facility".

Previous scenarios considered cases where pre-investment risk were reduced by signing long-term contracts that guarantee part of the revenues. This scenario goes one step further and considers the effects on the delivery of the FlexPlan methodology of the access to new revenue streams in the decision to invest in flexibility provision assets or systems.

One important topic to note on the outset is that providers of balancing services are likely to be able to provide congestion management services. Reflecting that, TSOs have used (and in some countries such as Italy or Belgium still use) bids aimed at the balancing market for the provision of congestion. To achieve that, the only additional requirement in these bids is that they include a location component (required for congestion but not necessarily for balancing). Even if that approach is not open to DSOs as they are not

[1] For further information, please see https://www.entsoe.eu/network_codes/eb/

required to provide balancing services, it shows that very similar products could be used for both services and, as such, their effects can be considered together.

4.2 Impact assessment

To avoid repetition with the discussion on the previous scenario, this section focuses on evaluating the impact of the new features being introduced in this scenario.

4.2.1 Advantages

From the point of view of the delivery of the FlexPlan strategy, the main advantage of removing barriers for the provision of balancing and congestion services is the creation of additional revenue lines for potential investors. In addition, this will also affect the overall efficiency and innovation in the system which can have important effects on the costs of these services on consumers. The different effects that are at play are discussed in this section.

From the perspective of facilitating investment, the main effect is that, by participating in these markets, potential investors can obtain additional revenues which will improve the profitability of their investments. One issue to remark is that investors need to be able to stake different revenue sources. For example, even if an asset sells its capacity in the long-term congestion management market, it could still sell again that capacity in the balancing markets whenever that capacity will not be activated for congestion. This would facilitate investment by allowing assets to obtain multiple revenue streams.

Furthermore, participation in these markets would make investment decision less time bound. By allowing investors to start recovering revenues from the moment the assets are operational (without the need to wait until the market for long-term contracts is available), it means there will be a more dynamic investment cycle for these assets which would facilitate the development of these businesses.

From a system-wide efficiency point of view, an advantage is that allowing all technologies to provide balancing and congestion management services generates an efficient use of the resources. When some technologies are excluded from the provision of these services, there is a risk that more efficient providers cannot participate in the market and, as such, there is a reduction on the overall efficiency of the system.

Furthermore, participating in these markets would increase the amount of flexibility being traded in these markets which would improve the efficiency in the operation of the market. In the same way that renewable generations, other products of flexibility (e.g. demand response) are weather dependent. As a result, quantifying the flexibility they can provide in the short-term can be difficult to estimate. By allowing them to participate in these short-term markets, these providers can obtain a better estimate of their flexibility that they can make available to the system. By increasing the liquidity in the markets, this would facilitate a more efficient allocation of resources.

Finally, another advantage is that allowing all technologies to trade on ancillary service markets removes limitations on the type of business models that companies taking the role of aggregators could propose. This would allow that potentially innovative business model arise. For example, a company could decide to aggregate their expected flexibility to participate in the day-ahead market (increasing their reliability in that market) as their additional flexibility is sold as ancillary services. This approach would not be possible if the company cannot sell that flexibility into these markets.

4.2.2 Drawbacks

The main drawback of allowing all technologies to participate in the provision of ancillary services is the increase in complexity this could bring to the system. This modification would require that all components of the markets are adapted to the different technologies (e.g. pre-qualification rules for the different technologies need to be in place) as well as ensuring that the different tools using in the operation of the system can account for these modifications.

Market products should be adapted in order to make it possible for the new flexible resources participating in the ancillary services markets to compete on a "level playing field" basis with the traditional generators for which markets and products were initially thought. For instance, a real possibility to bid flexibility for big industrial factories could subsist only if market products will cope with the limited flexibility of the industrial production cycles. This could prompt for the introduction of block or conditional bids.

The currently already being undertaken adaptation of product and pre-qualification procedures represents a significant amount of work, which is to ensure technological neutrality in the markets being designed for future ancillary services.

4.2.3 Technical issues and barriers

The balancing and congestion products being considered at a European level are being designed to ensure that they deliver the need of the SOs without consideration of what technologies will be able/unable to provide them. However, the academic literature has shown that other providers of flexibility such as batteries or demand response have the capacity to provide all of these products.

Nevertheless, even if technically can be delivered, it does not mean that in practise this can be done. The delivery of these products by these providers of flexibility could require modifications in the communication channels used by the SOs. Therefore, until these changes are not in place, it would be difficult to participate in the market. Furthermore, it will be necessary that the procurement process of these products is also adapted to the characteristics of all different technologies. Examples of changes that are required are the need to develop a methodology for the pre-qualification of the other flexibility providers and the definitions of the typologies of bids to account for characteristics of these technologies (e.g. allowing for a recovery time that allows batteries to recharge).

Additional barriers that have been identified by the literature arise from the values selected for some of the attributes of the products traded in those markets. For example, when TSOs defined balancing products, most of them assuming a minimum size for the bid of 1 MW. This is quite a high threshold that batteries and demand response providers could struggle to provide. To address this issue, there are proposal to reduce the size of some of the products (especially those related to congestion management) to smaller thresholds (current discussions proposing a reduction to 0.1 MW).

Even with these smaller proposals, aggregators aiming at delivering these products would need to coordinate a significant number of other flexibility providers. This presents the challenge to develop communication mechanisms that identify and triggers the optimal dispatchment with those providers. The development of these mechanisms can be time-consuming and aggregators will need to undertake this investment before they can start attracting flexibility providers.

A final barrier that needs to be considered is the potential interaction between TSOs and DSOs. Some of the assets providing demand response (and renewable generation) are connected to the distribution network. Therefore, if the TSO wants to activate them, there needs to be a coordination with the DSO to avoid that this activation creates problems for the DSO (e.g. by creating local congestion). As a result, it is important that the operations of both TSOs and DSOs are well coordinated.

4.2.4 Enablers

Work is ongoing by both academia and industry to remove the barriers identified above. An example of these efforts is the work being undertaken by the industry to develop balancing and congestion products that are technologically neutral. These products will need to be combined with markets definitions that account for all the different technologies (e.g. they should include a methodology for the pre-qualification of batteries or demand response) to ensure that they do not represent barriers to the delivery of the FlexPlan methodology where all technologies are treated in the same basis.

Another enabler necessary to ensure that the FlexPlan methodology is delivered is the proliferation of aggregators. There are multiple agents that can provide aggregation services (e.g. energy retailers, energy cooperatives or energy communities) and aggregation can take multiple forms (e.g. aggregation of flexibility or aggregation of funds for investment). Therefore, by further defining the activities required from agents providing that role, guidelines would be able to facilitate the provision of these services and their incorporation into the energy system.

Linking with the need to facilitate the creation and operation of aggregation services, a tool that could enable these operations is the creation of a flexibility register as proposed by ACER (paragraph 72 in the draft guidelines). As set by ACER: "The service providing units or groups shall be only required to register one application to participate in different products or services in a Member State [...] where applicable, data shall be made visible and interoperable among existing registers referring to different balancing products, i.e. service providers shall not register information twice that is already enrolled for the same service providing unit or group." Therefore, this register would make it easier for aggregators to provide multiple services without the need of re-register all assets as well as facilitate the competition between aggregators as they do not need to register assets already register by other aggregator.

5 Conclusions

As a conclusion of the impact assessment analysis carried out in this deliverable on regulatory barriers and enablers facilitating/hindering the application of concepts and methodology of the FlexPlan project, the scenario 3 regulatory context is strongly recommended for a successful enabling of the provision of services from flexible subjects connected to T&D grids.

For a more comprehensive analysis of the proposed regulatory provisions, the reader is sent to deliverable D6.3. In this deliverable, key action points are proposed and some conclusions are drawn for the future regulatory activities which are deemed to be key for a seamless implementation of the concepts and methodology proposed by the FlexPlan project.

6 Bibliography

[1] FlexPlan Consortium, «D6.2 Identified regulatory limitations and opportunities based on the regional cases,» 2023.

[2] European Commission, «Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity,» 5 June 2019. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.158.01.0054.01.ENG&toc=OJ:L:2019:158:TOC. [Consultato il giorno 5 January 2020].

[3] European Commission, «Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU,» 5 June 2019. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.158.01.0125.01.ENG&toc=OJ:L:2019:158:TOC. [Consultato il giorno 5 January 2020].

[4] European Union Agency for the Cooperation of Energy Regulators, «Framework Guideline on Demand Response (Final Version),» December 2022.

[5] FlexPlan Consortium, «D5.2 - Grid development results of the regional studies».

[6] FlexPlan Consortium, «D1.2 - Probabilistic optimization of T&D system planning with high grid flexibility and its scalability,» 2022.

[7] FlexPlan Consortium, «D6.3 - Lessons and reccommendations on pan-European level regulation, policied and strategies (Draft for Public Consultation),» 2023.

[8] International Renewable Energy Group (IRENA), «Redesigning Capacity Markets: Innovation Landscape Brief,» 2019.

[9] M. Á. Lynch, S. Nolan, M. T. Devine e M. O'Malley, «The impacts of demand response participation in capacity markets,» *Applied Energy,* vol. 250, pp. 44-451, 2019.

[10] H. Auer e B. Burgholzer, «D2.1 Opportunities, Challenges and Risks for RES-E Deployment in a fully Integrated European Electricity Market,» Market4RES Project, 2015.

[11] The European Commission, «Capacity mechanisms,» 2022. [Online]. Available: https://energy.ec.europa.eu/topics/markets-and-consumers/capacity-mechanisms_en.

[12] T. Aagaard e A. Kleit, «Why capacity market prices are too high,» *Utilities Policy,* vol. 75, n. 101335, 2022.

[13] J. F. Wilson, «Over-Procurement of Generating Capacity in PJM: Causes and Consequences,» Wilson Energy Economics, 2020.

[14] OneNet project, A set of standardised products for system services in the TSO-DSO-consumer value chain, 2021.

[15] European Commission, «Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing (Text with EEA relevance.),» 2017. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R2195&from=EN.