Considering flexibility in network expansion planning: present practices and regulatory conditions

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***Abstract*—There are strong regulatory signals prompting European system operators to consider flexible resources as an active subject in the grid expansion planning. The present paper is based on the first results from H2020 project FlexPlan, namely a European regulatory analysis. The study combines results of literature screening and survey of the existing practices drawing a picture of the present pan-European regulation and political targets to ensure that the subsequent project activities are correctly oriented. The study is structured around several key issues: flexible resources, including consideration of these in planning, ownership of energy storage, cost-benefit analysis, including rules for allocation of costs; Interaction between TSOs and DSOs. The paper concludes that despite strong efforts from ENTSO-E to develop common methodologic principles, there are still several missing elements in the puzzle. This strengthens the importance and proper timing of FlexPlan project, both for testing novel grid planning methodologies coping with the present challenges and providing sound results considering different timeframes.**

***Index Terms*—Network congestion, Planning of network expansion, European Regulation, FlexPlan.**

I. Introduction

The opportunity to consider the usage of flexible resources as a support of grid planning, has been clearly highlighted in the most recent European Directives (e.g. internal energy market (IEM) Directive [1] of the package “Clean Energy for All Europeans”). However, methodologically and technically this still remains an "uncharted territory", and FlexPlan (2019-2022) is the first Horizon 2020 project directly addressing this issue by proposing an innovative grid planning tool and validating it in large-scale realistic regional cases over Europe. The present paper is based on one of the first results from the project, namely a European regulatory analysis.

II. Background for the Study

A. FlexPlan novel grid planning tool

The H2020 FlexPlan project aims at establishing a new grid planning methodology considering the opportunity to introduce new storage and other flexibility resources in electricity transmission and distribution grids as an alternative to building new grid elements. FlexPlan creates a novel grid planning tool, whose ambition is to go beyond the state of the art of planning methodologies, by including the following innovative features: integrated Transmission and Distribution (T&D) planning, consideration of flexibility solutions as candidates for grid planning, full inclusion of environmental analysis, probabilistic contingency methodologies replacing the N-1 criterion, optimal planning decision over several decades at the same time.

However, FlexPlan is not limited to building a new tool but it also applies 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. These six regional cases are built using realistic grid models and generation/load scenarios over three target years (2030, 2040 and 2050). A strong attention is given to grid modelling both at pan-European level and at national level, including T&D grid models and additional modelling efforts allowing assessment of the environmental and social impacts of T&D planning. In this way, the FlexPlan project tries to answer the question of which role the flexibility can play and how its usage can contribute to reduce planning investments yet maintaining (at least) the current system's security and reliability levels.

The present paper is based on one of the first results from the project, namely the analysis of the regulatory *status quo* in Europe. Aim of this screening is to get a picture of the present overall pan-European regulation and political targets to ensure that the subsequent project activities are correctly oriented. This is complemented by a reference to the existing practices at both Transmission and Distribution System Operators (TSO and DSO) levels. The objective is then to analyse the existing regulation, identify possible regulatory gaps and raise the need for the consideration of additional topics in future regulation.

B. The screening methodology

The activity applies qualitative evaluation methods, based on data collected through literature screening and survey-based research. The screening covers a selection of the relevant documents. The documents considered in this study have been issued by several types of stakeholders, including:

- The European Commission (EC), issuing Directives and Regulations, including Network Codes (NCs)/Guidelines
- ENTSO-E, which is responsible for development of NCs/Guidelines, including standard methods for cost-benefit analysis
- Interest organisations and Industrial Associations as Eurelectric, European Distribution System Operators

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(E.DSO), Groupement Européen des entreprises et Organismes de Distribution d' Energie (GEODE) and The European Federation of Local Energy Companies (CEDEC)

The study focuses on a pre-defined selection of issues, which have critical importance for FlexPlan project and are called "topics of interest". These topics represent either some key assumptions that will have to be made within the project activities, or/and some attributes, which can be directly or indirectly decisive for the development and later for the implementation of the project outcomes. Altogether, it was defined 17 topics, belonging to the following categories:

- Flexible resources, including consideration of these in planning, ownership of energy storage, etc.
- Cost-benefit analysis, including rules for allocation of costs, criteria for evaluation of new projects, etc.
- Interaction between TSOs and DSOs, including interactions during planning, sharing of resources, roles and responsibilities
- Other subjects, including incentive mechanisms, criteria for development of scenarios, reliability criteria, etc.

In addition to this, the project team carried out a survey among DSOs and TSOs asking them about their current practices related to the identified topics of interest for this study. The survey involved three European TSOs and four DSOs.

III. Results of the Screening

As the scope of this paper does not allow to cover all defined topics of interest, the present analysis will be therefore limited to a selection of 8 of the 17 identified, which are addressed next. These topics are discussed one by one, including a reference to existing regulation and some identified gaps. The full version of the study can be found in [2].

A. Requirements related to consideration of flexible resources in planning.

The importance of the flexible resources is clearly stated in the Internal Energy Market (IEM) Directive [1], which has a specific section (art.32) dedicated to incentives for use of flexibility sources in distribution, stating that the distribution network development plan shall also consider demand response, energy efficiency, energy storage facilities or other resources that the DSO has to use as an alternative to system expansion. Furthermore, the same document defines that when elaborating the Ten-Year Network Development Plan (TYNDP), TSOs shall fully take into account the potential for the use of demand response, energy storage facilities or other resources as alternatives to system expansion. The EC Regulation 2019/943 on the internal market for electricity [3], which is linked to the above mentioned Directive, states that in order to integrate the growing share of renewable energy, the future electricity system should make use of all available sources of flexibility, particularly demand side solutions and energy storage. The document actually puts on equal terms redispatching rules for generation and demand response. In ENTSO-E's 3rd Guideline for Cost Benefit Analysis (CBA) of Grid Development Projects [4], flexibility of demand is considered as a consistent part of the estimation of the socio-economic welfare. Despite the clear message from the EC in the aforementioned regulations, results from the conducted survey indicated that none of the survey responding System Operators (SOs) consider flexible resources in their current planning practices.

One can conclude that there is a clear indication emerging from the present regulatory framework and supported by a broad agreement across different stakeholders that flexible resources should be used as a viable resource for the operation of the power system and thus it should be considered in the planning procedures of the power grid. It is however difficult to see any common well-established practice in Europe, meaning that the process is still under development.

B. Ownership and operation of energy storage.

Although this topic is not explicitly addressed in FlexPlan, and the project does not aim at taking any specific position on this subject, this issue is nevertheless important with regards to the establishment of a regulation to support a future planning methodology taking into consideration the role of storage and flexibility.

The most recent version of IEM Directive [1] presents the official position of the EC regarding ownership of energy storage facilities by respectively DSOs and TSOs. The document reaffirms the position stated in the previous drafts of the Directive, which, as a general rule, does not allow SOs to own, develop, manage, or operate energy storage facilities. However, art. 54 of the same document refers that SOs are allowed to own, operate or manage such devices, among other conditions, if these devices are "are fully integrated network components and the regulatory authority has granted its approval", which can pave the way for many exceptions. Shedding more doubt into this subject, there is still an ongoing public discussion about involvement of SOs into ownership, operation and management of energy storage facilities. It can also be noticed that the most recent version of recasts has been partially modified, in order to take into account input coming from some stakeholders, among others Eurelectric [5], expending the possible terms of derogation for SOs for operational purposes. Additionally, it seems it could be possible to own and operate batteries for some new actors formalised in the IEM Directive, as active customers and possibly Citizens Energy Communities (CECs), where the public discussion about roles and responsibilities for CECs is still ongoing.

C. Rules for allocation of costs and incomes between TSOs and DSOs in new common investment projects.

There is a clear message from the EC that socio-economic welfare should be taken as the main indicator for the prioritization of investments in new grid projects. From the Transmission side, following the requirements of the EU Regulation 347/2013 on guidelines for trans-European energy infrastructure [6], ENTSO-E has developed a CBA of Grid Development Projects, ensuring a common framework for multi-criteria CBA for TYNDP projects. However, there are no commonly agreed rules for allocation of costs between TSOs and DSOs in common investment projects. More recently, a joint TSO-DSO report [7] presents the separate views of TSOs and DSOs on cost allocation:

- DSO view: The DSO duty to expand the network has to be weighed against any (new) right to limit network usage. In order to maximise social welfare (e.g. by minimising overall system costs) a proper assessment is needed.

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- DSO view: Balancing services based on assets connected on the DSO level should, for economic reasons, not lead to any additional constraints in DSO networks. If this is the case, TSO and the market actor interested in using this asset connected to the DSO network on the balancing market should cover the full costs of any grid enforcement according to the national regulations on the allocation of network expansion costs.
- TSO view: In case of additional constraints in DSO's networks, a regulatory framework should be established in which the compromise between the additional value of the flexibility not available to the balancing markets due to these constraints and the network expansion that resolves those congestions is evaluated and, in any case, ensures a proper allocation of the corresponding additional costs.

The survey results indicate that the present practice is based on a split of costs at transmission system level. However, this practice may be reconsidered in case flexibility resources from distribution networks will be actively employed and coordinated for the provision of system services to TSOs. For the present, there is no regulatory framework, applicable to this case.

D. Multi-criteria vs. cost-based approach for evaluation of new projects.

The ENTSO-E's 3rd CBA guideline [4] describes the common principles and procedures for performing combined multi-criteria and cost-benefit analysis using network, market, and interlinked modelling methodologies for developing Regional Investment Plans and the EU-wide TYNDP. There are several reasons for selection of this combined approach. It is important to repeat the point made by ENTSO-E in its CBA guideline: costs mostly rely upon scenario-independent factors like routing, technology, material, etc., while benefits are strongly correlated with scenario specific assumptions. As stated in the EC Guide to Cost-Benefit Analysis of Investment Projects, Economic appraisal tool for Cohesion Policy 2014-2020 (2014) [8] : "*In contrast to CBA, which focuses on a unique criterion (the maximisation of socio-economic welfare), multi-criteria analysis is a tool for dealing with a set of different objectives that cannot be aggregated through shadow prices and welfare weights, as in standard CBA.*" Therefore ENTSO-E favours a combined multi-criteria and cost benefit analysis that is well-adapted to the proposed governance and allows an evaluation based on robust indicators, including monetary values.

The survey indicated that the multi-criteria approach is applied by all responding TSOs. On DSOs side the practice seems to be more diversified, even though there is a preference for multi-criteria approaches.

E. What cost function should be applied to reliability in order to include this into CBAs

The present study indicates that the main challenge is to represent reliability in monetary terms. The commonly used key indicator for reliability is the lost load, which is monetised via the Value of Lost Load indicator (VOLL). The Regulation on IEM [3] demands that by 5 July 2020, for the purpose of setting a reliability standard, regulating authorities shall determine a single estimate of the VOLL for their territory. According to ENTSO-E's guideline [4] the value for VOLL that is used during project assessment should reflect the real cost of outages for system users, hence providing an accurate basis for investment decisions. A level of VOLL that is too high would lead to over-investment, a value that is too low would lead to underestimated effects of possible contingencies and this could bring to an inadequate security of supply level. It is also stated that the experience has demonstrated that estimated values for the VOLL vary significantly by geographic factors, differences in the nature of load composition, the type of affected consumers, the level of dependency on electricity in the geographical area impacted, differences in reliability standards, the time of year and the duration of the outage. Therefore, using a general uniform estimation for VOLL would lead to less transparency and inconsistency, and greatly increase uncertainties compared to presenting the physical units, as for example the lost load (GWh/year), Average Interruption Time (AIT) in minutes, or the Expected Energy Not Supplied (EENS) indicator.

In general, the EC insists on using a CBA estimation in all decision-making processes concerning the power industry. This applies to several aspects like risk-preparedness, demand connection, network expansion planning, etc. This seem to be complicated by the above-mentioned local variations in VOLL values. Considering this, one can conclude that a simplified quantitative evaluation method is needed in order to weight the consideration of the contingencies with other factors as for example social welfare.

F. Sharing of resources between TSO and DSO: what are the priorities?

The IEM Directive [1] defines that DSOs shall cooperate with TSOs for the effective participation of market participants connected to their grid in retail, wholesale and balancing markets. Delivery of balancing services stemming from resources located in the distribution system shall be agreed with the relevant TSO.

However, further screening and survey of the present practice indicated that at present there is no common regulatory or practice background allowing to draw clear conclusions on this topic. The necessity of defining this is clearly highlighted both at the institutional level and by the stakeholders.

G. Responsibilities for congestion management and balancing.

According to the IEM Directive [1] while performing its main tasks (the efficient, reliable and secure operation of the distribution system), the DSO shall procure the non-frequency ancillary services needed for its system in accordance with transparent, non-discriminatory and market-based procedures, unless the regulatory authority has assessed that the market-based provision of non-frequency ancillary services is economically not efficient and has granted a derogation. According to the same document, TSO is responsible, in that context, for ensuring the availability of all necessary ancillary services, including those provided by demand response and energy storage facilities. Several ENTSO-E's documents, including [4] and [9] clearly presume that responsibility for balancing and congestion management is TSOs' responsibility. The guideline for TSO-DSO cooperation [10] outlines the future responsibilities for the operators:

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- TSOs - maintaining overall system security via frequency control, Load Frequency Control (LFC) block balancing and congestion management (across borders and on the TSO level) and voltage support in the transmission network in an electricity system
- DSOs - managing voltage stability and congestion on their grids

Looking forward, the overall evolution of roles and responsibilities depends upon the time horizon. In the first 10-20 years it is reasonable to suppose that TSOs will remain responsible for system balancing and congestion management in their own networks, while DSOs could be allowed to deal with congestion in the distribution networks, provided that the DSO will be able to obtain sufficient resources to this. In H2020 project SmartNet [11] it was raised a concern about limited liquidity and potential exercise of market power at markets for local DSO-level resources. It is also worth mentioning that the EC has started the formalisation process of several new business actors, including CECs by indicating a scope of their roles and responsibilities in the IEM Directive [1]. Eurelectric [12] looks at Microgrids and in particular CECs as an important future resource, which can be endorsed with several new duties (especially balancing responsibility) when acting either as a supplier, as an active customer, as a DSO, or as any other system user.

H. Technology maturity level, flexibility technologies and their relation to network codes.

ENTSO-E's NC on demand connection [13] sets harmonised standards for providing connection of renewable energy production plants and demand response facilities at the point of connection. Among the capabilities set in this NC there is the possibility of automatic or remotely controlled disconnection of loads. However, the way the TSO and DSO access to flexible resource is not explicitly addressed in this NC. In TYNDP framework the scenarios include assumptions about cost development for different technologies and corresponding levelized cost of electricity, providing a possible vision on their technical development.

It is also necessary to mention that there is an on-going public consultation by the European Commission (open until 2020-05-14) related to development of new network codes, and code on demand side flexibility is mentioned as one of them. However, the drafting process might not start before 2022.

IV. Discussion and Conclusions

Summarising the screening process above and bearing in mind the overall picture, it seems evident that the EC strongly emphasises the need for efficiency in different activities of the power system, including a technological scope and social-welfare among others. One example of this emphasis relates to the inclination towards the utilisation of already existing resources, such as demand response, which might have the potential to reduce the necessity for new grid investments. The EC therefore proposes a consideration of existing flexibility resources as a consistent part of network expansion planning and considering demand response and storage with the same priority as generation in dispatching and re-dispatching procedures.

Furthermore, the necessity to apply market-based mechanisms whenever possible is underlined in several regulatory documents with reference to many network operative aspects, e.g. for the procurement of resources for ancillary services or even for system defence and restoration services [14].

The application of CBAs is put forward as a unified justification criterion to activate new investments. At the very same time, it is necessary to mention that the EC shows a very pragmatic approach on several critical issues, as for example the above-mentioned issues related to ownership and operation of energy storage. The most recent recast of the IEM Directive shows modifications of the initial terms along with introduction of new actors as CECs. Possibly, the final solution will emerge at the end of a learning process connected to technologic maturity.

It is clear that the methodological efforts by ENTSO-E in developing several network codes and guidelines have greatly contributed to a common understanding and approaches among the European TSOs. This unified approach however not always completely agreed with DSOs, and quite different views among TSOs and DSOs on several key issues have been noticed. The general trend and expectations are that DSOs will be getting more and more active role in operation of the power system, requiring more interaction with TSOs on different levels. Therefore, these disagreements may potentially become show-stoppers in the future common projects. More formal dialogue between TSOs and DSOs is needed for alignment and coordination of their views. For the time being FlexPlan as project has probably to consider both points of view and make evaluations on a case-to-case basis.

Looking further at different practices at TSOs and DSOs, it must be mentioned ENTSO-E's efforts have resulted in several commonly agreed requirements, methods and approaches, many of which have been officially formalised as EU Regulations. For the scope of FlexPlan one of the most important factors is probably the common CBA guideline for TSOs with a clear set of principles and procedures for performing combined multi-criteria and cost-benefit analysis using network, market and interlinked modelling methodologies for developing Regional Investment Plans and the Union-wide TYNDP. On DSOs side the practice seems to be much less standardized, with preference of multi-criteria approaches.

Regarding the evolution of roles and responsibilities, in a 10-20 years' timeframe it is reasonable to suppose that TSOs will remain responsible for system balancing and congestion management in their respective networks, while DSOs could be allowed to deal with congestion in their own distribution network. It is also worth mentioning that the EC has started the formalisation process of several new business actors, including Citizens Energy Communities. The introduction of these new actors could change the landscape and roles/procedures applied both in the planning and in the operation phases.

Finally, it must be remarked that there are strong regulatory signals prompting European system operators to consider flexible resources as a new important active subject in the grid expansion planning process formulation. Despite strong efforts from ENTSO-E to develop common methodologic principles, there are still several missing elements in the puzzle. This strengthens once again the importance and proper timing of FlexPlan project, both for testing new innovative grid planning methodologies coping with the present challenges and

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providing sound results considering different timeframes. On one side, short-term aspects (such as the creation of new NC) can benefit from the project analysis at pan-European level, and technical results considering the inclusion of flexibility solutions in grid planning studies. On the other hand, a comprehensive scenario assessment up to 2050 and the final synthesis of the results in the form of regulatory guidelines, can be helpful tools to National Regulators and the EC.

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