MARKET ENABLING INTERFACE TO UNLOCK FLEXIBILITY SOLUTIONS FOR COST-EFFECTIVE MANAGEMENT OF SMARTER DISTRIBUTION GRIDS

Deliverable: D10.3

Regulatory recommendations for flexibility options and markets

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Author(s)	Institution	Contact (*e-mail, phone*)
Ellen Beckstedde	Vlerick	ellen.beckstedde@vlerick.com
Leonardo Meeus	Vlerick	leonardo.meeus@vlerick.com
Janka Vanschoenwinkel	VITO	janka.vanschoenwinkel@vito.be
Kris Kessels	VITO	kris.kessels@vito.be
Mauricio Correa	Comillas	mcorrea@iit.comillas.edu
Tomás Gómez	Comillas	tomas.gomez@iit.comillas.edu
Rafael Cossent	Comillas	rafael.cossent@iit.comillas.edu
Sophia Giovanett	E.DSO	sophia.giovanett@edsoforsmartgrids.eu
Catarina Augusto	E.DSO	catarina.augusto@edsoforsmartgrids.ee
Kirsten Glennung	E.DSO	kirsten.glennung@edsoforsmartgrids.eu
Jacopo Tosoni	EASE	j.tosoni@ease-storage.eu
Mashood Nasir	EASE	m.nasir@clerens.eu
Emin Aliyev	EASE	e.aliyev@ease-storage.eu
Gonçalo Faria	E-REDES	goncalo.faria@e-redes.pt
Carlos Pedro Marques	E-REDES	carlospedro.marques@e-redes.pt

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Abbreviations

BRP	Balancing Responsible Party
DSO	Distribution System Operator
MCP	Mixed Complementarity Problem
MPEC	Mathematical programme with equilibrium constraints
NRA	National Regulatory Authority
TSO	Transmission System Operator
UMEI	Universal Market Enabling Interface

1 Executive Summary

This deliverable aims to show how different flexibility mechanisms can be combined and discusses why regulatory sandboxes and market power remedies can be important for the optimal implementation of these mechanisms. Three main chapters follow this executive summary (Chapter 1) and the introduction (Chapter 2).

Chapter 3: General overview of combining flexibility tools

This chapter summarises the main findings of EUniversal D5.1 (2021), where the combination of flexibility tools was analysed from the perspective of the EUniversal stakeholders (DSOs and flexibility market operators), in three steps.

First, a definition of the following six flexibility tools is provided: flexible access and connection agreements, dynamic network tariffs, local flexibility markets, bilateral contracts, cost-based mechanisms and obligations.

Second, the compatibility of flexibility tools is discussed separately for congestion management and voltage control. Although the 15 interactions between the six flexibility tools were analysed in EUniversal D5.1 for each service, a summary of the most important recommendations is provided here:

- Dynamic network tariffs and flexible connection agreements can be compatible for congestion management as they target different flexibility needs and address different network costs.
- Dynamic network tariffs and local flexibility markets can be complementary for congestion management as they target different flexibility needs. However, the combination of the two tools must be designed considering different aspects such as reliability, contracting timeframe, the frequency of the need, the number of participants, uncertainty and complexity.
- Dynamic network tariffs are not compatible with any other flexibility mechanisms for voltage control as dynamic tariffs are not considered suitable to provide these services to the DSO.
- Flexible connection agreements and local flexibility markets raise the challenge that the same flexible capacity could be allocated simultaneously in both mechanisms for congestion management and voltage control, but create the opportunity that flexibility can be activated in a cost-effective way.
- Local flexibility markets and bilateral contract can be compatible for congestion management and voltage control in network regions where competitive local flexibility market outcomes cannot be guaranteed.
- Obligations with flexible connection agreement or local flexibility markets can be complementary for congestion management and voltage control as obligations intend to guarantee a minimum availability level and local markets or flexible connection agreements aim to meet the specific requirements adapted to local characteristics.
- Cost-based mechanisms with bilateral contracts or obligations seem to have weak compatibility to address all congestion management or voltage control needs of the DSO in an optimal way.

Finally, two limitations of the analysis were identified to close Chapter 3: using a high-level definition of the flexibility tools and neglecting the impact of flexibility tools on other markets. These limitations introduce the following chapters as they will examine the significance of these issues and provide regulatory recommendations to deal with these issues.

Chapter 4: The importance of regulatory sandboxes

The previous chapter discussed the compatibility between the flexibility tools based on their high-level definition. In reality, the implementation of these tools is more complex, and regulators must make various design choices. Therefore, Chapter 4 examines the impact of different implementation options on the compatibility between flexibility tools in two parts.

First, an overview of the implementation options of dynamic network tariffs, flexible connection agreements and local flexibility markets is provided to illustrate the magnitude of the issue. This overview summarises the findings of EUniversal D1.1, where the regulation frameworks and planned regulatory reforms of at least 6 (European) countries were analysed, and the discussions of EUniversal D2.2, D5.1, D5.4 and D10.1. Although a detailed overview is given in Section 4.1, Table 4 summarises the dimensions that should at least be considered during the implementation of dynamic network tariffs, flexible connection agreements, and local flexibility markets.

Table 4 of Section 4.1: Summary of dimensions considered during the implementation of dynamic network tariffs, flexible connection agreement, and local flexibility markets.

Dynamic network tariffs	Flexible connection agreements	Local flexibility markets
• Addressed network costs • Tariff components • Locational granularity • Temporal granularity • Differentiation among grid users	• Customer type • Allocation of non-firm capacity • Activation of curtailment • Compensation • Contract specifications	• Use case and voltage level • Incentives for local markets • Market rules and • Product definition • Integration in the existing sequence of markets • Roles and responsibilities of market parties

Second, regulatory sandboxes are proposed as a solution for regulators to test the impact of different implementation options in practice. The current developments of regulatory frameworks in 13 countries and regions were analysed by the EUniversal task participants and clarified in three steps. First, the definition of regulatory sandboxes and other types of regulatory experimentation is given. Second, the current practices of the following ten regulatory sandboxes are described based on the dimensions proposed in Schittekatte et al. (2021): Austria, Belgium (Brussels, Flanders, Wallonia), France, Germany, Lithuania, Norway, Poland and Spain. Finally, the results of the sandbox analysis are used to create a more general perspective on the risks and opportunities of regulatory sandboxes. We find that there is an opportunity that sandboxes bring innovative use cases by unusual project promoters, but this comes with a risk that innovators might rather be looking for subsidies or regulatory advice than a regulatory sandbox. Besides that, we find that there is an opportunity that regulatory sandboxes will inspire regulatory innovations. Still, there is a risk that administrators might use sandboxes as an excuse for the delayed implementation of regulation.

Table 7 of Section 4.2.3 summarises what we have learned from this comparison of regulatory sandboxes. It is too early to conclude on what the best design is, but the consequences of the different choices that need to be made when designing a sandbox have been clarified in the table. Here it must be noted that these consequences are rather linked to the dimension of the sandbox than to the design choices itself: every impact must be considered for each design choice. These recommendations can help countries that already have a sandbox to reconsider some of their design choices, and it also provides guidance to countries that still have to start designing their regulatory sandbox.

Table 7 of Section 4.2.3: Overview of the implementation options of regulatory sandboxes and the possible impact of these decisions on the outcome of the sandbox projects.

Dimension	Design choices	Impact of decision
Application process	• Dedicated calls • Continuous application	• Timing of workload of the application process • Possibility to highlight topics during application • Possibility to provide funding during application

Eligible project promoters	• Open, without definition • Open, with specified definition	• Opportunity to have innovative use cases by unusual project promoters
Derogations	• Targeted list • Open	• Opportunity to have innovative use cases by unusual project promoters • Opportunity to inspire new regulation • Risk that innovators might be looking for regulatory advice
Administration	• Regulatory only • Ministry only • Regulator and ministry • Other involved agencies	• Regulation and legislation under scope of sandbox to which derogations can be given • Opportunity to inspire new regulation • Possibility to provide funding
Length of derogations	• Maximum length of initial project • Extension allowed or not	• Time for experimentation and development of results • Opportunity to inspire new regulation • Possibility to intervene in the sandbox project
Funding	• Funding as part of sandbox project or not • Other funding sources are allowed or not	• Innovators might rather be looking for subsidies than a sandbox • Business case of the project when the regulatory sandbox ends
Transparency and reporting	• Internal or public periodic reporting • Internal or public final report	• Dissemination of lessons learned • Opportunity to inspire new regulation

Chapter 5: The importance of market power remedies

The analysis of Chapter 3 did not consider the interaction of flexibility tools on other markets while, in practice, these tools might interfere with existing markets such as the wholesale, redispatching and balancing market. Therefore, Chapter 5 focuses on one open issue of the interaction of flexibility tools on other markets, namely the integration of local flexibility markets in the existing sequence of electricity markets which raises market power concerns, in two steps:

First, the relevance of this issue is examined by developing a bi-level optimisation model that captures the strategic behaviour of flexibility providers. The possible strategic behaviour of flexibility providers is examined for four different market sequencing options: (1) the nodal wholesale market that includes transmission and distribution network constraints; (2) the zonal wholesale market without network constraints followed by an integrated redispatching market that manages the network congestion at transmission and distribution level created by the wholesale market in a coordinated way; (3) the zonal wholesale market followed by separate DSO flexibility, TSO redispatching and TSO balancing markets in that order, which implies that congestion at distribution level is treated first; and (4) the zonal wholesale market followed by separate TSO redispatching, DSO flexibility and TSO balancing markets in that alternative order, which implies that congestion at transmission level is managed first. To analyse the strategic behaviour, a bi-level model is introduced in which the strategic flexibility provider in the upper-level acts as a first-mover that anticipates the effect of its offers on the market outcome of the lower-level optimisation problems. It was found that flexibility markets can trigger games among flexibility providers. In our analysis, six types of strategic behaviour were identified that can be divided into three categories: driving up prices within the market, creating and solving additional congestion between two markets, and pursuing activation in the most profitable market(s) of the total market sequence. In practice, these games will be difficult to be detected by regulators as they can be performed by relatively small players. This is of practical relevance for market surveillance, as regulators that have the mandate to perform market oversight activities need to be aware of these new games that might occur to be able to detect them. Besides that, it was observed that the nodal wholesale market outperforms the other sequencing options in our numerical example, but there is no clear second best among the alternative market sequences. This is of practical relevance for the timing aspects of local flexibility markets that determine how these markets will be integrated into the existing sequence of electricity markets.

Second, three market power remedies that regulators can use to reduce the impact of strategic behaviour in flexibility markets are proposed:

- Long-term flexibility contracts. As the flexibility reserved in long-term contracts can no longer participate in other real-time markets, games that anticipate the market sequence and strategically arbitrage between different markets can be no longer be performed by these flexibility providers.
- Market supervision. The possibility to be fined for market manipulations by surveillance entities can motivate flexibility providers to refrain from strategic behaviour.
- The use case of flexibility. By reducing the frequency and predictability of the flexibility needs, the possibility of flexibility providers to anticipate the market sequence can be reduced.

2 Introduction

The EUniversal project, funded by the European Union, aims to develop a universal approach on the use of flexibility by Distribution System Operators (DSO) and their interaction with the new flexibility markets, enabled through the development of the concept of the Universal Market Enabling Interface (UMEI) – a unique approach to foster interoperability across Europe.

The UMEI represents an innovative, agnostic, adaptable, modular, and evolutionary approach that will be the basis for the development of new innovative services, market solutions and, above all, implementing the real mechanisms for active consumer, prosumer, and energy communities' participation in the energy transition. In this context, Deliverable D10.3 aims to create regulatory recommendations for flexibility options and markets. Accordingly, this document will consist of three main parts.

Chapter 3 provides a general overview of the compatibility between six flexibility tools based on the main findings of EUniversal D5.1 (2021), where the combination of these tools was analysed from the perspective of the EUniversal stakeholders (DSOs and flexibility market operators). We were inspired to dive deeper into the following two limitations of the analysis of Chapter 3 in the remaining of this deliverable:

- The compatibility between the flexibility tools was defined based on their high-level definition. In reality, the implementation of these tools is more complex and various design choices must be made.
- The analysis did not consider the interaction of flexibility tools on other markets. In reality, these tools might interfere with existing markets such as the wholesale, redispatching and balancing market.

Accordingly, Chapter 4 examines the impact of different implementation options on the compatibility between flexibility tools in two parts. First, the magnitude of this issue is illustrated by providing an overview of the implementation options of dynamic network tariffs, flexible connection agreements, and local flexibility markets. Second, regulatory sandboxes are proposed as a solution to test these interactions. An overview of the current developments on sandboxes is given based on the analysis of the regulatory framework in 13 countries.

Chapter 5 focuses on one open issue of the interaction of flexibility tools on other markets, namely the integration of local flexibility markets in the existing market sequence, which raises market power concerns. First, the magnitude of this issue is illustrated by developing a bi-level optimisation model to capture the strategic behaviour of flexibility providers in flexibility markets. Second, three market power remedies are proposed that might serve as a solution to strategic behaviour in flexibility markets.

Finally, the outcomes of this deliverable can serve several other purposes:

- The findings on the combination of flexibility tools in Chapter 3 can give regulatory recommendations on the compatibility between these tools. The research questions identified in this chapter can serve as inspiration for future research and H2020 projects.
- The overview of the implementation options of distribution network tariffs, flexible connection agreements and local flexibility markets in Chapter 4 can inspire the design of flexibility mechanisms, the use cases of regulatory sandboxes, and future research and H2020 projects. The national analysis of the regulation of regulatory sandboxes in this chapter can be used as a starting point by regulators and governments to implement or improve their schemes for regulatory sandboxes.
- The results on strategic behaviour in flexibility markets of Chapter 5 might be of practical relevance for market surveillance and the debate on integrating local flexibility markets in the current sequence of electricity markets in Europe. The overview of market power remedies

in this chapter can serve as a starting point for regulators to implement or improve schemes to reduce market power concerns.

- The findings and regulatory recommendations of all three parts will serve as an input for EUniversal Deliverables D10.4 and D10.5, creating a scalability and replicability analysis and roadmap of the EUniversal solutions.

3 General overview of combing flexibility tools

This chapter provides a general overview of the compatibility between the following six flexibility mechanisms: flexible access and connection agreements, dynamic network tariffs, local flexibility markets, bilateral contracts, cost-based mechanisms and obligations. This general overview summarises the main findings of EUniversal D5.1 (2021), where the combination of these flexibility tools was analysed from the perspective of the EUniversal stakeholders (DSOs and flexibility market operators).

First, a high-level description of the six flexibility tools is given. Second, a summary of the compatibility between the different tools is provided for congestion management and voltage control. Finally, two limitations of the analysis are described that will serve as input for the remainder of the deliverable.

3.1 Definition of the six flexibility tools

This section gives a high-level description of the six flexibility tools, based on the definitions used in Section 3.1 of EUniversal D5.1.

- **Flexible access and connection agreements** are non-firm grid connections agreed between the system operator and new network users, which implies that the system operator can curtail the demand or supply of the new network user under the agreed volume and periods.
- **Dynamic network tariffs** are time (and locational) differentiated network tariffs that can be adjusted to reflect the distribution network's temporal and spatial cost variations.
- **Local flexibility markets** are long-term and short-term pools in which the network needs of the DSO are matched with the offers of flexibility providers in a market-based way.
- **Bilateral contracts** are binding, negotiated agreements between two parties, the system operator and the flexibility provider.
- **Cost-based mechanisms** are used to remunerate the flexibility providers based on the actual costs of providing the flexibility service determined via an acknowledged audit process.
- **Obligations** are the mandatory service provision from the flexibility service providers to the DSO, often without financial compensation.

3.2 Compatibility between flexibility tools

While certain flexibility mechanisms as standalone may fail to provide the required grid services, the combination of these mechanisms might be able to address these DSO needs optimally. EUniversal D5.1 highlights two important parameters to identify complementarities between flexibility mechanisms: context attributes and evaluation criteria. First, context attributes are defined as a set of characteristics of the DSO flexibility needs used to assess each flexibility tool's potential to be effective for these DSO needs. As a result, tools that fail to target certain context attributes effectively might be combined with other flexibility mechanisms that are more suitable for these attributes. Second, evaluation criteria are general principles to discuss how valuable flexibility mechanisms are for acquiring certain grid services. Here, it might be avoided to combine tools that perform poorly on the same evaluation criteria.

It must be noted that the optimal combination of flexibility tools might vary for different DSO grid services. Therefore, the compatibility of flexibility tools is examined separately for congestion management and voltage control. EUniversal D5.1 indicates that all analysed flexibility mechanisms are suitable for congestion management, considering their context attributes and evaluation criteria. For voltage control, this is not the case due to the local nature of the service. Table 5.2 of EUniversal D5.1, included in Annex I, shows that bilateral contracts and obligations are suitable for voltage control services. The use of flexible connection and access agreements, local flexibility markets, and cost-based mechanisms can be useful for voltage control if appropriately designed for the use case. Finally, dynamic network tariffs do not fit voltage control. Keeping in mind the suitability of each flexibility mechanism, we will now examine in more detail the compatibility of these flexibility tools for congestion management and voltage control.

Congestion management

A complete overview of the compatibility of the 15 interactions between the six flexibility tools for congestion management can be found in Table 5.3 of EUniversal D5.1 provided in Annex I. The most important interactions are now highlighted:

- **Dynamic network tariffs and flexible connection agreements.** There are two reasons these flexibility tools can be compatible. First, they target different flexibility needs. As dynamic network tariffs rely on the uncertain reaction of network users and apply for foreseen situations, additional flexibility mechanisms, such as flexible connection agreements, might be used to address remaining and unexpected flexibility needs by DSOs. Second, they address different network costs. While flexible connection and access agreements focus mainly on the investment costs associated with network connection, dynamic network tariffs target overall network costs.
- **Dynamic network tariffs and local flexibility markets.** These flexibility tools can be compatible as they target different flexibility needs. While dynamic network tariffs rely on the uncertain reaction of network users and apply for normal foreseen situations, additional flexibility mechanisms, such as local flexibility markets, might be used to address remaining and unexpected flexibility needs by DSOs. However, the combination of the two tools must be designed considering the context attributes and evaluation criteria as they seem to have a lower performance on similar aspects. For example, due to the implicit characteristic of tariffs and the local character of flexibility markets, the reliability of both mechanisms is relatively weak compared to other flexibility tools. In order to provide grid services in a reliable way, this evaluation criterium has to be considered in the design of the tariffs and local markets. Other parameters that can be important are the contracting timeframe, the frequency of the need, the number of participants, uncertainty and complexity.
- **Flexible connection agreements and local flexibility markets.** This combination raises challenges as the same flexible capacity could be allocated simultaneously in both mechanisms if they are not appropriately designed. However, this combination comes with the opportunity that flexibility can be activated cost-effectively as the price of flexibility is determined both in an administrative and market-based way.
- **Local flexibility markets and bilateral contract.** These flexibility tools can be compatible in some network regions where competitive local flexibility market outcomes cannot be guaranteed.
- **Obligations with flexible connection agreement or local flexibility markets.** Combining these flexibility mechanisms can be complementary as obligations intend to guarantee a minimum availability level and local markets or flexible connection agreements aim to meet the specific requirements adapted to local characteristics.
- **Cost-based mechanisms with bilateral contracts or obligations.** The combination of these flexibility options seems to have weak compatibility to address all flexibility needs of the DSO in an optimal way.

Voltage control

A complete overview of the compatibility of the 15 interactions between the six flexibility tools for voltage control can be found in Table 5.4 of EUniversal D5.1 provided in Annex I. The most important interactions are now highlighted:

- **Dynamic network tariffs.** The combination of dynamic network tariffs is not compatible with any other flexibility mechanisms as dynamic tariffs are not considered suitable to provide voltage control services to the DSO.

- **Flexible connection agreements and local flexibility markets.** These flexibility tools could be combined for voltage control. Similar to congestion management, this raises a challenge on the double activation of the same flexibility but an opportunity for the cost-efficient activation of voltage control services.
- **Flexible connection agreements and bilateral contracts**. The combination of these flexibility mechanisms could be possible considering different timeframes and locations, but the conditions of both tools have to be clearly stated.
- **Local flexibility markets and bilateral contract.** These flexibility tools can be compatible in some network areas where competitive local flexibility market outcomes cannot be guaranteed.
- **Obligations with flexible connection agreement or local flexibility markets.** This combination can be complementary if obligations guarantee a minimum amount of flexibility, and additional flexibility can be guaranteed with flexible connection agreements or local flexibility markets.
- **Cost-based mechanisms with bilateral contracts or obligations.** The combination of these flexibility options seems to have weak compatibility to address all flexibility needs of the DSO in an optimal way.

3.3 Limitations of the analysis

The evaluation of the previous sections, which summarises the findings EUniversal D5.1, highlights different combinations of flexibility tools that can create extra benefits for the system. However, at least the following two aspects could additionally be analysed, which will be further examined in the remainder of this deliverable and will each come with their respective recommendation for regulators.

First, the importance of regulatory sandboxes. The previous sections examine the compatibility of flexibility tools based on their high-level definition. In reality, implementing these tools is complex and various design choices must be made. The impact of these implementation options on the compatibility between flexibility tools remains an open issue. In the first part of Chapter 4, the magnitude of this issue is illustrated by providing an overview of the implementation options of dynamic network tariffs, flexibility connection and access agreements, and local flexibility markets. The second part of Chapter 4 examines the current developments on regulatory sandboxes that might serve as a solution to test the impact of these different implementations.

Second, the importance of market power remedies. The previous sections examine the compatibility of flexibility tools without considering the interactions these flexibility tools have on other markets. In more detail, the integration of local flexibility markets in the existing market sequence remains an open issue and raises market power concerns. In the first part of Chapter 5, the magnitude of this issue is illustrated by developing a bi-level optimisation model to capture the strategic behaviour of flexibility providers in flexibility markets. The second part of Chapter 5 proposes three market remedies that might serve as a solution to reduce strategic behaviour in flexibility markets.

Finally, interesting research areas were identified in the previous sections that could serve as inspiration for further research projects.

- While this chapter examines the combination of flexibility tools based on the stakeholder perspectives of EUniversal D5.1, a quantitative analysis could be made considering different context attributes and evaluation criteria.
- While this chapter highlights the importance of regulatory sandboxes in examining the impact of different implementation options of flexibility tools, these interactions could also be analysed numerically using equilibrium models.

- While this chapter highlights the open issue of strategic behaviour in flexibility markets, the interaction of flexibility markets on existing markets considering other context attributes or evaluation criteria could be considered.
- While this chapter points out the interaction of flexibility markets on other markets, the influence of dynamic network tariffs, flexible connection agreements, bilateral contracts, cost-based mechanisms and obligations on other markets could be analysed.

4 The importance of regulatory sandboxes

The previous chapter discusses the complementarity between six flexibility tools using the high-level definitions of these tools. However, flexibility mechanisms are more complex in practice, and different design choices must be made. As a result, unforeseen interactions that increase or reduce the compatibility of these tools might arise during implementation. This chapter will first illustrate the significance of this issue by giving an overview of the implementation options that can be selected for dynamic network tariffs, flexible connection and access agreements, and local flexibility markets. Second, we will analyse the current developments on regulatory sandboxes that might serve as a solution for this issue.

4.1 Issue: the impact of different implementation options

With implementation options, we mean all options that can be chosen on all dimensions of the flexibility tool during the implementation or design of this tool. Table 1, Table 2, Table 3 and Table 4 give the overview for dynamic network tariffs, flexible connection and action agreements, local flexibility markets, and a general overview, respectively. Examples of bilateral contracts, cost-based remuneration and obligations can be found in Section 3.5 of EUniversal D5.1.

Dynamic network tariffs. Table 1 consists of but is not limited to the implementation options of dynamic network tariffs. This overview is based on the analysis of EUniversal D1.1 on the current regulation frameworks and planned regulatory reforms on distribution network tariffs in the following eight countries: Belgium (Brussels, Flanders and Wallonia separately), France, Germany, Norway, Poland, Portugal, Spain and the UK. Also the finding of Section 3.3 of EUniversal D5.1 served as an input for this table.

Table 1: Detailed overview of the implementation options of dynamic network tariffs.

Dimension	Implementation options
Addressed network costs	• Residual charges • Forward-looking charges
Tariff components, used alone or in combination	• Fixed charges (€/connection) • Volumetric charges (€/kWh) • Capacity charges (€/kVA or €/kW)
Locational granularity	• Nodal • Zonal • DSO control area
Temporal granularity	• Applied tariff component: energy, capacity, … • Number of periods: days, hours, minutes, peak/off-peak, … • Notification of peaks: ex-ante, ex-post,…
Differentiation among grid users	• Generation or demand type • Voltage level • Magnitude of energy generation or consumption • Metering device or synthetic load profile

Flexible connection and access agreements. Table 2 consists of but is not limited to the implementation options of flexible connection and access agreements. This overview is based on the analysis of EUniversal D1.1 on the current regulation frameworks and planned regulatory reforms on flexible connection agreements in the following six countries: Belgium (Flanders and Wallonia separately), France, Germany, Norway, Spain and the UK. Also the finding of Section 3.2 of EUniversal D5.1 served as an input for this table.

Table 2: Detailed overview of the implementation options of flexible connection agreements.

Dimension	Implementation options
Customer type	• Technology targeted: distributed generation, load, electric vehicles, heat-pumps,… • Applied to old or new connections • Mandatory or voluntary agreements
Allocation of non-firm capacity	• First come, first served • Pro-rata • Market-based
Activation of curtailment	• Dynamically or time scheduled • Activated by DSO or manually
Compensation	• None • Financial: compensation for curtailed supply, connection discount, tariff discount,… • Faster connection
Contract specifications	• Negotiated or standardized • Duration of contract

Local flexibility markets. Table 3 is a summary of the findings of EUniversal D1.1, D2.2, D10.1 and the intermediate results of D5.4. It must be noted that this overview is rather characterized by open issues than practical design choices as flexibility markets are still under development and different implementation options are still being discovered.

Table 3: Detailed overview of the implementation options of local flexibility markets.

Dimension	Implementation options/open issues
Use case and voltage level	• Congestion management • Voltage control • Deferral of network investments • Planned maintenance • Unplanned events
Incentives for flexibility markets	• Financial • Reputational • Regulatory
Integration in electricity market sequence	• Coordination with other markets • Market opening • Market closure • Reservation
Market rules	• Market closure • Market objective • Network information considered during the market clearing • Pricing scheme • Auction type • Bid selection • Baseline approach

Product definition	• Market closure • Tailored or generic • Fixed or open • Short or long-term • Active or reactive power • Availability or activation price • Aggregation allowed or not
Roles and responsibilities of market parties	• DSOs • Market operators • Flexibility providers

To summarise, the dimensions of Table 4 can at least be considered during the implementation of dynamic network tariffs, flexible connection agreements, and local flexibility markets.

Table 4: Summary of dimensions that should be considered during the implementation of dynamic network tariffs, flexible connection agreement, and local flexibility markets.

Dynamic network tariffs	Flexible connection agreements	Local flexibility markets
• Addressed network costs • Tariff components • Locational granularity • Temporal granularity • Differentiation among grid users	• Customer type • Allocation of non-firm capacity • Activation of curtailment • Compensation • Contract specifications	• Use case and voltage level • Incentives for local markets • Market rules and • Product definition • Integration in the existing sequence of markets • Roles and responsibilities of market parties

4.2 Recommendation: regulatory sandboxes

In recent years, the impact of different implementation options on the compatibility of flexibility tools has been examined by academics. One example is the recent work of Nouicer et al. (2020) and Abdelmotteleb et al. (2021). Both analyse the compatibility between explicit demand-side flexibility (e.g. flexible connection agreements) and implicit demand-side flexibility (e.g. distribution network tariffs) under different implementation options, such as variations in tariffs components or compensation levels for flexibility. While further developments are being made in literature, regulators can use regulatory sandboxes to test various implementation options in practice.

Therefore, we will now illustrate the current practice of regulatory sandboxes based on the survey-based analysis of the following 13 countries and regions: Austria, Belgium (Brussels, Flanders, Wallonia), France, Germany, Ireland, Lithuania, Norway, Poland, Portugal, Spain and Sweden. A blank version of the survey used by the EUniversal task participants for this analysis can be found in Annex II. In the remainder of this chapter, the findings of the surveys[1] are described in three steps. First, an overview of regulatory tools for innovation and a definition of regulatory sandboxes will be given. Second, trends in current practices of regulatory sandboxes will be described. Finally, recommendations on the risks and opportunities of regulatory sandboxes will be shared.

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[1] We would like to thank the following experts for their participation in the sandbox surveys and their contributions to the findings in this chapter: Ms Glaser from the Austrian Ministry BMK; Ms Pandich, Ms Cunningham and Mr Hussey from Irish Regulation CRU; Mr Kazlauskas from the Lithuanian energy company Ignitis Group; Ms Hillestad, Ms Roll and Mr Varden from the Norwegian NRA NVE-RME; Ms Mataczynska from the Polish DSO PGE Dystrybucja S.A.; and Ms Eriksson from the Swedish NRA EI.

4.2.1 Overview of regulatory tools to enable innovation

In what follows, we will give an overview of regulatory tools described in Schittekatte et al. (2021) and support each tool with a new example that arose in the survey-based analysis performed in the context of this deliverable.

Traditional tools used by regulators to stimulate innovation of system operators are the remuneration of innovative network investments, competition for innovation grants and waivers (Schittekatte et al., 2021). Waivers are regulatory exemptions that can be explicitly granted to all concerned parties following a regulatory decision or implicitly granted by regulators turning a blind eye to new activities or actors that do not fall under the current regulatory framework (Schittekatte et al., 2021). In our analysis, an example of remuneration of innovative network investments was identified in the response of the Norwegian National Regulatory Authority (NRA) NVE-RME. Since 2013, NVE-RME can approve that the TSO and DSOs receive full financial coverage via grid tariffs for research and development projects that meet certain criteria. Until October 2021, NVE-RME has approved 215 projects under this scheme, of which an overview can be found on their website (NVE-RME, 2021b).

Recent developments on regulatory tools for innovation are typically called regulatory experimentation. Schittekatte et al. (2021) describe regulatory experimentation as a temporary removal of regulatory barriers, which can exempt market players from certain rules or responsibilities to inform the revision of existing regulations or inspire new regulations. Regulatory experimentation can be seen as a complementary framework to traditional tools for innovation and is currently being rolled out in different European countries. Based on the analysis of Italy, the Netherlands and Great Britain, Schittekatte et al. (2021) define three types of regulatory experimentation: regulatory pilots, pilot regulation and regulatory sandboxes. CEER also recognised the importance of these three regulatory tools for experimentation in their recent position paper on dynamic regulation (CEER, 2021). We will now give more details and some examples of the three types.

Regulatory pilots. Regulatory pilots are controlled experiments where the regulator targets a specific technology or innovation. In this context, pilot projects are approved by the NRA on a case-by-case basis. One example is the regulatory pilots organised by the Italian regulator ARERA that, since 2010, experimented with topics such as public operators for EV charging infrastructure, smart grids for DSOs and deployment of energy storage by TSOs (Schittekatte et al., 2021). Another example was found in the survey responses of Portugal, where regulatory pilots on dynamic network tariffs, storage ownership by DSO and balancing services by demand-side flexibility have been organised by the regulator ERSE (IEA, 2021).

Pilot regulation. In this case, the regulator specifies a derogation to a specific regulation that directly applies to all concerned entities without the need for a case-by-case approval. Since 2017, Italy has had at least two experiments with pilot regulation: one concerning an open protocol for interoperable in-home devices and the other concerning distributed energy resources' participation in balancing markets (Schittekatte et al., 2021). In our analysis, an additional example arises from the survey-based response of Sweden. The Swedish regulator EI allows all DSOs to test different tariff structures to specific customer categories to stimulate demand-side flexibility. Before DSOs start using this pilot regulation, they need to submit their information to EI, but no permission from EI is required when the project is shorter than three years. Upon the response of EI in August 2021, no DSO has used this opportunity yet in Sweden.

Regulatory sandboxes. Sandboxes are typically seen as a more open type of regulatory experimentation, in which regulated entities and market players may propose their own project and suggest their own regulatory derogations instead of the regulator. After submission, projects are approved by the NRA on a case-by-case basis. An analysis of the regulatory sandboxes in Great Britain and the Netherlands can be found in Schittekatte et al. (2021). The current regulation of 10 additional frameworks on regulatory sandboxes will be discussed in the next section.

4.2.2 Analysis of national regulation on regulatory sandboxes

This section examines the current practice of regulatory sandboxes in the following nine countries and regions: Austria[2], Belgium (which is represented separately by the regions Brussel, Flanders and Wallonia), France, Germany, Lithuania, Norway and Spain. While most regulatory frameworks are already in place, it must be noted that the regulation on regulatory sandboxes in Spain and Poland are currently still under development. Initially, the case of Ireland was also analysed, but the regulatory sandboxes in this country were too limited to be considered in the remaining of this section. Portugal and Sweden were not included as currently no framework on regulatory sandboxes is in place. The nine countries were analysed based on the framework of Schittekatte et al. (2021), which consists of the following six dimensions:

- **Eligible project promoters** are all parties that might propose and organise a regulatory sandbox.
- **Derogations** reflects the regulatory exemptions that can be given in the sandbox.
- **The length of derogation** represents the maximum number of years the sandbox will be organised.
- **Administration** describes the administrator of the regulatory experimentation that takes care of the application procedure, approval, monitoring and evaluation of the experiment.
- **Funding** reflects to which extent project promoters can make use of public financing for the regulatory sandbox.
- **Transparency and reporting** describe how much of the set-up and results of the regulatory sandbox are shared with the administrator and made publicly available.

A summary of the results can be found in Table 5. Please note that regulation is evolving fast, and national regulations must be checked to find the most recent developments of the discussed sandboxes.

Austria (BMK, 2021; FFG, 2021). In 2019, a first call of the funding programme Energie.Frei.Raum was launched in Austria. The aim of this first tender was to identify relevant regulatory challenges and the need for granting regulatory exemptions, as well as to assess possible topics and research questions that could be addressed in following calls of the programme (AIT et al., 2020). In October 2021, the second tender for regulatory sandboxes was launched (BMK, 2021; FFG, 2021). For this tender, eligible project promoters can be companies of any legal form, research institutions, and other non-commercial institutions. On the one hand, projects focusing on system integration and market models of renewable energy, storage and energy efficiency technologies might be submitted. On the other hand, projects focusing on the design of grid tariffs might be supported by funding and be given derogations from grid tariffs by the regulator under the scope of the Renewable Energy Package (EAG). In the second call, 4.6 million euros of funding is available by the Federal Ministry BMK, managed by Funding Agency FFG. The maximum length of the derogations is three years. For the administration of the Energie.Frei.Raum, the following roles are foreseen: the Federal Ministry BMK is the programme owner and responsible for providing funding and for facilitating legal pre-conditions for sandbox experiments, the FFG is the programme manager and performs the selection and funding of RDI-projects, and the regulator E-Control proves and approves the projects within the sandbox framework. The programme Energie.Frei.Raum offers funding for accompanying research to support regulatory learning. Additionally to projects that receive funding from Energie.Frei.Raum,

[2] The implementation process of regulatory sandboxes in Austria was dependent on the approval of the Renewable Energy Package (EAG). When receiving written feedback from the funding agency FFG and the Austrian Ministry BMK (April 2021), the EAG was passed as a government proposal in the Council of Ministers, but the decision in parliament was still pending. At the time of writing this deliverable (December 2021), the EAG has been passed and the framework for regulatory sandboxes has been put in place in Austria. More information is available at https://www.bmk.gv.at/themen/klima_umwelt/energiewende/energiefreiraum.html

any project tackling research questions within the regulatory sandbox framework, which is currently funded by an equivalent funding programme, might apply for a derogation under the scope of the Renewable Energy Package. Transparency and reporting of Energie.Frei.Raum will be in line with FFG procedures and rules. The regulatory authority will publish granted derogations according to the legal framework.

Belgium – Brussels (BRUGEL, 2019). In 2019, the regional regulator BRUGEL opened the application process for regulatory sandboxes in Brussels. To date, eight projects have been submitted, of which two regulatory sandboxes focusing on energy communities have already been granted (BRUGEL, 2021). All parties are eligible to submit innovation projects, and derogations might be given to all regulations under the regional responsibility. The typical length of the sandbox project is two years, and an extension of another two years may be requested. BRUGEL is responsible for taking decisions and evaluating the sandboxes. Besides that, it remained unclear from our analysis whether funding can be provided to the sandboxes via regulatory or other channels. Finally, the sandbox projects must report to BRUGEL every six months, and a final report will be published online at the end of the project.

Belgium – Flanders (Flemish Government, 2020; Flemish Government, 2021). Since the development of the legislation on regulatory sandboxes in 2019, one project related to energy communities has been granted in Flanders (Flemish Government, 2020; VITO, 2020). All parties are eligible to submit proposals to the Ministry via the Flemish Energy and Climate Agency called VEKA. The list of regulations to which exemptions can be granted is fixed and limited to the responsibility of the Flemish Ministry. Still, project promoters are open to proposing deviations to all articles within this list. The maximum length of derogation is ten years, with a possible extension of five years. VEKA is responsible for the administration of the sandbox, and the Flemish regulator VREG is not involved in the sandbox project. No funding is foreseen in the regulatory scheme for sandboxes, but projects are allowed to facilitate financing through other channels. Finally, sandboxes must annually report on the progress and results of the project. At the end of the project, a final report with the lessons learned and policy recommendations will be made available on the website of the Flemish government.

Belgium – Wallonia (CWaPE, 2021a, CWaPE, 2021b). Since 2019, three regulatory sandboxes have been granted in Wallonia, each exploring different innovations in the scope of energy communities (CWaPE, 2021b). All parties are eligible to submit projects to the regional regulator CWaPE, and derogations might be given to all regulation that falls under the regional responsibility. The maximum length of a project defined in the legislation is five years, while derogations of the three granted sandboxes were shorter (1-3 years). CWaPE is responsible for taking decisions and evaluating the sandboxes. Besides that, it remained unclear from our analysis whether funding can be provided to a sandbox via regulatory or other channels. Besides that, interim reports and a final report will be made available on the CWaPE website.

France (CRE, 2020). In 2020, the first call on regulatory sandboxes was organised by the French Regulator CRE. In total, 41 projects were submitted, of which a total of 12 sandboxes have been granted until July 2021. In CRE (2021), the summary from the first call and details on the second call can be found. The six dimensions will now be discussed for the projects of the first call. Eligible project promoters could be any legal entity, and derogations covering a targeted list of articles in the Climate Energy Law were demanded but open for any proposal within this list. The exemptions were granted for a maximum period of four years and can be extended only once more under the same conditions. The regulator is in charge of the experiment, but the division of the project monitoring tasks could be specific and adapted on a case-by-case basis. The regulatory framework for sandboxes is not a subsidy or state aid system. Still, nothing precludes the sandbox to be funded under existing innovation programs or to receive funds from public or private sponsors. Finally, a progress report is sent at least annually to the CRE.

Germany (BMWi & SINTEG, 2017; BMWi, 2021). In Germany, regulatory derogations could be given to innovative research projects under the SINTEG programme (BMWi, 2016) and can be granted to projects under the ongoing Reallabore der Energiewende of the 7th energy research programme (BMWi, 2021). Here, it must be noted that the focus of these funding programmes is not to grant projects that require regulatory exemptions but to fund economically not viable projects (BMWi & SINTEG, 2017). Our research indicates that no regulatory exemptions have been granted under the SINTEG programme. Besides that, it remained unclear how many of the research projects under the Reallabore der Energiewende programme have received regulatory derogations. However, regulatory sandboxes can be granted within the funding systems, and the following dimensions apply. All parties are allowed to participate in the funding programmes, and derogations are open for innovation; no regulation is directly targeted. No specific information was found on the maximum duration of the derogations, which depends on the innovation projects' characteristics. The German Ministry BMWi is the main administer of the funding program, and the German Regulator Bundesnetzagentur helps evaluate the projects on regulatory exemptions. At the end of the research project, a final report is published on the website of the ministry (BMWi & SINTEG, 2021).

Lithuania (LRV, 2021). In 2020, legislation related to energy innovations and their operation under a regulatory sandbox came into force in Lithuania. Until August 2021, there were not yet any sandboxes granted in practice. All parties are eligible to promote projects, and the derogations are open for innovation The derogation length is a maximum of one year for sandboxes related to trials that include services, products, business solutions and models, and three years for innovation projects related to energy infrastructure and technology. An extension of respectively one and two years is possible if accepted by the Lithuanian regulator VERT. Project promoters are responsible for the sandbox administration and under supervision of VERT. Sandbox projects can partially be co-funded via regulated tariffs, and interim and a final report should be submitted to VERT.

Norway (NVE-RME, 2021a, NVE-RME, 2021c). Although there has been a remuneration system for innovative network investments in place since 2013, over the years, the Norwegian regulator NVE-RME has been observing an increasing number of new project proposals from different market participants. As a result, NVE-RME developed an additional framework for pilot and demonstration projects in 2019. All regulated parties, including DSOs and market actors, may apply for regulatory sandboxes that can give amendments in the trading license or derogations from the legislation. The topics of the derogations are open for innovation. Until October 2021, nine projects have been granted derogations covering different tariff models, collective self-consumption of residents and flexibility services to DSOs and the TSO. The duration of the regulatory sandboxes is one to three years in most cases, with a maximum of five years. Participants must have a plan to return to the regular legal framework if they wish to continue operations after the expiry of the sandbox. NVE-RME is responsible for the administration of the sandbox project, and funding is possible under the Norwegian R&D scheme described in the previous section. The sandbox projects report periodically to NVE-RME, and NVE-RME requires that final reports be published online to encourage the distribution of knowledge from the pilot projects.

Poland (Minister Klimatu i Środowiska, 2021). The Polish Energy Law project (UC74) allows the Polish NRA URE to grant derogations from certain regulations to anticipate the need for new regulations adapted to future developments in the energy sector more quickly and effectively. The principles of regulatory sandboxes are still under development, and until December 2021, no projects have been granted. Under the current development of the Polish Energy Law, the following dimensions apply. The procedure for the NRA to select sandboxes from a list of regulations to which exemptions can be granted and the project procedure itself should be announced, organised, and conducted at least once a year. Following Art. 24b of UC74, eligible project promoters are any legal person or organisation which is not a legal person but is granted legal capacity by a separate act. The list of regulations to which exemptions can be granted is targeted to projects that facilitate the implementation of innovative technologies and services, system user cooperation models, technological or ICT solutions for the benefit of energy transformation, smart grids and infrastructures, development of local balancing, and efficiency of the use of existing infrastructures. The derogations can be granted for a maximum period of three years. They can be extended up to three years, depending on the NRA decision and the stage of development of the project. The national regulator URE is responsible for the administration of the sandbox and carrying out inspections of the project implementation. No funding is foreseen in the regulatory scheme, but projects are allowed to facilitate funding through other channels. Periodical reports and a final report will be published online.

Spain (CNMC, 2019; Spanish Government, 2020). Since the end of 2019, legislation on regulatory sandboxes has been developed in Spain. A high-level framework for sandboxes is currently included in parallel in two different pieces of legislation: “Real Decreto-ley 23/2020” by the Government and “Circular 3/2019” by the Spanish regulation CNMC. For both legislations, any party can be an eligible project promotor and derogations are open for innovation. However, the main objective of the Real Decreto-ley 23/2020 will be energy, climate and environmental sustainability, and the main goal of the Circular 3/2019 will be to contribute to improving the functioning of the wholesale electricity market and system operation. The maximum length of derogations is three years for sandboxes under circular 3/2019. For Real Decreto-ley 23/2020, the duration of the sandbox is limited, but the maximum length of derogations is not specified. The administration of the sandboxes under Circular 3/2019 falls under the national regulator CNMC and projects under Decreto-ley 23/2020 fall under the Ministry MITECO unless stated otherwise. No funding is foreseen in the Spanish regulatory framework, but projects can facilitate funding through other channels such as R&D+I projects (Orden CNU/320/2019) and experimentation by DSOs (Circular 6/2019). Finally, no details about transparency and reporting are currently mentioned in Circular 3/2019 and Decreto-ley 23/2020. Although this legislation has been in place for some time, no sandboxes have been granted until now. The reason is that further regulatory developments are still required to define the operational conditions. The Spanish Government has held a public consultation, but no information on the outcomes of this consultation and subsequent regulatory developments have been published by December 2021 (Spanish Government, 2021).

Overall, the following trends can be observed for each dimension of Table 5, which are in line with the findings of Schittekatte et al. (2021):

- When looking at the submission of regulatory sandboxes among the countries, we observe that this is typically organised within a dedicated call (Austria, France, Germany, Poland) or on a more voluntary basis (Brussels, Flanders, Wallonia, Norway).
- In general, countries do not define or limit the eligibility of project promoters (Brussels, Flanders, Wallonia, Germany, Lithuania, Norway, Spain). Still, the definition of eligibility can be more specified in some cases (Austria, France, Poland).
- We observe two trends when looking at the derogations given in regulatory sandboxes. First, a specific area of regulation can be targeted in the sandbox regulation, and within this area all kinds of derogations are possible (Austria, Flanders, France, Poland). Second, the allowed regulatory derogations can be as open as possible (Brussels, Wallonia, Germany, Lithuania, Norway, Spain).
- The responsibility of the administration of the regulatory sandboxes falls typically under the regulator (Brussels, Wallonia, France, Lithuania, Norway, Poland), the Ministry (Flanders) or both (Austria, France, Germany, Spain). It must be noted that project administrators can impact the scope of the regulatory sandboxes as different regulations and legislations might fall under the responsibility of the administrators. An example is the case of Belgium, where different derogations fall under the scope of the regulatory sandboxes in Flanders compared to Brussels and Wallonia because in Flanders, the Ministry is the administrator, and in Brussels and Wallonia, this responsibility falls under the regulator.
- The length of the derogations typically starts under five years (Austria, Brussels, Wallonia, France, Lithuania, Norway, Poland, Spain), but extensions can be given. The only exception to this is the

case of Flanders, where a maximum length of ten years is determined by regulation. However, it must be noted that, in Flanders, theory currently differs from practice as a regulatory sandbox of five years has been granted while the project promoters applied for a derogation of ten years.

- When looking at the funding of the sandbox projects, two trends can be observed. First, sandboxes can be part of a more extensive funding process (Austria, Germany, Lithuania, Norway). Second, funding is not included in the initial scope of the sandbox process, but project promoters are allowed to obtain financing through other schemes (Flanders, France, Poland, Spain).
- When looking at transparency and reporting, it can be observed that typically a periodic reporting scheme to the administrator is in place, and a final report with the lessons learned will be published online at the end of the sandbox project (Brussels, Flanders, Wallonia, Germany, Lithuania, Norway, Poland).

Table 5: Current national regulation of regulatory sandboxes in Austria, Belgium (Brussel, Flanders, Wallonia), France, Germany, Lithuania, Norway, Poland and Spain.

	Austria	Belgium			France	Germany	Lithuania	Norway	Poland	Spain
		Brussels	Flanders	Wallonia						
Sandbox status	Legal provisions entered into force in 2021. No projects granted until December 2021.	2 projects granted and 6 projects under evaluation until December 2021.	1 project granted until December 2021.	3 projects granted until December 2021.	12 projects granted under the first call in 2020. Second call closes in January 2022.	Sandboxes can be granted under the SINTEG and Reallabore der Energiewende funding programmes.	Regulation in place since 2020, no project granted until August 2021.	9 projects granted until October 2021.	Regulation under development, no projects granted until December 2021.	Regulation under development, no projects granted until December 2021.
Eligible project promoters	Companies of any legal form, research institutions, and non-commercial institutions.	All parties.	All parties.	All parties.	Any legal entity.	All parties.	All parties.	All parties.	Any legal person or organisation which is granted legal capacity by a separate act.	All parties.
Derogations	Targeted to exemptions from grid fees for research and demonstration projects	Open to all regulation under regional responsibility.	Targeted to specific list of regulation, but open for any proposal within this list.	Open to all regulation under regional responsibility.	Targeted to specific list of regulation, but open for any proposal within this list.	Open	Open	Open	Targeted to specific area of regulations.	Open
Length of derogation	Max 3 years.	Max 2 years, extension of another 2 years possible.	Max 10 years, extension of max 5 years possible.	Max 5 years.	Max 4 years, extension of another 4 years possible.	-	Max 1 or 3 years depending on the topic. Extension of respectively 1 and 2 years possible.	1–3 years in most cases, with a max of 5 years.	Max 3 years, extension of max 3 years possible.	Max 3 years for sandboxes under Circular 3/2019. Limited but no specified duration under Real Decreto-ley 23/2020.
Administration	Tasks divided among Ministry (BMK), Regulator (E-Control) and funding agency (FFG).	Regional regulator (BRUGEL)	Ministry through agency VEKA.	Regional regulator (CWaPE)	National regulator (CRE), but tasks could be divided differently in specific cases.	Tasks divided between Ministry (BMWi) and national regulator (Bundes-netzagentur).	Project promoter under supervision of national regulator (VERT)	National regulator (NVE-RME)	National regulator (URE)	Regulator (CNMC) under Circular 3/2019. Ministry (MITECO) for under Decreto-ley 23/2020.
Funding	Yes, 4.6 million euros of funding is available by BMK, managed by FFG in the second call.	-	No, but projects may facilitate funding through other channels.	-	No, but projects may facilitate funding through other channels.	Yes, sandboxes are granted when applicable in funding project.	Yes, partially co-funding via regulated tariffs possible.	Yes, possible via regulated tariffs possible under NVE R&D scheme.	No, but projects may facilitate funding through other channels.	No, but projects may facilitate funding through other channels.
Transparency and reporting	-	Six-monthly report to BRUGEL Final report will be published online.	Annually progress report to Ministry. Final report will be published online.	Interim reports and final report will be available on CWaPE website.	Annual progress report to CRE.	Final report will be available on BMWi website.	Interim reports and final report submitted to VERT.	Periodical report to NVE-RME. Final report will be published online.	Periodical reports and final report will be published online.	-

4.2.3 Risk and opportunities of regulatory sandboxes

In the last part of this chapter, regulatory sandboxes are examined from a more general perspective, using the framework of Table 6. Based on the experience of the previous section, we want to evaluate two aspects of regulatory sandboxes. First, do sandboxes speed up innovation? Second, do sandboxes speed up regulatory change? Overall, we found that both opportunities and risks can be identified for each question. We will now explain each part of Table 6 in more detail and elaborate with some examples.

Table 6: Identified risk and opportunities when using regulatory sandboxes.

	Opportunity	Risk
Do sandboxes speed up innovation?	Sandboxes can bring innovative use cases by unusual project promoters	Innovators might rather be looking for subsidies or regulatory advice
Do sandboxes speed up regulatory change?	Sandboxes can inspire new regulation	Sandboxes might be used as an excuse for delayed implementation of regulation

Sandboxes can bring innovative use cases by unusual project promoters

When evaluating if sandboxes speed up innovation, we found that there is an opportunity that sandboxes can bring innovative use cases by unusual project promoters.

To illustrate this, some examples of the analysed sandboxes that bring innovative use cases in the scope of the EUniversal project are now highlighted. These could be, among others, derogations covering distribution tariffs, taxes and levies, market-based procurement of flexibility, and distribution network management and planning. The HospiGREEN project in Wallonia examines periodic distribution tariffs in the context of renewable energy communities. These tariffs aim to provide an incentive for self-consumption that is useful for the network, i.e. to encourage customers to match their peak demand with local production and vice versa (CWaPE, 2020; IDeTA, 2021). Derogations to test dynamic network tariffs have also been awarded to sandboxes in Norway (NVE-RME, 2021a) and were stated as important in the regulatory framework of sandboxes in Austria (AIT et al., 2020) and Lithuania (LRV, 2021). Besides that, the Norwegian regulator has granted exemptions for the NorFlex project that examines the procurement of local flexibility for TSOs using the NODES platform, which is a partner of the EUniversal project (NVE-RME, 2021d).

An important aspect that influences the innovation of sandbox projects is the administrator. This was already illustrated in the case of Belgium, where different derogations fall under the scope of the regulatory sandboxes in Flanders compared to Brussels and Wallonia because in Flanders, the Ministry is the administrator, while in Brussels and Wallonia, this responsibility falls under the regulator. Additional opportunities for innovative use cases in the context of the EUniversal project and low voltage networks might be found when opening up the administration to other regulatory authorities such as GDPR and telecom. Here, it must be noted that the introduction of different regulatory authorities will come with additional coordination needs.

Innovators might rather be looking for subsidies or regulatory advice than a sandbox

When analysing if sandboxes speed up innovation, we found that there is a risk that innovators might rather be looking for subsidies or regulatory advice than a regulatory sandbox.

The risk that innovators are looking for subsidies might occur when regulatory sandboxes are part of a more extensive funding process, or project promoters can obtain financing through other schemes. When designing the sandbox framework, it might be interesting to evaluate if project promoters can combine both funding types and if any potential conflict of interest could arise.

The risk that innovators might be looking for regulatory advice was already recognised by Ofgem in 2018 as one of the main insights from running calls for regulatory sandboxes in 2017 (Ofgem, 2018). The report states that it is often unclear for innovators what they can and cannot do under current regulation and that innovators commonly need regulatory advice instead of a regulatory sandbox (Ofgem, 2018). In a recent report that summarises the first call for regulatory sandboxes in France, the French regulator CRE also acknowledges that they underestimated the work that comes with information sharing under the sandbox framework (CRE, 2021). That is why in future calls, project that do not specify which regulatory derogations are necessary and why will not be treated by the CRE, as the application process was too time-consuming in the first call. In some cases, however, giving regulatory advice is seen as an essential part of regulatory sandboxes. One example is the case of Norway, where the Norwegian regulator NVE-RME considers informing market participants about the applicable regulation an important aspect of regulatory sandboxes (NVE-RME, 2021a).

Sandboxes can inspire new regulation

When evaluating if sandboxes speed up regulatory change, we found that there is an opportunity that regulatory sandboxes will inspire new regulation.

Here, an important link must be made with the derogations dimension of regulatory sandboxes. Depending on the openness of the allowed derogations, new regulations can be targeted by the administrator beforehand or inspired by innovative use cases by unusual project promoters.

Currently, we are not aware of any specific regulation that has been changed due to the organisation of regulatory sandboxes in the analysed countries. The most promising examples were found in the case of Ofgem, where the regulator indicated that, in the future, the Emergent sandbox might influence the Balancing and Settlement Code, and the UKPN sandbox might affect the ongoing developments in regulation on network reinforcements and subsidies for EV charging points (Ofgem, 2021). However, specific examples of new regulations inspired by regulatory sandboxes might still arise in the future as most sandbox projects are still ongoing today, and the opportunity of regulatory learning is heavily integrated into most sandbox approaches.

Sandboxes might be used as an excuse for delayed implementation of regulation

When examining if sandboxes speed up regulatory change, we found that there is a risk that sandboxes might be used as an excuse for delayed implementation of regulation.

This risk can be seen as a grey zone between learning from regulatory sandboxes and delaying the actual implementation of regulatory frameworks. In their survey response, the Irish regulator CRU mentioned this as one of the main reasons to delay the development of regulatory sandboxes in Ireland. CRU stated that considering the urgency of implementing the Clean Energy Package requirements, it was more beneficial to develop an enabling regulatory framework that fully introduces energy communities and engages new market participants in aggregation and demand-side response than to create a sandbox approach for these new entities.

Regulatory recommendations

Section 4.2 defines the definition, current practice, risks and opportunities of regulatory sandboxes based on the analysis of 13 countries and regions. Table 7 summarizes what we have learned from this comparison of regulatory sandboxes. It is too early to conclude on what is the best design, but the consequences of the different choices that need to be made when designing a sandbox have been clarified. Here it must be noted that these consequences are rather linked to the dimension of the sandbox than to the design choices itself: every impact must be considered for each design choice. Table 7 can help countries that already have a sandbox to reconsider some of their design choices, and it also provides guidance to countries that still have to start designing their regulatory sandbox.

Table 7: Overview of the implementation options of regulatory sandboxes and the possible impact of these decisions on the outcome of the sandbox projects.

Dimension	Design choices	Impact of decision
Application process	• Dedicated calls • Continuous application	• Timing of workload of the application process • Possibility to highlight topics during application • Possibility to provide funding during application
Eligible project promoters	• Open, without definition • Open, with specified definition	• Opportunity to have innovative use cases by unusual project promoters
Derogations	• Targeted list • Open	• Opportunity to have innovative use cases by unusual project promoters • Opportunity to inspire new regulation • Risk that innovators might be looking for regulatory advice
Administration	• Regulatory only • Ministry only • Regulator and ministry • Other involved agencies	• Regulation and legislation under scope of sandbox to which derogations can be given • Opportunity to inspire new regulation • Possibility to provide funding
Length of derogations	• Maximum length of initial project • Extension allowed or not	• Time for experimentation and development of results • Opportunity to inspire new regulation • Possibility to intervene in the sandbox project
Funding	• Funding as part of sandbox project or not • Other funding sources are allowed or not	• Innovators might rather be looking for subsidies than a sandbox • Business case of the project when the regulatory sandbox ends
Transparency and reporting	• Internal or public periodic reporting • Internal or public final report	• Dissemination of lessons learned • Opportunity to inspire new regulation

5 The importance of market power remedies

In Chapter 3, the interactions between six flexibility tools were discussed. However, in practice, these flexibility tools might also influence existing markets such as the wholesale market, redispatching market and balancing market, and unforeseen (in)compatibilities between these tools might arise. This chapter will go deeper into one of these interactions: market power concerns that arise from the integration of local flexibility markets in the existing sequence of electricity markets. First, we illustrate the relevance of this issue by developing a bi-level optimisation model that captures the strategic behaviour of flexibility providers. Second, we propose three regulatory remedies that can reduce market power concerns.

5.1 Issue: the impact of flexibility markets on other markets – market power concerns

To describe the strategic behaviour of flexibility providers in a comprehensive and clear way, the research performed in the context of this deliverable is summarized in the following pages and made fully available online as a working paper[3].

5.1.1 Overview

DSOs face a major network integration challenge with the uptake of new, flexible technologies that come from the electrification of the transport, building and industry sectors. Luckily, due to their flexible characteristics, these new technologies do not only contribute to this DSO challenge but could also be part of the solution. For this reason, Article 32 of EU Directive 2019/944 states that DSOs are expected to procure flexibility in a market-based way when it is cheaper than expanding their distribution network unless the regulatory authorities have established that the procurement of such services is not economically efficient or would lead to severe market distortions or higher congestion. Different pilots and research projects on flexibility markets do already exist today (European Commission, 2021; Schittekatte & Meeus, 2020), but overall, the integration of these flexibility markets in the existing sequence of European electricity markets remains an important open issue (Meeus, 2020; Pollitt & Anaya, 2020). We were inspired by two streams of literature to contribute to this discussion.

The first stream relates to market sequencing options, often referred to as alternative TSO-DSO coordination schemes. As both TSOs and DSOs will consider flexible resources for congestion management and balancing services in the coming years, a debate around TSO-DSO coordination has been growing in Europe (Hadush & Meeus, 2018). CEDEC et al. (2019) describe the common vision by ENTSO-E and the four European DSO associations. Publications by academics such as Burger et al. (2019), Gerard et al. (2019), Vicente-Pastor et al. (2019) and Le Cadre et al. (2019) have started to analyse the performance of different sequencing options. Several authors have already referred to the strategic behaviour of market parties in this context, but it has not yet been modelled extensively. Therefore, the main contribution of this research is to model the strategic behaviour of market parties under the alternative sequencing options.

For our modelling approach, we were inspired by a second stream of literature on the inc-dec game. This increase-decrease game, often called the inc-dec game, is a profitable strategic arbitrage trading between an inter-zonal electricity market and an intra-zonal congestion management market. This game was first discovered during the California market crisis, where it played an important role in the creation of the crisis (Harvey & Hogan, 2001; Stoft, 1998). In the

[3] Beckstedde, E., Meeus, L., Delarue, E. (2021). Strategic behaviour in flexibility markets: New games and sequencing options. Working paper No. ESIM2021-05. Available at https://www.mech.kuleuven.be/en/tme/research/energy-systems-integration-modeling/pdf-publications/wp-esim2021-5

literature on the inc-dec game, two approaches are typically adopted. In the first approach, used by Dijk & Willems (2011), Holmberg & Lazarczyk (2015) and Hirth & Schlecht (2019), the Nash equilibrium between all (strategic) market players is solved analytically. In the second approach, used by Sarfati et al. (2019) and Sarfati & Holmberg (2020), the strategic behaviour of the market players is formulated by a bi-level equilibrium model. To the best of our knowledge, the literature on the inc-dec game does not yet consider the recent developments in distribution networks with flexibility markets, which is the focus of this research.

Therefore, we combine the literature on market sequencing options and the second approach of the literature on the inc-dec game to examine the integration of flexibility markets in the sequence of electricity markets. We identify old and new games that can be triggered by flexibility markets and compare the performance of the sequencing options under market structure sensitivity.

5.1.2 Methodology

Figure 1 shows a schematic overview of the relationship between market sequencing options and different market players. The following four market sequencing options are analysed: (a) the nodal wholesale market that includes transmission and distribution network constraints; (b) the zonal wholesale market without network constraints followed by an integrated redispatching market that manages the network congestion at transmission and distribution level created by the wholesale market in a coordinated way; (c) the zonal wholesale market followed by separate local DSO flexibility, TSO redispatching and TSO balancing markets in that order, which implies that congestion at distribution level is treated before congestion at transmission level; and (d) the zonal wholesale market followed by separate TSO redispatching, local DSO flexibility and TSO balancing markets in that alternative order, which implies that congestion at transmission level is managed before congestion at distribution level.

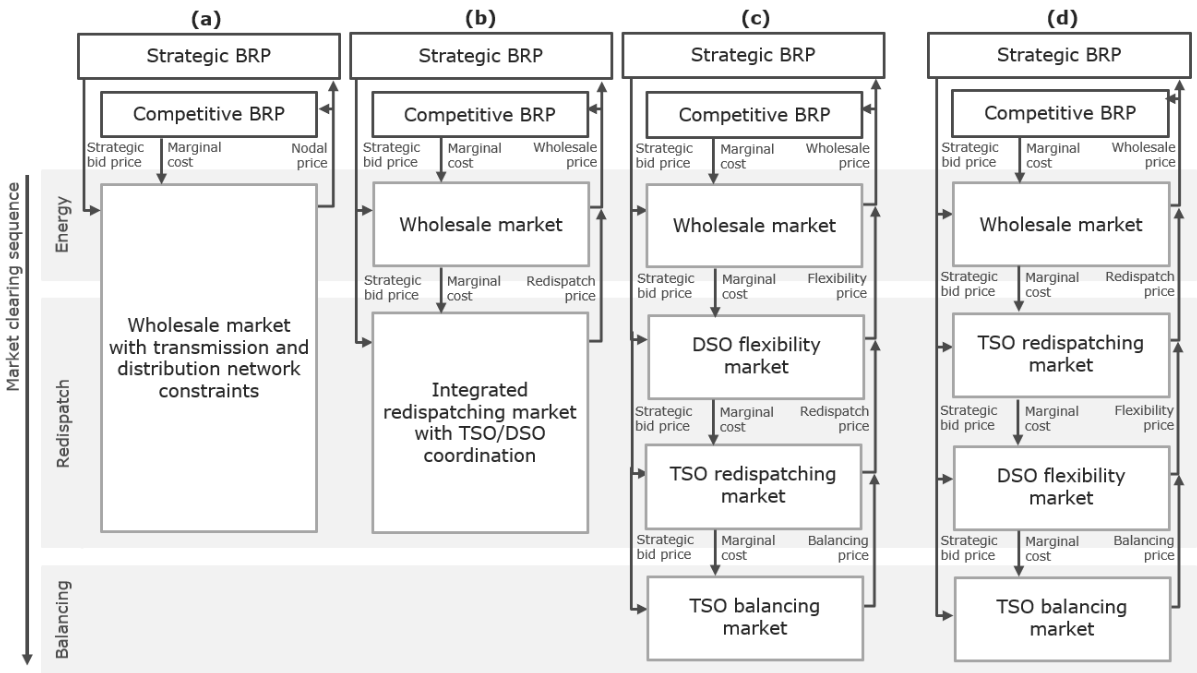

Figure 1: Schematic overview of the four market sequencing options: (a) the nodal wholesale market; (b) the zonal wholesale market followed by and integrated redispatching market; (c) the zonal wholesale market followed by separate local flexibility, redispatching and balancing markets in that order; and (d) the zonal wholesale market followed by separate redispatching, flexibility and balancing markets in that alternative order

For each sequencing option, we model perfect competition as the reference case and compare this to a situation where a strategic market party, represented by a Balancing Responsible Party (BRP), is the first mover in the market. As a result, there are eight versions of the model, all analysed for a single timestep. The competitive BRP will offer all units to the different markets at their marginal cost. This behaviour can be captured by a single-level model and is solved as a Mixed Complementarity Problem (MCP). The strategic BRP act as a first mover and adjusts its price offer to the strategic bid price by anticipating the reaction of the competitive BRPs in the second stage. This behaviour is captured by a bi-level problem that is formulated as a Mathematical Program with Equilibrium Constraints (MPEC), as shown in Sarfati et al. (2018) and Ruiz et al. (2012).

The eight versions of the models are all analysed for a numerical example that is illustrated in Figure 2 and builds further on the power system used by Hirth & Schlecht (2019), which starts from a one-hour snapshot of the German transmission network. The examined network contains two transmission nodes (N) and (S) that are interconnected by a constrained transmission line. We added two distribution nodes to transmission node (N): node (n1) by the constrained distribution line (n1N) and node (n2) by an overdesigned distribution line (n2N). Lastly, Figure 2 shows the location of the generator and load sources in the reference power system.

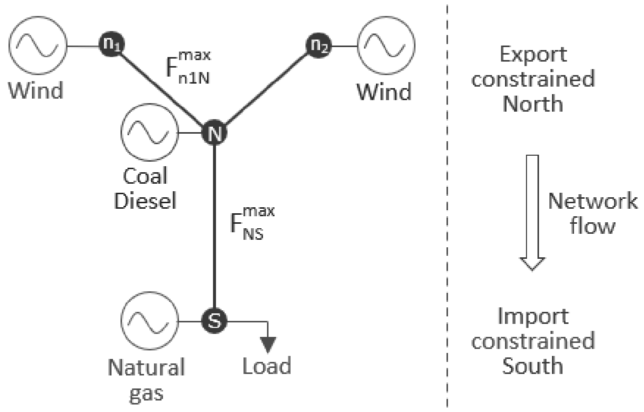

Figure 2: Schematic overview of the test case.

5.1.3 Results

The results are summarised in three parts: (1) the market outcome under perfect competition; (2) the illustration of strategic behaviour under the reference power system and the alternative market sequencing options; and (3) the impact of market structure on the performance of sequencing options. A more detailed analysis of the results can be found online in the working paper.

The market outcome under perfect competition. The following three trends can be observed when comparing the four market sequencing options under the reference power system and perfect competition. First, we find that each market sequence results in the same generation costs. This implies that, despite being activated in different ways, the final dispatch of the four market sequencing options is the same. Second, we find that under perfect competition and the reference power system, the costs towards consumers are lowest under the nodal pricing when considering congestion rent. Finally, we observe that although market prices and quantities of congestion management markets vary, the costs for congestion management are similar in the market sequences (b), (c) and (d).

The illustration of strategic behaviour under the references power system and the alternative market sequencing options. We identified six types of games that can be divided into three categories of strategic behaviour: driving up prices within the market, creating and solving additional congestion between two markets, and pursuing activation in the most profitable market(s) of the total market sequence. When looking at the overall trends, we find that the nodal wholesale market is most resistive to strategic behaviour. Still, it seems that there is no clear winner among the alternative market sequencing options.

The impact of market structure on the performance of sequencing options. To generalise the effect of the games illustrated in the previous paragraph, a Monte Carlo simulation is performed to analyse the impact of taking all different types and sizes of BRP portfolios under the reference power system. The following three observations can be made. First, we find that even small strategic players can exercise strategic behaviour and, on average, increase the total cost towards consumers. Second, we find that in analogy with the previous section, the nodal wholesale market outperforms the other market sequencing options when BRP sizes are smaller but can experience great distortions by the price-setter game of large strategic players. Here, it must be noted that the implementation costs of the four market sequences are not taken into account. Third, in analogy with the previous section, we find no clear second best among the alternative market sequencing options.

5.1.4 Conclusions

We analysed four market sequencing options that consider network congestion at transmission and distribution level in the context of strategic flexibility providers. We formulated an MCP and MPEC model to capture competitive and strategic behaviour in the alternative market sequences. A reference power system was defined to illustrate the wholesale market and congestion management's functioning of the four sequencing options under perfect competition and to discover six types of strategic behaviour triggered by redispatching and flexibility markets. Finally, the performance of the four sequencing options was examined under different market structures. In what follows, we highlight our two main findings and their practical relevance for regulators.

First, in analogy with the inc-dec game triggered by redispatching markets, we found that flexibility markets can create new games among flexibility providers. Six types of strategic behaviour were identified that can be divided into three categories: driving up prices within the market, creating and solving additional congestion between two markets, and pursuing activation in the most profitable market(s) of the total market sequence. We also observed that these bidding strategies would be hard to detect in practice as they can be performed by relatively small strategic players and are highly dependent on the considered power system and market sequencing options. This is of practical relevance for market surveillance and optimal transparency, as regulators that have the mandate to perform market oversight activities need to be aware of these new games that might occur to be able to detect them.

Second, we observed that the nodal wholesale market is more resistant to strategic behaviour and performs better than the other market sequencing options in our numerical example but can experience great distortions by the price-setter game of large strategic players. Besides that, we found no clear second best under the alternative market sequences as their relative performance is sensitive to the market structure and dependent on the analysed power system. These findings are of practical relevance for the debate on integrating distribution network constraints in the current sequence of electricity markets and show the importance of examining the impact of flexibility markets on other markets.

5.2 Recommendation: market power remedies

As shown in the previous section, the integration of flexibility market can bring market power concerns. Although there can be risks associated with these games, market players should not be restricted from having access to essential information to perform flexibility services. As a solution, this section presents three remedies that regulators can use to minimise the impact of strategic behaviour triggered by flexibility markets.

- **Long-term flexibility contracts** are contracts in which the available flexibility of flexibility providers is reserved a long-time before the actual delivery of the flexibility to the DSO. As the reserved flexibility can no longer participate in other markets of the market sequence, games that anticipate the market sequence and arbitrage between different markets can be no longer be performed by flexibility providers.
- **Market supervision** can be performed by surveillance entities such as REMIT that analyse the outcomes of electricity markets to detect and penalise market manipulation by market participants. The possibility to be fined can motivate flexibility providers to refrain from strategic behaviour.
- **The use case of flexibility** can be narrowed from structural flexibility needs to temporary congestion needs. By reducing the frequency and predictability of the flexibility needs, the possibility of flexibility providers to anticipate the market sequence can be reduced.

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Annex I – Relevant tables from EUniversal D5.1[4]

Table 5.2 on page 110 of EUniversal D5.1 is referred to in Section 3.3 of this deliverable and describes the applicability of the six flexibility tools for acquiring grid services for congestion management and voltage control.

Table 5-2. Applicability of the mechanisms for acquiring grid services

	Flexible connection and access agreements	**Dynamic network tariffs**	**Local market**	**Bilateral contract**	**Cost-based**	**Obligation**
Congestion management (Active power)						
Voltage control (Reactive power)						

Legend:

Suitability	High	Weak	Low

Table 5.3 on page 111 of EUniversal D5.1 is referred to in Section 3.3 of this deliverable and describes the compatibility of each interaction between the six flexibility tools for acquiring grid services for congestion management.

Table 5-3. Compatibility of the mechanisms for acquiring congestion management – active power

	Flexible connection and access agreements	Dynamic network tariffs	Local flexibility markets	Bilateral contracts	Cost-based	Obligation
Flexible connection and access agreements						
Dynamic network tariffs						
Local flexibility markets						
Bilateral contracts						
Cost-based						

[4] Online available at https://euniversal.eu/wp-content/uploads/2021/02/EUniversal_D5.1.pdf

Table 5.4 on page 114 of EUniversal D5.1 is referred to in Section 3.3 of this deliverable and describes the compatibility of each interaction between the six flexibility tools for acquiring grid services for voltage control.

Table 5-4. Compatibility of the mechanisms for acquiring voltage control – reactive power

	Flexible connection and access agreements	Dynamic network tariffs	Local Flexibility markets	Bilateral contracts	Cost-based	Obligation
Flexible connection and access agreements						
Dynamic network tariffs						
Local flexibility markets						
Bilateral contracts						
Cost-based						

Annex II – Survey on regulatory sandboxes

EUniversal T10.2 FRAMEWORK REGULATORY SANDBOXES

Please included consulted sources and references at the end of the document

Analysed country:

1. **Who are eligible project promoters or project organisers? Are they DSOs, communities, companies, third parties, others?**

Answer based on regulation:

Here the answer based on regulation and current law of the analysed country can be given

Answer based on current practices:

Here the answer based on the analysed sandbox, an observed trend among existing sandboxes or non-written rules coming from current practices can be given

2. **What derogations are allowed, or which exemptions can be given? Are these derogations or exemptions targeted, pre-defined by a certain list or open for proposal by innovators?**

Answer based on regulation:

Answer based on current practices:

3. **Could the sandbox be used for applications of the EUniversal project? Could the derogations cover topics such as distribution tariffs, taxes and levies, distribution network management and planning, market-based flexibility procurement, others?**

Answer based on regulation:

Answer based on current practices:

4. **What is the length of the derogations? Are extensions possible?**

Answer based on regulation:

Answer based on current practices:

5. **Who is in charge of the administration of the experiment? Is this the regulator, the ministry of the country, both or others?**

Answer based on regulation:

Answer based on current practices:

6. **Does the sandbox receive any funding? How is this funding recovered?**

Answer based on regulation:

Answer based on current practices:

7. **How transparent is the sandbox? How often should the sandbox report and how? Is it through workshops, reports, others? Is this information publicly available, or private?**

Answer based on regulation:

Answer based on current practices:

Overview:

Eligible project promoters	Derogations (targeted/ menu/open)	Application EUniversal	Length of derogation	Administration	Funding (yes/no)	Transparency

Sources of consulted documents: