Regulatory sandboxes: do they speed up innovation in energy?

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Abstract

Regulatory sandboxes are generally seen as an important tool to make policy and regulation evolve with the changes in our energy system and to create an equal playing field for new technologies and business models that arise with the energy transition. Although an increasing number of legal frameworks on regulatory sandboxes are being implemented in Europe, the pioneers in the Netherlands decided to close their sandbox program. These contradictory events lead to questions about the potential of regulatory sandboxes to bring innovation to the European energy sector. This paper contributes to this discussion by examining the experiences with regulatory sandboxes in Austria, Belgium, France, Germany, Great Britain,

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the Netherlands, Norway and Spain. We compare approved sandbox projects based on their scope and regulatory derogations to identify areas of innovation and regulatory learning brought by regulatory sandboxes. We also examine the legal frameworks of the concerned countries to evaluate the interaction between the implementation of the framework and its potential to bring innovation. In this way, we develop best practices on the topics of regulatory sandboxes and their implementation frameworks.

Key words

Regulatory Sandboxes, Regulatory Experimentation, Energy Regulation, Innovation, Research and Development

1. Introduction

In order to reach the ambitious targets of the European Fit for 55 package and REPowerEU Plan, innovations in how we generate, transport, trade and consume energy will be needed (European Council, 2022; European Commission, 2022a). As most of these activities are regulated in the energy sector, policy and regulation must evolve with the changes in our energy system and create a level playing field for new technologies and business models. The European regulatory entities recognize regulatory sandboxes as an important tool for developing dynamic regulation (ACER & CEER, 2019; CEER, 2021). These regulatory sandboxes are one way of organizing regulatory experimentation, in which energy actors may propose innovative projects that currently face regulatory barriers. After approval of the sandbox project, regulatory derogations are granted such that these new technologies or business models can be tested in a real environment. In this way, regulatory sandboxes aim to foster innovation and inspire new regulations to support the energy transition.

Regulatory sandboxes have already been adopted all over the world in various regulated sectors such as energy, finance and telecommunications. Although we focus our analysis on regulatory sandboxes in the European power and gas sector, this does not exclude other countries and sectors from inspiring

innovation and regulatory learning on this matter. As shown in the timeline of Figure 1, we distinguish two implementation waves of regulatory sandboxes in the area of power and gas in Europe. The first wave in 2015 consisted of early movers, such as the Netherlands, Great Britain and Germany. The second wave in 2019 came with the development of regulatory sandboxes in Belgium, Norway, France, Austria and Spain, which is related to the implementation of the Clean Energy Package (European Commission, 2022b). In the coming years, we might see more countries picking up regulatory sandboxes with Article 15(2a) of the amendment of the Renewable Energy Directive (EU) 2018/2001 that is proposed as part of the REPowerEU Plan and promotes the use of regulatory experimentation (European Commission, 2022c). However, the continuous evolution of technologies and regulation might also be the end of some sandbox frameworks, such as the example of the Netherlands. With the consultation of the New Energy Law in December 2020, the Dutch Ministry decided to close the sandbox regulation on energy sharing to create a level playing field under the new Energy Law that will come with the implementation of energy communities (RVO, 2021a). Currently, no other topics are considered relevant to open a new framework of regulatory experiments. The fact that one of the pioneering countries has decided to end its sandbox framework raises questions about the effectiveness of regulatory sandboxes in speeding up innovation in the energy sector.

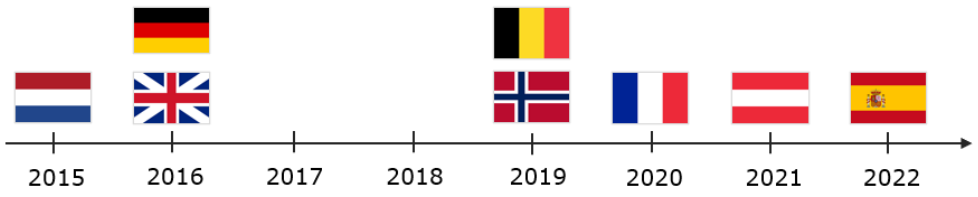

Figure 1: Implementation timeline of the examined frameworks on regulatory sandboxes.

The current academic literature on regulatory sandboxes in the European energy sector lacks conclusions to answer these questions and remains more descriptive on the possible topics and legal implementation frameworks of sandboxes. Lo Schiavo et al. (2013) describe the regulatory experimentation in Italy on

smart grids, smart metering and electromobility that was initiated in 2010. As the case of Italy can be seen as a regulatory pilot organized by the Italian regulator ARERA rather than an open framework for regulatory sandboxes, it is outside the scope of this paper. Other country-specific cases are analyzed in van der Waal et al. (2020), Veseli et al. (2021) and Brunekreeft et al. (2022). Using the concept of polycentricity, van der Waal et al. (2020) examine the dynamics between stakeholders of regulatory sandboxes in the Netherlands. Veseli et al. (2021) identify feasible topics for regulatory sandboxes in Austria based on the analysis of R&D projects and interviews with experts, and Brunekreeft et al. (2022) evaluate the SINTEG program in Germany based on interviews with experts and participants of the program. Other papers analyze and compare regulatory sandboxes in a collection of countries. Broeckx et al. (2019) discuss the examples of Great Britain, Germany and the Netherlands. The ISGAN (2019) casebook describes the different sandbox approaches of Australia, Austria, Germany, Italy, the Netherlands, the United Kingdom and the United States. Based on this analysis, ISGAN (2021) brings four policy messages on regulatory experimentation. Also Schneiders (2021) identifies practical limitations of regulatory sandboxes based on the experiences in Great Britain and the Netherlands and is the first to discuss the closure of the sandbox framework in the Netherlands. A comparison of the regulatory frameworks in the Netherlands, Great Britain and Italy was made by Schittekatte et al. (2021) using a six-dimension framework. An alternative framework to analyze regulatory experimentation based on the diverging approaches in Great Britain and Italy was proposed in Bovera & Lo Schiavo (2022) and used to divide worldwide experiences into three experimentation archetypes. Besides that, the report by Gangale et al. (2023) gives an overview of the main developments on regulatory experimentation in the EU Member States. Finally, several authors, such as Schittekatte et al. (2021) and Sunila & Ekroos (2022), discuss the need and potential of expanding regulatory sandboxes to European legislation.

This paper aims to complement the existing literature on regulatory sandboxes in the European energy sector by examining the outcomes of approved sandbox projects and identifying areas of innovation and

regulatory learning brought by these projects. An additional contribution is that we investigate the interaction between the design of the legal framework for regulatory sandboxes and its potential to bring innovation. Finally, we discuss the recent developments on regulatory sandboxes in Belgium, France, Norway and Spain, besides the European countries traditionally covered in academic literature, such as Austria, Germany, Great Britain and the Netherlands.

The remainder of this paper is organized into four parts. Section 2 introduces the legal frameworks for sandboxes in the eight examined countries. In Section 3, the potential of regulatory sandboxes is evaluated based on the outcomes of approved sandbox projects. Section 4 discusses how the implementation and design of regulatory sandboxes might influence its outcome. Finally, Section 5 summarizes the results and gives policy implications.

2. Overview of the examined sandboxes

A literature review using academic work and stakeholder reports was performed for the following eight European countries: Austria (AT), France (FR), Germany (DE), Great Britain (GB), the Netherlands (NL), Norway (NO), Spain (ES) and Belgium, in which the regions of Brussels (BR), Flanders (FL) and Wallonia (WA) were treated separately. In what follows, we introduce the sandbox frameworks of the examined countries using the chronological order of Figure 1 and two guiding questions: "Is the legal framework currently in place?" and "Have sandbox projects already been granted under the framework?". Table 1 summarizes our findings based on evidence collected until August 2022.

Dimension	**Yes**	**No**
Legal framework in place?	AT, BR, DE ('17-'22), ES, FL, FR, GB, NL ('15-'18), NO, WA	DE (>'22), NL (>'20)
Sandbox projects approved?	BR, FL, FR, GB, NL, NO, WA	AT, ES, DE

Table 1: Introduction of the examined legal frameworks on regulatory sandboxes.

In 2015, a legal framework for regulatory sandboxes called 'Experimenten Elektriciteitswet en Gaswet' was introduced in the Netherlands (RVO, 2022). The program focused on projects where participants

share electricity and/or operate the distribution network (RVO, 2021b). The government agency RVO approved 14 sandboxes between 2015 and 2018 (Lysias Advies, 2021). However, the Ministry decided to close the regulation in 2020 to create a level playing field under the new Energy Law that came with implementing a legal framework for energy communities (RVO, 2020). There is no ongoing consultation to open regulatory sandboxes to other topics and regulations.

Since 2016, innovation in the energy sector has been promoted in Germany and Great Britain. In Germany, the SINTEG funding program was developed to support real experiments on the energy transition (BMWi, 2016). While regulatory experimentation was outside the initial scope of this funding program, the SINTEG-V ordinance of 2017 allowed participants to request regulatory derogations to ensure the experiments could be tested in real environments (BMWi & SINTEG, 2017). With the evaluation of the SINTEG program, it became clear that no projects set up sandboxes under this amendment (Widl et al., 2022). In the meantime, the SINTEG-V ordinance expired, but funding programs to promote real experiments are still organized under the concept of Reallabore der Energiewende (BMWi, 2021). However, a general framework for regulatory derogations in the energy sector is currently not in place (BMWK, 2022). In Great Britain, the regulator Ofgem launched its Innovation Link at the end of 2016 and granted its first sandbox projects during the two application windows of 2017 (Ofgem, 2018a; Ofgem, 2018b). Since then, Ofgem has worked with over 350 innovators, of which several projects have received regulatory exemptions (Ofgem, 2020; Ofgem, 2021a).

In 2019, a legal framework for regulatory sandboxes came into force in Belgium and Norway. In the case of Belgium, the regulation was adopted at the regional level for Brussels, Flanders and Wallonia separately. Over the past years, projects considering energy communities have been approved in each region (Brugel, 2022a; Flemish Government, 2020; CWaPE, 2022c). The Norwegian regulator NVE-RME developed a framework for regulatory sandboxes after observing an increasing number of project proposals from different market participants in their remuneration program for innovative network

investments (NVE-RME, 2021a). Until October 2021, nine projects have been granted derogations, covering alternative tariff models, energy sharing, and flexibility services to DSOs and the TSO (NVE-RME, 2021b).

In 2020, a legal framework for regulatory sandboxes was introduced in France. Two project calls have been organized since the implementation of the legislation, which led to the approval of 27 projects by the French Regulator CRE and the Ministry for Energy and Climate DGEC (CRE, 2021a; CRE, 2022a).

As of 2021, a legal framework for regulatory sandboxes has been adopted in the Renewable Energy Package of Austria. This framework was implemented after the need for regulatory derogations was identified under the first call of the Energie.Frei.Raum funding program (AIT et al., 2020; Veseli et al., 2021). The second tender of the Energie.Frei.Raum aimed to promote innovation projects on network tariffs and market models for distributed energy resources. Approved projects can request regulatory derogations using the legal framework on regulatory sandboxes. Although the call closed in March 2022, details about the projects and the received derogations have not yet been published until August 2022 (FFG, 2022a).

In 2022, a framework for regulatory sandboxes was introduced in Spain by the Royal Decree of 568/2022 (MITECO, 2022). Since the implementation of the framework, no sandboxes have been approved until August 2022.

3. Evaluation based on the outcomes of approved regulatory sandboxes

In this section, we evaluate whether regulatory sandboxes bring innovation by looking at the use cases and derogations of existing regulatory sandboxes. We first discuss the methodology used to classify the sandboxes projects, then describe each category in more detail.

3.1. Methodology

We analyzed 72 sandbox projects[1] approved under the legal frameworks of Brussels, Flanders, France, Great Britain, the Netherlands, Norway, and Wallonia. Austria, Germany, and Spain were not included in our analysis as no sandboxes have been granted until August 2022. The projects were analyzed using the inductive thematic approach described by Gioia et al. (2013) and widely applied in qualitative studies. A recent example of another study in energy that applies this method is Mignon & Winberg (2023). This method provides a systematic approach to develop new concepts from qualitative data sources using first-order concepts, second-order themes, and aggregated dimensions. Next, we explain how we applied these elements to the list of approved sandbox projects.

The first step generates first-order concepts of the research data and aims to collect information about the sandbox projects without defining them into categories. The first-order concepts adopted in our analysis are one-sentence summaries of the project's aim and granted derogations. The second step produces second-order themes by aggregating the first-order concepts into larger groups of well-defined research concepts. In our analysis, we selected keywords from the one-sentence summaries of the sandbox topics. These keywords described technologies and activities commonly used in literature on energy transition, such as synthetic methane, energy communities, and dynamic network tariffs. The final step refines the generated second-order themes into aggregated dimensions. In our analysis, the sandbox projects were grouped considering similarities in their second-order keywords and granted regulatory derogations. This action led to five categories of approved sandbox projects: local energy, flex participation in electricity markets, distribution network tariffs, connection to electricity networks, and connection to gas networks. To illustrate the diversity of innovations within each aggregated dimension, subcategories were also defined for each category.

[1] We examined 6 projects in Brussels (Brugel, 2022a), 1 project in Flanders (Flemish Government, 2020), 27 projects in France (CRE, 2022a; CRE, 2022b), 11 projects in Great Britain (Ofgem, 2018a; Ofgem, 2018b; Ofgem, 2021a), 14 projects in the Netherlands (RVO, 2020; Lysias Advies, 2021; van de Waal et al., 2020), 8 projects in Norway (NVE-RME, 2021b) and 5 projects in Wallonia (CWaPE, 2022c).

An overview of the analyzed projects, first-order concepts and second-order themes can be found in the Appendix. Table 2 gives an overview of the (sub)categories, geographical scope, and number of examined sandbox projects. Next, we summarize the main characteristics of each category and describe the most prominent project examples.

Category	**Country (number of projects)**
Local energy	
• Energy sharing, collective self-consumption, and energy communities	BR (6), FL (1), GB (2), NO (1), WA (2)
• Energy sharing, including dynamic network tariffs	WA (3), NL (5), NO (1)
• Energy sharing, including dynamic network tariffs and network operation	NL (9)
• Peer-to-peer trading	GB (5)
• Consumer rights in microgrids	GB (1)
Flex participation in electricity markets	
• Wholesale markets	FR (1)
• Balancing markets	GB (2), FR (1), NO (3)
Distribution network tariffs	
• Alternative grid connection charges	GB (1)
• Dynamic network usage tariffs	FR (1), NO (3)
Connection to electricity networks	
• Technical solutions	FR (2)
• Flexibility solutions	FR (4)
Connection to gas networks	
• Synthetic methane	FR (17)
• Flexibility solutions	FR (1)

Table 2: Summary of the aim, geographical scope, and number of approved regulatory sandboxes.

3.2. Category 1: Local energy

The category local energy considers all sandbox projects that enable energy sharing between local grid users. As shown by the subcategories of Table 2, local energy can be traded in various ways, such as energy communities, collective self-consumption and peer-to-peer platforms. Besides, local energy projects are often combined with experiments on dynamic distribution tariffs and network operation by grid users. In total, 36 projects on local energy were approved in Belgium, the Netherlands, Great Britain, and Norway, covering half of the examined projects. All sandboxes received similar regulatory derogations, such as exemptions from metering and invoicing rules, network tariff rules, supplier rules and DSO governance

rules. Regulators can use the outcomes of these sandboxes as input for the national or regional implementation of (renewable) energy communities. As similar innovations and derogations are tested in the analyzed countries, the learning from these sandboxes might also be relevant for European countries that currently do not have a sandbox framework. Finally, three types of sandbox projects were selected to illustrate this category: the granted sandboxes in Brussels, the approved projects in the Netherlands and the Emergent sandbox in Great Britain.

In Brussels, six regulatory sandboxes on energy communities have been accepted until August 2022 (Brugel, 2022a). All projects aim to test new concepts on (renewable) energy sharing between nearby network users and examine alternative methodologies for invoicing network tariffs. In two projects, new tools to optimize the self-consumption rate of participants are also examined. To achieve this, regulatory exemptions regarding the responsibilities of suppliers, the methodology of distribution network and smart meter tariffs, the metering rules of DSOs and the prohibition of DSOs from being involved in activities related to electricity production were required.

In the Netherlands, two types of sandboxes were granted between 2015-2018: 'big experiments' and 'network projects' (RVO, 2020; Lysias Advies, 2021; van de Waal et al., 2020). The framework allows participants to share energy, balance the electricity grid through peak shaving and test dynamic electricity tariffs. In 'network projects' project promoters could also operate the network. Depending on the project's needs, participants received derogations from the prohibition of performing DSO tasks, the obligation to have a supplier permit, the rules regarding metering device requirements and data processing, the methodology to determine grid tariffs, and the rules regarding transparency and liquidity of the energy market.

In Great Britain, Emergent Energy Systems was awarded a regulatory sandbox to give the residents of their microgrids the possibility to switch electricity suppliers (Ofgem, 2022b). To achieve this, derogations

were required on the metering of premises and the metered data submission into settlement such that the participants' energy suppliers could settle the correct amount of electricity without entering bilateral arrangements with all other suppliers operating on the site.

3.3. Category 2: Flex participation in electricity markets

The category flex participation in electricity markets refers to all sandboxes exploring alternative business models and market designs to foster the participation of flexibility in wholesale and balancing markets. We find that these sandboxes occur in France, Great Britain and Norway. Although there is a clear trend in the type of innovation, we observe that different regulatory derogations to market rules and TSO responsibilities are needed to develop the projects in the analyzed countries. To illustrate this, three projects are described in more detail: the EDF sandbox in France, the Centrica sandbox in Great Britain, and the NorFlex project in Norway.

In France, the utility company EDF was granted a sandbox to explore the business model of a battery storage (CRE, 2021a). The project aims to combine the battery with a production source for primary frequency reserve provision, aggregate the same battery with other assets to provide secondary frequency reserves and switch the use of the battery between the two services. To achieve this, exemptions were required to allow EDF to combine the battery and production sources as one frequency service provider and to aggregate the battery with two separate production sources that provide different ancillary services.

In Great Britain, the Centrica sandbox (Ofgem, 2022a) aims to enable greater participation in balancing markets from customers that are currently not half-hourly settled and may not have access to half-hour settlement soon. To achieve this, Centrica Business Solutions received several derogations from the Balancing and Settlement Code on the classification and registration of metering systems, the allocation of supplier volumes, and the aggregation of half-hourly data.

In Norway, the TSO Statnett SF has two sandbox projects running on the participation of distributed energy resources in balancing markets (NVE-RME, 2021b). In the NorFlex project (NVE-RME, 2021c), Statnett SF collaborates with Agder Energi, Glitre Energi and NODES to access distributed energy resources for manual Frequency Restoration Reserve services through a shared flexibility market with the DSO. However, reaching the minimum bid quantity of this service using aggregated distributed energy sources is often challenging. Therefore, an exemption was required to the guidelines and responsibilities for TSOs regarding the minimum bid quantity.

3.4. Category 3: Distribution network tariffs

The category distribution network tariffs covers all sandbox projects exploring alternative grid connection charges and dynamic network usage tariffs to improve distribution network operation and give signals to network users. We find regulatory sandboxes on alternative grid connection charges in Great Britain and dynamic distribution usage tariffs in France and Norway. Although different innovations on network tariffs are tested, the analyzed projects required similar exemptions: the consent to deviate from regulated tariffing methodologies. This derogation indicates a clear understanding of the regulatory changes required to promote innovation in network tariffing. However, it is still an open discussion of how this innovation is best achieved (e.g., through alternative types of connection or usage charges methodologies). Two sandbox projects were selected to illustrate this category: the Charge Collective trial in Great Britain, and the Aktive Hjem sandbox in Norway.

In Great Britain, the Charge Collective trial (Ofgem, 2021b) by London Power Networks (LPN) and Eastern Power Networks (EPN) aims to examine new connection charges for electric vehicle charging points based on price-point discovery mechanisms. LPN and EPN proposed this innovative methodology to react to the recent measures taken to attract investors of public electric vehicle charging points. Due to these measures, DSOs were fully responsible for the connection costs of these new charging points instead of

sharing the costs with the charge point investors. For the implementation of the sandbox, LPN and EPN received derogations on the connection charging methodology of the Electricity Distribution License.

In Norway, the Aktive Hjem sandbox (NVE-RME, 2020) by the DSO Elvia aims to examine dynamic distribution network tariffs. In this way, customers get the opportunity to influence their grid rent and contribute to an optimal utilization of the electricity grid. The tariff structure consists of a fixed component in combination with an energy component that varies between the season and time. To implement this, Elvia received derogations to charge time-differentiated components in the distribution tariffs and differentiate tariffs between network users.

3.5. Category 4: Connection to electricity networks

The category connection to electricity networks covers all projects experimenting with technical and flexible solutions to connect new users to the distribution network or extend the capacity of existing distribution network users. All projects in this category were granted in France and required similar derogations for each subcategory. Projects using technical solutions required derogations to the technical connection documentation of distribution grids, and projects with flexibility solutions were granted derogations on the design and operating requirements of distribution network connections. To illustrate this category, two projects are described in more detail: the Amarenco project and the Boralex sandbox.

In France, the Amarenco project (CRE, 2022a) aims to optimize the connection of battery storage. In the connection studies of Enedis, it is assumed that this battery must be able to inject a power equal to its connection power at all times. As this assumption does not capture the countercyclical nature of storage, Amarenco requests Enedis to conduct connection studies based on hypotheses of Amarenco's operating curves. To achieve this, the French regulator CRE granted Enedis to derogate from its technical connection documentation.

In France, the Boralex sandbox (CRE, 2022b) seeks to increase the output of two wind farms above the maximum allowed connection capacity to the distribution network using curtailment measures to ensure the injected capacity remains within the required connection limits. To achieve this, derogations from the technical design and operating requirements for connecting to the distribution grids of Enedis were required.

3.6. Category 5: Connection to gas networks

The last category covers innovative projects connecting new production plants to the gas network. We found that regulatory sandboxes in the gas sector are currently dominated by projects considering synthetic gas injection and production in France. Policymakers might learn from sandboxes to reduce the current regulatory barriers to these projects. However, the overall impact of regulatory sandboxes on innovation in the gas sector might be limited as the approved projects are currently restricted in geographical and technical scope. Next, we describe the projects on synthetic gas in France in more detail. Besides that, we explain the SEM Energie Mayenne project, which considers the flexible connection of a biomethane plant in France and therefore illustrates an alternative way for regulatory sandboxes to bring innovation to the gas sector.

In France, 17 projects on synthetic gas production and injection have been approved under the first two calls for regulatory sandboxes (CRE, 2021a; CRE, 2022a). The reason for this is the current legal framework on gas injection into the gas network that only considers the recent developments in biomethane and does not explicitly include other gases such as synthetic methane gas. Therefore, all projects on other gases require derogations to the Energy Code to allow the connection of the project developer, the analysis of the quality of the gas produced and the injection of the gas by the project developer, provided that the feasibility of injecting synthesis gas containing hydrogen residues is proven.

In France, the SEM Energie Mayenne project (CRE, 2022a) aims to provide flexibility services with a compressed natural gas station to the public gas network such that the injection of biomethane can be developed without causing additional network investments. To achieve this, derogations from the network operator's obligation to fully reinforce the network to connect this biogas plant are needed. Besides that, the sandbox is required as currently, no legal, technical, contractual or financial frameworks exist for implementing flexibility solutions in the gas sector.

4. Evaluation based on the implementation framework of regulatory sandboxes

This section examines whether the implementation framework of regulatory sandboxes impacts the potential of these sandboxes to bring innovation. We first discuss the methodology used to analyze the implementation frameworks, then describe the dimensions of these frameworks in more detail.

4.1. Methodology

We examine the implementation frameworks on regulatory sandboxes in Austria, Brussels, Flanders, France, Germany, Great Britain, the Netherlands, Norway, Spain, and Wallonia. It must be noted that we discuss the legal framework of the Netherlands that was in place before its abolishment, and the SINTEG-V ordinance of Germany that allowed projects of the SINTEG funding program to request regulatory derogations. We use the framework of Schittekatte et al. (2021) to evaluate the implementation choices in each country. This framework considers the following six dimensions: eligible project promoters, administration, derogations, length of derogations, public funding and transparency. Based on the results of our regulatory analysis, we included one additional dimension considering the application process of the sandbox. Table 3 summarizes the implementation choices of the analyzed countries for each dimension of the regulatory framework and the lessons learned from this design choice. Next, we describe the findings for each dimension in more detail.

Dimension	Yes	No	Lessons learned
Can everyone apply?	BR, DE, FL, FR, GB, NO, WA	AT, ES, NL	• Most countries allow everyone to apply • Countries that limit who can apply typically adopt broad definitions, so eligibility has not really been an issue (except for the Netherlands, where DSOs were initially excluded but wanted to participate)
Regulator administers (with Ministry)?	BR, GB, NO, WA (AT, DE, ES, FR, NL)	FL	• If the ministry is not involved, it limits the scope of the sandbox (the approved sandboxes in France illustrate this point) • If the regulator is not involved, it limits regulatory learning (in Flanders, the regulator is not formally involved but informally consulted)
Possible derogations specified?	AT, FL, FR, NL	BR, DE, ES, GB, NO, WA	• Specifying derogations might restrict innovators • Not specifying derogations might still restrict innovators to certain sectors or national competencies of the administrator (in Norway and Spain, sandboxes are limited to the power sector) • In both cases, innovators need regulatory advice to identify regulatory barriers (which was one of the main learnings of the sandbox calls in France and Great Britain)
Dedicated call?	AT, DE, ES, FR, NL, GB (<2020)	BR, FL, NO, WA, GB (>2020)	• Dedicated calls allow regulators to highlight areas for regulatory learning but require updates to remain relevant (an example is the abolishment of the sandbox framework in the Netherlands) • Not having dedicated calls allows innovators to apply at times of need (which was the main reason for ending dedicated calls in Great Britain)
Length of derogations longer than 5 years, including extensions?	FL, FR, NL	AT, BR, GB, NO, WA	• Most countries keep the length of derogations down to 5 years • Some countries allow for longer derogations periods (an example is the Netherlands, where projects of 10-20 years were granted) • In both cases, the maximum length of derogations might not be given in practice (the approved sandboxes in Flanders and Wallonia illustrate this point)
Related to funding program?	AT, DE	ES, FL, FR, GB, NL, NO	• Most countries do not have a funding program related to sandboxes but allow external funding sources (in Norway, network companies can request revenue regulations to set up sandboxes) • Funding programs can be used as a call for interest for regulatory sandboxes (in Austria this led to the development of a general sandbox framework, in Germany this is not yet the case)
Public report at the end of the project?	BR, ES, FL, FR, GB, NL, NO, WA	-	• Most countries have public reporting obligations for finished projects • Although these obligations exist, they might not be met in practice (in the Netherlands, non-consistent reporting was observed when evaluating the sandbox program)

Table 3: Summary of the dimensions, national design choices and lessons learned from sandbox frameworks. Countries are not included when the dimension is not specified in the framework.

4.2. Dimension 1: Eligible project promoters

Eligible project promoters are all parties that might propose and organize a regulatory sandbox. Typically, project promoters can be (1) open to all parties or (2) restricted to a certain definition.

First, no definition of eligible project promoters is given in the case of Brussels (Brugel, 2019), Flanders (Flemish Government, 2019), France (CRE, 2020), Germany (BMWi & SINTEG, 2017), Great Britain (Ofgem, 2020), Norway (NVE-RME, 2021a) and Wallonia (CWaPE, 2022a).

Second, the definition of eligible project promoters is restricted in the case of Austria, the Netherlands and Spain. In Austria, project promoters can be companies of any legal form, research institutions, and other non-commercial institutions (FFG, 2022b). In the Netherlands, several detailed restrictions to project promoters are defined, and overall, the scope of project promoters is limited to homeowner's associations and energy communities (Staatsblad van het Koninkrijk der Nederlanden, 2015). Finally, eligible project promoters in Spain are limited to the lists of the Spanish Electricity Law 24/2013 (Spanish Government, 2013) and the European Directive 2019/944 (MITECO, 2022). This restriction implies, for example, that research institutions may not apply for a regulatory sandbox as they are not considered agents of the electricity system.

We find that in most cases, no restrictions on the eligibility of project promoters are defined, and sandboxes are open to all parties. Even when a definition is given, this is often kept very broad such that eligibility is generally not an issue. Only in the case of the Netherlands eligible project promoters were adapted to the objective of the regulatory sandbox, initially excluding some stakeholders that wanted to participate, such as DSOs (Staatsblad van het Koninkrijk der Nederlanden, 2015).

4.3. Dimension 2: Administration

The dimension administration describes who takes care of the application procedure, approval, monitoring and evaluation of the regulatory sandboxes. The responsibility of the administration of the regulatory sandboxes falls typically under (1) the regulator, (2) the Ministry, or (3) both.

First, the role of the administrator of the regulatory sandbox program is taken up entirely by the regulator in the case of Brussels (Brugel, 2022b), Great Britain (Ofgem, 2022c), Norway (NVE-RME, 2021a) and Wallonia (CwaPE, 2022c). It is interesting to note that the British regulator Ofgem cooperates with industry to grant derogations from the Balancing and Settlement Code and the Distribution Connection and Use of System Agreement (Ofgem, 2020).

Second, the Ministry administrates regulatory sandboxes in Flanders. More specifically, the Flemish Energy and Climate Agency VEKA is responsible for the regulatory sandbox program, and the Flemish regulator VREG is only consulted in specific cases (Flemish Government, 2019).

Third, administration tasks are divided between the regulator and the Ministry in Austria, France, Germany, the Netherlands and Spain. In Austria, the following roles are foreseen: the Federal Ministry BMK is the program owner and responsible for providing funding, the funding agency FFG is the program and funding manager and performs the selection of the projects, and the regulator E-Control is involved in the approval of the projects within the sandbox framework (AIT et al., 2020). In France, the regulator CRE is in charge of the sandbox program, but the approval of the sandboxes and the division of the project monitoring tasks are divided by the regulator and the Ministry DGEC on a case-by-case basis (CRE, 2021a; CRE, 2022a). In Germany, the German Ministry BMWi is the main administrator of the SINTEG program, and the German Regulator Bundesnetzagentur helps to evaluate the projects on regulatory exemptions (BMWi & SINTEG, 2017). In the Netherlands, the government agency organizes the sandbox program, and the regulator ACM takes up the advisory and monitoring role (van der Waal et al., 2020; Schittekatte et al., 2021). In Spain, the Ministry for the Ecological Transition and the Demographic Challenge MITECO is responsible for organizing the call for regulatory sandboxes. Later, the Secretary of State for Energy and the Spanish regulator CNMC will evaluate the requests depending on the nature of the regulatory exemptions requested (MITECO, 2022)

Our analysis indicates that the administration of regulatory sandboxes is typically adopted by the regulator or the regulator together with the Ministry. Depending on who takes up the administrator role, the sandbox framework might bring different opportunities for innovation and regulatory learning. If the Ministry is not involved, this can limit the scope of the sandboxes. An example is the case of France, where the Ministry was required to approve sandboxes on flexible network connections and synthetic methane injections (CRE, 2021a; CRE, 2022a). If the regulator is not involved in the sandbox administration, the regulatory learning from sandbox projects might be reduced. An example is Flanders, where the regulator is not formally involved but is informally consulted (Flemish Government, 2019).

4.4. Dimension 3: Derogations

Derogations reflect the regulatory exemptions that can be given to the sandbox projects. Typically, derogations are (1) undefined or (2) targeted to a specific list of regulations.

First, the regulatory derogations that can be granted under regulatory sandboxes are not specified in the sandbox frameworks of Brussels (Brugel, 2019), Germany (BMWi & SINTEG, 2017), Great Britain (Ofgem, 2022), Norway (RVE-RME, 2021a), Spain (MITECO, 2022) and Wallonia (CWaPE, 2022a).

Second, a specific list of regulations is targeted in the case of Austria, Flanders, France and the Netherlands. The second call on regulatory sandboxes in Austria focuses on projects regarding grid tariffs, system integration and market models of renewable energy, storage and energy efficiency technologies (FFG, 2021). In Flanders, the list of regulations to which exemptions can be granted is defined in the Energy Decree (Flemish Government, 2018). Also in France, each call for regulatory sandboxes specified a list in the Climate Energy Law to which derogations can be granted (CRE, 2020). Finally, in the Netherlands, exemptions in regulation regarding innovation in energy communities and homeowner's associations were targeted. (Lysias Advies, 2021).

We find that most sandbox frameworks do not specify which derogations can be granted to sandbox projects. Although the derogations that fall under the sandbox program are undefined, the allowed regulatory derogations might still be limited as they can be restricted to certain sectors, do not apply to European legislation and are strongly related to the responsibilities of the administrator(s) of the program. Examples are the sandboxes in Norway and Spain, which are open but limited to the power sector (RVE-RME, 2021a; MITECO, 2022). Besides that, it can be challenging for sandbox applicants to identify the regulatory barriers of their project, independent of whether derogations are specified or not. This need for regulatory advice was one of the main lessons learned in the first call for sandboxes in France and Great Britain (CRE, 2021b; Ofgem, 2018c).

4.5. Dimension 4: Application process

The application process describes when and how project promoters can submit a sandbox project to the administrator. When examining the submission of regulatory sandboxes among the countries, we observe that this is typically organized (1) continuously or (2) within a dedicated call.

First, projects can be continuously submitted in Brussels (Brugel, 2022b), Flanders (Flemish Government, 2019), Great Britain, Norway (NVE-RME, 2021a) and Wallonia (CWaPE, 2022c). In Great Britain, it is only since the refreshed Energy Regulation Sandbox in July 2020 that applications can be submitted at any time (Ofgem, 2020). Initially, sandboxes were organized in dedicated application windows, such as the two first windows set up in 2017 (Ofgem, 2018a; Ofgem, 2018b).

Second, regulatory sandboxes are organized in dedicated calls in the case of Austria, France, Germany, the Netherlands and Spain. Under the Energie.Frau.Raum in Austria, two calls have already been organized: the first call in 2019 aimed to define the scope and potential of sandboxes, and the second call in 2021 intends to grant the first projects (FFG, 2022c). The French regulator CRE has already closed two calls for regulatory sandboxes in 2021 and 2022, each attracting around 40 applications (CRE, 2021a; CRE,

2022a). In Germany, regulatory derogations could be granted to projects of the SINTEG innovation program (BMWi & SINTEG, 2017). During the regulatory experimentation in the Netherlands, yearly calls were organized from 2015 until 2018 (RVO, 2022). Finally, calls for regulatory sandboxes will be scheduled in Spain (MITECO, 2022).

Our analysis shows that continuous applications and dedicated calls occur equally in the analyzed countries. There are two lessons learned from organizing sandboxes in dedicated calls. First, dedicated calls typically introduce a regulatory theme in the sandbox invitation. Although this approach might foster regulatory learning, it requires regular updates of the regulatory framework by the administrator. An example of this is the case of the Netherlands, where the Ministry decided to close the regulation on sandboxes with the consultation of the New Energy Law instead of broadening the sandbox program to other areas (RVO, 2021a). Second, dedicated calls might rush innovators into applications, which was the main reason for ending dedicated calls in Great Britain (Ofgem, 2020).

4.6. Dimension 5: Length of derogation

The length of derogation represents the maximum number of years that regulatory exemptions will be given to the granted sandbox projects. This is defined by two parameters: the maximum length of the initial project and the possibility of having an extension. Typically, the total duration of the derogations can be (1) up to five years or (2) longer than five years. Here, it must be noted that Germany is not considered as the answer was unclear from regulation. Spain is not yet included as the maximum duration will only be specified during future calls.

First, derogations can last up to five years in the case of Austria, Brussels, Great Britain, Norway and Wallonia. In Austria, the maximum length of the derogations is three years and no details on further continuations seem to be provided (FFG, 2022b). In Brussels, the typical duration of a sandbox project is two years and an extension of another two years may be requested (Brugel, 2019). Also in Great Britain,

the derogations granted under the sandbox can last a maximum of two years (Ofgem, 2020). In Norway, the duration of the regulatory sandboxes is one to three years in most cases, with a maximum of five years (RVE-RME, 2021a). Finally, the maximum length of a project in Wallonia is five years (CWaPE, 2022a).

Second, regulatory sandboxes can close after more than five years in Flanders, the Netherlands and France. In Flanders, the maximum length of derogations is ten years, with a possible extension of another five years (Flemish Government, 2019). In the Netherlands, the default duration of the derogations granted under the sandboxes between 2015 and 2018 was ten years, with two exemptions of 15 and 20 years (Lysias Advies, 2021). Besides that, exemptions in France can be provided for four years and extended once more under the same conditions (CRE, 2020).

We find that the initial length of the sandbox projects is typically shorter than five years, but extensions can be given. In exceptional cases like Flanders and the Netherlands, regulatory derogations of ten years are allowed. Still, the maximum allowed project duration might not be granted in practice. An example is the sandbox in Flanders that received five years of derogations while applying for the maximum of ten years (Flemish Government, 2020). Also in Wallonia, the length of derogations is typically shorter than three years instead of the maximum of five years (CWaPE, 2022a).

4.7. Dimension 6: Funding

Funding reflects to what extent projects can use public financing to develop the regulatory sandbox. When looking at the funding of the sandbox projects, we found that (1) funding cannot be included in the initial scope of the sandbox process or (2) sandboxes can be related to innovation funding programs. Brussels and Wallonia are outside the scope of this analysis as it was unclear from the regulation whether a funding process is in place or not.

First, funding is not included in the initial scope of the sandbox process in Flanders (Flemish Government, 2020), France (CRE, 2020), Great Britain (Ofgem, 2020), the Netherlands (Lysias Advies, 2021), Norway

(NVE-RME, 2021b), and Spain (MITECO, 2022). However, in all cases, projects are allowed to facilitate financing through other channels.

Second, sandboxes are related to innovation funding programs in Austria and Germany. In the second call for regulatory sandboxes of the Energie.Frau.Raum in Austria, €4.6 million is made available by the Federal Ministry BMK and managed by the Funding Agency FFG (FFG, 2021). Besides that, regulatory derogations in Germany could only be requested by projects of the SINTEG funding program (BMWi & SINTEG, 2017).

Our analysis shows that, in most analyzed countries, regulatory sandboxes are not related to an innovation funding program. However, projects are typically allowed to use external funding sources. An example is Norway, where network companies can request revenue regulations for sandbox projects (NVE-RME, 2021b). Besides that, funding programs can be used to explore the interest of innovators for regulatory sandboxes. An example is the Energie.Frei.Raum in Austria that resulted in a legal implementation of a sandbox framework (AIT et al., 2020). A counterexample is the case of Germany, where regulatory derogations were allowed under the SINTEG funding program, but a general sandbox framework in the energy sector is not yet developed (BMWi & SINTEG, 2017; BMWK, 2022).

4.8. Dimension 7: Transparency and reporting

Transparency and reporting describe how the progress and results of regulatory sandboxes are shared with the administrator and made publicly available. We found that all countries have mechanisms for interim reporting in place, and a public report will be made available at the end of the project. Only in the case of Austria, it was unclear from the regulation what type of reporting mechanism is currently present.

In Brussels, project promoters must report every six months to the regional regulator Brugel and provide a final report with the conclusions and learned lessons, which will be published on the website of Brugel (Brugel, 2019). In Flanders, sandbox projects must annually report to the Minister on the progress and results of the project. Besides that, a final report with conclusions and policy recommendations will be

published on the website of the Flemish government (Flemish Government, 2019). Also in France, projects must send yearly progress reports and a final evaluation report to the French regulator CRE. The CRE will publish this final report as part of its annual report on the sandbox program (CRE, 2020). In Germany, a final report is made available on the website of the Ministry at the end of each research project of the SINTEG program (BMWi & SINTEG, 2021). Innovators in Great Britain have to report their progress at the most quarterly or at a frequency that reflects the trial's objectives and arrangements. Besides that, a final report containing the experiences and insights of the project will be published by Ofgem (Ofgem, 2020). In the Netherlands, projects must submit a progress report every January. Only for the sandboxes granted in 2018, it is explicitly stated that the final document will be publicly available (RVO, 2020). In Norway, a final report with the project's results will be made available on the website of the NVE-RME to encourage the dissemination of knowledge from the pilot projects. The regulator might request periodic reporting, but this depends from project to project (NVE-RME, 2019; NVE-RME, 2020; NVE-RME, 2021a; NVE-RME, 2021c). A steering committee will continuously evaluate sandbox projects in Wallonia, and a final report will be made available on the CWaPE website at the end of the project (CWaPE, 2022a). Intermediate reporting is only required for some sandbox projects, especially if the project consists of different phases (CWaPE, 2020; CWaPE, 2022b). Finally, project promoters in Spain will send a final report to the Secretary of State for Energy within three months after the completion of the project. The publication of the results is negotiated in the sandbox agreement, but the main finding will at least be integrated into an annual report on regulatory innovation in the electricity sector by the Secretary of State for Energy (MITECO, 2022).

We find that most countries have public reporting obligations in place for finished projects. Although these reporting obligations exist, they might be challenging to complete in practice. For example, Lysias Advies (2021) states that reporting regulatory sandboxes in the Netherlands was not always complete, and various levels of detail could be observed between the different projects. This made it difficult for the

RVO to compare the projects and evaluate the sandbox program (Lysias Advies, 2021). As a result, some innovations possible under the sandbox program were not translated to all energy communities under the new Energy law, as adequate regulatory learnings on these innovations were missing.

5. Conclusion and policy implications

Regulatory sandboxes are seen as an essential tool to foster innovation and regulatory learning during the energy transition. While legal frameworks for regulatory sandboxes are increasingly introduced in Europe, the pioneers in the Netherlands are closing their sandbox program. These diverging events indicate the need for a thorough evaluation of the current legal frameworks for regulatory sandboxes. Do regulatory sandboxes really speed up innovation? We contribute to this discussion by evaluating the outcomes of existing sandbox projects and examining the interaction between the design of the legal framework for regulatory sandboxes and its potential to bring innovation. We include Belgium, France, Norway and Spain in our analysis, besides the European countries that are generally discussed in regulatory sandboxes.

We examined 72 existing sandbox projects in Brussels, Flanders, France, Great Britain, the Netherlands, Norway and Wallonia. Using an inductive thematic approach, we divided these projects into five main categories of innovation: local energy, flex participation in electricity markets, distribution network tariffs, connections to electricity networks and connections to gas networks. These categories provide a clear view of the advancements achieved by current sandbox projects and reinforce the idea that sandboxes are an effective instrument for fostering innovation.

We also compared the legislation on regulatory sandboxes in Austria, Brussels, Flanders, France, Germany, Great Britain, the Netherlands, Norway, Spain and Wallonia. Using a 7-dimensional framework, we came to the following two conclusions. First, the entity responsible for the administration of the sandbox program and the derogations that can be granted to sandbox projects are the most important parameters when designing a sandbox framework, as they directly impact the potential for regulatory learning and

the scope of sandbox projects. Second, our analysis indicates that the application process and the reporting of the lessons learned also influence the performance of the sandbox framework. While a call-based application process allows regulators to highlight regulatory themes, it can rush innovators into applications. Furthermore, even though reporting obligations are typically included in sandbox frameworks, effective implementation in practice is essential for both technical and regulatory learning to occur.

We identified two policy implications. First, the outcomes of existing sandbox projects validate the idea of using regulatory sandboxes to promote innovation under the REPowerEU Plan and indicate important areas for future regulatory learning. More specifically, the projects on synthetic methane injection in the gas network illustrate that sandboxes can promote the diversification of the gas sector. The projects on flexible connections to the electricity network show that regulatory derogations can accelerate the rollout of renewables. Second, to promote innovation and regulatory learning, it is important to make the regulatory scope of the sandboxes as open as possible while keeping it tangible for project applicants. Best practices found in the analyzed regulatory frameworks are twofold: including multiple regulatory entities in the administration process and having an open approach towards regulatory derogations while providing regulatory advice to sandbox applicants. Besides that, administrators should continuously evaluate and update the sandbox program, especially if they organize dedicated calls.

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Appendix

Table 4 gives an overview of approved sandbox projects and inductive thematic approach of Section 3.

Category 1: Local energy		
Subcategory 1.1: Energy sharing, collective self-consumption, and energy communities		
Name (country) duration	Project summary, *with keywords in italic*	Granted regulatory derogations
1. Marius Renard (BR) 21/12/2021-20/12/2023	*Share electricity* from a *cogeneration* plant in the same building and test new concepts of *metering and billing* network tariffs.	Derogations from supplier obligations, present distribution network tariffs, smart meter installation tariffs, billing and metering rules of tariffs.
2. SunSud (BR) 21/12/2021-20/12/2023	*Share solar energy* within a building with social housing and test new concepts in terms of *metering and billing* network tariffs.	Derogations from supplier obligations, present distribution network tariffs, smart meter installation tariffs, billing and metering rules of tariffs.
3. HG Stockel Energy (BR) 29/03/2022-28/03/2024	*Share solar energy* within the same building and test new concepts in terms of *metering and billing* network tariffs.	Derogations from supplier obligations, present distribution network tariffs, smart meter installation tariffs, billing and metering rules of tariffs.
4. ThorPark (FL) 07/02/2020-06/02/2025	*Share energy* between the buildings on the of an industrial site.	Derogations from supplier responsibilities.
5. MikroFlex (NO) 31/10/2019-01/04/2024	*Sharing surplus energy* from self-produced electricity between residents on the same farm and farm number.	Derogations to the definition of a plus consumer beyond the connection point, from billing and metering rules of distribution network tariffs.
6. MéryGrid (WA) 01/03/2019-28/02/2021	Test *energy management system* to improve *collective self-consumption* in a *community* with industry, generation, *batteries.*	Derogations from billing and metering rules of distribution network tariffs.
7. Cannock Chase (GB)	Maximise the participant's benefits by optimizing the *time-of-use retail tariffs*, the *self-consumption* rate of *solar* energy using *storage*, and providing *balancing and flexibility services*.	Unclear from project description.
8. Trent Basin (GB)	Maximise participant's benefits by optimizing the self-consumption rate of solar energy using storage.	Unclear from project description.
9. Tour&Taxis Energy (BR) 29/03/2022-28/03/2024	*Share solar energy* within the same building and test new concepts in terms of *metering and billing* network tariffs.	Derogations from supplier obligations, present distribution network tariffs, smart meter installation tariffs, billing and metering rules of tariffs, the right to choose peak/off-peak grid tariffs for locally produced energy.
10. Les Bambins (BR) 01/07/2020-30/06/2022	Create a *renewable energy community* and test new concepts in terms of *metering and billing* network tariffs.	Derogations from supplier obligations, present distribution network tariffs, smart meter installation tariffs, billing and metering rules of tariffs, the right to choose peak/off-peak grid tariffs for locally produced energy, the prohibition for DSOs to be involved in producing activities.
11. LogisCER (WA) 01/05/2022-31/10/2023	*Energy sharing* in a *renewable energy community* of public housing.	Derogations from metering rules, network tariff rules, supplier obligations, and governance rules for DSOs (e.g., the right to install production and being involved in the sharing of energy).
12. Greenbizz Energy (BR) 09/02/2021-08/02/2023	Create a *renewable energy community*, test new concepts in terms of *metering and billing* network tariffs, develop application to *optimize local self-consumption*.	Derogations from supplier obligations, present distribution network tariffs, smart meter installation tariffs, billing and metering rules of tariffs, the right to choose peak/off-peak grid tariffs for locally produced energy.
Subcategory 1.2: Energy sharing, including dynamic distribution tariffs		

13. HospiGREEN (WA) 01/11/2020-01/11/2023	Implementation of a *renewable energy community* and improve *collective self-consumption* (by giving *network tariff discounts* for self-consumed energy).	Derogations from metering rules, supplier obligations, network tariff rules, and invoicing rules of network tariffs.
14. E-Cloud (WA) 01/05/2019-30/04/2020	Implementation of a renewable energy community and improve *collective self-consumption* (by giving *network tariff discounts* for self-consumed energy).	Derogations from metering rules, supplier obligations, network tariff rules, and invoicing rules of network tariffs.
15. Endona (NL) approved in 2015 for 10 years	*Share energy*, balance the electricity grid through *peak shaving* and test *dynamic electricity tariffs*.	Derogations from the prohibition of performing DSO tasks, the supplier obligations, the rules regarding metering device requirements and data processing, the methodology to determine grid tariffs, and the rules regarding transparency and liquidity of the energy market.
16. Aardehuizen (NL) approved 2016 for 10y	See Endona, all 'big experiments' in the Netherlands have a similar project summary.	See Endona, all 'big experiments' in the Netherlands could request the same regulatory derogations.
17. Eemnes (NL) approved in 2017 for 10 years	See Endona, all 'big experiments' in the Netherlands have a similar project summary.	See Endona, all 'big experiments' in the Netherlands could request the same regulatory derogations.
18. MET Amersfoort (NL) approved 2018 for 10y	See Endona, all 'big experiments' in the Netherlands have a similar project summary.	See Endona, all 'big experiments' in the Netherlands could request the same regulatory derogations.
19. Groene mient (NL) approved 2015 for 10y	See Endona, all 'big experiments' in the Netherlands have a similar project summary.	See Endona, all 'big experiments' in the Netherlands could request the same regulatory derogations.
20. ACRus (WA) 01/04/2022-31/03/2025	See Endona, all 'big experiments' in the Netherlands have a similar project summary.	See Endona, all 'big experiments' in the Netherlands could request the same regulatory derogations.
21. Vassinghaugen borettslag (NO) 31/10/2019-31/10/2024	*Sharing surplus production* from self-produced electricity between residents in the same building and test a new *distribution Time-of-Use tariff model*.	Derogations to the definition of a plus consumer, and tariff methodologies to differentiate network tariffs of consumers and add a time of use energy component to the distribution tariff.
Subcategory 1.3: Energy sharing, including dynamic distribution tariffs and network operation		
22. Parq Green (NL) approved in 2015 for 10 years	*Share energy*, balance the electricity grid through *peak shaving*, test *dynamic electricity tariffs* and *operate* the distribution network.	Derogations from the prohibition to perform DSO tasks, the obligation to have a supplier permit, the rules regarding metering device requirements and data processing, the methodology to determine grid tariffs, and the rules regarding transparency and liquidity of the energy market.
23. Collegepark Zwijsen (NL) approved 2015 for 10y	See Parq Green, all 'network projects' in the Netherlands have a similar project summary.	See Parq Green, all 'network projects' in the Netherlands could request the same regulatory derogations.
24. Noordstraat 111 (NL) approved 2016 for 10y	See Parq Green, all 'network projects' in the Netherlands have a similar project summary.	See Parq Green, all 'network projects' in the Netherlands could request the same regulatory derogations.
25. Schoonschip Amsterdam (NL) 2016 for 10 years	See Parq Green, all 'network projects' in the Netherlands have a similar project summary.	See Parq Green, all 'network projects' in the Netherlands could request the same regulatory derogations.
26. Villa de verademing (NL) approved 2016 for 10y	See Parq Green, all 'network projects' in the Netherlands have a similar project summary.	See Parq Green, all 'network projects' in the Netherlands could request the same regulatory derogations.
27. Republica Papaverweg (NL) 2017 for 20 years	See Parq Green, all 'network projects' in the Netherlands have a similar project summary.	See Parq Green, all 'network projects' in the Netherlands could request the same regulatory derogations.
28. Zevenheuvels, Wezep (NL) 2018 for 15 years	See Parq Green, all 'network projects' in the Netherlands have a similar project summary.	See Parq Green, all 'network projects' in the Netherlands could request the same regulatory derogations.

29. Kleine duinvallei (NL) approved 2018 for 10y	See Parq Green, all 'network projects' in the Netherlands have a similar project summary.	See Parq Green, all 'network projects' in the Netherlands could request the same regulatory derogations.
30. Bad noordzee (NL) approved 2018 for 10y	See Parq Green, all 'network projects' in the Netherlands have a similar project summary.	See Parq Green, all 'network projects' in the Netherlands could request the same regulatory derogations.
Subcategory 1.4: Peer-to-peer trading		
31. EDF (GB)	*Peer-to-peer* energy trading platform.	Unclear from project description.
32. Empowered (GB)	*Peer-to-peer* energy trading platform.	Unclear from project description.
33. Verv (GB)	*Peer-to-peer* energy trading platform.	Unclear from project description.
34. BP (GB)	*Peer-to-peer* energy trading platform.	Unclear from project description.
35. F&S Energy Ltd (GB)	*Peer-to-peer* energy trading platform.	Unclear from project description.
Subcategory 1.5: Consumer rights in microgrids		
36. Emergent (GB) 14/07/2022-13/07/2024	Delivering the *right to switch electricity supplier* for residential customers on *microgrids*.	Derogations from the metering, metering data and invoicing rules.
Category 2: Flex participation in electricity markets		
Subcategory 2.1: Wholesale markets		
Name (country) duration	Project summary, *with keywords in italic*	Granted regulatory derogations
37. Eqinov (FR) 01/07/2023-30/06/2027	Enhance the *business model* of demand response by valuing *upward demand flexibility* via the load-shedding block exchange notification mechanism NEBEF.	Derogations to the load-shedding block exchange notification mechanism to allow the valuation of an increase in consumption.
Subcategory 2.2: Balancing markets		
38. OVO Energy (GB)	Examine an *innovative tariff* for customers with *storage heaters*, allowing the valuation of *flexibility and grid balancing services*.	Unclear from project description.
39. Centrica Business Solutions (GB) 01/09/2022-31/08/2024	Enable *participation in balancing services* from customers that are currently not half-hourly settled and may not have access to half-hour settlement soon.	Derogations from the Balancing and Settlement Code on the classification and registration of metering systems, the allocation of supplier volumes, and the aggregation of half-hourly data.
40. EDF (FR) 31/03/2023-30/03/2027	Explore and optimize the *business model* of a *battery* storage in *ancillary services markets*.	Derogations to allow a battery to aggregate with (multiple) existing balancing service providers and participate in (multiple) ancillary service markets.
41. NorFlex (NO) 01/08/2021-01/04/2022	Access *distributed energy resources* for *manual Frequency Restoration Reserve services* through a shared flexibility market with the DSO.	Derogations from the guidelines and responsibilities for TSOs regarding the minimum bid quantity.
42. eFleks (NO) 17/08/2020-01/11/2020	Stimulate the participation of *flexibility* in *manual Frequency Restoration Reserve services*.	Derogations from the guidelines and responsibilities for TSOs regarding the minimum bid quantity.
43. Fast Frequency Reserves (NO) 21/01/21-03/10/21	Examine the design of *Fast Frequency Reserves* to stimulate the participation of flexibility.	Derogation from responsibilities of TSOs regarding the provision of guidelines on their operation of task and responsibilities.
Category 3: Distribution network tariffs		
Subcategory 3.1: Alternative grid connection charges		
Name (country) duration	Project summary, *with keywords in italic*	Granted regulatory derogations
44. Charge collective (GB) 01/11/2021-30/10/2023	Examine *alternative connection charges* for *electric vehicle* charging points based on price-point discovery mechanisms.	Derogations on the connection charging methodology of the Electricity Distribution License.
Subcategory 3.2: Dynamic network usage tariffs		

45. Engie B2C (FR) 01/02/2022-31/07/2023	Offer a *new peak tariff* to customers at low voltage levels to reduce/postpone their consumption during peak network periods.	Derogations to the tariff methodologies to offer new tariffs, which consider critical network peaks, to low voltage customers.
46. SmartNettleie (NO) 10/02/2020-31/12/2021	Examine a new *Time-of-Use distribution tariff model*.	Derogations to tariff methodologies to add a time of use energy component to the distribution tariff.
47. Topplastprising (NO) 13/11/2019-30/04/2020	Examine *dynamic distribution network tariffs* using peak load pricing.	Derogations to tariff methodologies to allow the differentiation of network tariffs of consumers that normally belong to the same category.
48. Aktive hjem (NO) 02/10/2020-31/10/2021	Examine *dynamic distribution network tariffs*.	Derogations to tariff methodologies to differentiate network tariffs of consumers and add a time of use energy component to the tariff.
Category 4: Connection to electricity networks		
Subcategory 4.1: Technical solutions		
Name (country) duration	Project summary, *with keywords in italic*	Granted regulatory derogations
49. AFR 20/ Amarenco (FR) 01/07/2023-30/06/2027	*Optimal connection* of *storage* to the *distribution network* of Enedis.	Derogations to the technical documentation of Enedis when carrying out connection studies.
50. WPD (FR) 01/01/2023-31/12/2026	Speed up *connection request* of a *wind power plant* by an alternative connection to the *distribution network* with a direct feeder and a reactive power range that deviates from standards.	Derogations to the technical documentation of Enedis and distribution network tariffs to allow WPD to pay a compensation for the additional grid losses due to deviations in reactive power.
Subcategory 4.2: Flexibility solutions		
51. Boralex (FR) 02/03/2022-01/03/2026	*Connect wind power plants* with installed capacities above the allowed standards to the *distribution network*, provided that the power injected remains within limits.	Derogations to on the technical design and operating requirements for connection to the electricity grids.
52. BayWa r.e. (FR)	*Connect* three *wind power plants* and one *solar power plant* with installed capacities above the allowed standards to the *distribution network*, provided that the power injected remains within limits.	Derogations to on the technical design and operating requirements for connection to the electricity grids.
53. Fibre excellence Tarascon SAS (FR) 07/02/2022-07/02/2026	*Connect* new production units with installed capacities above the allowed standards to the *distribution network*, provided that the power injected remains within limits.	Derogations to on the technical design and operating requirements for connection to the electricity grids.
54. Enedis Reflex (FR) 23/07/2021-23/07/2025	Testing *flexibility* to *optimize the network sizing* and to allow for more *renewable energy* without additional *network investments*.	Derogations to on the technical design and operating requirements for connection to the electricity grids.
Category 5: Connection to gas networks		
Subcategory 5.1: Synthetic methane		
Name (country) duration	Project summary, *with keywords in italic*	Granted regulatory derogations
55. SAS HYMOOV 1 (FR) 01/06/2021-31/05/2025	*Injection of synthetic methane* from pyrogasification and methanation into the *gas network*.	Derogations to allow a detailed injection study, the possibility of registering the project in the biomethane capacity register, the connection of the project owner, the analysis of the quality of the gas produced and the injection of the gas produced.
56. SAS GDL/ Quairos (FR) 28/04/2021-27/04/2025	*Injection of synthetic methane* from pyrogasification into the *gas network.*	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
57. Pau Béarn Pyrénées (FR) 03/12/2021-02/12/2025	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
58. PMMCU (FR) 31/12/2021-30/12/2025	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.

59. Storengy Méthycentre (FR) 24/06/21-23/06/25	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
60. Storengy Hycaunais (FR) 04/06/2021-03/06/2025	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
61. Energo (FR) 15/11/2021-14/11/2025	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
62. SAS HYMOOV 2 (FR) 01/07/2023-30/06/2027	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
63. SAS HYMOOV 3 (FR) 01/07/2023-30/06/2027	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
64. SAS HYMOOV 4 (FR) 01/07/2023-30/06/2027	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
65. SAS HYMOOV 5 (FR) 01/07/2023-30/06/2027	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
66. Bordeaux Metropole (FR) 01/07/23-30/06/27	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
67. Arkolia Energies (FR) 01/07/2023-30/06/2027	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
68. Enosis (FR) 01/07/2023-30/06/2027	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
69. CUMA des éleveurs du bergeracois (FR) 01/07/2023-30/06/2027	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
70. Siah Croult Et Petit Rosne (FR) 01/07/2024-30/06/2028	*Injection of synthetic methane* from methanation into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
71. SEMARDEL (FR)	*Injection of synthetic methane* from pyrogasification into the *gas network*.	See SAS HYMOOV 1, all projects on synthetic methane in France received the same regulatory derogations.
Subcategory 5.2: Flexibility solutions		
72. SEM Energie Mayenne 01/07/2023-30/06/2027	Provide *flexibility services* with a compressed natural gas station to the public *gas network* such that the *injection of biomethane* can be developed without causing additional *network investments*.	Derogations from the gas network operator's obligation to fully connect new users. Missing legal, technical, contractual or financial frameworks for implementing flexibility solutions in the gas sector.

Table 4: Overview of the approved sandbox projects and the inductive thematic approach.