Interreg Sudoe
TR@NSnet
European Regional Development Fund

Funseam
Fundación para la Sostenibilidad Energética y Ambiental

Energy transition AND regulatory sandboxes

Joan Batalla-Bejerano, Director General of Funseam
Manuel Villa-Arrieta, Researcher of Funseam

Project funded by the Interreg Sudoe Programme through the European Regional Development Fund (ERDF)

Energy transition and regulatory sandboxes

This document runs as part of the European cooperation TR@NSNET project. This European project, financed by FEDER funds, and brought to fruition by the consortium led by the French Toulouse III University - Paul Sabatier includes the participation of the Foundation for Energy Sustainability (Funseam), the Polytechnic University of Madrid, the University of Lisbon, the University of Beira Interior, the University of La Rochelle, the CIRCE Foundation, and the Technological Corporation of Andalusia (CTA). It aims to contribute to the challenge of ecological transition by defining a new model of Living Lab in the context of open innovation.

Publication Data: 10 March 2022
ISBN 978-84-09-39554-5

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1. Introduction

Achieving climate goals requires the decarbonization of our respective economies, a process that will not be possible without incorporating disruptive technologies into the energy sector. This process of decarbonization requires moving towards a new low-emission energy paradigm that is also capable of guaranteeing security of supply and economic competitiveness. But transforming the current model is not easy due to the large number of unknowns regarding this process. It is therefore necessary to define solid and resilient policies which are capable of responding to an environment that is going to be changeable.

Moving towards a carbon-neutral economy is a major challenge and it will not be possible unless a huge amount of effort is put into innovation. In this sense, in the specific case of the energy sector, new and cleaner technologies are required that are cheaper and that improve competitivity when compared to existing ones. It is also necessary to have an intelligent and sustainable system that allows for the creation of new innovative business models.

Although a firm commitment to innovation is necessary and crucial, this alone is not enough. To guarantee that climate objectives can be met, regulation needs to advance at the same pace. The energy system, which is complex already, needs to undergo a profound and far-reaching transformation, and the regulatory framework must evolve to facilitate this change and guarantee the best protection of consumer interests.

In the current competitive business context, more and more companies are developing innovation processes (technological and non-technological) as they strive for peak performance, which then translates into success. And guaranteeing the success of all the innovations that companies develop requires overcoming the different barriers that exist, be they technological, social or cultural, as well as market or the organizational and those of a regulatory nature, all of which are the object of study in this report. In many cases, technological innovations are more advanced than regulatory

innovations and it is therefore necessary to review current regulatory frameworks because they often only reflect innovative solutions that existed at the time of definition and are not always capable of responding to the new business models associated with the innovations that have emerged in recent years. Aligning the regulatory framework with innovation processes should serve as a stimulus when it comes to investing in solutions mean that decarbonization can be achieved.

The greatest challenge is being able to define a new action framework where regulation is a key factor that stimulates the appearance of new models rather than acting as an obstacle. This goes hand-in-hand with the ultimate goal of making the innovative process profitable and the results scalable. At the same time, the actors that are innovating to create new products and business models need a designated and safe test environment that allows them to test their disruptive solutions in the energy field, reducing the degree of uncertainty that is always characteristic of any R+D+i project.

To solve this problem, in recent years, there has been a push to use regulatory sandboxes, a tool which supports innovation. This tool is intended to respond to the needs of the agents by creating controlled time frames that facilitate the testing and validation of new technological developments, new business models and even new regulations that do not fit into the current regulation. Given the mismatch between regulation and innovative solutions not previously considered, the use of these test environments makes it easier for regulators to experiment with clauses which means that they can begin to advance technological solutions and related innovative business models.

When applying them to the context of the energy transition, regulatory sandboxes provide an experimental environment to stimulate and encourage innovation, as well as to develop and replicate new business models that have encountered barriers in current energy and market regulation. They can provide stable framework conditions for a set time and a limited geographical area, opening or repealing regulations with the aim of developing new energy products or services in a real-world environment without the need to apply the

current regulation which has been designed to make a centralized energy sector work.

The application of regulatory sandboxes is for solutions that were not previously considered or deemed necessary, but are related to new challenges that the energy sector faces as a whole:

- Development of flexible services to operate any electricity system characterized by an increasing amount of energy from renewable sources
- Reduction of possible environmental impacts
- Sector coupling
- Integration of energy storage
- Management of the new local electricity communities
- Consumer empowerment as a key aspect
- Protection of consumer interests

Faced with these challenges, regulatory sandboxes make it easier to address the following innovation goals:

- Develop new for energy management products
- Develop new services related to peer-to-peer energy sharing and flexible services
- Develop technological platforms for Blockchain that simplify certifying the origin of renewable energy
- Develop new rate models based on dynamic prices.
- Create business models that include new areas, such as electrical storage or recharging electric vehicles

In addition to its innovative nature and the significant benefits it provides, there are already many international initiatives aimed at implementing this type of tool in the energy sector. Regulatory sandbox programs are starting to be developed in Germany, Italy, South Korea, the Netherlands, Singapore and the United Kingdom, as well as Australia, Austria, France, Ireland, Sweden or Denmark. The SUDOE region is no exception. In Spain, the Royal Decree-Law

23/2020, of June 23, 2020[1] allows the government to establish regulatory test benches within the set of measures introduced. In France, the law of November 8, 2019 on energy and climate, known as the "Energy-Climate Law"[2], meant that a regulatory sandbox was introduced into the energy sector. And Portugal passed Resolution No. 29/2020 of the Council of Ministers l at the beginning of March 2020, thus establishing the general principles for the creation and regulation of free technology zones (ZLT) which represents a normative sandbox project[3]. According to the Portuguese documents, the ZLT are geographic spaces for experimentation in a real or near-real environment which are used to test innovative technologies, products, services and processes that span across sectors, requiring different regulators or competent authorities.

The analysis of these experiences and identification of the most relevant aspects is the subject of this document. Each of these contexts has its own peculiarities, but it is possible to take inspiration from them for implementation in the SUDOE region. Thus, this report studies the advantages of regulatory sandboxes in any energy transition process. The objective is to capture a detailed review of the characteristics of the use of these instruments within the energy sector. The document analyses the institutional barriers that technological innovation has encountered when it comes to decentralizing the operation of electrical systems, as well as the solutions that can be obtained with these instruments. This report also tries to identify the determining factors that can increase the effectiveness of the implementation of new business models, the emergence of start-ups and the study of consumer empowerment as an essential part of achieving decarbonization of the economy through the energy transition.

It is crucial to understand and learn how to improve regulation to meet the future challenges that the energy transition will face. The definition and establishment of these new test environments can undoubtedly serve as an instrument to support innovation.

[1] https://www.boe.es/eli/es/rdl/2020/06/23/23/con
[2] https://perma.cc/5XYM-8VDA
[3] https://files.dre.pt/1s/2020/04/07800/0000200005.pdf

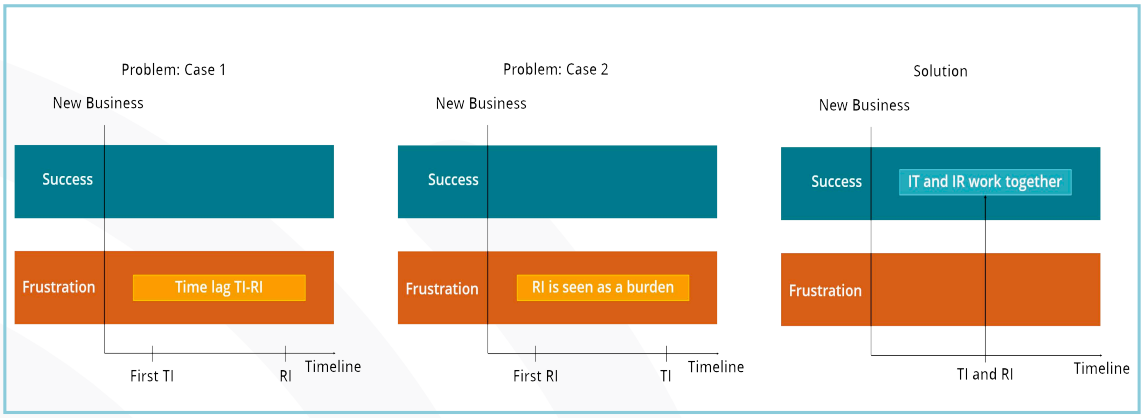
2. Regulatory sandboxes to drive the energy transition

The effects of climate change are increasing and this means that we must make an unprecedented effort in terms of innovation. The new business models that technological advances may bring with them are decisive for rethinking the future operation of energy systems, responding effectively to the needs of consumers and protecting the environment. Research and innovation are the best tools to drive the energy transition and address climate change (Pellerin-Carlin, T., et al., 2017).

In this process of change, regulatory innovation is essential in order to bring together the benefits of new technological advances with the requirements of the market and society, and thus protect consumer rights. In order to decarbonize our economy, it is necessary for innovative processes to be carried out in a way that creates harmony between the regulatory, technological and business spheres. However, technological innovation and regulatory innovation have different rates of growth, and have therefore been addressed at different stages of the global innovation process, with regulation normally lagging behind technological innovations (Case 1 in Figure 1).

The imbalance between technological and regulatory development does not mean that the latter is not comparable to the former. Regulatory frameworks in the market economy seek to create opportunities so that new business models or technical and technological innovations help solve or advance the country or regional objectives. A clear example of this in the context of the energy transition is the *Clean energy for all Europeans package*, approved in 2019 by the European Union after more than three years of debate and discussion. Regulation can also be anticipated by creating regulatory frameworks that facilitate the adoption of technological innovations and new business models that make it possible to achieve global objectives. However, regulation has traditionally been seen as a barrier for innovators, who consider it an administrative burden that increases market entry costs (Case 2 in Figure 1).

Figure 1.
Technological Innovation (TI) and Regulatory Innovation (RI).



Source: Own elaboration.

The energy transition does not have a single set path that will lead to the decarbonization of the economy, but it is necessary to do it in such a way that the negative impact for all actors involved is limited. There are multiple challenges, each with their own particularities depending on the geographical area and the energy sector in question. In the specific case of electricity, in terms of the decentralization and flexibility of the system, the aim is to carry out an effective and efficient adjustment of the variability of demand with the variability of the (main) renewable energy resources, which ties in with the aims of the Smart concept.

To order to respond to the need for a permanent balance between supply and demand that characterizes the operation of all electrical systems, as well as climate challenges, there are different solutions that include energy efficiency, electrification, energy storage, carbon capture and utilisation and the use of other energy types such as natural gas and hydrogen. This occurs in a context where, along with digitization and new information technologies, new activities and business models arise that cross the limits of the sector itself. Moreover, new economic agents, such as the aggregator and the prosumer and consumer empowerment are necessary, as is facing new regulatory challenges in terms of data, privacy, security, and flexibility of the same regulation (BMWi, 2019).

Ultimately, for the energy transition, policies on energy and innovation must be orchestrated with complementary actions that serve as a multisectoral link and allow feedback between stakeholders. And this is where regulatory sandboxes come into play because they are tools that are considered to be facilitators of innovation in the same way that *Innovation Hubs* (CGAP-World Bank, 2019) are.

Given the requirements of the energy transition, among the benefits that could be achieved by using *Energy Regulatory Sandboxes* (ERS) in the energy field is its impact on company innovation. Innovation happens faster when companies can test new ideas in controlled and limited environments, and therefore minimize risk. At the same time, consumers benefit because new and useful technological products can be brought to the market sooner, having been tested previously. Direct communication between developers, companies and regulators creates a more cohesive and supportive industry. Successive trial and error within a controlled environment mitigates risks and unintended consequences, such as unseen security flaws when a new technology is accepted by the market too quickly.

In addition to promoting energy innovation, by using ERS, regulators seek, can understand and learn how to improve regulation to face the challenges that lie ahead thanks to the flexible nature of electricity networks operation. In short, these test environments are an instrument to support innovation to overcome regulatory barriers in the energy transition. The FinTech sector has experience in using this but since it is only starting to be used in the energy sector, the current task is to study the projects that have already been put into practice.

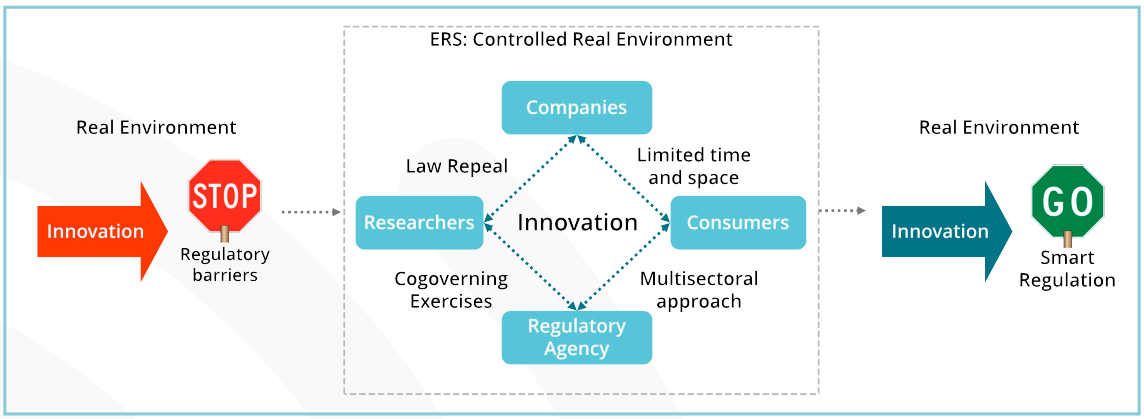
Technically, sandboxes serve to facilitate testing and the implementation of innovations on a small scale for a limited time, in a "real" and controlled environment similar to that of the market (IDB, 2020). Due to their characteristics, they offer companies and industries overall new opportunities to accelerate the use of knowledge, data and technology shared between sectors and clients. They can provide a forum for the participation and observation of start-ups, institutions, and innovative ecosystem players in a

secure off-market environment (*Industry Sandbox*, 2018). This is an environment in which the regulations are kept up-to-date so as not to fall by the wayside in relation to technological advances. In this regard, regulatory sandboxes can be seen as a support for innovation offered by regulation.

Faced with the problem of the gap between technological innovation and regulatory innovation (because disruptive technologies and associated new business models do not comply with current rules and regulations), regulatory sandboxes bring together a series of clauses that allow innovations to be tested, making application of the current rules more flexible. Experimentation clauses and exemptions are the main tools that can be used to open the legal framework to innovations and allow the use of regulatory sandboxes (BMWi, 2019). On the other hand, faced with the problem of the poor perception that innovators have of regulation, regulatory sandboxes include governance mechanisms and/or the leadership of an organization with a supranational mandate that allow the multisectoral and multidisciplinary nature of the innovations required by the energy transition to coordinate different actors and regulatory agents (IDB, 2020).

In a real environment (see Figure 2), innovative business models may encounter difficulties when trying to adapt to the current regulatory framework because these innovations had not been previously imagined by regulators. Furthermore, in the absence of coordinated action towards a common goal between the regulator, innovators and consumers, these stakeholders cannot receive the benefits of these innovations. With a regulatory sandbox, the real environment becomes a controlled environment with limited time and space within which a multisectoral approach involving the participation of innovative actors (companies or start-ups), consumers, innovation agencies and regulatory agents can be used to evaluate the repeal of regulations and laws and the creation of governance or function responsibility structures, such as the entry of new economic agents. The ultimate goal is that in the uncontrolled environment innovations can work and regulators can learn to create *Smart regulation*, and that all stakeholders are able to reap the benefits of innovations.

Figure 2.
Application of regulatory sandboxes to make current regulation Smart.



Source: Own elaboration.

For the energy transition, ERS programs should focus on projects that aim to implement *Smart* solutions and are resilient to any regulatory framework so that they are capable of adapting to an uncertain technological environment that changes over time. They must address solutions that can provide overall benefits to the system by fostering innovation and lifting regulatory barriers that block solutions. The creation and financing of these programs can be launched with research and innovation instruments in which legislative measures are tested with experimental clauses that serve as the basis for a new energy policy (IDB, 2020; Ofgem, 2020). Thus, the involvement of regulators is key in that they must be involved in enabling regulatory sandboxes from the outset and have an active role in fostering innovation towards more sustainable energy systems.

Also, learning is just as important as experimentation in ERS. For innovators who perceive regulatory barriers, the review of a project proposal by experts from regulatory bodies is extremely valuable in the event that a regulatory derogation is necessary. Furthermore, learning among innovators can be enhanced if trusted knowledge exchanges between competitors are organized (IDB, 2020). Competition between the innovating parties is crucial to achieve greater acceptance by consumers. For regulators and legislators, testing in regulatory sandboxes provides valuable evidence to help understand if and how regulation should change permanently.

In light of all the advantages of regulatory sandboxes, it must be pointed out that a fundamentally different regulatory framework where the rules can be deactivated, adapted or replaced as desired, is not created within these test environments. Ultimately, innovations supported by sandboxes must be able to operate within existing, albeit modified, sectoral and regulatory frameworks (Ofgem, 2020). The most far-reaching and detailed modification of the regulation follows the administrative procedures of each country.

From a global point of view, the main objective is to achieve Smart regulation. Nowadays, the improvement of regulation as a public policy to be applied in all its interventions is considered an essential tool to be developed and implemented by all Administrations. In the case of the energy sector, continuing to move towards a better one is essential given the magnitude of the requirements that any decarbonization process of our economy entails. These are challenges to which it is possible to respond by implementing regulatory sandboxes and seeing unquestionable benefits, as shown in Table 1 below.

Table 1.
Energy transition and regulatory sandboxes.

Requirements for energy transition	• Regulatory flexibility in test environments. • Validation of multisectoral and multidisciplinary scope. • Consumer empowerment, not only as an aim but also as an actor for feedback on their new needs. • Regulator accompaniment • Governing mechanisms for actors involved in test environments. • Innovator protection • Integration of innovation agencies. • Simplification of administrative procedures.
Solution provided by regulatory sandboxes	• Creation of a safe space for emerging technologies and new models of associated business. • Including safeguards for markets and consumers. • A monosectoral and multisectoral focus. • Role of active regulator and/or coordinator as a facilitator. • Establishing feedback mechanisms between innovators, consumers & regulators.

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Benefits	• Innovation happens faster when companies can test new ideas without overhead costs, such as compliance and comprehensive protection of consumer interests. • It is better to test innovation in a live environment with real consumers. • The test increases innovator access to capital. • Consumers benefit because new and useful technology arrive to the market more quickly. • Direct communication between developers, companies and regulators creates a more cohesive and supportive industry. • Successive trial and error tests within a controlled environment mitigate risks and unintended consequences, such as unseen security flaws when a new technology is accepted by the market too quickly.

Source: Own elaboration based on BMWi 2019, Ofgem 2020, IDB 2020.

3. Recommendations for designing and applying regulatory sandboxes in the energy field

In recent years, regulatory sandboxes have seen significant growth, mainly in the FinTech sector, and more specifically in Blockchain technology. Similarly, in the energy sector, in order to drive the energy transition forward, there have been recommendations to design and apply these experimentational environments. In July 2019, the German *Federal Ministry for Economic Affairs and Energy* (BMWi) published the document *Making space for innovation – The handbook for regulatory sandboxes* (BMWi, 2019), and in August 2020, the British regulator Ofgem published the document *Energy Regulation Sandbox: Guidance for innovators* (Ofgem, 2020). These are without doubt key reference documents regarding the design of this type of tool.

Although the regulation responds to the individual characteristics of each country, meaning that the regulatory sandboxes must be adapted to each national regulatory framework, these test environments have several phases in common. Figure 3 identifies these phases and the actions carried out by the two main agents: the regulator and the innovator. The latter refers to companies or start-ups that seek to introduce an innovative product in the market, be it a disruptive technology or a business model that encounters barriers in the current regulatory framework.

In the definition of this type of tools, it is necessary for their design to respond in relation to the desired objectives. Regarding this fundamental point, the program developed by Ofgem itself offers different tools that vary depending on the specific needs of the innovation. In this sense, the British regulatory body offers *bespoke guidance* for when innovators want to try a new proposal, but are not sure how the current regulation would apply. It has a "Comfort" tool for when innovators are concerned about

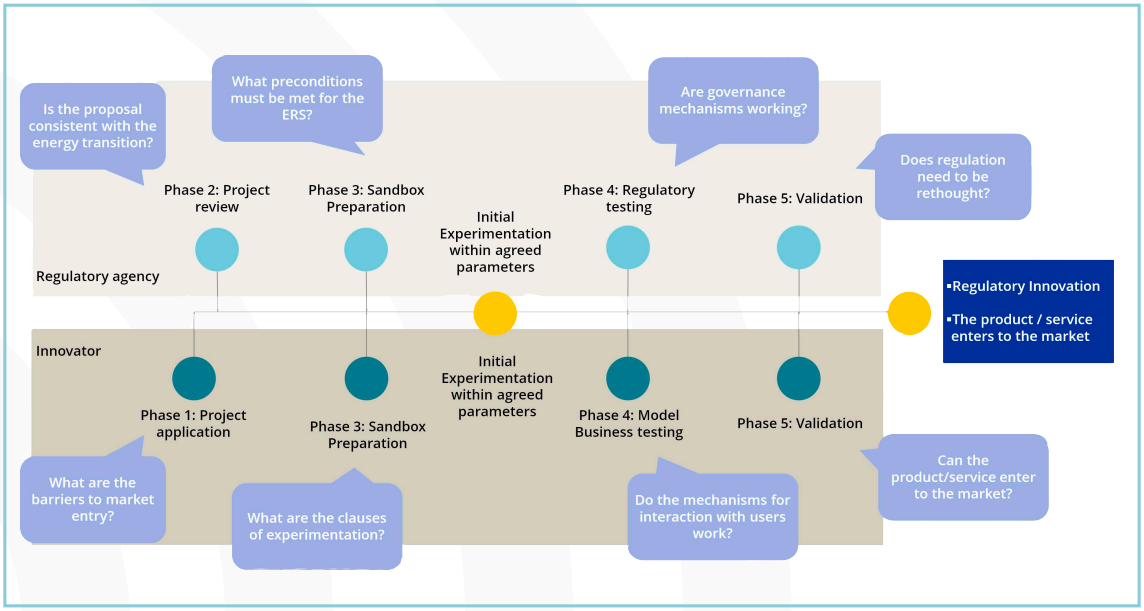
non-compliance with the current regulation and the subsequent consequences, a "Confirmation" tool for when they need to assure clients and investors that the proposals are permitted to enter the market and a “Derogation” tool for when they have identified a rule that they cannot comply with.

Once the objectives have been defined, the process of planning and executing the regulatory sandbox itself is important. A series of requirements for before and after starting the test is outlined in Figure 3 and presents in a very synthetic way the phases that must be considered during the design phase. There are many issues that need to be addressed in each of these phases. Below, in addition to exploring each one in depth, other relevant issues that can be of use to innovators when defining their application in a regulatory test environment are highlighted. The partial or total application in these phases depends on the type of tool that the regulator offers for each innovation. The positive confirmation that the regulator can give an innovator on the viability of their innovation within the current regulatory framework will avoid performing the tests within a controlled environment. Likewise, the temporal scope of these phases is determined by milestones that inform decisions regarding the operation of the innovations in the real environment.

In a stage prior to beginning the phases described below, the regulator requests participation through open calls in order to study the current regulation regarding ERS. In Phase 1, the innovators present their proposals for participation and demonstrate that their innovations are in line with the objectives of the energy transition and reflect the regulatory problems or the barriers that exist to reach the market from institutional agents. In Phase 2 the regulator decides if the innovators' proposal is eligible. In Phase 3, the innovators and regulators specify the regulatory sandbox by defining the derogations, the start date and the duration. In Phase 4, the tests begin. In this phase, it is important to define their duration as this prevents the risks of working outside the repealed regulatory framework. Phase 5 is a feedback period between the regulator and the innovator during the execution of the

test. Phase 6 is the end of the testing period and the beginning of validation, review and analysis of results so that the innovator is able to determine if special licenses for operation and/or the Smart regulation design can be granted.

Figure 3.
Application phases of a regulatory sandbox.



Source: Own elaboration.

Phase 1:
Presentation of the proposal – Action of the innovator:

The innovators submit their application to the ERS by presenting the evaluation of the commercial feasibility of the innovations, the legal and regulatory risks and the possible measures of their mitigation. According to BMWi, it is important to define goals and develop measurement indicators at this stage and ensure the participation of other interested parties by connecting with innovation networks or business networks. Innovators must also plan the time and resources to be used and specify sources of funding for the test environment. For this phase, BMWi recommends innovators ask themselves the questions in Table 2 below in order to help them refine their application to a regulatory sandbox.

Table 2.
Initial phase of application of a regulatory sandbox in the energy field (ERS).

Stage	Questions to answer
Formulating goals and developing indicators	• "What are the key objectives of the ERS?" • "What does the project want to find out?" • "How can objective achievement be measured?"
Making sure stakeholders are on board	• "Which stakeholders are responsible for implementation, overseeing and direction? In other words, who are the main stakeholders?" • "Which stakeholders will play an active role in the implementation?" • "Which stakeholders should be involved from time to time to improve the preconditions for the ERS?" • "Which stakeholders in the environment surrounding the ERS could influence the sandbox?" • "What are the different interests that exist regarding the ERS?"
Designing and using networks	• "Are there already networks that could be persuaded to participate?" • "How can relevant participants be brought together in a network?" • "How will cooperation be organized within the network?" • "Can network structures from other regions or projects be transferred to the ERS?"
Planning time and resources	• "In what periods should the ERS be prepared, planned and implemented?" • "What resources should be allocated to the individual steps?"
Looking for possible funds	• "Are there any ways to use public funding?"

Source: Own elaboration based on BMWi 2019, Ofgem 2020, IDB 2020.

Phase 2:
Verification of the proposal of the innovators – Action of the regulator:

Once the proposals are received, the regulator must make their decisions within the framework of the requirements set out in the call for applications, including the objectives of the energy transition and the protection of consumer interests. Although innovations may potentially be attractive to consumers, it is understood that new proposals not previously considered within the current regulatory framework may put their interests at risk. The ERS must allow new products and services, but without running the risk of harming the consumer; Innovators must consider how their proposals engage

consumers and manage risk, even if they are not products or services that directly reach consumers. Regulators must assess proposals by balancing the benefits and risks for all stakeholders.

If the proposals meet these parameters, merely reviewing the proposals and presenting recommendations to the innovators is the first step towards creating shared environmental, economic and social objectives. It is important to remember that since the publication of the United Nations 2030 Agenda for sustainable development, institutions are defined as coordinating agents of change for the fulfilment of the Sustainable Development Goals (SDGs) and companies are called upon to be leading actors of sustainable growth. The regulator can analyse the participation of other administrative institutions seeking the dynamism of the energy sector for the benefit of consumers. Here, too, the regulator can make recommendations for innovators to analyse the market entry of their products without the need for a regulatory test or on access to financing mechanisms for these environments.

Table 3 presents some of the questions that regulators could ask about the proposals of the innovators in the design of an ERS in the current socioeconomic scenario of the energy transition.

Table 3.
Verification phase of the proposal for the application of a regulatory sandbox in the energy field (ERS).

Stage	Questions to answer
Meeting application requirements	• "Does the innovator's proposal meet the application requirements?" • "Can the regulator grant special operating licenses without the need to carry out an ERS?"
Support for national objectives	• "Does the proposal bring benefits to the energy transition of the country, region or city?" • "Can the proposal bring benefits to other social or environmental objectives?"

Continued on next page

Stage	Questions to answer
Innovative proposal	• "Is it a new product, service, business model or methodology that is not available in the market?" • "Does the innovation align with the strategic direction of the expected changes in the energy system?"
Benefits to consumers	• "Does the innovation have the potential to benefit the consumer?" • "Is it aimed at a specific type of consumer or in a situation of vulnerability?" • "What are the benefits for consumers?"
Compatibility	• "Is there a clear regulatory barrier that requires a response?" • "What prevents the innovator from advancing their plans?" • "What support does the innovator require and why is it not possible to progress without it?" • "Is the test proposed by the innovator a solid design?" • "Can the innovator bring their product to market without the need for an ERS test?" • "Can the regulator grant special operating licenses without the need to carry out an ERS?"
Recommendations to the innovator	• "What recommendations could be given to the innovator to effectively facilitate the market entry of their product?"
Formulate goals and develop indicators	• "Are the innovator's plans well-developed? Do they have clear goals and criteria for success?" • "What are the key objectives of the ERS within the institutional context?" • "What does the project want to discover?" • "How can the objective achievement be measured?"
Design and use institutional networks	• "What is the institutional or administrative, technical, regulatory and market scope of the ERS within the framework of the energy sector?" • "Are there other administrative institutions that should be involved?" • "How can relevant participants be brought together in a network?" • "How will cooperation and governance be organized in the network?" • "Can network structures from other regions or projects be transferred to the ERS?"
Looking for possible funds	• "Does the innovator have funds available?" • "Can innovators access public funding for innovation?"
Exit strategy	• "Does the innovator have a clear exit strategy from the ERS?" • "Does the innovator demonstrate that the different exit routes available have been considered?"

Source: Own elaboration based on BMWi 2019, Ofgem 2020, IDB 2020.

Phase 3:
Preparation of the energy regulatory sandbox – Joint action between the regulator and the innovator:

Following the regulator's proposal in Phase 2 and responding to its questions and following recommendations, Phase 3 already has the active participation of the regulator to determine each party's commitments. Legal obstacles and possible derogations that must be carried out and the repercussions that doing so may bring, mainly for consumers, are identified here as are ways to mitigate existing risks. During this phase, the tests financial support and duration are defined and measures to determine their success or failure as well as a strategic plan to complete the test are identified. It is also crucial to review the actions that other external agents must carry out, such as external audits or security validation in data handling. And crucially, a plan for transition must be established after the trial period.

Following the roadmap proposed by BMWi, Tables 4 and 5 summarize the questions that can be asked during this Phase. By answering these questions, innovators can approach regulator involvement with robust parameters that set the boundaries of sandbox implementation. Similarly, both innovators and other stakeholders in the energy transition can analyse these questions in order to answer how they can make use of the findings or achievements. Although several of these questions must be analysed beforehand, at this stage and with the help of the regulator, the innovators can prepare the legal aspects of the test and the design of the implementation.

Table 4.
Preparation of legal aspects.

Stage	Questions to answer
Identification of legal obstacles	• "Which areas and which specific legal provisions are important for the implementation of the ERS?" • "What rules and regulations prevent or block the introduction of the technology or business model?"

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Stage	Questions to answer
Identification of possible exemptions	• "What experimentation clauses or other possibilities for exemptions exist?"
Identify the route to obtain a waiver	• "What preconditions must be met for the exemption to be used?" • "Which authorities are responsible for issuing the exemption?" • "Is there experience with the practical application of these rules elsewhere?" • "Which authority has already issued an exemption for other cases?"
Risk coverage	• "What risks are there of the tests causing harm to users, observers and third parties?" • "Who would be responsible for this damage?" • "How can these risks be insured?"
Compliance with state aid rules	• "Will public funding be used to support the ERS?" • "Does the support comply with State aid rules?"

Source: Own elaboration based on BMWi 2019, Ofgem 2020, IDB 2020.

Given the uncertainty of defining the regulatory exemptions that can be applied, it is important to clarify that they are considered to be experimentation clauses or recommendations for action for a public body, concession of powers to remove requirements for a public or private body to provide documentation or use certain equipment, spaces, or facilitate any technical requirement. Its duration must be clearly defined because the expiration date is a point from which the current regulation can respond again. In many cases, and in accordance with the institutional system, the jurisdictional limits must be overcome by the clauses: it is possible that the technical exemptions to the operation of energy innovations go beyond the limits of the tax agencies and this is why the latter must be involved in the test design. It goes without saying that the requirements for exemption must comply with the legal framework. Reviewing regulation through the lens of an innovation helps the regulator identify where regulations are redundant or present undue barriers (Ofgem, 2020).

Another key uncertainty in defining the ERS is test funding. The review of these projects and programs indicates that they do not have a line of financial

support that is directly related to their design. BMWi and Ofgem point out that public financing for regulatory sandboxes is determined only by mechanisms to support innovation. Innovators must ensure that they have secured the necessary investment that permits them to carry out the tests, a task related to the implementation of the product or service (Ofgem, 2020). The international consulting firm Ernst & Young Global Limited (EY, 2018) highlights that in the FinTech field in some countries the financial support of a banking institution is required. In the German case, BMWi highlights the importance of its energy research fund "Living Labs for the energy transition" which held 100 million euros per year between 2019 and 2022, with which project partners can test new technologies and business models in real conditions on an industrial scale and from a holistic approach.

The financing of the projects must cover not only the direct costs of carrying out the tests but also the costs of their risks. In this sense, the ERS programs suggest that the risks must be covered by the innovators. In the particular case of electric mobility, for example, in the ALEES (Autonomous Logistics Electric EntitieS for city distribution) project in Belgium, whose business model is based on the use of autonomous electric vehicles for logistics distribution in cities, the risk coverage is the responsibility of the vehicle manufacturer (BMWi, 2020; and Fraunhofer, 2019). However, in the case of additional charges and fees that innovators have to incur during testing, BMWi aims to reimburse innovators for this economic burden, which is the case of the German SINTEG (*Smart Energy Showcases*) program.

Table 5.
Implementation design.

Stage	Questions to answer
Choose the correct duration and place	• "How long will it take to achieve the goals of the ERS?" • "Which district, town/city or rural region is best suited to answer the questions posed by the ERS researchers?" • "What area should the ERS cover?"

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Stage	Questions to answer
Clarifying who is responsible for monitoring and evaluation	• "What need is there for supervision and direction of the ERS? Who will perform these tasks? " • "Who will evaluate the ERS?" • "What is the response to (critical) developments in the ERS?"
Defining indicators and data sources for the evaluation	• "Which indicators are suitable metrics for achieving the objectives of the ERS, in particular with regard to the desires of the different partners to obtain specific information?" • "What data is already available or can be used?" • "What data should be collected for the evaluation?" • "What reporting requirements follow from this for ERS stakeholders?" • "What methods are appropriate?"
Information feedback, coordination and governance	• "What communication channels will stakeholders use?" • "How often will meetings be held?" • "How will users interact?" • "What will the scope of the coordinator be?" • "Governance of a national, international, private or public institution?"
Making specific use of findings	• "How will the results be used?" • "How will you ensure that the legislature can learn from the ERS?"

Source: Own elaboration based on BMWi 2019, Ofgem 2020, IDB 2020.

Phase 4:
Experimentation – Joint action between the regulator and the innovator:

Phase 4 is the period of experimentation in the test environment, or in other words, the performance of the tests within the agreed parameters. Here, the innovator starts their innovation and studies its operation under controlled conditions which emulate the real environment. Here, regulator participation is active, mainly to learn about the effect, risks, scope, and scalability of regulatory derogations. The innovator must submit periodic reports of the tests based on the agreed parameters, and the other actions proposed initially must be complied with (such as hiring the auditing firm and ensuring compliance with the consumer safeguard mechanisms). The ERS are focused on coordinating the interaction of a product, technically already validated, with the regulation that protects the interests of all the parties interested in the energy transition, but it is not focused on technically "mature" the product during the experimental period. In this sense, it is recommended to consider the questions in Table 6

below in this phase as they are related to the management of test environments from the point of view of the experimental process. The answers can feed back into the previous phases.

Table 6.
Management of regulatory sandboxes.

Stage	Questions to answer
Information feedback	• "Are the channels of communication between the regulator, the innovators and other participating parties working?" • "Is the stakeholder response time correct?"
Governance	• "Do governance mechanisms work?"
Interact with the user	• "Do the interaction mechanisms with users work?"
Deviation correction	• "Is the trial long enough?" • "Are there other risks to stakeholders not identified previously?"

Source: Own elaboration based on BMWi 2019, Ofgem 2020, IDB 2020.

Phase 5:
Validation – Joint action between the regulator and the innovator:

Validation implies knowing if the ERS fulfilled its goals within the framework of the objectives as described in its design and related to the energy transition. The positive or negative result of the validation does not imply the restructuring or adaptation of the regulation, meaning the decision to maintain the regulatory exemptions, replicate them or escalate them. The market entry of the innovation does not necessarily depend on the overall result of the test, or in other words on the modification of the regulation for the effective operation of the innovation. It is possible that the result of the test of an innovative business model related to a *Smart energy technology* (networks, self-consumption, aggregation, etc.) can validate its entry into the market with the current regulation without negatively affecting the interested parties. However, special operating licenses may also be granted to innovators upon completion of the test in the ERS. Similarly, the regulator can obtain the information necessary to update the future guidelines towards a Smart regulation.

The objective of the tests in the sandboxes is not the tests themselves, but rather the release of the proposals to the market. However, it is also equally beneficial for an innovator to know the limits of their proposals and determine if they are not suitable for energy markets. Proving that something does not work is also an advantage for consumers. Table 7 presents some questions that can be asked in this phase.

Table 7.
Validation of tests in regulatory sandboxes for the energy transition.

Stage	Questions to answer
Innovation	• "Can the innovation enter the market?" • "Are special clauses required to enter the market?"
ERS	• "Is the ERS satisfactory for all parties?" • "Was it correctly designed to address the energy transition?" • "Do the waivers granted work?"
Future actions	• "Can the results be replicated by other innovators, regions, institutions, etc.?" • "Should the derogations studied be extended?"

Source: Own elaboration based on BMWi 2019, Ofgem 2020, IDB 2020.

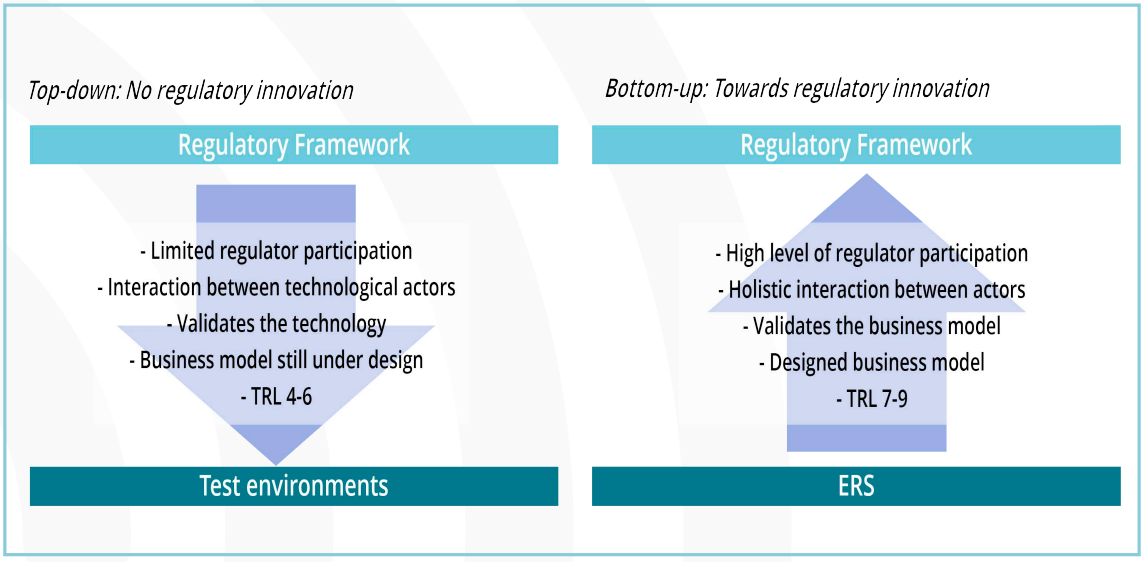
4. International experiences

When approaching the analysis of the different ERS initiatives, it is necessary to first define what we understand by regulatory sandbox to differentiate it from other experimental programs that involve regulation and are related to the energy transition. Delimiting it is not easy, since the design of regulatory sandboxes depends on the characteristics of each country as well as the level of previous experiences in their own innovation programs. However, we can classify the experimentation tools into two types depending on the maturation of the technology to be tested. On the one hand, we find test environments whose objective is to help mature technologies with high future potential but that require certain special validation conditions to know how to exploit it. These technologies, with TRL (*Technological Readiness Level*, a European Union scale) of between 4 and 6, require special regulatory conditions that allow innovators to reduce operating costs. At a higher level we can find the ERS, whose objective as indicated above is to seek to market new business models based on technologies with TRL of between 7 and 9, but that presents some uncertainty due to the current regulation. Therefore, the regulator plays an active role here, working alongside the innovator to identify ways to reduce this uncertainty.

Based on the technological level of the innovations to be tested, we can identify other factors that differentiate ERS from other test environments, such as the type of actors involved and the regulator's level of participation (see Figure 4). Test environments other than ERS involve regulation from a *top-down approach*. The objective is to help validate technological innovations and complete the design of the business model with which to enter the market. Therefore, the controlled environment only involves the technological actors with a limited participation of the regulator. On the contrary, the ERS makes it possible to analyse the relationship of innovations with the current regulatory frameworks from a *bottom-up approach* to help exploit their benefits in the market, given that the technical and technological uncertainties have already been overcome.

Therefore, an environment is designed that allows a holistic interaction between different agents, such as innovation agencies, institutions and consumers, and always with the active participation of the regulator, since it seeks to respond to the uncertainties of the regulatory framework that may lead to the non-completion of innovations beneficial to climate goals.

Figure 4.
Difference between regulatory sandboxes and other test environments in the energy field.



Source: Own elaboration.

When addressing international experiences, we have taken as a basis the information presented in the first half of 2019 by ISGAN (the International Smart Grid Action Network), which provided details of thirteen countries that have implemented regulatory sandbox programs or that are preparing to design and plan them (ISGAN, 2019). This list is as follows:

- Countries that have been discussing an ERS program: Denmark and Ireland.
- Countries that are in the design and proposal stage of a RSB program: Austria, France, Norway, Sweden, Spain.
- Countries that have already designed ERS programs: Germany, Belgium, Italy, South Korea, the Netherlands, Singapore, Australia, and the United Kingdom.

Between 2017 and 2019, in Germany and the Netherlands, regulators had already adapted the set of rules for regulatory experimentation. Regulators in Italy (ARERA) and the UK (Ofgem) are already in a position to encourage innovation and have enough room to experiment. In Norway, the regulatory body (NVE) considers that the current legislation also provides enough room for experimentation. France has already designed and proposed changes and expects their implementation soon. Countries such as Australia, Austria, Brazil, Denmark, India, Ireland, Jordan and Singapore are discussing rule changes for regulators to experiment with (ISGAN, 2019).

Innovation programs other than the ERS:

According to ISGAN, 2019, in the countries that have opted for the energy transition, there is an important role for demonstration pilot projects and experimentation areas. Projects focused on the validation of technologies for the self-consumption of communities and on the study of ecological, economic and social aspects, but not on regulatory aspects with the characteristics described above in the ERS design. *Bioenergiedorfs (The Bioenergy Village)* in Germany, *Experimenteerregeling* in the Netherlands, and Thor Park in Belgium are just some examples.

In the case of Australia, we can identify that the *regulatory sandbox arrangements to support proof-of-concept trials in the Australian national electricity market* program does not meet the requirements for an ERS as described above. Although this seeks to facilitate test environments in the electricity market to encourage innovation with the potential to contribute to the long-term interests of consumers, it cannot be classified as an ERS because it seeks to study technologies in "proofs of concept". This situation is similar in Austria. The *Energy.Free.Room project* seeks to ensure that the results of the research and pilot projects can be implemented in a technologically viable way (renewable energy integration, storage and energy efficiency).

Regulatory sandbox programs in the energy field (ERS):

In the case of the Netherlands (NLD), the *Experiments Decentralized,*

Sustainable Electricity Production (EDSEP) is an ERS that seeks to identify the obstacles presented by the *Electricity Act*, current electricity law, for the development of local collective solutions for the production of renewable energy and making it more efficient to use. This program carried out several projects in which the exemptions had two approaches: First, the project networks can have the function of a supplier, producer and distributor of energy at the same time as they manage their own mini-grid. Second, the large experiments cooperate with the DSO, while the network remains owned by the network operator and they care about flattening the load profile and balancing supply and demand. By taking on these tasks, experimenters become part of a polycentric energy system with decision-making units at various levels (van der Waal, Esther, et al., 2020).

Likewise, the German program (GER) *Smart Energy Showcases - Digital Agenda for the Energy Transition* (SINTEG) is an ERS that demands a high level of innovation in that they must be business models with rapid entry into the market. Similarly, the case of the United Kingdom can also be classified as ERS. In it, Ofgem's *Innovation Link* offers support on energy regulation to companies looking to launch new products, services or business models. It offers quick and candid feedback on regulatory issues and provides project-by-project regulatory support in cases where current regulation prevents the launch of products or services that could benefit consumers.

As a unique case, Hawaii, in the United States (US), is taken as an example of another form of regulatory experimentation. *Hawaii's development of performance-based regulation to support distributed generation and innovative product offerings* is an integrated regulatory approach to support the deployment of energy storage, self-consumption, and innovative solutions to support grid transformation. The experimentation here is based on the study of electricity rates, which, if successful, can be implemented as a regulatory innovation in other states of the country. The program has an outstanding participation of *Utilities*, administrative institutions, renewable energy promotion associations and environmental groups (ISGAN, 2019).

Table 8.
List of regulatory sandbox programs focusing on energy.
Key: A: Period; B: Characteristics of the projects; C: Exemption made; D: Technological level; E: Public financing; F: Participation of the regulator; G: Result.

Country	1. NLD	2. GER	3. ITA	4. UK	5. US
Objectives	Check the electricity law	Technological solution, product, service or business model	Functionalities for the networks, regulation of incentives to promote innovation deployment and actors in the electricity markets	Technological solution, product, service, rate model, business model, and regulation	New business models
A	2013-2019	2017-2020	2010-2019	2017- on	2018-2020
B	Small and large	Unspecified	Small	Unspecified	Unspecified
C	Network governance	At the request of the proponent or proposal of the regulator	Project dependent	Unspecified	Unspecified
D*	High	High	Medium	High	High
E	No	Yes	Yes	No	No
F	Medium	Unspecified	Medium	High	High
G	Limited*	Positive	Unspecified	Unspecified	Unspecified

Source: Own elaboration based on ISGAN 2019; Ofgem 2020; van der Waal, Esther, et al., 2020; and IDB, 2020.

***** Statement by van der Waal, Esther, et al., 2020.

(*) TRL criterion: 7-9, High; 4-4, Medium; and 2-3, Low.

In an analysis of the programs of the United Kingdom, Italy and the Netherlands within the framework of the European green transition, (Schittekatte, Tim, et al., 2021) highlight that, although the scope of regulatory experiments is expanding and encompassing the gas legislation,

most of the experimentation is taking place at the lowest tension level. The authors argue that for the green transition to be successful, it will be necessary to innovate in terms of technologies at the transmission level. For example, "power-to-x" technologies that enable industry integration.

5. Success factors of a regulatory sandbox in the energy field

As described above, regulatory sandboxes allow broad benefits to be achieved for innovation processes. As one more innovation tool, it complements the scope of other test environments that reach the maturity of technologies, to specify the market entry of new business models. In the energy context, sandboxes are being proposed to help achieve the profitability of business models associated with the objectives of the energy transition, such as decentralization and flexibility in the operation of the electricity system.

The contexts reviewed show that the ERS are being used to test and validate operating licenses for prosumers, for governance in the Blockchain system to be applied to the identification of origin of electricity transactions, and the models of association and ownership of microgrids (Ahl, A., et al., 2019). Similarly, they have been used to study market policies: liberalization, the microgrid auxiliary services market, emissions regulation, network codes for microgrid interconnection, Peer-to-Peer (P2P) policy, models of ownership, exchange, infrastructure and energy together with institutional innovation mechanisms. Each test depended on local conditions and the interests of the parties involved and the results cannot be universally applied.

In the case of creating energy communities, the ERS can be used to study the gap between technology and institutions and also incorporate economic, social and environmental dimensions. The reasoning here is that omitting any one of these dimensions would mean that an essential pillar of institutional change is missing. Energy community building and regulatory sandboxes can enable substantial institutional development across all dimensions by leveraging multiple perspectives, sharing knowledge, and reducing cross-sector silos. A gradual and multidimensional approach can contribute to interoperability between current and future systems through the staggered syncretic progress (Ahl, A., et al., 2019).

Within the energy transition, the use of other energy vectors other than electricity such as natural gas, renewable gas or hydrogen, as well as other sources of low-carbon power generation is also considered. In this sense, the ERS also help test new regulated business models in markets other than electricity. Despite there being different approaches in the degrees of technology maturity, the programs of the United Kingdom and Australia (AEMC, 2019) highlight this objective while taking into account that there are several companies in the gas sector that are making heavy investments in new energy processes that include new energy vectors.

Before applying sandboxes to the energy context, it is necessary to identify the factors that determine the success of these test environments. The objective is simply to contribute to the effectiveness of the application of this new tool to the innovation within the energy sector. In this sense, we can group the entire series of variables that determine the success of an ERS into three key factors: its relationship with the energy transition, the maturity level of the innovations to be tested, and their holistic nature.

Relationship with the energy transition:

The ERS are focused on making the decentralization and flexibility of the energy system viable. The scope of technological action of these two objective pillars of the transition is seen in the use of Smart technologies in the energy system and includes advanced use of ICT and digitization to achieve higher levels of efficiency and effectiveness in the provision of services to consumers. This is a success factor because decarbonization is the path that the energy sector has taken. Any other technological proposal based on the continuation of centralized or non-flexible systems would go against regulatory innovation.

In evaluating the evidence, the question should also be whether it has resulted in new insights to guide the energy transition by looking at regulation and not just whether the experimentation itself is efficient in providing added value to innovations. Learning potential, rather than replication potential, should be central in evaluating experimentation for regulatory innovation (van der Waal, Esther, et al., 2020).

The large amount of progress seen in the energy transition with respect to other previous sectoral transformation processes is the importance given to the consumer in this case. Regulatory sandboxes in this sense have a consumer benefit perspective and are normally focused on vulnerable consumers as default. The benefits that can be seen in this aspect are based on higher service standards or reducing bills.

Maturity level of innovations:

The ERS aim to validate business models resulting from already validated technologies. Any other model associated with a non-validated technology will not have an impact on the Smart renewal of the regulation. For the cases in which the technologies do not have a high maturity level, the experimentation program tests are carried out in environments in which the regulator allows the innovator to mature their technology without regulatory support because consumers or other interested parties are not at risk. In the case of the ERS, testing business models is accompanied by the study of the current regulation because they can quickly bring benefits to the interested parties, so the involvement of the regulator helps to reduce the barriers that the current regulation has for obtaining these benefits.

Holistic character of evidence:

This factor is transversal to the two above in that decentralization and flexibility implies not only advancing in technological and regulatory innovation but also in social innovation. The redistribution of the processes of generation, storage and distribution of energy close to the consumer brings with it the rethinking of the responsibility, administration and governance of the systems. For this, it becomes necessary to analyse the operation of energy systems with a polycentric governance approach (van der Waal, Esther, et al., 2020). The holistic nature of the ERS is also related to the transversality of the energy sector in the different industrial, business and institutional sectors. Therefore, the active participation of the interested parties in the results of the tests is fundamental for the success of the ERS. Information feedback between actors can be based on the management of strategic niches and agent networks as useful frameworks to explore aspects of innovation management (van der Waal, Esther, et al., 2020).

6. Situation of the SUDOE region

This report was created within the framework of the European project Tr@nsnet. The objective of this project is to design a new Living Lab model based on the principles of open innovation but that also allows for the analysis of the regulatory aspects that determine the entry into the market of new technologies and business models that seek to contribute to the energy transition.

The Living Labs are open innovation ecosystems that aim to allow the development of new products and services in near-to-reality scenarios in which end-users are involved in a co-creation process in real conditions, based on a partnership between public and private agents. The user is at the centre of the research process to imagine, develop and create innovative services or tools that meet the needs of everyone. One of the key points of the Living Labs is their favourability to allow the evaluation of technical and technological aspects. However, the regulatory aspects are not included in the elements for evaluation in these environments. This is clearly seen in the ENoLL Living Labs certification methodology.

In this sense, the Tr@nsnet project seeks to integrate the experimentation methodology of the Living Labs with the new regulatory evaluation tools proposed in the Energy Regulatory Sandboxes. With the integration of regulatory aspects in the operating methodologies of the Living Labs, these test environments would be strengthened, allowing not only the evaluation of technical and environmental aspects, but also the regulatory aspects that determine the viability of disruptive business models. And this is the spirit of this report: an advance in the design of a new Living Lab model updated with the analysis of the regulatory aspects that encompass the effectiveness of the energy transition. This is the backdrop against which we consider the situation of the ERS in the SUDOE region.

Situation in the European Union

Before addressing the general aspects of the SUDOE region, we will outline the European regional perspective.

At the end of 2019, ACER and CEER pointed out relevant aspects for regulatory innovation in Europe in their "Bridge Beyond 2025" document. In their conclusions, they highlight that, although several Member States are carrying out regulatory experimentation, there is no equivalent provision at an EU level (ACER and CEER, 2019). ACER and CEER claim that this could limit the effectiveness of national action when EU rules unintentionally get in the way and therefore propose the provision of an "EU umbrella for the regulatory sandbox approach". They also state that the resulting knowledge should be shared among the NRAs to avoid the need to replicate the pilot projects in each Member State and speed up decisions regarding the need to adapt regulation or legislation. According to (Schittekatte, Tim, et al., 2021), ACER and CEER do not discuss the practical application of regulatory experimentation at the EU level, and highlight that the involvement of an EU actor seems crucial. The authors propose that ACER should be the coordinator of the relevant NRAs in an EU-wide regulatory sandbox that follows the example of the British case. But this is an ambitious option that would require a significant regulatory effort.

Situation in Spain

In Spain, the Royal Decree-Law 23/2020, of June 23, 2020[4] allows the government to establish regulatory test benches that permit the introduction of "novelties, exceptions or regulatory safeguards that contribute to facilitating research and innovation in the field of the electricity sector" within the set of measures introduced. This is intended to promote a more agile development of the regulation of the energy sector based on prior testing of the regulations on new technologies or solutions. As early as the 2021-2022 action plan, the CNMC[5] plans to develop a closed test environment to experiment safely with unique projects to develop a regulation adapted to the rapid pace of innovation in the sector.

Within the scope of regulatory innovation, the CNMC[6] Circular 3/2019 from

[4] https://www.boe.es/eli/es/rdl/2020/06/23/23/con
[5] https://www.cnmc.es/sites/default/files/editor_contenidos/CNMC/20210507_Plan%20de%20Actuaciones_def.pdf
[6] https://www.boe.es/buscar/doc.php?id=BOE-A-2019-17287

November 20, of the CNMC, established the conditions and requirements for the execution of demonstration projects that can contribute to the improvement of the operation of the wholesale electricity market and system operation, provided the following criteria are met:

a) The product or service object of the project is innovative, is not currently being offered on the market or is different from the model currently used.
b) The applicant can demonstrate that the innovation will be beneficial for the consumer.
c) The System Operator or, as the case may be, the distribution network manager, justify the absence of risks for the operation of the system or for the affected distribution network, respectively.
d) There is some requirement in the regulations that prevents the implementation of the innovation.
e) There is a well-developed plan for testing the innovation. The plan will include clear objectives, criteria and indicators of success and a specific execution period that should not exceed thirty-six months.

Situation in France

In France, the law of November 8, 2019 on energy and climate, known as the "Energy-Climate Law"[7] , introduced a "regulatory sandbox" in the energy sector. This regulatory sandbox allows the Commission de Régulation de l'Énergie (CRE, the Energy Regulation Commission) to grant exemptions to the conditions of access and use of networks and facilities for the experimental deployment of innovative technologies or services in favour of the energy transition and Smart networks and infrastructures. This system provides a legal framework which is adapted to projects that allows innovations to be tested but that would ultimately require changes in the applicable legislative and regulatory framework. In 2020, the CRE announced the application of the "regulatory sandbox" in a paper which described the application procedure and the follow-up of the experimental projects for which the CRE has given its approval. In 2021, the CRE opened a second application phase, which lasted until January 14, 2022.

[7] https://perma.cc/5XYM-8VDA

Situation in Portugal

At the beginning of March 2020, the Portuguese government, through Resolution No. 29/2020 of the Council of Ministers, established the general principles for the creation and regulation of technology free zones (ZLT), a regulatory sandbox project. Portugal intends to adopt a flexible and innovative approach to new technologies, companies and products in the field of energy in order to encourage innovation and increase the attractiveness of the country as a testing centre. This will be done through the creation of digital innovation hubs as collaboration networks that include specific competence centres provided by companies, for their development, testing and experimentation. The objective of the Government is to establish, in collaboration with regulators, universities and market agents, among others, the conditions to gradually create new business models and solutions in the energy field. The areas of work proposed in this sandbox are the Internet of Things, the development of Smart cities and the improvement of the Smart grid. The legal framework and the regulatory frameworks that are implemented must be guided by the following principles and objectives:

a) Definition of a regulatory model that provides legal certainty and transparency;
b) Attention to the specific needs of the different sectors of the economy, in particular to those that are subject to greater regulation;
c) The safety of people and goods, the protection of consumers, respect for privacy and the rules for the protection of personal data;
d) Transparency and non-discrimination, valuing pioneering projects and guaranteeing the integration of existing ZLT in the initiative;
e) The promotion of territorial cohesion, based on the constitution of innovation poles, in the most remote or peripheral areas;
f) The publication of project results;
g) Ethical and responsible use of technologies.

7. Conclusions

This report tries to identify the application of regulatory sandboxes, instruments of innovation support, to the decarbonization process of the economy. The document has addressed the description of the requirements of the energy transition, the characteristics of the regulatory sandboxes and the benefits that can be seen. A proposal has also been made for the design of this type of regulatory test environment based on the review of programs recently designed in Germany and the United Kingdom. A review of existing programs and projects in other countries is made to finally describe the key factors that determine the success of a regulatory sandbox in the energy sector. The study also presents the current situation of sandboxes in France, Portugal and Spain, countries of the SUDOE region.

The achievement of the decarbonization of the economy is based on an innovative base that must succeed in transforming the energy sector, guaranteeing security of supply and economic competitiveness. The energy sector requires new and cleaner technologies, cheaper and competitive improvement of existing ones and an intelligent and sustainable system that allows for the creation of new innovative business models. It is no easy task. Going from a centralized system to a flexible and decentralized one, creates great uncertainty regarding the energy transition. As the system moves towards a decentralized structure, with a greater participation of end-users and a wider variety of new agents and service providers, there is a need to design new regulatory frameworks that can better support the integration of advanced technologies, Smart grids and business models.

When integrating innovation process into the current regulatory frameworks, we can identify two issues that can be problematic for the new business models that arise from new technological developments. The first is the gap between technological and regulatory innovation. Basically, regulators cannot foresee all the innovations that could lead to decarbonization, so unfortunately it will be out of step with the rapid advance of technological innovation. And the second problem occurs, in many cases, when regulatory frameworks are

designed to promote innovation and innovators may find them to be an administrative burden and generate market entry costs.

As a solution to these problems, regulatory sandboxes have been conceived as facilitators of innovation along the same lines as test environments (Innovation hubs, for example), but allowing institutional barriers to be overcome from a bottom-up approach and integrating the active participation of the regulator in the tests of the new business models of the innovators of the energy transition. From this position, the regulator can review the difficulties that innovative business models have in energy legislation, market structure and infrastructure investment mechanisms. The objective of the integration between innovators, regulators and other stakeholders in the energy transition is none other than to accelerate innovation and allow the replication and development of new business models by proving the repeal of current rules and regulations.

Regulatory sandboxes create a safe space for innovators, for emerging technologies and for new business models linked to the energy transition. They make regulation more flexible in periods of validation of the multisectoral and multidisciplinary scope of business models. They empower the consumer to discover their needs and respond to them efficiently and effectively, and integrate other agents of innovation. Indispensable for the transformation of the energy sector, innovation occurs faster when companies receive the support of regulators and can offer investors and consumers the guarantee that their innovative products or services do not break any regulations. Direct communication between developers, companies and regulators creates a more cohesive and supportive industry. And consumers benefit because new and helpful technology products come to market faster.

From the review of international experiences, several issues that need to be addressed in the design of future regulatory sandboxes in the energy sector are identified. These test environments have been designed to go beyond the support that has been given to the maturation of new technologies in test environments until now. The objective is to help break down the barriers that

innovators encounter when entering the market with products that have not been previously considered by regulators, that is, already mature technologies with robust business models. In this sense, regulatory sandboxes require business models to be able to function in the market, but allow innovators to validate certain regulatory aspects that are not yet clear or that put the decision of investors and consumers at risk. Combining the interests of regulators, innovators and consumer protection, the successful outcome of sandboxes does not imply that products must go to market or that regulators must necessarily modify the current regulation. If an innovator decides not to enter the market after a regulatory sandbox, it is also favourable because all parties know which technological trends put the objectives of the energy transition at risk. For the regulator, the study of regulation in situ helps it to be in line with technological innovation and the creation of new business models and allows it to accompany the innovator by responding to its uncertainties.

Although each country's energy sector is particular to its location, the design and application of regulatory sandboxes can be analysed in five phases: presentation of the proposal by the innovator, review by the regulator, joint preparation of the sandbox, performance of tests and validation of the innovations and of the *sandbox itself*, although its partial or complete path will depend on the uncertainties of the innovators. There are various options that can be offered: some innovators may be unsure how current regulation would apply to their innovations and what the consequences of non-compliance would be, for which only a few recommendations may be needed; other innovators need to guarantee that they do not breach regulations and finally, there are more complex tools for innovators who have already clearly identified a regulatory barrier that they can study with the regulator, for example, in the case of regulatory redundancy.

Similarly, from the review of international experiences there are three key factors for the success of a regulatory sandbox in the framework of the energy transition. The first is the direct relationship that the proposals must have with the climate objectives. Decarbonization is the path that the economy has taken and a technological proposal based on the continuation of centralized or

inflexible systems would not drive regulatory innovation. Second, the sandboxes aim to validate business models resulting from already validated technologies. For cases in which technologies do not yet have business models designed, the sector already has extensive experience in programs that do not study regulatory barriers or risks to consumers. And third, just like the energy transition, the sandboxes must have a holistic nature with which to advance in technological, regulatory and social innovation upon which the decentralization and flexibility of future energy systems depend.

In relation to the SUDOE region, we see how Spain, France and Portugal are moving towards the creation of clear regulations for the creation of test spaces with characteristics of regulatory sandboxes linked to the energy transition. Facing the challenges associated with climate change requires promoting innovative solutions. In this sense, demonstration activities are extremely relevant. The Living Labs are an excellent platform to test and validate the functionalities of new energy products and services in a controlled but real environment. However, as the energy sector is partially regulated, the development and validation of innovative solutions are often held back by regulatory factors. The regulatory framework defines the technical and economic aspects that must be considered by agents operating in the energy sector and, on occasions, it is not prepared to test temporary schemes and mechanisms without modifying the current regulatory norms.

Fostering innovation in the sector requires a new regulatory approach that offers new entrants or technology start-ups to test new business models that solve the challenges of the energy transition. ERS could be a solution to develop, test and scale innovation and technology in the energy sector. These products are made available to a limited number of customers, giving regulators and innovators the opportunity to assess their performance in a controlled environment. This environment ensures that companies act without regulatory constraints. Additionally, regulators can learn how new products work in a relatively risk-free environment and design regulations as needed.

The inclusion of "Energy Regulatory Sandbox Tools" in the operation of the

Living-Labs in the context of the energy transition, objective of the Tr@nsnet project, would allow academic, public and private actors to validate techniques, technologies and services before being introduced in the market. The ultimate goal of this type of mechanism or tool is to accelerate innovation and facilitate the effective entry of energy solutions with a high impact on society and on the economic and climate objectives of, in our case, the SUDOE region.

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