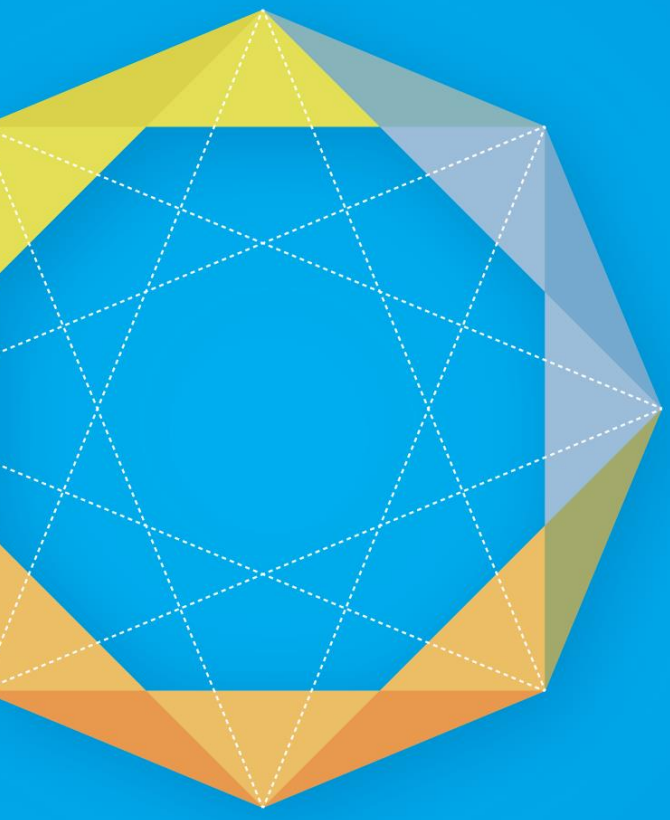
European Commission

Regulatory Sandboxes

Policy Report drafted by WG5's Regulatory Sandboxes Task Force



ETIP SNET

European Technology and Innovation Platform
Smart Networks for Energy Transition

Authors:

- Venizols Efthymiou (University of Cyprus)
- Nikos Hartziargyrou (ICCS National Technical University of Athens)
- Mark McGranaghan (EPRI)
- Marco-Robert Schulz (Siemens Energy)
- Jochen Kreusel (T&D Europe)
- Ricardo Almeida Henriques (E-REDES)
- Andrei Morch (SINTEF Energy Research)
- Dagmar Jarásová (SFÉRA)
- Rad Stanev (Technical University of Sofia)
- Aris Dimeas (ICCS Nationa Technical University of Athens)
- Athanase Vafeas (Dowel Innovation)
- Michele de Nigris (RSE)
- Iva Maria Gianinoni (RSE)
- Rainer Bacher (Bacher Energie)
- Mahboubeh Hortamani (BAAM Consulting)
- Shafi Khadem (International Energy Research Centre, Tyndall National Institute)

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EUROPEAN COMMISSION
Directorate-General for Energy
Directorate B – Just Transition, Consumers, Energy Efficiency and Innovation
Unit B5 – Innovation, Research, Digitalisation, Competitiveness
Contact: Andrea Hercsuth
E-mail: andrea.hercsuth@ec.europa.eu

European Commission
B-1049 Brussel

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ABBREVIATIONS

ACER	Agency for the Cooperation of Energy Regulators
ARERA	Italian Regulatory Authority for Energy, Networks and Environment
BAU	Business as Usual
CAPEX	Capital Expenses
CBA	Cost and Benefit Analysis
CEC	Citizen Energy Communities
CEER	Council of European Energy Regulators
DER	Distributed Energy Resources
DC	Direct Current
DG	Directorate General
DNO	Distribution Network Operator
DSO	Distribution System Operator
DR	Demand Response
DUoS	Distribution Use of System
EC	European Commission
EMA	Energy Market Authority
ERSE	Portuguese Regulator
ETIP SNET	European Technology and Innovation Platform for Smart Networks for the Energy Transition
EU	European Union
EV	Electric Vehicle
G2V	Grid to Vehicle
HLUC	High Level Use Case
IP	Intellectual Property
ISO	Independent System Operator
IT	Information Technology
kW	kilo Watt
kWh	kilo Watt hour
MW	Mega Watt
MWh	Mega Watt hour
NRA	National Regulatory Authority
OEB	Ontario Energy Board

OPEX	Operational Expenses
PBR	Performance Based Regulation
PIM	Performance Incentive Mechanism
R&D	Research and Development
R&I	Research and Innovation
REC	Renewable Energy Community
RES	Renewable Energy Systems
RSP	Regional System Planners
SME	Small to Medium Enterprise
TRL	Technology Readiness Level
TSO	Transmission System Operator
TUoS	Transmission Use of System
UK	United Kingdom
V2G	Vehicle to Grid
WACC	Weighted Average Cost of Capital
WG	Working Group

EXECUTIVE SUMMARY

This policy paper answers the request from the European Commission to ETIP SNET to provide the opinion of the energy stakeholders in industry, technology vendors and academia in using regulatory experimentation for expediting the process to meet the strategic objectives of Green Deal and REPowerEU. A regulatory sandbox, as defined by CEER, is the general framework that innovators can apply to test their innovative products, services, and methodologies for a certain period. It may imply a derogation from standard regulations, subject to conditions imposed by the regulator, and in some emerging cases derogation may not be necessary.

Through the investigations conducted to compile this report, it is identified that the main characteristics associated with regulatory sandboxes are related to the following:

- Set up to support innovative solutions to promote regulatory learning.
- Limited timeframe implementation.
- Occurring in a limited part of a sector or area [6] but, in the case of grid operators, they can embrace a large portion of the network.
- Controlled in a (near) real-world environment.
- TRL 7-9
- Can imply a regulatory derogation.
- Regulatory sandboxes can be "policy-oriented" or "innovator-oriented" [9]. Policy-oriented regulatory sandboxes are launched by regulators to address specific goals, while innovator-oriented are led by sector stakeholders to bring a new product or service to the market.

The main conclusions coming from the 46 distinct contributions of ETIP SNET stakeholders to a dedicated questionnaire are:

➢ **Barriers when implementing innovative solutions in the market**

- Regulatory and legal hurdles may limit the implementation of innovative solutions, either because the current regulatory framework does not support certain types of spending or because it does not allow certain types of activities.
- Resistance to change among stakeholders who may be skeptical about the value of the innovation, or the potential risks involved is a significant challenge.
- Lack of clear business models that support innovation, while maintaining reliability and regulatory compliance.
- Conflicting pursuits from actors in the same ecosystem. Lacking openness towards innovation and willingness to collaborate with stakeholders to demonstrate the value and potential benefits of innovative solutions.
- Lack of maturity in new technologies and lack of capacity of equipment suppliers to implement new technologies on a large scale.
- Insufficient remuneration schemes and lack of incentives for operators to implement innovative technologies.
- Lack of coordination among public agencies responsible for innovation funding and complex application processes leading to a fragmented and inefficient system.
- Lengthy and complicated processes surrounding the implementation of innovative solutions, which can deter developers from participating in innovation activities.
- The traditional cost-of-service approach to electric price formation, which relies on forecasting fixed cost obligations, thus obstructing experimentation with innovative technologies and business models.

- **Main areas with real value needing regulatory experimentation**
  - Flexibility markets: regulatory experimentation for effective use of implicit DR, explicit DR, smart use of storage in all forms including EVs and aggregated flexibility coming from energy communities.
  - Demand Response to manage peak electricity demand, reduce costs, and increase grid reliability.
  - Energy Communities: support Energy Communities formation, operation, and integration into the grid, including Self Consumption and Peer-To-Peer Trading for Energy Sharing.
  - Energy Storage: experiment with new business models and pricing structures that can support the deployment of storage technologies and use of storage systems as network assets.
  - Electric Mobility: Regulatory experimentation to manage the charging infrastructure, incentivize the adoption of electric vehicles, and address the challenges of grid integration (smart charging, V2G and G2V).
  - Design of tariffs: TUoS and DUoS tariffs that determine the types of expenditures prioritized (OPEX vs. CAPEX) for grids including payback periods. Develop effective incentive-based targets and rewards to meet the challenges of the energy transition and the shift from central to distributed sources of energy.
  - Gas Networks: Innovative experimentation on renewable gas with benefit for the whole energy system and for the final consumers.
- **Types of experimentation tools preferred by the industry**
  - Innovative regulatory sandbox is the preferred option, offering the parallel experimentation of all identified options to reach optimal solution faster through real life implementation.
  - Embedding sandboxes in a permanent institutional framework ensuring monitoring, evaluation and follow-up.
  - Regulatory experimentation tracked at European level carefully selected case studies strategically sited to ensure consistency with new directives and regulations, but deployment through concrete field experiments in member states.
  - Preference for experimentation tools for technical assurance, so that technologies can be implemented by other grid operators more quickly.
  - Incentive regulation to realize the strategic goals, especially with regards to the energy transition towards decarbonization.
  - Development of a publicly available grid model, including market structure representation. This can provide opportunities for new innovations to be evaluated in a system representing holistically the real world to assess benefits.
- **Lessons learnt through regulatory experimentation - success factors**
  - A major success factor is the involvement of private and public stakeholders in the design and participation in regulatory sandboxes, as well as in the derivation of conclusions from the trial. Close collaboration with regulators along the entire development process.
  - Regulatory sandboxes should not be technology biased. Any restrictions can reduce the availability of new solutions/technologies.
  - There can be jurisdictional constraints in designing regulatory sandboxes. One important jurisdictional constraint concerns compliance with EU legislation, which the NRA should take into consideration when designing the regulatory sandbox investigation. Following successful completion of the planned investigations with positive results, implementation and scaling up should be pursued following targeted amendments to the EU legislation with the support of CEER.
  - Some regulatory sandbox experiments may not allow sufficient time to evaluate the full benefits or issues of a particular innovation or new regulation. Monitoring and characterizing benefits over an adequate period is important.
  - Involving consumer participation and deploying equipment at consumer premises is always more difficult than anticipated.

- Avoid unnecessary duplication by wide dissemination of on-going innovation trials that involve regulatory and policy adjustments and build on previous efforts.

The last question in the questionnaire requested evidence of best practices for turning positive results from sandbox experiments into European regulatory adjustments. Answers were received reporting such cases from Ireland (ESB), Norway (Adger Energi Node project), Germany (Next Kraftwerke), Italy (Energy Center of the Politecnico di Torino), Austria (Siemens Energy Austria GmbH), Slovakia and USA (Energy Research Economics – LLC).

Areas for regulatory experiments implemented and considered in EU countries and internationally regarding integrated grids, customer and markets, storage, generation, and digitalization are listed, and examples of European and International Regulatory Sandboxes on the Energy Sector are provided.

Collectively, EUREC Members have reviewed the paper and fully support the conclusions and recommendations of this policy paper. Regulatory sandboxes are an essential tool for the optimization and subsequent deployment of innovative technologies as developed by members of EUREC as research organizations. For the areas where regulatory experimentation adds value, EUREC members highlighted the importance of modeling/simulating the impact of the proposed sandbox prior to its implementation. EUREC members also commented on the preferred types of experimentation tools – regulatory sandboxes can be hindered by strict national regulatory policies. Regulators should therefore commit to greater flexibility in terms of requests from industry for derogations from specific national rules.

1. Introduction

The energy transition requires fundamental changes in the energy matrix, which is composed of various variables such as the ones mentioned in ETIP-SNET High Level Use Cases (HLUC) [1]. The transition requires a broader regulatory approach since innovation is currently limited to improved system / grid operation. More effective regulation is required to foster innovation in facilitating the emerging technologies and market, digitalization and to increase transparency to support EU aspirations to accelerate the energy transition process. ACER believes that the regulatory environment will create new opportunities for innovation to prosper [2] and for that, better, evidence-based, [3] regulation is needed to support citizens and the industry to aim for a functioning EU Single Market. The European Union and its Member States can have a crucial role in promoting innovation since they can provide various regulatory experimentation tools to stimulate innovation among regulated stakeholders [4].

Regulatory sandboxes can be considered as a tool for testing new solutions in a practical manner [5] and these have a huge potential for future-proof regulation [3] since they provide the right environment to test technologies, products, and services when they are not compliant with the current regulatory framework. This allows for learning about the advantages and disadvantages that a certain innovation carries and, with the knowledge gained from the experiment, developing the right regulatory framework to implement it [6,7]. In regulatory sandboxes, both regulated entities and market players can propose the projects and suggest regulatory derogations [8]. They have been implemented in more than half of the CEER Members [9] and are used in various sectors such as finance, aviation, health, transport and legal services [3].

In the energy sector, regulatory sandboxes can reduce the barriers to entry that innovative businesses often face, encourage innovation, and promote economic growth while protecting consumers by identifying and mitigating risks early on [10, 11, 12]. By allowing companies to test new products and services in a controlled environment, regulatory sandboxes can help ensure that only safe and effective solutions are brought to the market, which in turn can help build trust with consumers and stakeholders [13].

In this paper, we (ETIP SNET experts representing the industry, manufacturers, academia, researchers, and market participants including end users) shall explore how regulatory sandboxes can be used to improve innovation implementation and introduce market-ready products/services in the energy sector. We will examine the different types of regulatory sandboxes and their key features, as well as the benefits and challenges of implementing regulatory sandboxes in the energy sector. By doing so, we aim to provide insights into how regulatory sandboxes can be used to support innovation and promote economic growth in the energy sector.

1.1 Regulatory experimentation and regulatory sandboxes

Regulatory experimentation is normally associated with various types of tests, with different characteristics, such as Test Beds, Living Labs, and Regulatory Sandboxes, which are distinguished based on different variables such as the test motivation, the implementation timeframe, present stakeholders and their roles and used mechanisms [14], amongst others. CEER launched a Dynamic Regulation Innovation Toolkit [9] which differentiates different dynamic regulatory tools:

- **Pilot project:** small-scale in-field trial to evaluate innovative approach/functionality/technology. It involves grid operators and regulatory approval is necessary.
- **Regulatory sandbox**: general framework that innovators can apply to test their innovative products, services, and methodologies for a certain period. It implies a derogation form standard regulations, subjected to conditions imposed by the regulator.
- **Regulatory experiments**: large-scale policy-driven sandbox in which derogations are awarded to grid operators to test changes in regulation combined with new grid technologies.
- **Pilot regulations**: establishment of an ex-ante regulatory framework that defines a transitional regime to cope with novel issues impacting the power system.

Inside the regulatory sandboxes term is a huge variety of concrete experiences. CEER affirms that “there is no single version of regulatory sandbox which provides regulators with different tools for different contexts and tasks” [9]. It is then necessary to adopt a common language to refer to different forms of regulatory experimentation [4] so that the involved stakeholders and regulators can understand which type of regulatory experimentation tool is best suited for their specific implementation case.

These are the main characteristics associated with regulatory sandboxes:

- Set up to support innovative solutions to promote regulatory learning.
- Limited timeframe implementation.
- Occurring in a limited part of a sector or area [6] but, in the case of grid operators, they can embrace a large portion of the network [9].
- Controlled in a (near) real-world environment [14].
- TRL 7-9 [14].
- Can imply a regulatory derogation [9].
- Regulatory sandboxes can be "policy-oriented" or "innovator-oriented" [9]. Policy-oriented regulatory sandboxes are launched by regulators to address specific goals, while innovator-oriented are led by sector stakeholders to bring a new product or service to the market.

2. Methodology

To elaborate this paper, ETIP-SNET gathered an expert task force which is composed by 16 members of the association stakeholders, coordinated by members of Working Group 5, to develop a common view of the ETIP-SNET stakeholders experience on regulatory sandboxes. The analysis is composed by two different parts:

Literature review: In this part, the members of the task force assessed the state-of-the-art of regulatory experimentation in some EU Member States (Germany, France, Ireland, Italy, Netherlands, Portugal, France, Slovakia), and in some countries worldwide (Australia, Canada, New Zealand, Singapore, United Kingdom, United States, Switzerland, Norway), to find some relevant examples of regulatory sandbox projects. To complement this analysis, an academic and grey literature review was performed.

Questionnaire and Interviews: To gather the perspective from the stakeholders, a questionnaire with relevant questions related to the topic was elaborated on EUSurvey, and it was distributed to the experts of ETIP SNET and their respective associations including the members of the Governing Board and the members of all the Working Groups together with some relevant external stakeholders. This was complimented with some one-on-one interviews where the questions addressed were the same as the ones present in the questionnaire. The addressed questions are the following:

1. Which are the needs and barriers that you have identified when implementing innovative solutions in the market?
2. What are the main areas where you see real value and need for regulatory experimentation?
3. Which types of experimentation tools are preferred by the industry? If possible, can you provide evidence as to why?
4. Which are the lessons you have learned through regulatory experimentation in your sector? Can you identify any success factors or documented failures?
5. Can you identify any evidence of best practices for turning positive results from sandbox experiments into European regulatory adjustments providing permanent impact for all market participants including citizens?

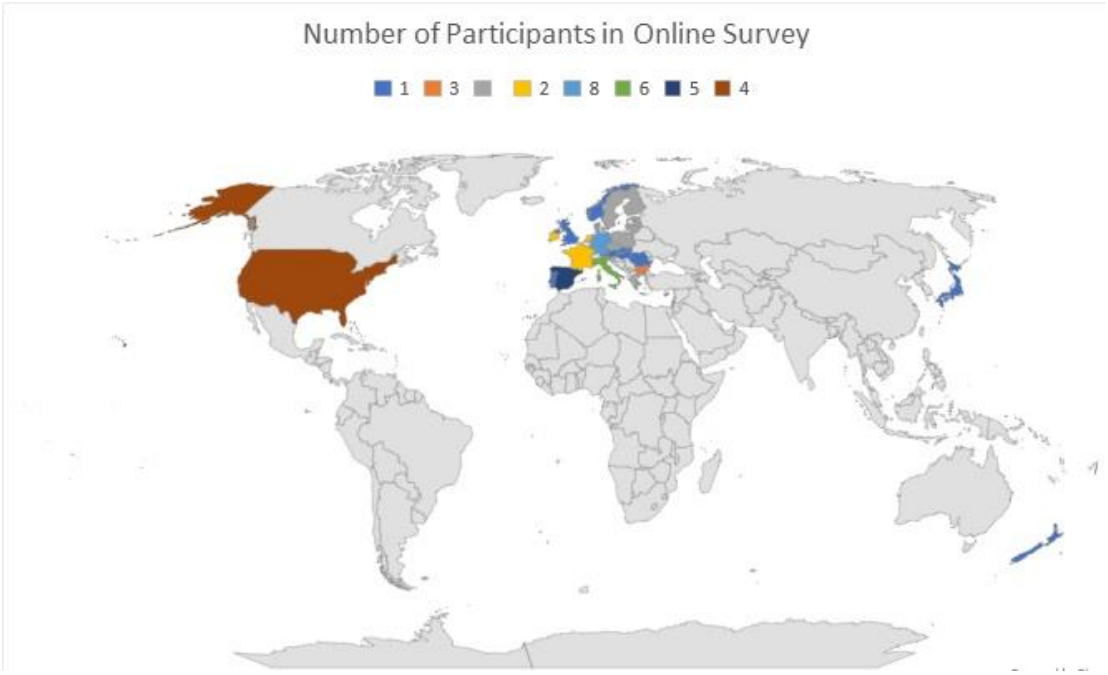

Figure 1 Map visualising the number and location of participants

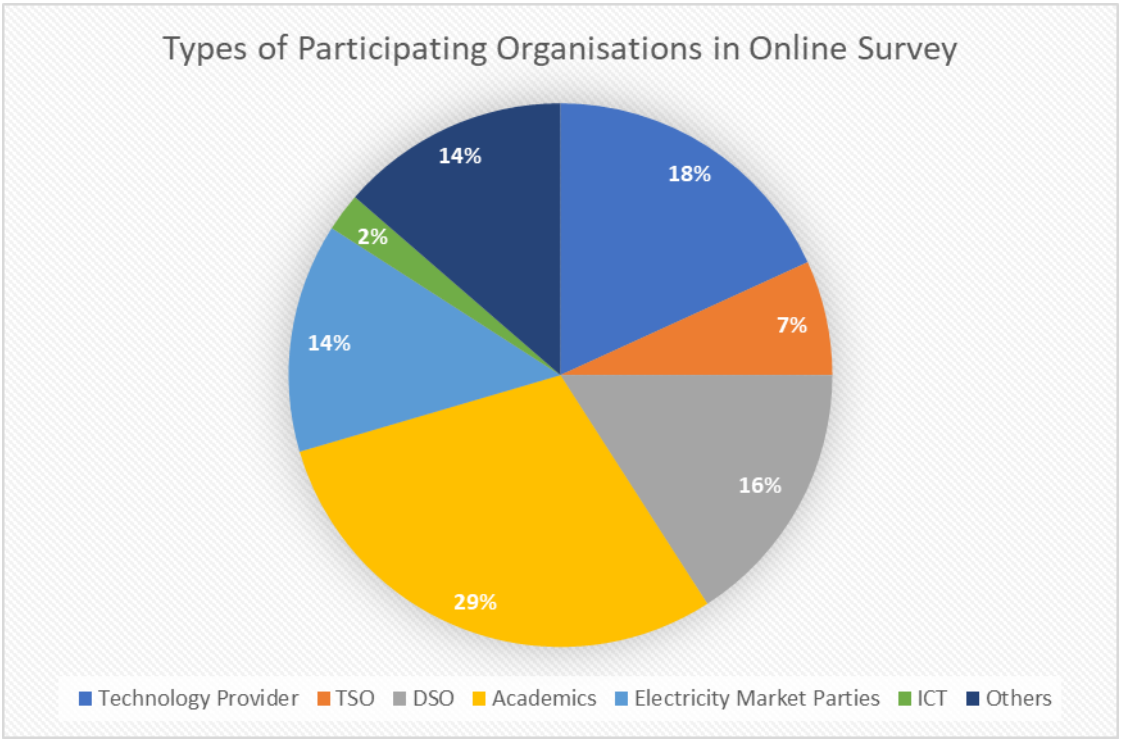

Figure 2 Pie chart showcasing organisational sectors of participants

Based on the 46 responses from the questionnaire and from the information gathered in the literature review, the task force members compiled the responses to all five questions mentioned above.

The methodology used to develop this paper has some limitations, which are the following:

- The stakeholders that answered the questionnaire do not cover all the EU Member States involved in the ETIP-SNET, which means that some perspectives and examples might be missing in this report.
- Only some EU Member States and some countries worldwide were analysed in the literature review based on the contributions of the members of the Task Force, EDSO and ENTSOe.

This policy paper on regulatory sandboxes has extensively been reviewed by the Governing Board of ETIP SNET, EDSO, ENTSOe and EUREC. Valuable contributions were received that complimented the findings of the Task Force.

More specifically, EUREC Members have reviewed the paper and fully support the conclusions and recommendations of this policy paper. Regulatory sandboxes are an essential tool for the optimization and subsequent deployment of innovative technologies as developed by members of EUREC as research organizations. For the areas where regulatory experimentation adds value, EUREC members highlighted the importance of modeling/simulating the impact of the proposed sandbox prior to its implementation. EUREC members also commented on the preferred types of experimentation tools – regulatory sandboxes can be hindered by strict national regulatory policies. Regulators should therefore commit to greater flexibility in terms of requests from industry for derogations from specific national rules.

3. Identified needs and barriers when implementing innovative solutions in the market

To successfully implement innovative solutions in the market, it is important to identify and address several key needs and barriers. These include technical challenges such as integrating the innovation with existing systems and ensuring data security and privacy, regulatory hurdles that may limit implementation, and difficulty in measuring the success of the innovation and demonstrating its value to potential investors or customers. Other barriers include limited resources or funding for research and development, financial risks, and resistance to change among stakeholders who may be sceptical of the value of the innovation, or the potential risks involved. Addressing these needs and overcoming these barriers is crucial to the successful implementation of innovative solutions in the market.

3.1 Barriers to implement innovative solutions in the market

The responses from the experts are indicated below but in general they are more focused on the faced barriers to innovation and not direct need for regulatory experimentation. However, the content is important to note since it might generate interest to policy makers / regulators and urge change actions that can include regulatory experimentation practices to expedite the required innovation change.

- Regulatory and legal hurdles may limit the implementation of innovative solutions, either because the current regulatory framework does not support certain types of spending or because it does not allow certain types of activities.
- Resistance to change among stakeholders who may be skeptical about the value of the innovation, or the potential risks involved is a significant challenge.
- Lack of clear business models that support innovation, while maintaining reliability and regulatory compliance.
- Conflicting pursuits from actors in the same ecosystem. Lacking openness towards innovation and willingness to collaborate with stakeholders to demonstrate the value and potential benefits of innovative solutions.
- Lack of maturity in new technologies and lack of capacity of equipment suppliers to implement new technologies on a large scale.
- Insufficient remuneration schemes and lack of incentives for operators to implement innovative technologies.
- Lack of coordination among public agencies responsible for innovation funding and complex application processes leading to a fragmented and inefficient system.
- Lengthy and complicated processes surrounding the implementation of innovative solutions, which can deter developers from participating in innovation activities.
- The traditional cost-of-service approach to electric price formation, which relies on forecasting fixed cost obligations, thus obstructing experimentation with innovative technologies and business models.
- High- and middle-income countries are more likely to have regulatory sandboxes compared to low-income countries. It is observed that poor economic conditions combined with the high cost of setting up and operating a regulatory sandbox may decrease the likelihood of a country establishing one.
- Risk Washing, meaning that sandboxes creating a perception of regulatory oversight and risk mitigation while potentially overlooking or downplaying certain risks. Within this perception, sandboxes may lead to social disruptions, privacy violations, selection bias, and undermine trust in institutions.
- Fear of distortion of competition by giving an advantage to sandbox firms over non-sandbox firms. There is concern that competition may lead to a race to the bottom in terms of regulatory standards through the use of sandboxes. If regulators adapt the sandbox concept without sufficient experience or resources, it could compromise the effectiveness of sandboxes and create an uneven playing field among firms.
- Distribution system operators unwilling to engage with small entities and EU rules requiring third party access to networks and the ability of consumers to switch supplier.
- There are concerns about sandboxes potentially leading to "cognitive capture," where regulators become too sympathetic to the positions of the firms they oversee.

3.2 Prerequisites to implement innovative solutions in the market

- The regulatory authorities must be engaged whenever the set-out experimentation includes changes in the prevailing regulation. In such cases, they should actively participate in the innovation programme to ensure that the proposed solutions align with regulatory requirements and that the necessary regulatory changes are made to support their implementation. The engagement of regulatory authorities can also help build trust and confidence in the solutions, leading to smoother adoption and implementation in the market.
- It is important to note that the absence of a well-defined link between the innovation ecosystem and the regulatory body creates challenges in incorporating experimental findings into new regulations. This poses a significant hurdle for novel solutions that surpass existing regulations or operate in areas where regulations are unclear, limiting them to laboratory testing without further development.
- Another set of prerequisites to implement innovation solutions on energy, includes financial compensation and incentives for the developers when conducting the designed experimentation. Through this approach it is anticipated that positive results will signal the required business cases that can utilise the tested innovations for real life implementation and scaling up that will reward the investors.
- The availability of live pilot sites, which provide real data, real people involved, and real outcomes, is crucial to test and validate innovative solutions. These prerequisites can help ensure that the innovative solutions are effective in fostering innovation, improving customer outcomes, and promoting sustainable energy solutions. Real data is crucial for the effective implementation of sandboxes. It is important to promote the aspects of complete, anonymized data which abide by the FAIR principles. To this end, the concept of Common European Energy Data Spaces can be considered as a prerequisite for sandbox implementation.
- There must be an adequate communication capacity that can differentiate and cater to different categories of stakeholders, such as SMEs, municipalities, citizens, and local policy makers. This can help ensure that stakeholders are engaged in the process and their feedback is considered in the sandbox's development and in the implementation of the innovative solution.
- Innovative solutions in the energy sector require thorough market research to understand the needs and opportunities of the target audience. A comprehensive analysis of the competitive landscape is also vital to determine how the proposed solution will stand out from existing products and services.
- Innovative solutions should adopt a step-by-step approach that allows for early learning about customer acceptance and operator capabilities. This approach can help to validate the innovation's value and demonstrate its potential to investors and customers. Furthermore, the use of early learning can help to identify areas for improvement and provide valuable feedback to the developers.
- Regulators should have the necessary skills to accurately assess the innovative nature of applications. They need to establish a comprehensive approach, which involves multiple tiers of support from initial idea to final licensing of a full-scale product, with sandboxes being one tier of support.

4. Main areas for regulatory experimentation

As already said, the electricity sector is going through a major transformation due to the increasing adoption of renewable energy sources and the need to reduce carbon emissions. In this context, regulatory experimentation can play a crucial role in facilitating innovation, reducing regulatory barriers, and promoting competition in the electric sector.

4.1 General directions: where to focus

Focus to areas with shared benefits

The main areas for focusing regulatory experimentation are those with shared benefits and may require changes to existing market rules/systems (including network planning and operation, use of flexibility, energy communities etc) - there is a significant influence of the existing market rules and systems, which hinders experimentation with business models/services that don't fit the existing paradigm. A New Zealand example is testing the option for a customer (one location) to have multiple electricity service providers (called multiple trading relationships) - the basic premise is enabling separate reconciliation and settlement of services at a single location. The opposition from incumbents has been matched only by the enthusiasm from firms wanting to test new business models. It has taken nearly 7 years to go from idea to trial, despite the system changes and costs being relatively minor.

The biggest areas for regulatory sandboxes are those cases in which players from both the regulated and the competitive sectors must take coordinated actions to put new solutions or business cases into practice. Many examples can already be signalled to clarify further the needed action:

- Interoperability in in-home appliances, EV charging, Data Spaces, etc.
- Use of flexibility in achieving optimal solutions of systems including smart charging of EVs etc.

Enhance learning process

Ultimately, a properly designed and operated regulatory sandbox should enhance the learning process of all involved stakeholders including regulators and policymakers. A lot of valuable experience and information can be gained from these pilots, even when they fail. Spotting the directions that are not advisable to take or should be avoided is also a gain.

Challenges in integrating innovation with existing systems

One significant challenge is integrating the innovation with existing systems while ensuring data security and privacy. To overcome these challenges, regulatory sandboxes need to have clear frameworks and incentives that support the development and testing of innovative solutions. It is essential to ensure that developers have access to the resources they need to develop and test solutions adequately while also ensuring that there are clear guidelines and frameworks in place to minimize financial risk.

Carefully thought processes give confidence that they can deliver but attempts to prove it via a trial might create conflict among the involved stakeholders or create precedence in required changes.

Constraints posed by regulation, market design or grid codes

In the competitive sector one of the cases in which regulatory constraints could appear is when innovations depend on measures in the regulated sector or on rules provided by market design or grid codes. An obvious example for the first group is the dependency of aggregation services on a smart meter infrastructure. An example for the second group is the realization of control power offerings by aggregating distributed resources, which is prohibited in some electricity markets because either pools were not accepted or there was a minimum capacity per unit way above typical distributed resources. Business models for storage also fall in this category because they are (among other factors) heavily affected by the structure of use of system fees.

A stable supply of electricity imposed solely on conventional power companies distorts competition and impedes decarbonization. Regulatory experimentation should help to smoothly introduce the paradigm change of emerging technologies and flexibility in demand to safeguard the continuity of stable quality supply.

An issue often encountered with uptake of innovative solutions is that the full benefit for regulated entities, and thus the business model behind the solution itself, are fully known only after the solution has been deployed on a wide scale. Particularly for digital solutions, benefits arising from a small-scale pilot will often be proportionally lower in

comparison to the costs, than with large-scale deployment. Thus, TSOs (or DSOs) should be able to justify expenditures (to their shareholders, or to NRAs), when full benefits are unclear.

Focus on grid flexibility

The broad area related to grid flexibility should be a domain of focus, in particular demonstrating best regulatory practices to share flexibility value across the energy value chain. Such experimentation should leverage IoT, edge computing and digital twin technologies to facilitate layered optimisation throughout the energy value chain leveraging transactive controls.

Focus on energy monitoring and management

In the energy field, one of the main areas with a need for regulatory experimentation are energy monitoring and management. While, in the monitoring area, it would be useful to follow the approach used in the experimentation of Chain2 in Italy (standard CEI TS 13-82, 83, 84) (summarised in Section 8.1), in the area of management, it is necessary to experiment with the integration and interaction between different devices. i.e., loads of the house.

4.2 Areas where regulatory experimentation adds value

Flexibility markets: regulatory experimentation for effective use of implicit DR, explicit DR, smart use of storage in all forms including EVs and aggregated flexibility coming from energy communities. Remove barriers in the participation of aggregated distributed resources, because either pools were not accepted or there is a minimum capacity per unit way above typical distributed resources. Experiment with **time-of-use tariffs** to allow the embedded benefits of DR to contribute to the optimal balance of the energy mix avoiding valuable RES curtailment.

Demand Response programs to manage peak electricity demand, reduce costs, and increase grid reliability. Current regulatory frameworks often limit the participation of **residential customers**, and there is a need to experiment with new approaches to incentivize their participation. In the **area of management**, it is necessary to experiment with the integration and interaction between different devices (for example loads of the house) with the DSO to ensure observability/flexibility of the demand.

Energy Communities: There is a need to experiment with new regulatory frameworks that can support the Energy Communities formation, operation, and integration into the grid. This includes **Self Consumption** and **Peer-To-Peer Trading** for Energy Sharing (Renewable Energy Communities (REC) and Citizen Energy Communities (CEC). Support energy storage as part of REC and CEC (including e-Cars as distributed storage capacity).

Energy Storage helping the integration of renewable energy into the grid, improve grid resilience, and reduce costs. Regulatory frameworks for energy storage are still evolving, and there is a need to experiment with **new business models** and **pricing structures** that can support the deployment of these technologies. For example, use of storage as network assets or storage in homes, particularly for implementing explicit demand-response, etc.

Electric Mobility: The electrification of transportation is expected to have a significant impact on the electric sector, creating new challenges and opportunities. Regulatory experimentation can help develop new approaches to manage the **charging infrastructure**, incentivize the adoption of electric vehicles, and address the **challenges of grid integration** (smart charging, V2G and G2V).

Design of tariffs: TUoS and DUoS tariffs that determine what types of expenditures are prioritized (OPEX vs. CAPEX) or what payback periods are reflected in regulatory schemes is impacting innovative solutions. **Incentive-based** Targets and rewards should be carefully developed by the regulator. Ability to avoid **procurement** issues and try out something without having to prove that it is unique and hence does not need to be tendered.

Gas Network: Innovative experimentation on **renewable gas** with benefit not for the gas operators themselves but for the whole energy system and for the final consumers. The absence of regulation on some issues that are crucial to promote sustainability and the renewable gas market should also be emphasized, as for example the innovative technological solution of “reverse flow”: that is the best option (in the biomethane sector) to optimize the connection of biomethane plants to the gas network. Reverse flow is not regulated by the Authority with, consequently, no definition of the tariff remuneration envisaged for the operators (DSO and TSO) who manage the different assets involved.

LVDC & MVDC networks: The regulatory and standardisation barriers impede the development and deployment of Middle Voltage (MV) and Low Voltage (LV) DC Networks and Technologies, especially in the energy communities.

Similarly, grid codes are needed for the MVDC and LVDC for its wider application and integration with the AC network mainly at distribution level.

More areas where regulatory experimentation can support innovation and fast evolution of technologies and systems in support of energy transition are:

- For transformational use cases with the potential to accelerate the transition to the renewable energy system. For example, when TSOs or DSOs are obliged to cover for grey losses on the system to be offered the option to purchase 'Green electricity to cover the evaluated portion of losses' and not necessarily buy them from the market.
- For cross-functional (regulation, market model, market roles, value chain, business model, customer engagement, technology, processes, and laws) use cases to test **end to end scenarios** and to learn the interdependencies.
- Hydrogen: Low levels of promotion of this renewable source, even at legislative and normative level.
- Operation and participation of storage technologies beyond batteries in ancillary services.

5. Type of experimentation tools that are preferred by the industry

The experts coming from the field of operators, manufacturers, market participants, research bodies and academia representing the core of the membership of ETIP SNET consider the following of critical importance to pave the way to sustainable implementation following positive experimentation results:

- The required experimentation tools are not necessarily unique or onerous. We consider regulatory support to be a key ingredient of learning-by-doing. This means exemptions from the market rules are available promptly with a decision-making process which reflects the risk (eg, a regulatory sandbox framework) and options to ringfence reliability and quality performance for experiments (particularly for regulated networks). Some examples can be:
    - Access to the regulator for advice
    - Regulators commit to fast reaction time to requests / decisions, e.g., weeks, not months.
    - Derogations from specific rules are available for time limited periods for a specific reason.
    - A reasonable commitment that derogations or amendments will be applied generally and without delay if the experiment demonstrates customer value.
- Innovative regulatory sandbox is the preferred option, offering the parallel experimentation of all identified options to reach optimal solution faster through real life implementation. The size of the sandbox sample should be in the criteria to decide the planned experimentation cycles, carefully selected to give convincing results. In all experimentations the regulated entities i.e., DSO, TSO etc including the regulator, should actively be involved to contribute through their vast experience to achieve fast and convincing results and be ready to extend as required and actively facilitate the implementation of optimal results achieved.

  Additionally, we should underline that it depends on the type of innovation project in question. The three main approaches are equally useful:
    - Regulatory sandboxes, for example in the case of emerging operational requirements of energy communities,
    - Pilot regulations, for example in the case of local grid congestion (local project),
    - Regulatory pilot projects, for example in optimizing the use of various types of energy storage (existing regulation already existing elsewhere).
- Embedding sandboxes in a permanent institutional framework ensuring monitoring, evaluation and follow-up is helpful, particularly as such framework ensures building up and preserving knowledge on the sandbox methodology itself.
- Regulatory experimentation should be carefully tracked to ensure consistency with new directives and regulations to be deployed. They should, however, be deployed through very concrete field experiments in member states aiming to test associated regulatory innovation at scale. The test can run several years, evolving in the process with the NRA involved to monitor associated deployments to approve reverse engineer network code adaptions by the Operators, based on the lessons learnt. TSOs and DSOs should be incentivised to deploy associated innovation at pre commercial stage and maintain it (similarly to the Nodes TSO DSO project at Adger Energi Norway for instance).
- Preference for experimentation tools for technical assurance. We often see that many initiatives are duplicated across the power system. We would like experimentation to contribute towards technical assurance, so that this can be implemented by other grid operators more quickly.
- Incentive regulation to realize the strategic goals, especially with regards to the energy transition towards decarbonization and incentives to support the “main areas”:
    - Profit sharing for macroeconomically positive innovations like usage of (“grid serving”) flexibility or avoidance of redispatch costs. Currently, DSOs have no real incentives for any kind of activities as additional OPEX would be at risk and potential additional profits would be deducted from the grid fees.
    - Also (timely and/or project-specific) overriding of unbundling rules, e.g., in terms of Power- to-X and storage usage.

- The Italian Regulator ARERA is a good example of required innovative experimentation. Recent resolution incentives provide the finances to pilot projects of technological innovation related to natural gas infrastructures. The Authority envisaged different areas of experimentation, including projects for optimizing network management. More specifically, Pilot Projects can concern one of the 3 purposes identified by ARERA:
    - Methods and tools for optimized network management.
    - Innovative uses of existing infrastructures to receive renewable gases, including hydrogen.
    - Innovation interventions on the infrastructure to increase energy efficiency.

6. Lessons learned through regulatory experimentation and identified success factors and documented failures

The experts coming from the field of operators, manufacturers, market participants, research bodies and academia representing the core of the membership of ETIP SNET, as well as a selection of international participants, provided perspectives on lessons learned. Both success factors and documented failures provide important input for future use of regulatory sandboxes to develop new policies and strategies for the energy transition and the roles of important stakeholders. Some of the important lessons learned included:

- An important success factor in many cases involved the inclusion of major private and public stakeholders in the design and participation of regulatory sandbox trials, as well as in the development of the conclusions from the trial.
    - Example - Carbon capture trials involving broad stakeholder participation resulted in the development of the EC Carbon Storage directive issued in 2009 (Directive 2009/31/EC) and became the basis of individual state regulations.
    - Much closer collaboration with regulators and agencies along the entire development process is needed.
    - The voices of customers and the public are very important to shape the R&D landscape and financing instruments according to the real needs of the market.
    - Regulations/legal framework must be defined in consultation with industry.
    - Success example - In the Netherlands, a green deal between some electrical companies and authorities resulted in pilots of Direct Current (DC) distribution applications in a few buildings. This resulted in a very advanced industry and fast improvement of installation rules to allow this new technology. Today the Netherlands is the best prepared country in Europe to move forward with technologies and applications for Direct Current installations.
    - It is important to understand the new business model potential of innovations and the associated regulatory sandboxes that are needed. The business models involve the roles of all stakeholders.
    - Involvement of the consumer (tariff design, feedback on issues and implementation, understanding costs and benefits) is key to success for any program where the regulation impacts the consumer.
    - Success example – Renewable Energy Communities (RECs) trials in Italy - thanks to the early experimental transposition of 2018/2001 (RED-II) Directive by the Italian Law, the project had the opportunity to cluster the entire service-provision supply chains to design and activate RECs: designers, technology providers (meters, digital platforms, PV, Hydro, storage), installers, maintainers, ICT-IoT-AI service providers, lawyers, etc. making "live pilot sites" available (real data, real people involved, real outcomes). Today a series of RECs are legally established and technically working. A series of technical, legal, governance and management lessons learned are now at the base of next steps.
- Regulatory sandboxes should not be technology biased. Any restrictions can reduce the availability of new solutions/technologies.
    - A related requirement is to have the needed platforms and support technologies in place in order to properly evaluate the benefits of an innovation or new technology. For instance, interoperable market processes or platforms provide the foundation for evaluating innovations in technologies at all levels that will facilitate customer and community participation and the resulting issues and benefits.
    - Pilots of new technologies should still respect all product safety standards and requirements (supplier & customer).
    - It can be difficult to translate regulatory requirements into technical requirements.
- Regulation development is usually structured with rigid requirements and prescriptive approaches for implementation. This makes it difficult to realize the benefits of new technologies which may not be considered during the regulation development. More adaptive and flexible regulations that allow implementations of innovative approaches to accomplish broad goals may be needed. Performance based regulation in Hawaii and RIIO in the UK are examples of approaches with these goals.

- A related requirement is that there needs to be timely and non-bureaucratic cost acceptance of risky investments or operating costs if these are covered by the regulatory sandbox.
- There can be jurisdictional constraints in designing regulatory sandboxes. One important jurisdictional constraint concerns compliance with EU legislation, which the NRA should take into consideration when designing the regulatory sandbox investigation. Following successful completion of the planned investigations with positive results, implementation and scaling up should be pursued following targeted amendments to the EU legislation with the support of CEER.
- Some regulatory sandbox experiments may not provide sufficient time to evaluate the full range of benefits or issues with a particular innovation or new regulation. Monitoring and characterizing benefits over an adequate period is important.
    - Also, stakeholders and partners lose interest if no long-term perspective for the investments is there. The incentives provided for the regulatory sandbox trial should be long-term to avoid stranded assets and to properly evaluate the costs and benefits. (Example – German project SINTEG that left regulatory provisions in effect after the trial period ended - https://www.bmwk.de/Redaktion/DE/Evaluationen/SINTEG/evaluation-sinteg-executive-summary-2022.pdf?__blob=publicationFile&v=8).
    - Another example involves regulatory solutions to deal with reverse power flows. Italian pilot projects experimented with different approaches for dealing with reverse power flows (https://www.researchgate.net/publication/275705689_The_Italian_Regulatory_Framework_for_Developing_Smart_Distribution_Grids/link/571082b808ae74cb7d9f069f/download) and the evaluation of these trials is still ongoing. The publication of the final ranking of Pilot projects, worthy of incentives, is scheduled for July 2023. Then detailed implementation plans are required with potential solutions by 2026. If initial experience from the trials is not permanently introduced, the applications lose momentum and benefits are not realized.
- Design and setup of the experiment (lessons from FlexForum New Zealand - https://www.araake.co.nz/projects/flexforum/) - Key activities are finding willing participants, scoping the idea, designing the operational parameters, getting decisions to proceed. Resourcing is key to each of these; willingness often depends on access to the extra resources needed to scope the idea / designing the operational parameters. DSOs are critical to enabling DER trials but are relatively tightly constrained in their resourcing and funding – especially for non-BAU innovation.
    - Involving consumer participation and deploying equipment at consumer premises is always more difficult than anticipated.
    - Reporting and sharing results can often be an afterthought unless a serious focus and funding is included for this task. Issues can include IP protection and funding for the effort involved.
    - Technical workshops and trainings for mid-level managers and regulatory staff can promote a more rapid diffusion of knowledge.
    - For consumer-focused technologies, it is important to verify technology installation and setup, reliability, communications, data collection and management, and user interfaces, in addition to actual benefits and economics (CHAIN2 Italy - https://arxiv.org/pdf/2107.03345v1)%3C%22).
    - It is also important to evaluate the impact of the product on the customer: the commissioning of the product, evaluating the practical and implementation difficulties, as well as the difficulties of using new technologies and their acceptance by the end user.
    - Delays in implementing regulatory sandbox concepts that are key to demonstrating important innovations can have significant impacts on innovation progress and participating organizations. An example involved developing the concept of a Common Energy & Flexibility Market in the Ireland case study of the EU Lighthouse Smart City Project, Positive City Exchange (www.cityxchange.eu). Difficulties in developing regulatory sandbox trials for this implementation impacted SME's as well as public support for the energy transition. Further the CENTS Project (Cooperative Energy Trading System - http://www.centsproject.ie/) funded jointly by the Irish State and SMEs (c. €8 million) was cancelled due to similar difficulties in 2022 and knowledge arising out of the Positive City Exchange project difficulties in Ireland.

- There should be a publicly available grid model, including market structure representation on this grid model. This provides the opportunity for new innovations to be evaluated in a system representing the real world. This can provide the basis for benefits assessment and decisions about supporting innovative technology deployments.
    - Success example – A market coupling approach for participation in electricity markets was first evaluated in two market regions that were merged into a single market in the Nordics. After the initial test period, the solution was further extended towards becoming a European market coupling. A volume coupling between two regions was a pragmatic starting point that created trust in the methods and paved the way for broader application.
    - Another difficulty is that national regulations may be different than European regulations. One example is the regulation on energy communities, which is currently not allowed in Germany, but which is foreseen at European level. Regulatory sandboxes can move towards evaluating approaches that may reduce differences between national regulations and European regulations.
- Ideas for innovations that involve regulatory and policy adjustments and involvement are plentiful and there are trials going on around the world. It is critical to learn from all these efforts to avoid unnecessary duplication and build on previous efforts. Databases like Eirie (https://pantera-platform.eu/the-eirie-platform-is-live-now/) and EPRI Technology Portal (https://techportal.epri.com/) can help support this coordination.
- An Austrian DSO stated that he followed some discussions with regulators, which unfortunately showed that there is low interest among them for regulatory sandboxes. Or, better to say they have interest, but don't want to accept money expenses in the tariff calculation discussion. This makes the DSOs not willing to invest in innovative pilot projects, because the rest of the earnings before interest and taxes (EBIT) is too low for risk money expenditures.

7. Best practices for turning positive results from sandbox experiments into european regulatory adjustments

7.1 General directions

From the responses received, the stakeholders consider the following as critically important to pave the way to sustainable implementation following positive experimentation results:

- The involvement of all the players in the supply chain: to be functional, an experiment must reproduce a scenario as real as possible, convincing the DSO / operators, service providers and citizens / end users. As a result, all phases will be evaluated including product configuration, installation and commissioning, verification of correct operation, market value and positive optimal contribution to the energy mix.
- Of utmost importance is the active involvement of the end user, who uses the product: the availability of users for an experimentation is a crucial aspect for having an exhaustive experimentation, therefore the correct involvement allows a correct conclusion, to then proceed with the official regulation. Experimentation should involve end users with or without assets to be complete and of universal value. If this is not sensibly taken care off, negative effects can spring that can lead to the social division.
- Experimentation should not be theoretical but instead addressing an area where there is an issue to be resolved. Exhaustively study all options with the appropriate stakeholders, plan all design options so that success is highly probable, and only then try it on the real interconnected grid using a thoroughly designed 'regulatory sandbox' that avoids rules stopping trying it out and fine tuning it. This living lab approach using actively all relevant stakeholders, the expected outcome of such trials is 90% success with the remaining 10% provided from learnings in the trial within the living lab set up, identified for the purpose.
- Regulatory experimentation requires commitment of National Regulatory Authorities from day one feeling the responsibility to real implementation following positive CBA outcome. It is also key to enable real transactions and so be able to test the end system down to monetisation to citizens and new use cases such as public EV charging or other emerging services. The evidence, for Regulators to be convinced of positive outcome should be well defined and be part of the implementation work of the consortia conducting the experimentation. The process should include embedded scope for refinements based on results achieved to meet optimal convincing results.
- To achieve permanent impact for all market participants, including citizens, it is important for sandbox experiments to be transparent, replicable, and scalable. This can be achieved by involving a diverse group of stakeholders, including regulators, industry experts, technology providers and citizens, in the design and implementation of sandbox experiments, and by documenting and sharing the results and lessons learned from these experiments with a wider audience. By having regulated entities within the team implementing the trials and have a say in the actual design and implemented refinements leading to the positive results safeguards real life implementation. In addition to transparency at all stages, when mandatory coordination and unification of rules before and after acceptance of the results that involves public committees will safeguard wider implementation.
- Projects in regulatory sandboxes should contain work packages enabling regulatory and authorities to effectively monitor and engage with the developers and relevant stakeholders at key milestones. After project closure clear recommendations should be formulated how to change the framework to make the positive outcomes sustainable (provided, of course, the outcomes are positive). A permanent institutional framework following up on such changes and involving all stakeholders is a must for following up positive results achieved. To this end, we underline the following needs:
    - Ideally, regulatory experimentation should be a responsibility and focus of the work of National Regulatory Authorities, under the guidance and agreement of ACER where required.
    - Legislation must be adapted not just based on EU regulation and directives but based on practical experiences from bottom up.
    - Getting political support for sensible, innovative programs requires working with all political and social groups, so long term initiatives are not hobbled by incoming administrations.

- There is a need of an EU umbrella for sandbox regulation based on the EC/ACER 2019 paper "Bridge to 2025". This can help to lower entry barriers for NRAs and also widen the scope of possible areas of applications where EU rules prevent further experimentation.

7.2 Concrete examples

ESB (Ireland)

- 5.5kW ADMD proven economic, and funding agreed with Regulator for use in all new housing designs.
- Use of simplified process for connecting generation up to 50kVA established with Pilot that has extended from 100 to 800 units and now ready to be regularized as policy.
- Deployment of HTLS conductors - jumped directly from tiny pilot to standard use over 6 months and doubled network capacity in lies where it was deployed.

Digital4Grids (France)

The Adger Energi Node project demonstrates the value of bottom-up implication of Flexibility service provider and citizen in the context of a city in Norway through the prototype implementation of a TSO-DSO project. The key has been to enable real transactions and so be able to test the end system down to monetization to citizens and new use cases such as public EV charging.

Germany: Next Kraftwerke

Although it has not been developed in a regulatory sandbox, the development of aggregator services in Germany is a good example. Such services have become possible around 2009 due to changes in the regulatory framework (acceptance of smaller units and pools in the control power market). This development has been driven by the relevant stakeholders by adjusting the framework and developing the business idea in parallel - and I assume in close coordination.

Energy Center of the Politecnico di Torino (Italy)

The case of early experimental transposition of 2018/2001 (RED-II) Directive by the Italian government (Art. 42bis of the Law called D.L. 162/2019 "Milleproroghe", according to L. n.8/2020 published on GU n. 51 of 29 February 2020. The result is a series of RECs that can be considered as "sandbox experiments".

Energy Research Economics – LLC (USA)

The most successful service diversification, offering customers of all circumstances choices in how they buy power, is Oklahoma Gas and Electric that offer customer highly dynamic rates (hourly pricing of different structures) and fixed bill, where the cost of power for the year is set in advance and is unchanged for that period regardless of the profile and level of usage, bracketed around conventional demand and energy rates and time-of-use prices. This is the portfolio approach to pricing power that matches diverse demands best a supply sources. Developing it will benefit from sand box testing.

Germany

Only in the financial sector are there already regulatory sandboxes (FINTECH). These tools have not yet been introduced in industry. Comparable instruments such as Living Labs (Reallabore) in Germany or IPCEI have just started, first results will be presented in due course.

Greece

The Hellenic Electricity Distribution Network Operator (HEDNO) recently launched a corporate-led sandbox, which offers a more flexible and adaptable approach prior to transitioning into a regulatory sandbox. HEDNO handles and oversees the entire sandbox operation as a corporate activity by providing a controlled, time-bound, live testing environment with the Hellenic Regulatory Authority for Energy (RAE) acting as a passive observer. This sandbox does not provide explicit regulatory concessions, but it benefits from feedback provided by the regulator. The regulator's involvement ensures that innovation is encouraged for the benefit of consumers and competition. On the other hand, this design allows the regulator to support the launch of a regulated sandbox in the short term without burdening its strategic plans and staff. The insights gained from the sandbox will help RAE to adopt the sandbox framework from HEDNO and operating it in the future as a regulatory sandbox.

The first HEDNO's Sandbox action was a Datathon dealing with the development of artificial intelligent (AI) algorithms for detecting intentional nontechnical electricity losses in the grid. The objective of this initiative was to create a concrete framework (access to real data, experimentation timeline, technical support, assessment KPIs e.g.) for testing AI innovative solutions to the specific problem, and at the same time to raise awareness and engage with potential candidates for the sandbox. The Datathon was a great success with over 250 entries and a final with 10 companies that took place in May 2023.

Norway

The results of the market coupling that started with a "regional experiment" have been significant, improving efficiency by integrating markets across Europe. Starting in one region created the trust and experience needed to scale to a European level. Possibly a similar process could be used to address the challenges listed in 1 in the states and regions that are most mature technology-wise, and then expand the regulation as experience and positive results become visible.

Siemens Energy Austria GmbH

A high transmission line power improvement can be achieved by increase of the operation voltage (e.g. from 245 kV to 420 kV). Such an improvement usually requires a new insulation coordination and by following the standard therefore higher towers and distances are necessary, i. e. it ends up with a new transmission line and needs a new approval as well. However, new arrestor technology allows a safe operation of an existing transmission line with higher operation voltage and by thus achieving a high transmission line power improvement. However, as grids are the backbone of our modern society everybody must follow the standards which are available since years and don't reflect all the time the latest state of available technology.

Based on the above, a high-power improvement of an existing transmission line (e.g., from 245 kV to 420 kV) is possible and can be demonstrated by a sandbox experiment. This innovative solution needs no construction work and physical change of the transmission line corridor and towers. Therefore, the impact to environment and citizen could be reduced to a minimum compared to any comparable transmission line power improvement.

Slovakia

Regulatory sandbox experience: Project - Subscription system for electricity

The solution is based on a system of prepaid electricity consumption. Paying in advance will work similarly to the prepaid services of mobile operators. The subscription for electricity is considered as a basic building component of the future national solution of the energy poverty assistance system.

8. Examples of European and International Regulatory Framework on the Energy Sector

A successful transition to next generation electricity and energy systems requires careful consideration of a range of issues that will ultimately redefine the regulatory framework and utility business models. Regulatory sandbox concepts allow evaluations of new regulatory approaches, innovations, incentives, and requirements for the different stakeholders in the energy system.

In the paragraphs below an extensive compilation of European and international regulatory experimentation activity is presented together with lessons learned. In the table below a summary of the findings is presented.

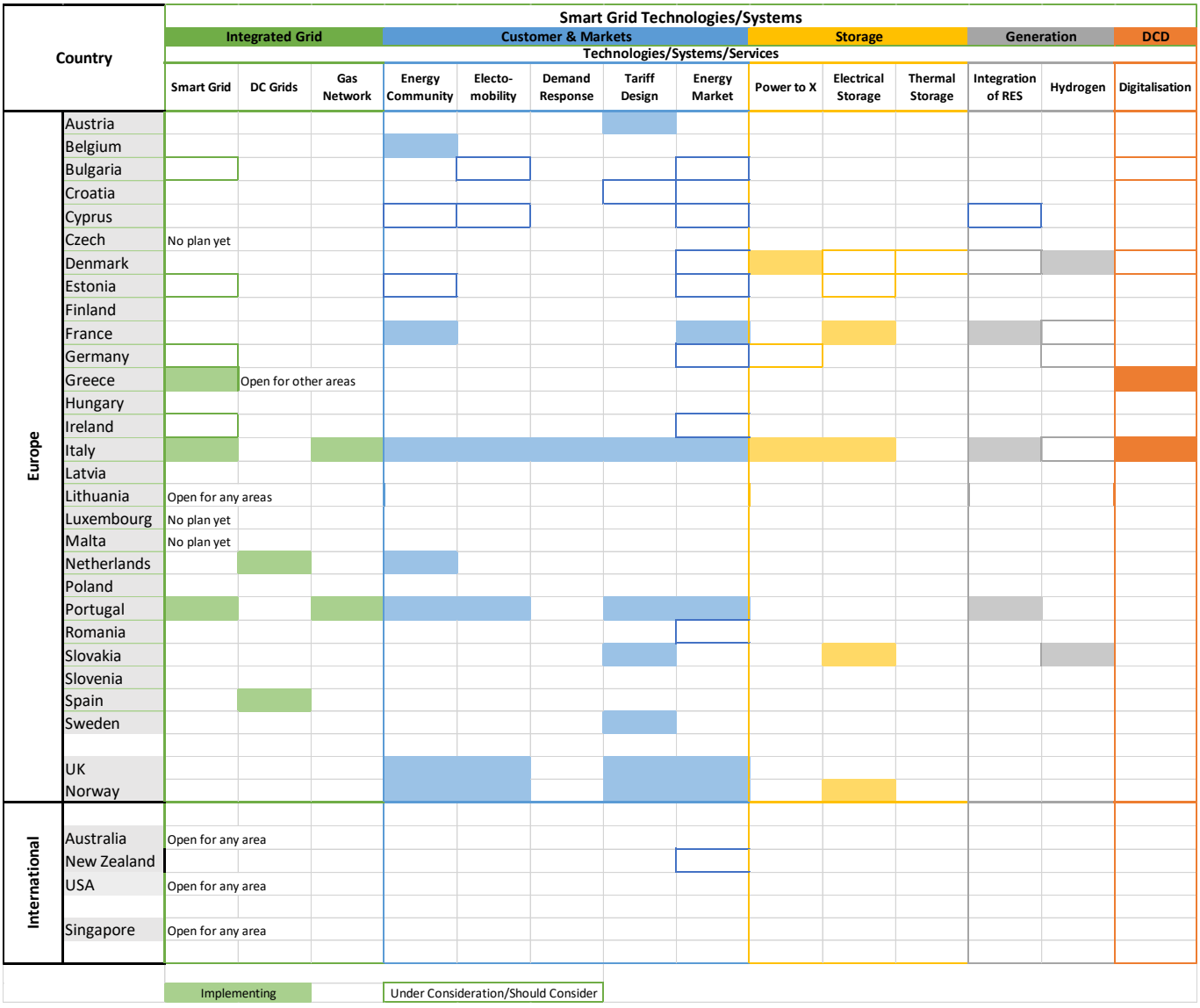

Figure 3: Summary – Implementing and Considering Areas for regulatory experiment in EU and International Countries

8.1 Examples

Australia

The Australian Energy Regulator (AER) has also established a Regulatory Sandboxing function that aims to help energy innovators and start-ups navigate complex regulatory frameworks and enable the trial of new products and services that delivers greater choice and cheaper energy options for consumers. Support for sandbox projects includes a sandbox toolkit [15] with an Innovation Enquiry Service (IES), which provides innovators with informal guidance on how a new technology, service or business model can be delivered under current regulation. The sandbox toolkit also includes a regulatory waiver power for the AER and a trial rule change process for the Australia Energy

Market Commission (AEMC), which allows for both temporary exemptions from existing rules and for time-limited new rules to be created so that innovative trials can go ahead.

Canada

The Ontario Energy Board (OEB) Innovation Sandbox offers creators a way to submit ideas for projects that have the potential to bring about innovation in the delivery of natural gas or electricity services, as well as broader energy technology and service sectors. This sandbox also includes the consideration of regulatory barriers that could prevent implementation and work to overcome those potential barriers. The OEB sandbox allows innovators to directly share projects that involve testing a new product, service or business model that is not widely in use in Ontario, even if isn't connected to a utility partner. Other parameters include that the proposed innovation relate to natural gas or electricity services and provide real benefits to consumers.

Germany

Germany launched the eighth 'regulatory sandbox for the energy transition' in November 2021. The DELTA project ('Darmstadt Energy Laboratory for Technologies in Application') brought together twelve partners from industry and research, including municipal companies and innovative startups, in a joint effort to demonstrate how the urban energy transition can be implemented in practice. The regulatory sandboxes for the energy transition are an initiative within the 7th Energy Research Programme of the Federal Ministry for Economic Affairs and Energy. Their aim is to test on an industrial scale how various energy technologies interact in the energy system. In the process, individual research findings are collated and prepared for practical implementation. Accompanying research is conducted to document the carbon emissions savings achieved. The DELTA regulatory sandbox involves investments worth more than €110 million over a period of five years, with €40.1 million being provided by the Federal Ministry for Economic Affairs and Energy. The German regulatory sandbox programs take advantage of a formal legal structure for these sandbox projects [16].

Italy

For more than 10 years, the Italian Energy Regulatory Authority (ARERA) has been committed to supporting the efforts of all players, both on the network and on the market side, to introduce innovations that can accompany and facilitate the rapid transformation of the power system [17, 18, 19, 20]. The regulatory experimentation initiatives launched by ARERA through public calls are legally based on the regulatory powers established by law 481/1995 [21]. In each experiment, participants are allowed a specific regulatory exemption/derogation. So far, in only one case (that is, on regulatory experiments concerning Collective Self-Consumption) a modification of the legislation has proved to be necessary (to allow energy sharing). In general, regulatory experimentation initiatives are launched in its various forms (pilot projects, pilot regulations and regulatory experiments) to test some new form of regulation; therefore, evaluation is very important. Only following the positive outcome of the experiments according to the provisions of the call, also considering the external evaluation based on public consultation acts, will the Authority confirm (or not confirm, or amend) the regulatory framework adopted for the experimental initiative. All final regulatory decisions are then taken directly by the Authority itself, after extensive public consultation of the interested stakeholders.

Since 2018, the Italian NRA has preferred to launch pilot regulations instead of regulatory sandboxes, at least in the power sector, considering that the small-scale containment, typical of sandboxes, may ultimately not be sufficient to provide a sufficiently robust experience to extend the consequent regulatory measures to large-scale environments. ARERA has also designed this type of experimentation to avoid problems of non-discrimination between market participants in the sandboxes versus non-participants. However, the most recent call for experimentations in the gas sector (see page 28) is substantially conceived as a "regulatory sandbox" (in the meaning given by CEER [9]).

Smart Grids: In 2010 a call for proposals targeted to DSOs for smart grid pilot projects was issued to promote improved quality of service and the connection of significant amounts of distributed generation in identified critical MV network zones [22]. Projects were asked to develop automation, protection and control systems using open communication protocols with network users. By way of derogation from the ordinary tariff system, the decision provided for a 2% increase in the rate of return on invested capital for a period of 12 years. Six main innovative functionalities have been trialled by the 7 selected demonstration projects, carried out in the period 2012-2015: 1) observability of active resources connected to MV networks; 2) advanced voltage regulation; 3) active power modulation; 4) anti-islanding; 5) fast fault isolation in MV networks; 6) electricity storage at MV level. Overall, the projects showed an increase in hosting capacity and provided important elements for the design of tailored "output based" incentive mechanisms for large scale implementation of two out of the six innovative functionalities (i.e., observability of active resources and advanced voltage regulation).

Electric mobility: With ARERA Decision 242/10 [23], four pilot projects were carried out to test on-field different business models for EV charging, to set up the regulatory framework needed to support the large-scale development and deployment of electro-mobility in Italy. In this case, also market players were involved together with DSOs, who could participate in this initiative only under an unbundling obligation to separate the recharging assets from distribution assets and with a multi-vendor requirement. By way of derogation, a special monomial tariff (with no fixed components) was introduced for EV public charging during the demonstration phase and is still enforced. Further, a tariff-funded contribution was awarded to the selected demonstration projects. More than one thousand EV charging points were installed among twenty municipalities all over Italy in the trial period from 2012 to 2015. The results showed that the DSO business model does not bring any advantage, at the same time bearing distortions with retail competition. The multi-vendor requirement proved to be too complex. Localization of charging points confirmed to be most crucial decision. In the end, ARERA took the position that the DSO business model should be considered no longer applicable to any further initiative for the development of electric charging.

Energy storage systems: In 2011, the Italian TSO (Terna) was legally entitled to the ownership and operation of storage units, to mitigate curtailment and support the dispatching of non-programmable plants, specifically wind-sourced generation units. In 2012 pilot projects involving the use of storage systems were awarded concerning three "energy-intensive" and two "power-intensive" applications. Extra remuneration of capital cost (a +2% in addition to the ordinary return rate) is provided for a period of 12 years, under the condition that a given target of wind curtailment is avoided (50% in the first two years of operation). Energy intensive applications were implemented to reduce RES curtailment along HV lines in Southern Italy. Power intensive applications were implemented to increase power system security in Sicily and Sardinia. Overall, 75 MW of storage facilities have been installed, including different kinds of batteries. Considering only time-shift effects, the benefit/cost ratio of the specific network service aimed at by the operation of TSO-owned storage (i.e., avoiding curtailment) resulted to be very low and Dynamic Thermal rating proved to be much more effective. For other services, storage units should be operated by market players, in a competitive framework. As outcome of the experiments, the TSO is no longer allowed to own and install storage units.

"Chain 2" Communication between 2nd generation Smart Meters and interoperable In-Home Devices: A nation-wide trial, open to several providers of In-Home Devices and associated services, was launched by ARERA in 2017 [24], in order to monitor the performance of "Chain 2" communication in electricity (LV) smart meters of 2nd second generation (2G). No extra funding was required on top of ordinary tariffs for DSOs nor payment towards IHDs manufacturers. No derogation was requested, but only a manual anticipation of the future automated procedure for initial handshaking between 2G smart meters and interoperable IHDs. Each market party participating in the survey had to automatically collect data on messages received by IHDs from smart meters; DSOs had to collect data on messages sent by each smart meter coupled with IHD; a platform was set up to assess the actual performance level of Chain 2. The communication was implemented through Power Line Carrier [25] and extremely satisfying results in terms of success rates were achieved. The initiative has allowed to confirm the effectiveness of this open communication protocol, which can be used by market parties to enrich their offers. Therefore, since 2019 the innovation has been released to all customers equipped with 2G electricity meters. It is expected that 2G-SMs enable more customized schemes of "Time of Use" prices (an overall ToU scheme is already in place in Italy and covers around 20 million customers).

Flexibility Services and Demand Response: In 2017, ARERA started to launch the so called "pilot regulations", which are meant as ex-ante regulatory frameworks defining a transitional regime to cope with a novel issue impacting the power system [26]. As a concrete step of the long path towards a complete review of the regulation of dispatching market, in order to exploit the emerging flexibility resources, a decision was issued by ARERA concerning "Opening of the Ancillary Services Market to the participation of both RES and demand units, thanks to aggregation through virtual dispatchable units". The decision addressed a regulatory experiment initiative that was split in several calls, each aimed at testing the performance of new aggregation of resources [27]. This allowed Terna in 2017 (and recently DSOs [28]) to propose demonstration projects concerning the provision of flexibility and demand response services by DERs and variable RES, providing an extra capacity-based remuneration to these resources on balancing markets. As of December 2021, more than 220 units have been enabled through the so-called "UVAM" experimentation1 conducted by Terna, with a total capacity of almost 1300 MW and 17 different balancing service providers involved. Experiments are ongoing, supplying regular quarterly report illustrating the results obtained.

[1] UVAMs are "Authorised Mixed Virtual Units", i.e., combining Consumption and Production Units.

Collective Self-Consumption: Second, following Law 8/2020, ARERA launched a pilot regulation for electricity sharing in collective schemes (jointly acting self-consumers and Renewable Energy Communities), introducing a novel regulatory approach (compliant with Directive 2018/2001/EU) and testing new tariffs and business models [29]. By way of derogation from the ordinary tariff system, the unitary tariff components related to the transmission and distribution network are not applicable to the shared energy. Furthermore, collective self-consumption participants receive an extra revenue for the shared energy (100 €/MWh for jointly acting self-consumers and 110 €/MWh for RECs, as fixed by the Ministry of Economic Development). To date, the number of RECs created under this experimental scheme is around 30; the size of photovoltaic plants installed in this context typically ranges between 20 kW and 60 kW: this is influenced by the extension that RECs can have within the experimentation, which is limited to users under the same MV/LV transformers. At the end of 2022, based on the results of the experiments, ARERA Decision 727/2022/R/EEL was issued, that increases the extension of the REC to power plants and users under the same primary (HV/MV) substation. The ministerial decree establishing the incentives is expected shortly. The full implementation of REC regulation will unlock several REC projects involving power plants and users with greater sizes.

Smart Charging of EVs at home: Third, in 2020 a further pilot regulation was launched to promote smart charging of electric vehicles in places not accessible to the public [30]. ARERA Decision allows the automatic increase (thanks to 1G and 2G smart meters functionalities) of the maximum withdrawal power for LV users when this is needed for the EV charging process. Users participating in the trial can exploit up to 6 kW of charging power for their EVs during (off-peak) night-time, Sundays, and holidays, while still paying a reduced tariff corresponding to a 3-kW supply. To date, more than one thousand users applied: about 60% of requests were approved, for a total of 534 users. While lot of requests are concentrated in the provinces of Milan and Rome, almost 70% of charging points are in single households, the remainder being stand-alone car garages or apartments. It should be noted that the results will be used also to design the most suitable tariff scheme. The initiative attracted a lot of interest from the beginning and therefore a participative workstream was launched in 2020, namely the “Focus Group on EV recharge”, which was open to the participation of several associations dealing with electromobility.

Quality of Service (for DSOs): To face the recent deterioration of network reliability in critical areas, ARERA introduced a large-scale DSOs "regulatory experiment" in 2019 [31]. The initiative enables DSOs to suggest optional (unconventional) regulations to aim at improving the quality of service in a way that will decrease the power supply interruption rates. Two experimentation windows were given in 2020 and 2021. After two years the experimental tests will be concluded in 2023. Depending on the results ARERA will determine potentially if, how and which regulations should be changed.

Gas system innovation: A call for proposals for pilot projects on innovative solutions for renewable gases, hydrogen and gas infrastructure has been recently initiated and opened within 11.2022 and 02.2023. The incentive mechanism is aimed at both supporting innovation in gas infrastructure and targeting innovative uses of the existing infrastructure to accommodate an increasing gas input. Directed exclusively to projects of tariff regulated natural gas supply service operators with initial technology readiness level TRL5 or TRL6 and targeting to reach TRL8 at the final trial phase, the option of derogation from the present regulation is given (from ARERA) in case that this is needed and useful for the performance of the experiments (which shall not exceed 3 years [32]).

Netherlands

In the Netherlands, the Dutch Ministry of Economic Affairs issued an executive order ‘Experiments Decentralized, Sustainable Electricity Production’ (EDSEP) that entered into force in 2015. The admission started in 2015 and ended in 2018. Over that four- year period, 18 projects were initially awarded a sandbox, many of which are still active. Currently, a follow-up executive order is being proposed that expands the size and scope of projects that can enter the sandbox. Also, more traditional players such as DSOs and energy suppliers will be allowed to apply. Examples of activities that fall under the scope of the new decree are running a local flexibility market and new business models for aggregators.

Portugal

Portugal recognized the issue related with the incongruence between the development of new technologies and the existing regulatory framework. The necessity to adopt a solution to solve this was considered and the importance of testing services and innovative technologies were established as one of the main priorities, since Portugal aims to be one of the leaders on the regulation of emerging technologies such as artificial intelligence and blockchain.

On April 21st, 2021, a regulation was published by the Portuguese government which established the regulatory framework (DL 67/2021) for the creation of regulatory sandboxes (Zonas Livres Tecnológicas (ZLT)) [33, 34]. This

regulation establishes the process and the criteria that allows the creation of physical environments with specific locations where, in a near-real world environment, experiments can be developed to test innovative technologies, products or services.

To create a regulatory sandbox in Portugal, it is necessary to submit a report to manifest an interest to create one to the Portuguese Innovation Agency (ANI). Then, this agency contacts the National Regulation Authority (NRA) of the sector respective to the entity and analyses the interest. If the criteria to create regulatory sandboxes is addressed, an authorization to submit a proposal is guaranteed to the interested entity, which has to be evaluated in accordance with various criteria. The Portuguese regulation considers two types of regulatory sandboxes: one that impose a derogation to a specific regulation and another that does not impose this. After being approved, the authorization to implement the proposed regulatory sandbox is published in the national official journal.

On the energy sector, regulatory pilots have been implemented in Portugal since 2018 by ERSE (Portuguese NRA), which were implemented in different areas. Some of the regulatory pilots do not comply with the current regulatory framework for regulatory sandboxes since they were established before the entry into force of the DL 67/2021.

Tariff Design: Between June 2018 and May 2019 a regulatory experiment was conducted by the NRA, in collaboration with E-REDES (Portuguese DSO), with 82 participants where it was introduced new network access tariffs to encourage the industrial customers, selected by the DSO, to shift their consumption, where it was given to the participants at least 48 hours' notice before to the periods where higher prices would be applied. This experiment was introduced in the Directive 6/2018 [35] where it was introduced a derogation from the current tariff system for high and medium voltage networks. On the report published at the end of the experiment [36] it was stated that 52 of the 82 participants observed a reduction in the network tariffs due to the new tariff design.

Energy Communities: In 2021, the self-consumption regulation [37] was established which allows the set-up of regulatory experimentations to test technological and business model solutions related to self-consumption and renewable energy communities. In these pilots, transitory derogations can be granted, while being monitored by the NRA. The projects had to be approved by the NRA, after consulting the network operator, and the maximum duration of the project is 1 year when it is necessary to submit a report with the outcomes of the project. In this regulation, it was mandated to the MV and HV grid distribution operator (E-REDES) to submit, after 6 months from the entry into force of the regulation, a regulatory experiment proposal to test two alternative energy communities' energy sharing rules, complimentary to the ones defined in the Article 36. This project is still ongoing with its final results to be published.

Smart grids: The Regulation of the Services of Intelligent Power Distribution Networks [38] mandated the Low Voltage DSO (E-REDES) to propose a pilot project related to the possible uses of smart meter data on the quality of service. The project, approved on 28 April 2020, lasted for one year and involved around 25,000 low voltage customers. It was possible to conclude that smart meter data can be used by DSOs to investigate voltage level complaints by customers.

Electric Mobility: The electric mobility regulation [39] provides any entity legal framework to submit to ERSE a project proposal with the possibility to derogate some provisions of the regulation to promote innovation in the electric mobility sector. The projects have a maximum duration of three years, and the results need to be made publicly available and reported to ERSE to inform possible regulatory change.

Singapore

The Singapore Energy Market Authority (EMA) created its sandbox to "actively enhance our regulations and seek ideas that could support new energy technologies and business models." In its Framework for A Regulatory Sandbox for The Energy Sector in Singapore, issued in 2017, EMA described its sandbox to provide it with an avenue to review its regulatory frameworks and to provide appropriate regulatory flexibility. Among the EMA challenges for innovators are ensuring reliability and rate designs and settlement mechanisms for the integration of distributed energy resources.

Slovakia

Since its establishment in 2001, the Regulatory Office for Network Industries has gone through many challenging periods. There have been a lot of changes, but the Office´s mission has remained unchanged, since until the network industries have a monopoly character, regulation will still be necessary. Over the "transport" of energy on its route from the production source to the outlet in the consumer´s apartment will permanently have to watch a certain state authority that prevents the abuse of the supplier´s or network operator´s monopoly position at the expense of consumers.

The Office, as a state authority in network industries where there is no competition, strikes a balance between the interests of investors and consumers. It must take care to protect the interests of consumers, as well as the interests of investors. Naturally, an investor would not do business in this field if he did not make profit. Therefore, the Office must create an environment where, on the one hand, it pays for the entrepreneur to invest, but, on the other hand, the consumer does not pay too much. In other words, the prices must be fair for both sides.

The Regulatory Office for Network Industries pursues its mission based on Act No. 250/2012 Coll. on Regulation in Network Industries, and, by setting tariffs and terms of their application in network industries, and terms of carrying out the regulated activities.

The regulated activities include:

- Generation, transmission, distribution and supply of electricity and related services,
- Activities of the short-term electricity market operator,
- Production, transmission, distribution, storage and supply of gas and related services,
- Production, distribution, and supply of heat,
- Production, distribution, and supply of drinking water by public water supply system,
- Wastewater (sewage) collection and treatment through public sewage system,
- Collection of surface water and energy water from watercourses, utilization of the hydropower potential of watercourses.

The Regulatory Office for Network Industries is a state authority which is independent from both state power and regulated entities. In carrying out its activities, the Office is not subject to any political or business groups.

As of July 1, 2019, the Office renewed its membership in the Council of European Energy Regulators (CEER).

The reason is the ambition to strengthen the office's international activities, as well as cooperation and collaboration in the creation of legislative regulations at the EU level together with other European regulators.

Switzerland

The Swiss Federal Office of Energy issued a rules and directive [40, 41] which lay down the principles and conditions for submission and evaluation of applications for funding (grants) for energy research projects, pilot and demonstration projects, as well as for authorisation of sandbox projects in 2022 and 2023.

United States of America

In the United States and many other places around the world, the traditional utility business model based on cost-of-service regulation (COSR) has worked well for many years but is increasingly out of step with a new set of market conditions – aging infrastructure, advances in technology, and flat-to-declining load growth driven by rising deployment of energy efficiency, demand response, and other distributed energy resources (DERs). COSR favours utility capital investment in long-lived assets and discourages utilities from taking advantage of the general shift in the economy to service-based solutions provided by third parties. COSR is primarily focused on rewarding inputs (capital investment) rather than outputs (performance against desired policy objectives).

United Kingdom

Regulatory approaches will need to be more flexible and encourage innovation in addressing needs of the energy system to meet requirements of the transition to a decarbonized system with widely distributed resources that must be integrated with both local and wholesale markets. One approach that starts to address this need for flexibility is the concept of Performance-Based Regulation (PBR).

The UK's RIIO (Revenue = Incentives + Innovation + Outputs) is widely regarded as the most comprehensive performance-based regulatory system developed to reflect changing market conditions, allow utilities to take advantage of the growing service economy, and reward utilities for achieving desired outcomes. RIIO seeks to reward utilities for innovation and for delivering outputs that meet the changing expectations of consumers and society. The RIIO model can be broken down into four main features to encourage utilities to innovate and achieve favourable outputs: 1) a multi-year rate plan; 2) the total expenditure (totex) approach; 3) performance incentives; and 4) an innovation fund.

RIIO-2 is the second set of price controls implemented under our RIIO model. It covers price controls in the period 2021 to 2028 (different periods for transmission and distribution). It is designed to be an investment programme to transform the energy networks and the electricity system operator to deliver emissions-free green energy in GB, along with world-class service and reliability. OFGEM is now taking input from stakeholders on the future of energy institutions and governance [42] that addresses reform in three areas.

1. Energy system planning: Introduce new Regional System Planners ("RSP(s)") to ensure there is accountability for regional energy system planning.
2. Market facilitation of flexible resources: Assign a market facilitation function to a single entity with sufficient expertise and capability, to deliver more accessible, transparent, and coordinated flexibility markets.
3. Real time operations: Keep real time operations within the distribution network operators (DNOs), ensuring clear accountability for network reliability and safety.

This concept of performance-based regulation is becoming more common in other jurisdictions where higher penetration of renewables, the need for flexibility, integration of policy objectives with system planning and operation, and support for innovations that can accelerate the energy transition are driving factors. In the United States, Hawaii is the first state to move fully in the direction of performance-based regulation [43]. Performance-based regulation in Hawaii includes a set of alternative regulatory mechanisms intended to focus utilities on performance and desired outcomes, such as increased renewable energy, lower cost, and improved customer service. The suite of new performance mechanisms includes an Interconnection Approval performance incentive mechanism ("PIM"), which incentivizes faster interconnection timelines for small-scale solar and storage systems, and an LMI Energy Efficiency PIM, which incentivizes increased collaboration between the utility and the energy efficiency program administrator to provide low-to-moderate income customers with opportunities to better manage their energy consumption. The Commission also approved an AMI Utilization PIM, which incentivizes the utility to harness the opportunities offered by advanced meters to begin providing immediate customer benefits. The Decision and Order also approves a portfolio of Scorecards and Reported Metrics, which will track and measure utility performance across a wide spectrum of categories to provide valuable data that can inform future planning and development efforts.

8.2 Other examples

Green Mountain Power

Vermont utility Green Mountain Power introduced a trial program using residential batteries to meet grid constraints and facilitate more renewables in the region [44]. The trial verified the efficacy of residential batteries for meeting grid needs and it also saved its customers millions of dollars with them. The program has since been ratified by the state's Public Utility Commission as a permanent residential storage tariff, which means battery installations — and utility savings — will continue to rise. Green Mountain Power already has over 2,500 utility-controlled batteries sitting in customer homes, adding up to around 13 megawatts. By discharging those batteries during hours when ISO New England grid faces monthly and annual peak demand, GMP reduces the payments it owes to the grid operator. Those savings — $3 million in the first three quarters of 2020 — pass on to the utility customer base. Households that host the batteries also benefit from backup power when the grid goes down. The network supplied 16,000 hours of backup power this year. The tariff offers two routes to batteries - a customer can pay the utility $55 per month to lease two home batteries; that covers installation costs and lasts for 10 years. After that, the customer can keep using the battery as long as it functions, and GMP will collect and recycle the equipment when its useful life ends. For people who want to see what the market has to offer, there's a "bring your own device" option, in which Green Mountain Power pays an upfront sum to the customer for buying and connecting a battery.

Microgrid Projects and Resiliency

There have been many projects in the United States that explore different options for supporting local microgrids that can provide a resiliency benefit to customers within the microgrid while also offering other energy management functions that can benefit both the customers within the microgrid as well as the overall grid (flexibility). The Fairmount Heights residential microgrid project involves a subdivision of net-zero, low-to-moderate income houses with the support of a $200,000 grant from the Maryland Energy Administration (MEA) [45]. It is implemented by a collaboration of the Housing Initiative Partnership (HIP), Emera Technologies (microgrid technology provider) and PEPCO (the investor-owned utility). The grant supports a community solar and battery energy storage system that will be shared by six homes in the neighbourhood that will provide flexibility for their energy use while also providing reliability and resiliency for the neighbourhood. The unique aspect of this project is the ownership and operation

structure involving the builder, the utility, and the homeowners. Many trials of this nature are also occurring in California where resiliency can be a very important benefit with the additional concern for wildfires. For instance, the California Public Utilities Commission (CPUC) has approved the rules of its programme to offer US$200 million funding for microgrid projects in the service areas of the state's investor-owned utilities (IOUs). This Microgrid Incentive Programme (MIP) aims to accelerate the commercialisation of clean energy microgrids that can support disadvantaged vulnerable communities (DVC) impacted by grid outages, giving them a reliable supply of low carbon energy during wildfire seasons and other causes of disruptions [46].

Electric Vehicle Charging Infrastructure Investments and Management

There are many innovations designed to accelerate the adoption of electric vehicles and support the development of charging infrastructure. These can involve regulatory innovations around tariffs, interoperability considerations, management to avoid grid constraints, etc. California is a good example of programs in this category. In 2022, California adopted a rule that requires all new passenger vehicle sales to be zero emission by 2035. To support this transition, a major investment in electric vehicle charging infrastructure is needed. The California Energy Commission estimates that by 2030 California may need up to 1.2 million EV chargers to support an estimated eight million passenger electric vehicles and an additional 157,000 chargers to support non-passenger vehicles, such as trucks and buses. There are currently over 1.2 million electric passenger vehicles on California's roads, and significantly fewer chargers than will be needed in 2030. To supplement the over $6 billion of recently authorized state taxpayer funds and funds from the federal government (at least $383 million dedicated for California from the Infrastructure Investment and Jobs Act plus more monies coming from the Inflation Reduction Act), the state's utility regulator is poised to authorize $1 billion of new ratepayer funds between 2025 and 2029 [47]. This is in addition to $1.8 billion of ratepayer funds already allocated. From these major ratepayer investments, the utility regulator in California is preparing to create a rebate program to promote electric vehicle infrastructure deployment. The proposal contemplates utility customers throughout the state being able to leverage multiple funding sources by drawing simultaneously on federal and state funds as well as the new utility rebate programs. Many aspects of this program will have to be worked out, such as ownership and management of the behind the meter charging infrastructure and may include sandbox elements.

9. Conclusions

As is seen in this policy paper on regulatory experimentation, the energy transition requires fundamental changes in the energy matrix, which is composed of various variables.

To get the opinion of the stakeholders connected to ETIP SNET five questions were compiled and addressed to all the connected experts. The 46 responses received from experts, were compiled into single concise responses by members of the task force formed by the Governing Board of ETIP SNET to guide the compilation of this report and these are presented in the paragraphs 3 to 7 of this report.

In addition, the Task Force has conducted a detailed state of the art exercise to identify national, European, and international experience in regulatory experimentation to complement rightly the responses from the experts. The outcome of this state-of-the-art search is presented in summary in section 8 of this report. These cover an extensive compilation of European and international regulatory experimentation activity in 12 countries together with lessons learned.

To sum up, these were the main conclusions gathered in this policy paper from the responses to the 5 questions:

Which are the needs and barriers that you have identified when implementing innovative solutions in the market?

- Barriers:
    - Regulatory and legal hurdles
    - Resistance to change among stakeholders who may be sceptical of the value of the innovation, or the potential risks involved.
    - Lack of clear business models
    - Conflicting pursuits from actors in the same ecosystem
    - Implementation of new technology that may not yet be industrialized and the capacity of equipment suppliers to implement new technologies on a large scale.
    - The current remuneration schemes of operators that do not encourage the efficient use of grid capacity.
    - Limited resources or funding for research and development for all required parties including Regulators.
    - The measurement the success of the innovation and demonstrating its value should be suitably addressed.
    - Lack of coordination among public agencies responsible for innovation funding
    - National laws and regulations that fall outside the scope of practicing sandbox experimentations.
    - Lengthy and complicated processes surrounding the implementation of innovative solutions.
    - Implementing innovation solutions for energy is normally welcomed by utilities and / or customers but can face notable resistance from several, who prefer proven experience and reliability.
    - The traditional cost-of-service approach to electric price formation, which relies on forecasting fixed cost obligations.
- Prerequisites:
    - Regulatory authorities must be engaged whenever the set-out experimentation includes changes in the prevailing regulation.
    - The absence of a well-defined link between the innovation ecosystem and the regulatory body creates challenges in incorporating experimental findings into new regulations.
    - Financial compensation and incentives for the developers.
    - Availability of live pilot sites, which provide real data, real people involved, and real outcomes, is crucial to test and validate the innovative solutions.

- Adequate communication capacity that can differentiate and cater to different categories of stakeholders.
- Thorough market research to understand the needs and opportunities of the target audience.
- Innovative solutions should adopt a step-by-step approach that allows for early learnings about customer acceptance and operator capabilities.

What are the main areas where you see real value and need for regulatory experimentation?

- The main areas for focusing regulatory experimentation are those with shared benefits and may require changes to existing market rules/systems.
- A properly designed and operated regulatory sandbox should enhance the learning process of all involved stakeholders including regulators and policymakers.
- One significant challenge is integrating the innovation with existing systems while ensuring data security and privacy.
- The broad area related to grid flexibility should be a domain of focus, in particular demonstrating best regulatory practices to share flexibility value across the energy value chain.
- In the competitive sector one of the cases in which regulatory constraints could appear is when innovations depend on measures in the regulated sector or on rules provided by market design or grid codes
- In the energy field, one of the main areas with a need for regulatory experimentation are energy monitoring and management.
- Concrete examples:
  - Flexibility markets
  - Demand response
  - Energy communities
  - Energy storage
  - Electric mobility
  - Design of tariffs
  - Gas network
  - Deployment of renewable energy systems
  - Cross functional use cases
  - Grid operational stability and planning use cases
  - Citizen, prosumer and consumer use cases
  - Quality of service
  - Hydrogen

Which types of experimentation tools are preferred by the industry? If possible, can you provide evidence as to why?

- The required experimentation tools are not necessarily unique or onerous, we consider regulatory support to be a key ingredient of learning-by-doing.
- Innovative sandbox regulation is the preferred option, however that it depends on the type of innovation project in question.
- Embedding sandboxes in a permanent institutional framework ensuring monitoring, evaluation and follow-up is helpful.
- Regulatory experimentation should be tracked at European.
- Preference for experimentation tools for technical assurance.

- Incentivized regulation to realize the strategic goals, especially with regards to the energy transition towards decarbonization and incentives

Which are the lessons you have learned through regulatory experimentation in your sector? Can you identify any success factors or documented failures?

- A major success factor resulted to be the involvement of major private and public stakeholders in the design and participation in regulatory sandboxes, as well as in the development of the conclusions from the trial.
- Regulatory sandboxes should not be technology biased.
- Regulation development is usually structured with rigid requirements and prescriptive approaches for implementation.
- There can be jurisdictional constraints in designing regulatory sandboxes.
- Some regulatory sandbox experiments may not provide sufficient time to evaluate the full range of benefits or issues with a particular innovation or new regulation.
- There should be a publicly available grid model, including market structure representation on this grid model.
- Ideas for innovations that involve regulatory and policy adjustments and involvement are plentiful and there are trials going on around the world.
- The Failure of the most important element of the EU Lighthouse Smart City Project - Positive City Exchange

Can you identify any evidence of best practices for turning positive results from sandbox experiments into European regulatory adjustments providing permanent impact for all market participants including citizens?

- The involvement of all the players in the supply chain
- The active involvement of the end user, who uses the product.
- Experimentation should not be theoretical but instead addressing an area where there is an issue to be resolved.
- Regulatory experimentation requires real commitment of National Regulatory Authorities from day one and be ready to real implementation following positive CBA outcome.
- It is important for sandbox experiments to be transparent, replicable, and scalable.
- Projects in regulatory sandboxes should contain work packages ensuring a permanent and intensive involvement of regulators and legislative authorities.

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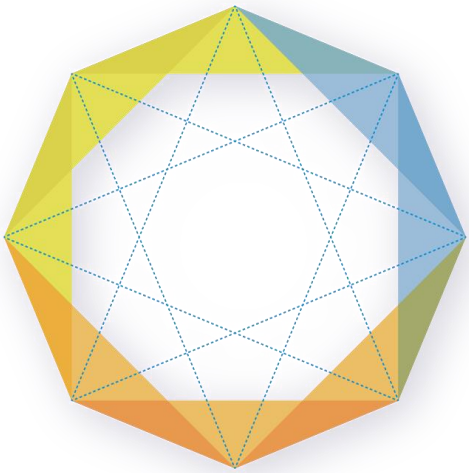

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