

Lawrence Berkeley National Laboratory

LBL Publications

Title

Regulatory Sandboxes and Other Processes to Expedite Utility Adoption of Advanced Grid Technologies

Permalink

<https://escholarship.org/uc/item/1t2060kh>

Authors

Relf, Grace

Whiting, Matia

Schwartz, Lisa C

et al.

Publication Date

2025-06-09

Copyright Information

This work is made available under the terms of a Creative Commons Attribution-NonCommercial-NoDerivatives License, available at <https://creativecommons.org/licenses/by-nc-nd/4.0/>

Peer reviewed

Regulatory Sandboxes and Other Processes to Expedite Utility Adoption of Advanced Grid Technologies

Grace Relf, Matia Whiting, Lisa C. Schwartz, and Evan Cappers

June 2025

Disclaimer

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, or The Regents of the University of California.

Ernest Orlando Lawrence Berkeley National Laboratory is an equal opportunity employer.

Copyright Notice

This manuscript has been authored by an author at Lawrence Berkeley National Laboratory under Contract No. DE-AC02-05CH11231 with the U.S. Department of Energy. The U.S. Government retains, and the publisher, by accepting the article for publication, acknowledges, that the U.S. Government retains a non-exclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this manuscript, or allow others to do so, for U.S. Government purposes.

Acknowledgements

The work described in this study was conducted at Lawrence Berkeley National Laboratory and supported by U.S. Department of Energy (DOE) Office of Electricity under Contract No. DE-AC02-05CH11231.

The authors thank the individuals who participated in interviews that informed this report, listed in Appendix A, Fernando Palma and Kerry Cheung, DOE, for sponsoring and reviewing this work, and Jeff Deason, Berkeley Lab, for reviewing the report.

Table of Contents

Table of Figures	iii
List of Tables	iii
Executive Summary	1
1. Introduction	5
1.1 Motivation for this Research	5
1.2 Methodology and Scope	6
1.3 Terminology and Definitions	7
2. Utility Innovation on Advanced Grid Technologies: Needs and Barriers	9
2.1 The Need for Innovative Grid Technologies at Scale	9
2.2 Challenges to Utility Innovation and Technological Change	14
3. Regulatory Sandboxes: Tools for Advancing Innovation	20
3.1 The History of Regulatory Sandboxes	20
3.2 Benefits and Risks of Regulatory Sandboxes	22
3.3 Regulatory Sandboxes: Design Features and Implementation Practices	24
3.4 Regulatory Sandboxes: Roles and Responsibilities	29
3.5 A Taxonomy of Sandbox-Type Mechanisms	30
4. Regulatory Sandboxes in an Ecosystem of Innovation	33
4.1 Other Innovation Vehicles	33
4.2 How Innovation Vehicles Address Barriers to Innovation	37
4.3 Elements of Ecosystems of Innovation in States with Sandbox-Type Mechanisms	40
5. Case Studies: Sandbox Examples from Across the United States	44
5.1 Funding Opportunities	45
5.2 Pilot Processes	48
5.3 Rate Cases or Rulemakings	50
5.4 Regulatory Sandboxes	52
5.5 Notable Examples from Abroad	55
6. Conclusion	58
7. References	60
Appendix A. List of Organizations Interviewed	A-1
Appendix B. Key Takeaways from Sandbox Case Studies	A-2
Appendix C. Literature and Resources	A-4

Table of Figures

Figure ES 1. Landscape of U.S. States Exploring and Implementing Sandbox-Type Mechanisms.....	2
Figure ES 2. Taxonomy of Sandbox-Type Mechanisms.....	2
Figure ES 3. Innovation Vehicles.....	3
Figure 1. Scope of Technologies Covered in the Report.....	7
Figure 2. Technology to Market Process	10
Figure 3. Projected EV Load Growth from 2023–2040	12
Figure 4. Financial Sector Regulatory Sandboxes by Region	21
Figure 5. Timeline of Sandbox-Type Mechanisms in the Electricity Sector	22
Figure 6. Taxonomy of Energy-Sector Regulatory Sandbox Mechanisms	31
Figure 7. Utility Innovation Tools.....	33
Figure 8. A Flowchart for Determining Whether to Use a Regulatory Sandbox in the FinTech Sector.....	38
Figure 9. States Exploring and Implementing Sandbox-Type Mechanisms	44
Figure 10. Singapore EMA's Sandbox Evaluation Criteria and Process Flow	56

List of Tables

Table 1. Commercially Ready Advanced Grid Technologies.....	11
Table 2. R&D Investment as a Percentage of Budget by Industry.....	17
Table 3. Potential Benefits of Regulatory Sandboxes.....	22
Table 4. Risks of Regulatory Sandboxes.....	23
Table 5. Best Practices and Examples of High-Level Sandbox Scoping Elements.....	25
Table 6. Specific Participation Requirements Best Practices and Examples	26
Table 7. Ongoing Sandbox Governance Best Practices and Examples.....	28
Table 8. Innovation Vehicles as Solutions to Regulatory Barriers to Innovation	39
Table 9. Innovation Vehicles in States with Sandbox-Type Mechanisms.....	40
Table 10. Sandbox-type Mechanisms by State	44

Executive Summary

Advanced grid technologies are increasingly important for ensuring that electric transmission and distribution (T&D) systems can meet growing demands. Traditional regulatory frameworks can hinder the ability of utilities to meet this challenge by discouraging innovation and interest in testing and deploying advanced technologies.

A *regulatory sandbox* is a mechanism that provides a structured environment for testing new technologies and business approaches under modified rules to increase the speed of adoption. This report catalogs regulatory sandboxes and similar mechanisms in the U.S. electricity sector, identifies process and structural considerations for developing them, analyzes learnings from examples across the country—particularly as they relate to advanced grid technologies—and highlights emerging best practices for implementing these regulatory approaches.

Regulatory Sandboxes

Mechanisms that provide a structured environment for testing new technologies and business approaches under modified rules to increase the speed of adoption

Example

The Connecticut Innovative Energy Solutions sandbox mechanism selects cutting-edge project proposals to run for a 12- to 18-month trial period before assessing results and quickly determining scaling strategies.

Advanced Grid Technologies and Regulatory Change

Advanced grid technologies are equipment, services, and applications (both hardware and software) that enhance T&D systems by unlocking new capacity and capabilities to meet electricity system needs. These technologies can help meet load growth, improve the grid's ability to withstand and recover from severe weather, respond to changing customer needs, and provide additional operational flexibility at lower cost than like-for-like equipment replacements. For example, dynamic line rating and advanced power flow control technologies can be 5-25% less costly than conventional options.¹

Adoption of advanced grid technologies, however, is typically slow. The process includes research and development (R&D), field validation and demonstration, scale-up and commercial launch, deployment, and market transformation. Utilities generally procure technologies in the market transformation stage, when the level of risk is low.

Regulatory structures contribute to this slow pace of change. Characteristics of the regulated utility sector and major regulatory barriers that limit utility innovation and adoption of advanced grid technologies include the following:

- Cost-of-service regulation incentivizes capital-intensive investments rather than new and innovative non-capital grid technologies that may cost less.
- Cost recovery practices create a lag between investments and cost recovery, cause uncertainty about whether costs will be recovered, favor tried-and-true technologies,

¹ White et al., 2024.

and contribute to risk aversion at utilities.

- Monopoly power granted to utilities can reduce incentives to control certain costs.
- Regulatory processes can be lengthy and litigious.
- Proceedings required for innovative regulatory processes may be de-prioritized given other, more urgent issues and resource constraints.
- Utilities continue to rely on traditional approaches to utility innovation, such as R&D and pilots, that typically have not resulted in transformative change.
- Utilities are cautious about introducing new technologies where their impacts on reliability or safety have not been fully vetted.
- Regulators and stakeholders often challenge early replacement of existing technologies.
- Utilities, regulators, and stakeholders lack awareness and education about regulatory sandboxes and other innovation vehicles.

This report focuses on regulatory mechanisms to advance innovative grid technologies after basic research but still earlier in the adoption process, during the pre-market transformation phases.

Regulatory Sandboxes in the U.S. Electricity Sector

Berkeley Lab researchers identified 15 jurisdictions that have explored sandbox-type mechanisms for electric utilities (Figure ES 1 and Chapter 5). Of those jurisdictions, 12 adopted such mechanisms, which are ongoing. Sandbox-type mechanisms can be broken down into four categories (Figure ES 2).

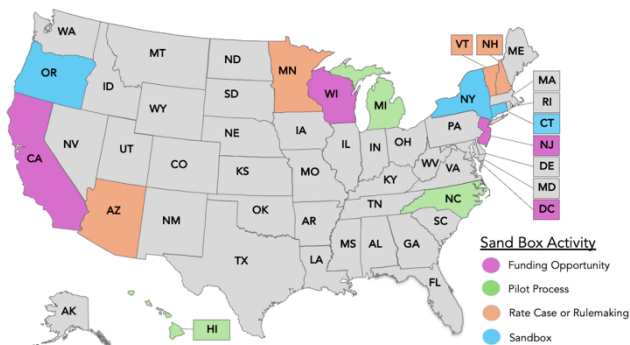


Figure ES 1. Landscape of U.S. States Exploring and Implementing Sandbox-Type Mechanisms

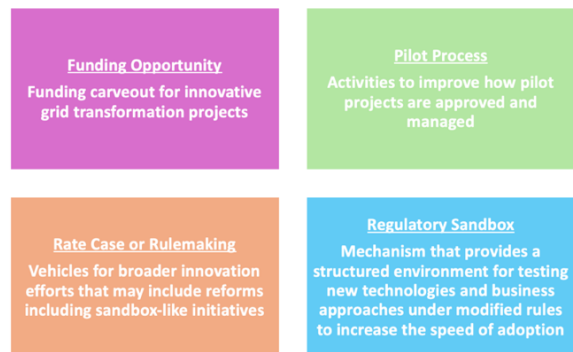


Figure ES 2. Taxonomy of Sandbox-Type Mechanisms

Regulatory sandboxes do not address every regulatory barrier to innovation. A broader ecosystem that supports innovation is needed. Every jurisdiction identified that has a sandbox-type mechanism includes other *innovation vehicles* that support expansion of advanced grid technologies (Figure ES 3).



Figure ES 3. Innovation Vehicles

Findings

While many sandbox mechanisms are still in the early stages, and there is limited experience to draw from to date, they have demonstrated value in the U.S. electricity sector and abroad. Benefits include testing specific technologies and services at a small scale before implementation at large scale, more nimbly adapting to customer needs and desires, learning how to create a culture of innovation at utilities and at regulatory commissions, increasing collaboration among stakeholders and eliciting their ideas to improve the electricity system, and adopting technologies and programs that improve reliability, resilience, and affordability. While there is support for these mechanisms, there also are areas for improvement. If tailored to specifically promote advanced grid technologies and provide more explicit requirements for scaling strategies, regulatory sandboxes have the potential to produce transformative results, such as widespread improvements for more efficient and cost-effective use of existing T&D systems.

Most sandbox mechanisms in the U.S. electricity sector have heavily focused on energy efficiency, demand-side management, and customer-sited resources. Many projects that started in sandbox mechanisms have scaled to standard offerings. However, many sandbox projects have not scaled, which may be a desirable outcome as long as learning-based outcomes were met.

Examples of sandboxes that have successfully tested advanced grid technologies include targeted deployment of energy storage to reduce distribution peak demand, conservation voltage reduction, volt-var optimization, and smart distribution circuits. Utilities also have tested T&D technologies and programs that increase reliability, such as advanced distribution system management, microgrids, and grid-enhancing technologies to increase T&D capacity.

Emerging Best Practices

Following are emerging best practices for designing and implementing a regulatory sandbox or similar mechanism.

- Terms and objectives must be clear, ambitious, and have buy-in from relevant utility and regulatory leadership and stakeholders.
 - Clearly define terminology such as “pilot,” “demonstration,” and “innovative” upfront and with stakeholder input.
 - Ensure that learning, speed, and eventual scaling are primary objectives.
 - Clearly identify scaling strategies and processes for projects that go through the sandbox mechanism.
- Identify barriers to innovation in the jurisdiction and determine what combination of sandbox mechanisms and other innovation vehicles will best address those specific barriers.
 - For example, sandboxes can be structured to reduce uncertainty of utility cost recovery and alleviate burdensome regulatory processes.
- Provide clear information on project eligibility, application processes, and selection criteria that align with program objectives and employ templates or standard formats to reduce administrative burdens.
 - Create multiple pathways to participation so that innovators and stakeholders other than utilities can put ideas forward.
 - Structure projects to be simple and responsive to customer needs and desires.
 - Follow best practices for pilot design and implementation.
- Establish clear reporting and evaluation requirements using metrics that align with desired outcomes.
 - Identify go/no-go checkpoints and criteria.
 - Create data and information-sharing requirements as part of reporting by utilities and third party participants.
- Dedicate sufficient staff resources to the sandbox, including cross-functional teams with pre-identified roles and processes for quickly reviewing applications (if relevant).
- Create channels for regular, candid, non-punitive conversations between regulators and utilities, other innovators, and stakeholders.
 - Consider using advisory councils and assigning non-decisional Commission staff to help foster open dialogue.
- Create processes for continuous learning and checkpoints to adjust the sandbox mechanism over time.
- Spread the word and use multiple communication channels for sharing information on the sandbox, including results and findings.

1. Introduction

Innovation is necessary in order to meet growing loads and threats facing electricity systems.² Numerous technologies exist today to solve challenges facing T&D systems in particular,³ and technologies are continuing to advance at a rapid pace. However, regulatory objectives and processes can be at odds with the ability and willingness of regulated utilities to test and deploy innovative technologies. States are increasingly recognizing the need to reduce regulatory barriers to advance adoption of advanced technologies that support grid needs, benefit utility customers, and achieve other state goals.

This report catalogs regulatory sandboxes, which provide a structured environment for testing new technologies and business approaches under modified rules to increase the speed of adoption, and similar mechanisms deployed in the utility sector to advance the speed of technological innovation for T&D systems. The report documents and categorizes types of approaches, provides lessons on fostering an ecosystem of innovation in the utility sector, identifies emerging best practices, and assesses the value that utilities have delivered to customers through these innovation vehicles.

1.1 Motivation for this Research

Utilities are entering a period of expected load growth for the first time in decades, driven by economic growth, electrification of buildings, transportation, and manufacturing, and new large loads such as data centers and semiconductor and battery manufacturing plants.⁴ At the same time, grid infrastructure is aging, required to operate in new ways with increasing levels of variable energy resources, and experiencing more frequent and severe weather events.

In response, utility spending on T&D systems, including both operations and maintenance expenditures and capital investments, has increased significantly in recent years. For example, California retail electricity rates for the three largest investor-owned utilities have doubled over the past five years, driven largely by distribution costs, including those that support wildfire mitigation.⁵ Utilities are simultaneously needing to expand T&D systems, replace aging assets, improve resilience, and adapt to changing operational practices, all while minimizing rate and affordability pressures to the greatest extent possible.

While these are big challenges, advanced technologies currently exist at commercially readiness levels that can support significant progress towards these objectives than like-for-like replacements. Technology continues to advance, and solutions are ever expanding. U.S. utilities can deploy currently available advanced grid technologies to unlock 20–100 gigawatts

² “Creating an environment that promotes innovation will be essential if the future power system is to do an adequate job of providing service that is safe and secure, clean and sustainable, affordable and equitable, and reliable and resilient.” National Academies of Sciences, Engineering, and Medicine (2021) at 2.

³ White et al., 2024.

⁴ EIA, 2023 and EIA, 2025(a).

⁵ Forrester et al., 2024.

(GW) of peak capacity, most of which can be deployed within 3–5 years at lower cost to customers compared to conventional approaches. However, utilities and regulators face barriers to adoption, such as the need to test technologies in a jurisdiction-specific setting, uncertainty around a value proposition for customers and utility cost recovery, and lack of understanding of new technologies and approaches. The U.S. Department of Energy (DOE) identified four key steps to support adoption of advanced grid technologies:⁶

1. Building an evidence bank for the value proposition of the technologies
2. Developing implementation and operational know-how
3. Refining planning and investment case approaches, and
4. Aligning economic models and incentives.

Regulatory sandboxes and similar approaches are an important tool for testing and documenting the use of advanced technologies and experimenting with new utility business models and incentives. When structured and used effectively, regulatory sandboxes can deliver on these four steps. These mechanisms create an ongoing laboratory that can be flexible and responsive to changing needs and an expanding technological landscape while documenting impacts, benefits, and lessons learned.

This report illuminates the potential for regulatory sandboxes as a tool to overcome barriers to testing and deploying advanced T&D technologies at scale. It is intended to provide foundational information on what regulatory sandboxes are, what they aim to achieve and how they are structured; support information sharing on their value proposition and real-world experiences of technologies that have successfully scaled through these mechanisms; and provide actionable information for utilities and regulators looking to implement regulatory sandbox mechanisms in their jurisdiction.

1.2 Methodology and Scope

Berkeley Lab researchers first conducted a literature review of published articles, reports, and other information related to regulatory sandboxes, utility pilot and R&D programs, and innovation in the utility and other sectors (Appendix C). We synthesized common and key findings related to the purpose and design of sandboxes, use cases, and potential risks, and identified best practices and areas for further research.

Researchers also conducted a comprehensive review of regulatory proceedings related to sandboxes and other innovation mechanisms.⁷ This research supported the development of a taxonomy of different types of innovation mechanisms and helped identify key programmatic examples for further review. Berkeley Lab dug deeply into regulatory filings to understand how such mechanisms developed and changed over time. In addition, researchers reviewed utility webpages dedicated to innovation, information available from international sources, and databases of pilots or similar programs.

⁶ White et al., 2024.

⁷ With assistance from E9 Insight.

Structured interviews with utilities, utility regulators, utility consumer advocates, national industry and trade groups, and consultants (Appendix C) informed our findings and case studies (summarized in Chapter 5).⁸

This report focuses on technologies related to T&D systems and related grid infrastructure; it does not focus heavily on generation-related assets or behind-the-meter technologies (Figure 1). In many cases, however, projects that are deployed through regulatory sandboxes and similar approaches expand beyond T&D. We discuss such useful and relevant examples as well. While the report aims to be as comprehensive as possible, it does not include every example of a utility-sector regulatory sandbox in the U.S. and abroad.

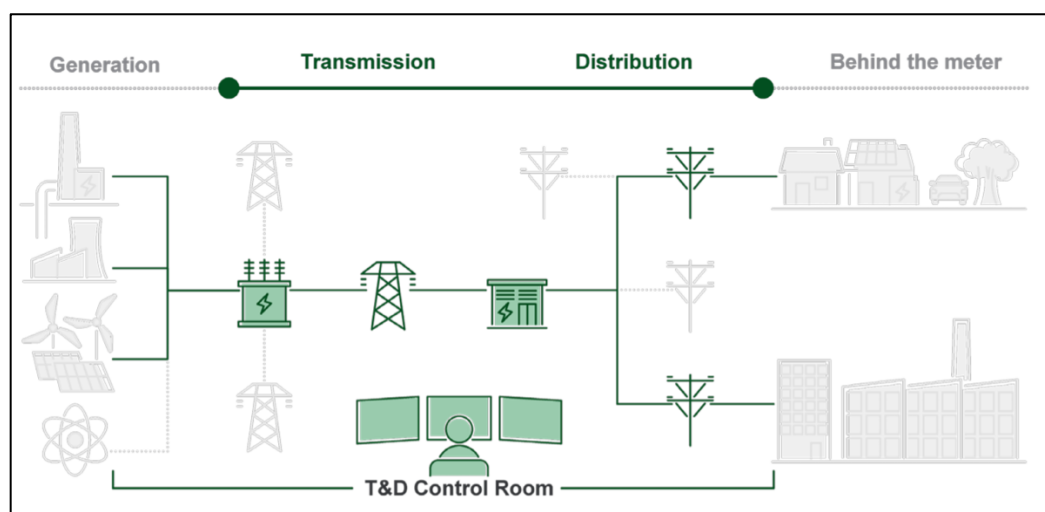


Figure 1. Scope of Technologies Covered in the Report (Source: White et al., 2024)

1.3 Terminology and Definitions

Unclear terminology has impeded successful pilot and innovation programs.⁹ Following are key terms used in this report, which jurisdictions can adapt to suit their needs.

- **Innovation** is “the search for, and the discovery, development, improvement, adoption and commercialization of new processes, new products, and new organizational structures and procedures.”¹⁰ Innovation requires both creating new ideas and implementing those ideas.
- **Innovation vehicle** refers to a program or mechanism specifically designed to promote testing and acceleration of ideas that go beyond the status quo. These may include things like R&D programs, startup incubators and accelerators, venture capital investments, pitch-fests or other events to bring entrepreneurs to investors, task forces,

⁸ Detailed case studies will be completed in phase 2 of this research and posted on Berkeley Lab's website as part of a toolkit for states to facilitate testing and timely adoption of innovative advanced grid technologies.

⁹ See, e.g., Michigan Public Service Commission Staff, 2020.

¹⁰ Costello, 2016 (definition from Shy, 1995).

or other intentional structures for promoting innovation.

- **Regulatory sandbox** is a type of innovation vehicle that offers a structured environment for testing new technologies and business approaches under modified rules to increase the speed of adoption. Regulatory sandboxes establish processes, with appropriate guardrails, for utilities to take on calculated risks that might not otherwise be feasible under standard regulatory practices and to quickly adapt to learnings during the trial phase and through identified scaling strategies.
- **Derogation** is a modification to or exemption from typical regulations or rules deployed as part of a regulatory sandbox.
- **Sandbox-type mechanisms** are a group of programs and mechanisms that act similarly to regulatory sandboxes, but have specific or unique identifying characteristics. These include funding opportunities, pilot processes, and rate case examples and are described in more detail in Chapter 2. In most cases, these programs fit under the broad definition of a regulatory sandbox because they deviate in some way from traditional utility regulatory processes. Because of the important differentiating features and naming conventions for each type of mechanism, however, we categorized each as its own type of mechanism that is similar to a regulatory sandbox.
- **Advanced grid technologies** are advanced equipment, services, and applications (both hardware and software) that enhance T&D systems by unlocking new capacity and capabilities to meet system needs.

2. Utility Innovation on Advanced Grid Technologies: Needs and Barriers

This chapter describes the importance of regulatory sandboxes for utilities in the face of increasing demands on the electricity system, currently available and emerging advanced grid technologies, and challenges to testing and deploying them. The scale of need and availability of solutions creates an urgent opportunity to reduce hurdles to technology adoption and promote rapid deployment to benefit utility customers. Regulatory sandboxes and sandbox-type mechanisms aim to bridge this gap between need and opportunity to deliver solutions at scale.

2.1 The Need for Innovative Grid Technologies at Scale

Utilities are facing increased pressure to simultaneously expand grid capacity, make the grid more reliable and resilient, accommodate increasing levels of variable energy resources, and maintain affordable rates. The growth of data centers and manufacturing and electrification of transportation and buildings are driving load growth, after nearly two decades of stagnant electricity sales.

Failure to implement solutions to these challenges is costly. In 2023, transmission congestion alone totaled an estimated \$11.5 billion in costs to utility customers.¹¹ In addition to building new grid infrastructure, utilities can improve grid management techniques, increase system visibility, and invest in technologies that enable more efficient grid operation.

2.1.1 Advanced Grid Technologies and Maturity Cycle

Technology development and deployment follows a maturity cycle that helps to identify whether and when technologies may become commercially available and ready for widescale deployment. Figure 2 depicts five stages of technology development and deployment, each involving different entities and resulting in various levels of technology penetration. Technology risk generally decreases with technology and market readiness levels.

¹¹ Shreve et al., 2024.

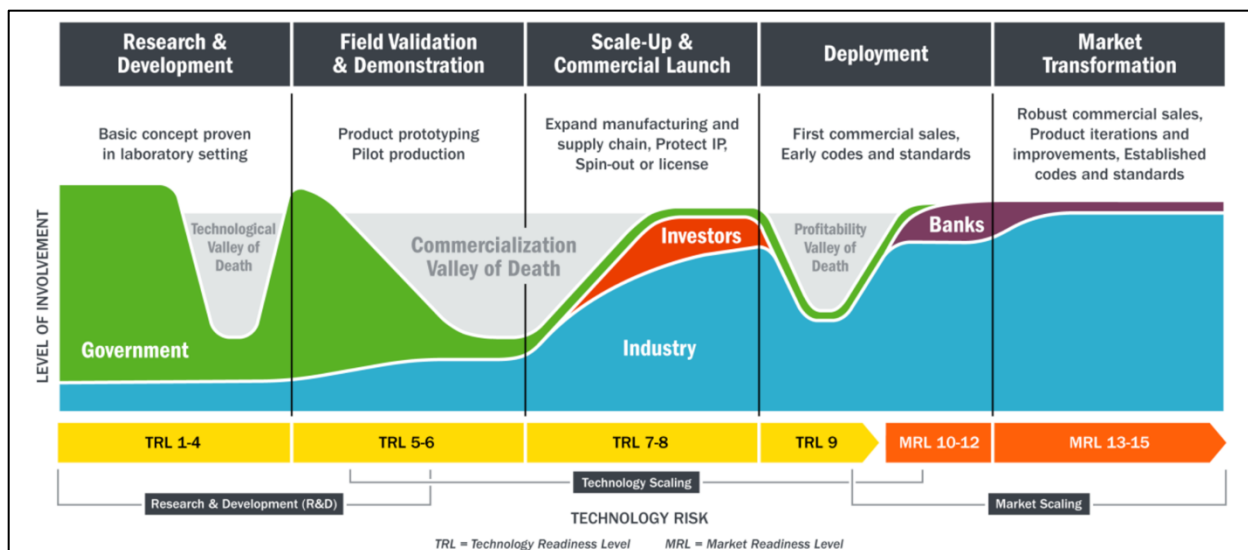


Figure 2. Technology to Market Process (U.S. DOE, ND)

Utilities may have minimal roles at the first four stages of the process, such as through R&D projects and pilot programs, due to regulations requiring utilities to demonstrate that technologies will provide tangible system and customer benefits. Utilities are most typically involved as buyers in the fifth stage, market transformation, where commercial sales are robust and technology readiness may be reflected in codes and standards. Entering the technology development and deployment process at an earlier stage often requires drawing from an evidence bank, or collection of findings and outcomes from existing trials and experience. This report focuses on pre-market transformation technologies.

Advanced grid technologies that are commercially available today, but have not yet reached full market transformation, could be adopted within 3–5 years to increase peak capacity on U.S. T&D systems by 20–100 GW at lower cost or greater value to customers compared to conventional approaches. DOE identified 20 such technologies that are commercially ready, but currently underutilized, grouped into four categories: (1) advanced transmission technologies, (2) situational awareness and system automation solutions, (3) grid enhancing technologies and applications, and (4) foundational systems (Table 1).¹²

¹² White et al., 2024.

Table 1. Commercially Ready Advanced Grid Technologies (White et al., 2024)

Category	Advanced Grid Solutions
Advanced Transmission Technologies	➤ Advanced Conductors ➤ Point-to-point High Voltage Direct Current (HVDC)
Situational Awareness and System Automation Solutions	➤ Advanced Distribution Management Systems (ADMS) and ADMS applications ➤ Distributed Energy Resource Management System (DERMS) ➤ Advanced Fault Location, Isolation, Service Restoration (FLISR) ➤ Volt/VAR Optimization (VVO) ➤ Smart Reclosers ➤ Power Factor Corrections ➤ Substation Automation & Digitization ➤ Advanced Sensors
Grid-Enhancing Technologies and Applications	➤ Dynamic Line Rating (DLR) ➤ Advanced Power Flow Control (APFC) ➤ Topology Optimization ➤ Virtual Power Plants (VPPs)¹ ➤ Energy Storage (as a T&D asset)² ➤ Advanced Flexible Transformers
Foundational Systems	➤ Communications Technologies ➤ Data Management Systems ➤ System Digitization and Visualization ➤ Alternate Timing and Synchronization

Innovative technologies also are emerging in the electric utility sector for better vegetation management, line inspections, cyber and physical grid security, artificial intelligence (AI) across multiple use cases, and other areas.¹³ It is critical that utilities are able to quickly test good ideas and weed out those that are not as effective in their service areas.

While many of these technologies have been tested, the evidence bank is still limited, and technologies perform differently based on unique grid architectures, weather, and other conditions. With safety as a top utility priority, utilities are hesitant to deploy anything on their systems before they conduct a controlled trial. Regulatory sandboxes create a dynamic, real-world environment for doing so.

2.1.2 T&D Capacity Expansion Needs

The transmission system is a bottleneck to new energy development in the U.S. Regional transmission systems are experiencing congestion and constraints today and will need to expand by over 60% by 2035 to meet expected future energy growth, and by over 120% in a high load growth scenario. In contrast, however, spending on transmission has steadily decreased in many regions since 2015.¹⁴ Rapid buildout of the transmission system is challenging because of complex interstate and multijurisdictional permitting, approval, and cost

¹³ See, for example, a suite of webinars covering utility sector innovations at: <https://www.naruc.org/events/innovation-webinars/>.

¹⁴ DOE, 2023.

allocation practices. These dynamics create a high value proposition for deploying advanced grid technologies that can expand transmission capacity (such as advanced conductors and dynamic line ratings) with existing infrastructure.

In addition, distribution systems are facing growing loads. These include electrification of building end-uses such as space heating and cooling, water heating, and other appliances and equipment, and electrification of transportation as adoption of electric vehicles (EVs) increases (Figure 3). These new loads create challenges for grid operations. For example, weather affects how heat pumps operate, and EVs can charge in unpredictable places and at unpredictable times. Improved grid planning processes for meeting electrification loads reliably and affordably will be needed.¹⁵

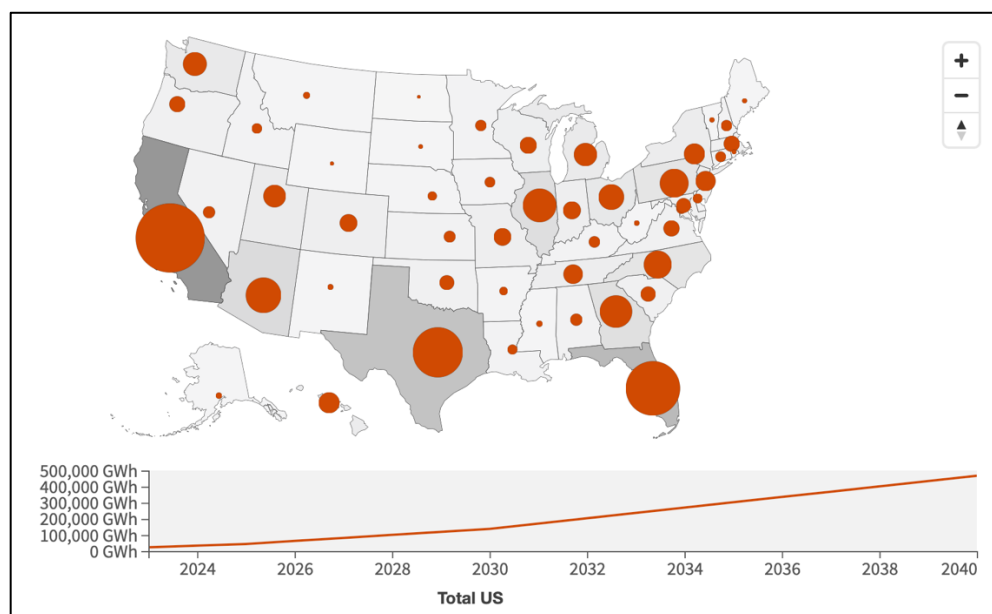


Figure 3. Projected EV Load Growth from 2023–2040 (Source: PWC, ND)

Electrification of end-uses and increasing levels of distributed variable energy resources also will require utilities to have greater grid visibility and control on a time and locational basis through such technologies as Distribution Automation (e.g., intelligent reclosers and TripSavers) and DER management systems (DERMS).

Regulatory sandboxes can enable valuable demonstrations of certain technologies and their potential replicability throughout the utility system.

2.1.3 Resilience Needs

Resilience is increasingly important for utilities at a time of significant load growth, aging grid infrastructure, and increasing severity and frequency of weather events and other hazards. Fifteen states require jurisdictional utilities to develop and file grid resilience plans, including proposed capital investments and other expenditures to help avoid and mitigate the effects of

¹⁵ Energy Systems Integration Group, 2024(a) and (b).

natural and human-caused disasters.¹⁶ T&D infrastructure is vulnerable to a wide range of threats, such as high winds, wildfires, flooding, earthquakes, physical and cyber attacks. Infrastructure also can cause or worsen resilience events — for example, by creating sparks or falling onto roadways used as escape routes.

Advanced grid technologies that support situational awareness and grid flexibility and reactivity improve system resilience. Situational awareness technologies include advanced sensors, which detect and monitor grid conditions in real time, advanced distribution management systems (ADMS) that allow for more sophisticated outage and asset management, and AI-monitored camera systems, which can alert operators to unusual conditions on the grid, such as fires. Grid flexibility, reactivity, and automation technologies include devices such as smart reclosers and fault location, isolation, and service restoration (FLISR) systems, both of which support rapid isolation of faults and power restoration.¹⁷

Regulatory sandboxes can pilot innovative resilience technologies and strategies, demonstrating their value and providing confidence in selected solutions to address local objectives and hazards.

2.1.4 Advanced Grid Management Needs

Variable energy sources are rapidly expanding on the grid. For example, 30 GW of utility-scale solar and over 10.3 GW of utility-scale battery storage came online in the U.S. in 2024.¹⁸ These resources create new challenges and opportunities for grid operators, as solar energy production changes from day to day and throughout the day. Energy storage can help manage these fluctuations or serve peak demand. These resources require grid operators to navigate a more granular balancing act between supply and demand and to operate thermal generating units in new ways. In some cases, those plants may need to operate in ways that they were not designed to do. These changes require more flexible operation of T&D systems.

Advanced grid technologies such as advanced power flow control, advanced flexible transformers, and deployment of energy storage as a T&D asset can support greater grid flexibility by redirecting power flow to lines with available capacity, increasing system efficiency, and absorbing or exporting generating capacity. Dynamic line ratings also provide enhanced situational awareness of the transmission system and can provide congestion relief at lower cost than building out new infrastructure.¹⁹

Regulatory sandboxes can test advanced grid management technologies and strategies in a controlled setting before scaling, minimizing risks.

2.1.5 Affordability Needs

To address these challenges, many utilities are making significant investments in the grid. At

¹⁶ Collins et al., 2025.

¹⁷ White et al., 2025.

¹⁸ EIA, 2025(b).

¹⁹ DOE, 2019.

the same time, retail electricity rates are rising. Rates rose nominally almost 5% per year from 2019 to 2023, driven principally by rising utility costs unrelated to load growth, such as fuel and purchased power and capital investments.²⁰ Maintaining energy affordability is critical to ensuring the safety and wellbeing of households and to support economic growth. Energy affordability becomes even more important as households and businesses increasingly rely on electricity as a primary fuel for maintaining building comfort and meeting transportation needs.

Regulatory sandboxes can be designed to help minimize cost impacts of new technologies and, for programs available to end-use customers (e.g., battery storage), ensure that both participating and nonparticipating customers will benefit from tested technologies. Sandboxes are an important tool for collecting real-world cost data and tangible and quantifiable information on program benefits.

2.2 Challenges to Utility Innovation and Technological Change

Investor-owned utilities operate in regulated environments to align private company behavior with public interests.²¹ The regulatory regime aims to protect customers while considering the financial viability of utilities. Necessarily, the regulatory process is deliberative, using established and often rigid processes to ensure that the rights of those involved are preserved and that decisions are made in the public interest. While these processes and practices exist for important purposes, certain aspects of utility regulation can create barriers to innovation and to quickly scaling new ideas, even following successful demonstration.

Certain aspects of current utility regulatory frameworks and characteristics of the regulated utility sector can stifle innovation. Creating an ecosystem of innovation for utilities requires reducing or removing these hurdles. Regulatory sandboxes are one tool to address these issues. Other innovation vehicles may be better suited to addressing certain challenges. Employing a suite of tools is important for comprehensively effectuating change.

2.2.1 Cost of Service Model and Cost Recovery

Cost-of-service regulation incentivizes capital-intensive investments. Traditionally, utilities operate under cost-of-service regulation in which utilities recover an authorized amount of revenue sufficient to fund their expenses and provide a reasonable return on capital investments. Under this model, utilities profit by investing in capital-intensive projects. This creates an incentive for utilities to propose and build large, utility-owned infrastructure. Some advanced grid technologies are owned by customers or third parties and typically do not provide an opportunity for utilities to earn a return, since they are not making the investment. That creates a disincentive to technology solutions that offset the need for new grid infrastructure.

Cost recovery practices disincentivize innovation. Utilities are risk-averse. Regulators are required to protect consumers from unjust rates and must consider whether investments in

²⁰ Forrester et al., 2024.

²¹ [Hempling, 2021](#).

innovative technologies may create undue cost shifts.²² Utility costs are reviewed and approved for inclusion in retail rates for customers. Costs incurred by investor-owned utilities that are not recovered through retail rates are borne by shareholders, impacting profitability and their ability to make needed investments in the future. In approving costs, regulators must consider whether customer rates are just and reasonable and provide the utility a reasonable opportunity to earn a return on investments that are prudently incurred and used and useful. Regulators must therefore disallow imprudent costs or may otherwise discipline utilities for imprudent actions, such as reducing their authorized rate of return on investments or imposing financial penalties.

This creates a strong incentive for utilities to invest in well-proven technologies. Innovative projects or investments may lack a strong evidence base that utilities can use to demonstrate to regulators and consumer advocates that the investment will be beneficial to customers. In addition, some advanced grid expenditures — e.g., software as a service or customer-owned energy storage systems — typically do not provide an opportunity for the utility to profit. That creates a lopsided risk equation, in which the utility's only upside is recovering their costs, and the downside could include cost disallowance or penalties.²³ In addition, the ability to pass costs onto customers reduces the utility's incentive to innovate in ways that will bring down business costs and improve profitability overall.²⁴ Without corrective actions, utilities face an uphill battle to invest in advanced grid technologies.

Monopoly power reduces incentives to control certain costs and creates an incumbent effect. In a competitive marketplace, businesses are pressured to innovate in order to remain cost-competitive and offer services that are attractive to customers with many choices.²⁵ Regulation aims to mimic some of these effects, but as industry incumbents, utilities do not face the same competitive pressures, limiting innovation. Any incumbent business — that is, a company that holds a large portion of the industry's market share²⁶ — typically does not offer innovation and disruptions. There is a strong incentive for utilities to maintain the status quo that has historically offered them a stable business environment.

The regulatory process is rife with barriers to innovation. The regulatory process is necessarily designed as a deliberative progression through a series of steps that allows regulators to obtain and review the information they need to make an informed decision, while preserving the rights of those with interests at stake in the proceeding. Lengthy regulatory timelines are not conducive to innovation, testing, and quickly scaling successful technologies and practices.

Utility regulatory commissions increasingly face new mandates, legislative priorities, and timelines, and they often are under-resourced.²⁷ Proceedings that are not of the highest priority,

²² Ibid.

²³ Lazar, 2016.

²⁴ Hempling, 2021.

²⁵ Ibid.

²⁶ See <https://www.investopedia.com/terms/i/incumbent.asp>.

²⁷ See, for example: Ciulla and Felder, 2021.

such as pilot or demonstration programs, often are placed on the backburner. In addition, regulators are increasingly soliciting more stakeholder and public input to improve their decision-making. While additional participation in regulatory proceedings can create more balanced and informed outcomes, it often increases proceeding timelines. This hinders timely consideration of new technologies and programs. In some cases, delays can render innovation proposals moot, as new technologies become available in the meantime. The timeline for typical sandbox-type mechanisms reviewed for this report was typically over a year, and in some cases, there were regulatory delays associated with implementing the sandbox or approved projects. For example, in Hawaii, a proceeding paused for several months as the Commission determined how to address shortcomings in sandbox design.²⁸

Adversarial regulatory processes also can hinder innovation.²⁹ Lack of collaboration between stakeholders can limit creativity and cause proceedings to take longer than necessary. In addition, it is challenging to establish a more flexible regulatory construct such as a sandbox when there is a lack of trust between stakeholders. For example, utility consumer advocates challenge proposed utility rate increases and question utility spending, aiming for fair rates for customers.³⁰ It is critical that consumer advocates understand the benefits of regulatory sandboxes and innovation and that they have some assurance or trust that utilities will not abuse the flexibility embedded into the structures put in place. Stakeholder support is a foundational requirement for establishing a regulatory sandbox.

Regulatory lag also can contribute to the utility's lack of interest in innovation. While multi-year rate plans (MYRPs) support financial efficiency by allowing utilities to identify cost savings that they can keep until rates are reset, this incentive to reduce spending can reduce spending on innovative projects.³¹ Further, utilities experience a gap between when they expend funds and when they recover those costs.

Traditional utility approaches to innovation have not resulted in transformative change. Utilities have experience conducting R&D and pilot programs and demonstrations as a means to experiment, test, and eventually scale new technologies and programs. However, the traditional utility business model can impede the desire to make significant investments in R&D and scale successful pilots and demonstrations beyond a testing phase. While R&D is foundational to innovation, utilities invest a disproportionately small percentage of their budgets in R&D (Table 2).³²

²⁸ HPUC, 2023(b).

²⁹ McDonnell, Gorman, and Field, 2022.

³⁰ <https://www.nasuca.org/about-us/>.

³¹ Lazar, 2016.

³² Sheahan and Zhang, 2019.

Table 2. R&D Investment as a Percentage of Budget by Industry (Costello, 2015)

Industry	R&D Intensity
All industries	3.3%
Manufacturing	3.8
Chemicals	4.5
Pharmaceuticals and medicines	10.3
Automobiles, trailers and parts	2.4
Computer and electronic products	10.6
Electrical equipment	2.9
Non-manufacturing industries	2.7
Software publishers	9.0
Computer systems design	8.4
Finance and insurance	0.7
Utilities	0.1

Pilot programs, both for utilities and in other sectors, frequently do not progress to full-scale programs. Reasons include the following:

- *Lack of, or unclear terminology.* Lack of clarity and understanding over what constitutes a pilot, demonstration, field study, or other test can create uncertainty over the purpose and scope of projects and cause approval and implementation delays.³³
- *Design flaws.* Poorly designed pilots can lead to misleading, biased, or inconclusive results. Utility reporting on pilot results also may lack clear metrics to determine successes or other critical outcomes and impacts.
- *Lack of process for scaling.* Utilities and regulatory processes often do not establish pathways for successful pilots and demonstrations to scale.³⁴
- *Lack of information sharing.* Lacking awareness of demonstrations conducted in other jurisdictions, utilities may conduct pilots that other utilities already have conducted, reducing the value of the results. Even with such awareness, utilities and regulators may want to collect jurisdiction-specific data.³⁵
- *Disputes.* Pilot programs and demonstrations can get caught up in disputes between parties.³⁶

These challenges and lessons apply to sandbox design as well. Ultimately, although pilots have not consistently led to actionable results for decision-makers, utilities and regulators continue to rely on them as a means to test new ideas.

³³ For example, the Hawaii Public Utilities Commission (HPUC) identified a concern that projects proposed through the Innovative Pilot Framework were not pilots, “in the sense of testing new ideas that have the potential to be scaled up if successful.” HPUC, 2023(a).

³⁴ NASUCA et al., 2022.

³⁵ Cappers and Spurlock, 2020; Michigan Public Service Commission Staff, 2020; Ciulla and Felder, 2021.

³⁶ Fairbrother et al., 2017.

2.2.2 Technological Concerns

Utilities are first and foremost concerned about safety and reliability rather than innovation. Without significant real world experience, advanced grid technologies without a clear evidence bank inherently pose a risk to the utility's fundamental obligations to serve customers safely and reliably. With load growth, aging infrastructure, and extreme weather events, utilities are increasingly investing in tried-and-true safety and reliability measures, which can shift funding away from innovative approaches that would enhance reliability, resilience, and energy affordability over the long run.³⁷

There are significant barriers to early replacement of existing technologies. Utilities typically do not seek to replace a technology that is not beyond its useful life or fully depreciated without remedies that would address possible stranded assets and lost revenue. Further, existing relationships with vendors can be tested by innovation, if a product or service is at risk of becoming obsolete in favor of newer products from other vendors.

2.2.3 Education and Leadership

An organizational champion is often necessary to promote a culture of innovation and drive sandbox development. In most interviews conducted for this report, participants emphasized the importance of a champion for innovation or noted individuals or organizations that acted as champions. In many cases, a single leader within an organization (such as a utility executive, Commissioner, commission staff member, or legislator) drove the development of the jurisdiction's sandbox. Moreover, leaders set a tone for innovation and created an environment where new ideas and disruptions are invited. This culture of innovation is critical throughout the organization, across functional areas. For example, it is not enough for a utility's regulatory department to develop innovative business model ideas if the accounting division isn't on board with the new approaches. Similarly, innovative programs coming from utility distributed energy resources (DER) teams may not move forward if the utility's operational team isn't willing to implement requisite changes. For utility commissions, it is important to have input from cross-functional teams when reviewing and approving projects that go through a sandbox mechanism. While an organizational champion is an important ingredient for success, it is important to guard against favoritism by the champion for certain technologies or programs.³⁸

Lack of information sharing creates uncertainty and limits spillover effects to expand the benefits of sandboxes. Interviewees also emphasized the need for education on the risks of maintaining the status quo and avoiding innovation, in addition to educational resources on sandbox programs, designs, and results. As identified by DOE³⁹, data sharing on possible net savings from advanced grid technologies is limited, which can hinder progress in considering alternatives to the status quo. Some interviewees noted that information and experience sharing is highly related to positive outcomes of sandbox mechanisms and spillover effects. For

³⁷ Costello, 2015.

³⁸ Ibid.

³⁹ White et al., 2024.

example, some utilities may think that a sandbox mechanism is too good to be true. In such cases, utilities that observe successful sandbox mechanisms are more confident that the regulator will implement the sandbox in ways that enable its success — for example, shorter review timelines and more certainty around cost recovery. Information on successful sandbox mechanisms also can help utilities and stakeholders justify the use of customer funds for sandbox projects, increase budgets, or stand up a new mechanism to support technology innovations.

3. Regulatory Sandboxes: Tools for Advancing Innovation

Sandboxes have historically provided a structured environment for testing new ideas, technologies, and programs as a means to reduce risk and provide meaningful learning outcomes before rolling them out more broadly. This chapter analyzes experience with sandboxes across various sectors, including more recent experience with *regulatory* sandboxes, to provide insight into best practices and ways to overcome common challenges. We detail important aspects of regulatory sandboxes as a tool for advancing innovation, including information on their history, types of sandboxes in the energy sector, design features, and roles and responsibilities for designing and implementing regulatory sandboxes.

3.1 The History of Regulatory Sandboxes

The term “sandbox” originated in the IT industry, where programmers created isolated environments to test new programming, code, and software so that any bugs or errors wouldn’t harm existing environments, create vulnerabilities, or otherwise create harm. The IT industry also deployed sandboxes to test suspicious code and reduce risk of attacks. The healthcare industry has used sandboxes to test experimental and innovative new treatments and services.⁴⁰ In these contexts, sandboxes are used to contain experimentation with potentially risky, but important new ideas and services.

The sandbox concept evolved and grew significantly in the 2010s, when the financial technology (FinTech, or companies that primarily rely on technology to provide financial services such as investing, saving, and borrowing money⁴¹) sector took off following the 2008 global financial crisis. Regulators responded to the financial crisis with increased scrutiny and regulatory reforms. At the same time, major advancements in technology allowed the financial sector to evolve at a rapid rate, with new startups and e-commerce companies disrupting traditional approaches and financial institutions. The renewed focus on consumer protection, combined with major changes in the industry created significant challenges for regulators in the sector.⁴² In 2012, the U.S. Consumer Financial Protection Bureau initiated Project Catalyst, which “focused on encouraging marketplace innovation so that new and emerging products can be developed that are safe and beneficial for consumers” via research collaborations, creation of communication channels across diverse stakeholders, and policy development.⁴³ The objectives and processes developed in this early sandbox-type mechanism are still foundational for regulatory sandboxes today.

Project Innovate, established by the U.K.’s Financial Conduct Authority in 2016, used the term *regulatory sandbox*, which aimed to explicitly support the growth of the FinTech sector and promote competition in the industry by helping new firms prepare for regulation, navigate

⁴⁰ Appaya, Gradstein, and Haji, 2020.

⁴¹ McKinsey & Company, 2016.

⁴² Zetsche, et al., 2017.

⁴³ CFPB, 2016.

regulation on an ongoing basis, and connect regulators with innovative ideas.⁴⁴ The effort emphasized the importance of **two-way communication between innovators and regulators** – a theme that persists in electricity focused regulatory sandboxes. From the development of Project Innovate through 2020, countries around the globe developed more than 70 financial sector regulatory sandboxes, shown in Figure 4.

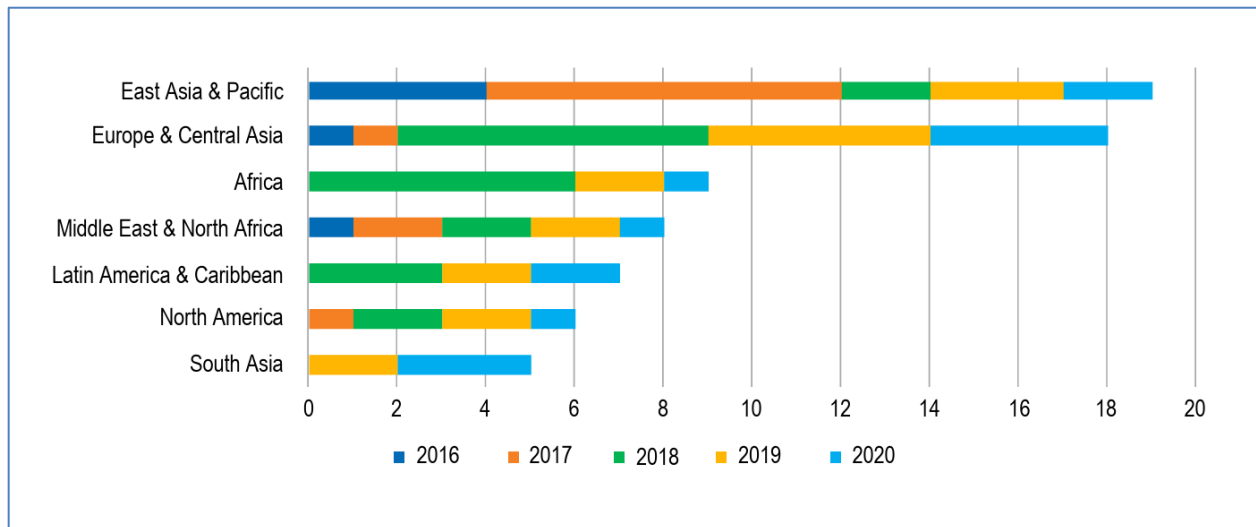


Figure 4. Financial Sector Regulatory Sandboxes by Region (World Bank Group, 2020)

In the European oil and gas sector, early adopters implemented sandbox-type mechanisms for regulatory experimentation around the same time as many in the FinTech sector, starting in 2015 with more countries adopting them over time. Similarly, electricity-focused regulatory sandboxes in the U.S. and abroad began to take off around 2017 and have expanded over time, as depicted in Figure 5.

⁴⁴ Friend, 2021.

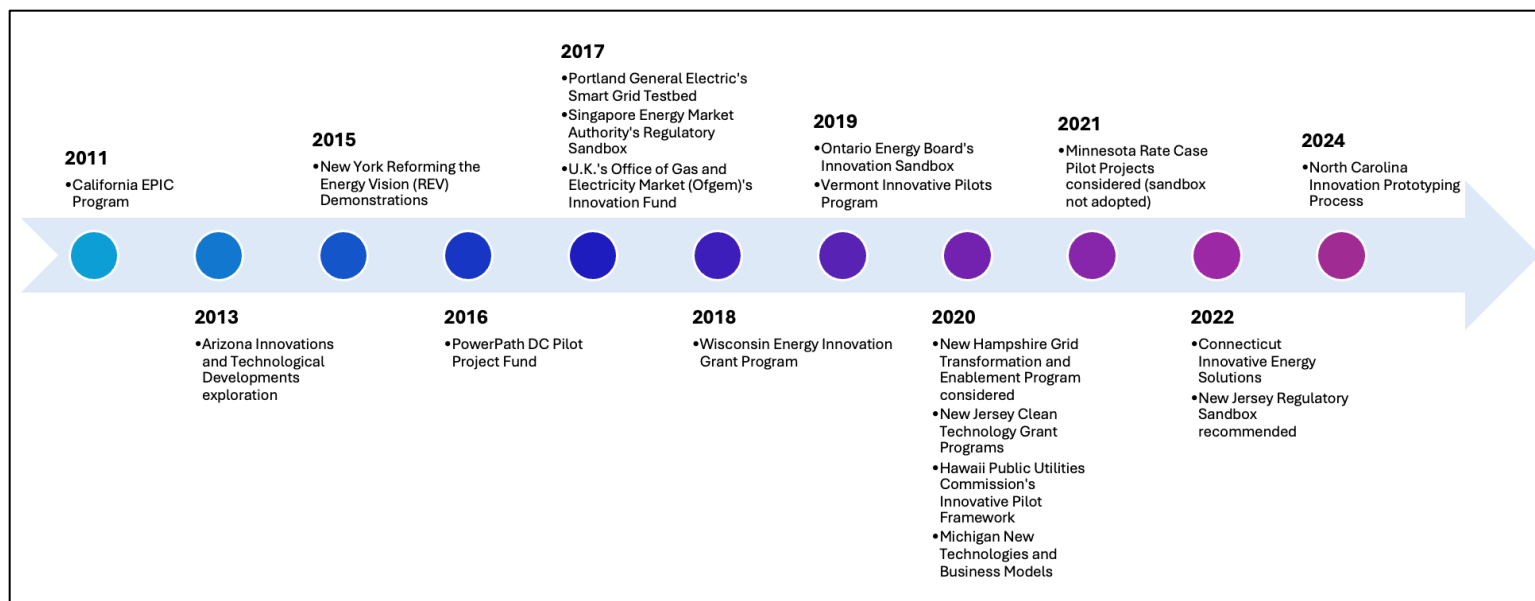


Figure 5. Timeline of Sandbox-Type Mechanisms in the Electricity Sector

3.2 Benefits and Risks of Regulatory Sandboxes

The literature indicates that regulatory sandboxes are a good tool to advance objectives such as promoting innovation, advancing information collection and knowledge sharing, improving economic outcomes, increasing grid reliability and resilience, better meeting customer needs, and increasing access to technologies (Table 3).

Table 3. Potential Benefits of Regulatory Sandboxes

Benefit Category	Details
Advancing innovation	- Advance innovation within businesses (both private industry and utilities) and create spillover effects, such as new external partnerships and reduced internal silos - Advance innovation in regulation and regulatory learning by highlighting potential areas for revised regulations and identifying gaps where new regulatory guidance or public policies may be needed - Reduce the cost of innovation by removing barriers to entry for innovative technologies and solutions before deciding if the solution should be scaled - Create evidence that there is a market for innovative technologies and encourage further technological advancements
Improving information collection and knowledge-sharing	- Collect insights and real-world data on new ideas - Build evidence to support a regulatory decision on a utility's plan for adopting advanced technologies - Provide opportunities for a more collaborative approach to achieve energy-related state goals - Improve coordination between regulators, governing bodies, utilities, industry, and other stakeholders, with clear and well-implemented knowledge-sharing and

	collaboration practices
Improving economic outcomes	• Improve stakeholders' ability to identify and capitalize on new economic opportunities, moving more quickly from idea to demonstration to scale • Create new pathways for emerging energy products and services to reach commercialization, stimulating investment and new jobs • Test emerging technologies that are more cost-effective than like-for-like replacements and contribute to energy affordability
Improving grid reliability and resilience	• Test emerging technologies that support grid reliability and resilience in response to changing grid conditions, such as increased penetration of variable energy resources and increasing severity of weather events
Better meeting customer needs	• More nimbly address customer needs and adapt to changing customer desires such as for better access to electric vehicle charging, improved building resilience, and adoption of distributed storage technologies
Increasing access to technologies	• Support access to advanced technologies for varied populations by encouraging third-party and utility collaboration and encouraging successful outcomes for all parties

As with any regulatory tool or reform, it is important to anticipate, and aim to mitigate, any potential risks. Regulatory sandboxes do pose some risks to customers, the grid, and to other stakeholders, including possible market distortions, negative impacts to customers, the grid, or society, and undue investment of time and resources in sandbox implementation. These are shown in Table 4, along with tactics and design elements that can help to reduce these risks.

Table 4. Risks of Regulatory Sandboxes

Risk Category	Details and Mitigation Strategies
Market distortions	• Create market distortions that can disrupt competition as businesses participating in the regulatory sandbox gain an advantage, creating barriers to other firms entering the market, even after the sandbox ends • Potentially erode a utility's monopoly status Mitigation strategies: Transparent eligibility criteria, objectives, selection criteria, and exit options, level opportunities for participation by different entities, and clear (and well-implemented) knowledge-sharing obligations
Negative impacts to customers (e.g. increased costs, unintended consequences of technologies, etc.)	• Negatively impact consumers as a result of the experimental nature of sandboxes and modifications to regulations intended for consumer protection (e.g. some customers may not have access to sandbox programs, sandboxes may create undue advantages for certain customer segments, rates may increase, etc.) • Negatively impact consumers when programs do not result in intended outcomes (e.g. technology costs may be higher than expected, technologies may not improve reliability or reduce load, etc.) Mitigation strategies: Include consumer safeguards among the eligibility criteria for submitted projects, maintain technology neutrality, create flexibility to adjust to program

	learnings in real time or end projects early
Negative impacts to the grid or society	• Fail to achieve the intended benefits of sandbox projects, resulting in negative impacts to grid reliability, safety, the environment, the economy, or other factors Mitigation strategies: Embrace learning/failure as a successful outcome, create flexibility to adjust to program learnings in real time or end projects early
Undue investment of time and resources in sandbox implementation	• Invest significant time and resources into sandbox development and implementation, distracting from other regulatory or utility needs • Fail to achieve innovation objectives of the sandbox • Act as an imperfect substitute for other regulatory change or enablers (e.g. invest time and resources into a sandbox when a simple change to a rule or policy would accomplish the same outcome) Mitigation strategies: Deploy best practices for sandbox design, consider whether a sandbox is the appropriate innovation vehicle to meet the challenge, create clear project management tools for sandbox implementation, build in opportunities to adjust the sandbox framework over time

Regulatory sandboxes are just one tool that regulators can deploy to meet these objectives and, in some cases, other innovation approaches (e.g., traditional pilots, innovation hubs, regulatory change, track-then-act, etc.) may be more appropriate. Regulators can assess whether the risks are acceptable based on their scale and potential impacts and likelihood of customer benefits and design sandboxes to minimize risks. Through our interviews, we generally found that jurisdictions that have implemented sandboxes think that they've been successful, indicating that the potential and realized benefits outweigh the risks.

3.3 Regulatory Sandboxes: Design Features and Implementation Practices

A number of articles and reports provide insights into design and implementation practices for regulatory sandboxes based on case studies and reviews of existing mechanisms (both in the energy sector and otherwise). Major considerations for designing sandboxes include developing high-level objectives, effectively scoping and identifying the bounds of the framework, identifying the derogations (i.e. exceptions or modifications to rules or regulations), defining program eligibility and the application process, establishing oversight, governance, and reporting requirements, and establishing funding and cost recovery expectations. In general, individual projects that go through a sandbox should also follow best practices for pilot design, which have been documented in relevant literature.⁴⁵

The following tables project provide best practices for designing a regulatory sandbox from the literature, our interviews, and a review of regulatory proceedings. We also provide examples derived from actual sandbox-type mechanisms.

First, the regulator and stakeholders identify the boundaries of the Sandbox, including objectives, scope, derogations from traditional regulatory frameworks, and funding (Table 5).

⁴⁵ See for example, Cappers and Spurlock, 2020, and Michigan Public Service Commission Staff, 2020.

Table 5. Best Practices and Examples of High-Level Sandbox Scoping Elements

Scoping Element	Best Practices	Examples
Program objectives	- Align objectives with wider regulatory constructs and policy objectives such as clean air, improved grid reliability, and improved grid resilience - Use stakeholder engagement processes to develop objectives - Clearly state objectives and provide information on what the sandbox is expected to achieve - Acknowledge that an outcome indicating that a product or service isn't suitable for the energy markets is still an informative outcome - Explicitly focus on facilitating scaling new products and services, not just running trials - Anchor objectives in showing that technologies can operate in real energy markets/systems and with real consumers - Ensure that learning, speed, and eventual scaling are primary objectives	Sandbox objective be high-level or specific, such as: - Support innovation and cultivate scalable solutions to meet state energy policy objectives - Quickly test and new market offerings, technologies, programs, and business models - Accelerate adoption of flexible grid resources and create a nimbler grid - Improve interconnection timelines and reduce interconnection costs
Program scope	- Clearly identify the regulatory barriers that the sandbox intends to address - Provide information on what markets, technologies, programs, and regulations are in scope and the limits of the regulator's authority with regards to derogations - Collaborate with relevant authorities if needed, depending on the scope of the sandbox	Sandboxes may be narrowly or broadly scoped, such as: - The Portland General Electric Smart Grid Test Bed, which focuses on demand response programs - The North Carolina Prototyping Process, which has broad eligibility but excludes energy efficiency and demand-side management - The New York REV Demonstrations, which aim to test business model changes to identify new revenue streams
Derogations	- Consider how specific to be with derogations or modifications to regulatory constructs – overly specific boundaries might restrict innovators, while being too broad may cause confusion over what the objectives are - Consider whether derogations should apply to all projects or whether one-off modifications are appropriate depending on the innovation the sandbox is supporting	Sandbox derogations can include: - Implementing expedited timelines for regulatory review - Eliminating the need for regulatory approval altogether - Eliminating the need for requests for proposals / allowing single-source vendor selection - Shared risk parameters between utilities and vendors

	○ The design may not always include derogations or exemptions from rules ○ Sandbox implementers may provide bespoke guidance to innovators looking to participate ● Identify foundational legal and regulatory frameworks for enabling responsible innovation and that allow for regulatory flexibility and minimal oversight ● Deploy other innovation vehicles instead of a sandbox when appropriate	Commissions may have existing legal frameworks to draw on in the design of their sandboxes (e.g. other processes that use expedited approval), or may need to work with legislators to identify and pass supportive legislation.
Funding and cost recovery	● Reduce uncertainty over cost recovery ● Look into funding sources beyond customers rates when designing a Sandbox ○ Regulators can consider allowing cost recovery even if trials aren't successful (even outside of a sandbox) ● Consider cost or risk-sharing requirements for innovators	Common practices include: ● Creation of funding carve-outs ● Identifying maximum project and total sandbox spending caps ● Stating that sandbox projects will receive cost recovery as long as they don't deviate from the approved scope (without approval)

Once the high-level boundaries of the sandbox are identified, administrators can develop more granular requirements and materials for the specific projects that will participate in the sandbox program, including eligibility and application requirements shown in Table 6.

Table 6. Specific Participation Requirements Best Practices and Examples

Participation Requirements	Best Practices	Examples
Program and project eligibility	● Develop eligibility and selection criteria well in advance and with comprehensive participation of relevant stakeholder groups ● Provide examples and information about previous successful innovators ● Use templates and standard format documents to ease administrative burdens ● Specify who administers programs and/or who is eligible to apply, including information about licensees and partnerships and any specifications for technologies or services ● Create multiple participation pathways for different entity types in order to reduce potential gatekeeping by utilities ● Create eligibility criteria that follow the outlined desirable innovation characteristics (e.g. reduced	Sandboxes may allow any number of projects that meet eligibility criteria within budget to move forward, or may use advisory groups to select a subset of proposals. Selection criteria may include: ● Technology readiness ● Implementation plan and project team qualifications ● Level of innovation ● Cost-effectiveness and economic impact The Connecticut IES program has participation pathways for innovators

	emissions, cost-effectiveness) and that follow best practices for pilot/demonstration design ○ Jurisdictions can create unique eligibility requirements to meet their goals, such as local vendor preferences or vendor cost sharing criteria ● Carefully specify eligibility criteria to protect customers from possible sandbox risks ● If applicable, develop a comprehensive and specific list of selection criteria ● Calibrate eligibility and selection requirements to recognize that developing a strong business case and demonstrating financial and technical capabilities be challenging for emerging technologies or businesses	alone, utilities alone, or utility/innovator partnerships.
Application process	● Consider whether to use open calls for applications, thematic calls, or to allow continuous applications ○ Identify how many cycles or calls will happen before undertaking a more comprehensive sandbox review ● Calibrated the process to avoid burdensome or prohibitive administrative requirements, but that is transparent about use of public funds	Different types of sandboxes use different application processes: ● Vermont's process requires no regulatory approval for in-scope programs and allows continuous project initiation ● The Connecticut IES uses cycles based on themes such as "Smart Energy Communities" ● Hawaii's Innovative Pilot Framework requires specific information in each "Notice of Intent" to initiate a pilot

Once projects are selected, ongoing monitoring, evaluation, and ability to adjust the sandbox structure is critical. Speed is a major objective for regulatory sandboxes, which aim to avoid endless pilots, reduce undue investment in unsuccessful experiments, and quickly move to scale. Design elements can help to build in regular off-ramps, allow for successful pivots, and move efficiently to full-scale, tariffed programs.

Table 7 shows design elements for oversight and governance, evaluation and reporting, exit strategies, and communications.

Table 7. Ongoing Sandbox Governance Best Practices and Examples

Elements of Sandbox Governance	Best Practices	Examples
Oversight and governance	• Ensure transparency in all aspects of the sandbox, particularly for activities that use public funds • Conduct an upfront feasibility assessment to determine whether a sandbox is viable in the jurisdiction • Consider who should be involved in oversight and governance to facilitate the desired outcomes ◦ Consider whether involvement of government agencies beyond regulators is needed to effectuate certain derogations (e.g. permitting or environmental agencies) • Maintain time limits on the sandbox or derogation and individual projects • Ensure commitment from the highest levels of the regulator and sandbox authorities at the outset • Limit regulatory oversight and administrative requirements to only those that are necessary, and provide as much flexibility in project implementation as possible • Create robust risk management procedures during the creation and design of regulatory sandboxes by developing go- no-go checkpoints and criteria • Create opportunities for interaction between regulators, utilities, and other sandbox participants ◦ In particular, create opportunities for open, candid, and non-punitive dialogue, such as by allowing non-decisional commission staff to consult with utilities and innovators on an ongoing basis • Ensure that sufficient resources are dedicated to management and oversight of sandbox • Outline the Commission's internal process for pilot review • Run parallel programs to compare outcomes (e.g., where there is utility ownership and 3rd party ownership, where there are utilities of different sizes and types)	Common and example practices include: • Use of advisory councils to guide the sandbox process and select projects • Time limits of between 12 – 18 months for individual pilots • Regularly scheduled check-in meetings for sandbox stakeholders
Evaluation and reporting	• Establish clear evaluation criteria and metrics for success that align with sandbox and project objectives and determine next steps for implementing results	Common reporting requirements include: • Quarterly pilot reports and more thorough annual or post-pilot evaluations

	○ Build in indicators of success beyond market efficiency, including spillover effects and social impacts ○ Have both utilities and innovators participate in evaluations ○ Use customer/participant surveys ● Create public reporting obligations for finished projects	● Requirements that utilities report on lessons learned and narratively describe what actions they will take based on those lessons
Exit Strategies	● Clearly identify project exit options ● Set up procedures for transitioning results into permanent regulation ○ These should be defined in advance of sandbox implementation to minimize market distortion and uncertainty	Common exit strategies include: ● Requirements that utilities assess whether the pilot will be scaled up, needs continued testing, or will be discontinued in a final report ● Determination by the regulator on whether the project will move to a tariff-based program
Communications	● Create a stakeholder engagement plan that includes all relevant stakeholders ● Create enthusiasm and momentum with pitch-fests, newsletters, webpages, webinars, press releases and other communication tools ● Stay in touch with innovators with ongoing light-touch surveys ● Create channels and processes to retain learnings and other information over time ○ Sandboxes may generate interest in areas beyond the sandbox scope that the regulator/utility can learn from	Common communications tools include: ● Program webpages (such as Connecticut and California) ● Expectations that grant recipients conduct webinars on their projects ● Use of innovation portals for innovators to submit ideas (such as in Hawaii and New York) ● Expectations that utility staff working on the sandbox will connect other departments with relevant innovators

3.4 Regulatory Sandboxes: Roles and Responsibilities

Key actors in the regulatory sandbox and their interest/role include:

- Public utility commissions: Regulators frequently drive sandbox creation. Regulators identify sandbox objectives, create straw framework proposals, grant regulatory derogations, and provide ongoing oversight and monitoring of the process.
- Utilities: Utilities participate in regulatory sandboxes as the primary project administrator. Utilities provide support on sandbox framework development and ongoing adjustments to its structure. As the project administrator, utilities also run their own pilots/demonstrations within the sandbox, partner with innovators, report on outcomes, and ultimately have the responsibility to promote advanced grid technologies through the sandbox while maintaining safety and reliability.
- Consumer advocates: Consumer advocates are important stakeholders for regulatory sandboxes. Consumer advocates that understand the value proposition for a sandbox

will provide support for the sandbox and individual projects while providing key oversight for effective and beneficial use of ratepayer funding.

- Innovators: Sandboxes can create a pathway for innovators to enter a traditionally opaque market and to demonstrate their technology or service in the real world. Collaboration and partnership by innovators in individual project design, implementation, adjustments, and reporting is critical to successful projects.
- Policymakers: Legislators and policymakers can provide high-level objectives for the electricity sector and enact laws that support sandbox creation.
- Customers: Customers typically pay for sandbox projects at least in part. Customers also benefit from sandboxes either through direct project participation or net benefits from innovation.
- Energy industry at-large: Spillover effects create a market that is more open to innovation and that advances more quickly, potentially supporting economic growth and job creation.

3.5 A Taxonomy of Sandbox-Type Mechanisms

When applied to the regulatory space, sandboxes are more narrowly defined than those that have been deployed in the IT or healthcare spaces because they seek specifically to modify or provide limited exemptions to regulations, rules, or requirements or to explore ways to improve regulation to reduce barriers to innovation. We define a regulatory sandbox as a **mechanism that provides a structured environment for testing new technologies and business approaches under modified rules to increase the speed of adoption.**

Regulatory Sandboxes

Mechanisms that provide a structured environment for testing new technologies and business approaches under modified rules to increase the speed of adoption

Within this definition, states and jurisdictions have adapted the regulatory sandbox structure to suit their individual needs and have used unique naming conventions for their programs. Through a review of U.S. regulatory proceedings, we identified themes that we have categorized into a taxonomy of electricity-sector regulatory sandboxes or mechanisms that are substantially similar to a regulatory sandbox (sandbox-type mechanisms). Figure 6 provides a taxonomy of sandbox-type mechanisms.



Figure 6. Taxonomy of Energy-Sector Regulatory Sandbox Mechanisms

Each category is a variation on a regulatory sandbox because each includes a derogation or modification to traditional regulatory rules and practices. There are significant differences in the structure of each mechanism. These different structures each have benefits and challenges, and may serve slightly different objectives.

- **Funding Opportunities:** These processes focus on establishing funding carveouts for innovative advanced grid technology projects. Funding opportunities act as a grant-type mechanism, meaning that there is a set level of funding available for projects. Entities may need to apply for funding for individual projects or have projects approved to qualify for the available funding. By bypassing traditional investment requirements, these allow for more flexibility in financial approval. Utilities and third-party implementers can leverage these funds to meet state clean energy goals.⁴⁶
 - *Benefits:* Funding opportunities typically include very clear requirements for projects that will qualify, sometimes including use of scoring criteria or threshold requirements. This, along with a pre-identified funding carve-out, reduces uncertainty around whether projects will be approved generally, and approved for cost recovery.
 - *Challenges:* Funding opportunities typically do not explicitly focus on examining and experimenting with regulatory or business model changes needed to promote innovation and are often more focused on specific technologies and services.
- **Pilot Processes:** These activities focus on improving how pilot projects are approved and managed. Common approaches include pre-approval mechanisms, expedited reviews, and streamlined oversight. The primary objective of these activities is to

⁴⁶ Funding from the IRA and IIJA, including GRIP funding, is not included in this review.

respond to the need for a more agile regulatory environment, enabling faster testing and scaling of new innovations.

- *Benefits:* Utilities and stakeholders have experience and are comfortable with pilots, and these processes aim to improve on that experience by creating fewer regulatory hurdles for pilot approval, setting timeline requirements to speed the process along, and by pre-authorizing funding caps or project types.
 - *Challenges:* Pilot processes often do not holistically address every challenge that utilities face in deploying pilots successfully, such as identifying clear exit and scaling strategies or modifying specific regulatory barriers beyond pilots. However, pilot processes can be designed to reduce or eliminate the specific challenges that exist in that jurisdiction.
- **Rate Cases and Rulemakings:** Rate cases and rulemakings can serve as a vehicle for broader innovation efforts. Multi-year rate plans (MYRP) and certain ratemaking reforms can create a supportive environment for sandbox-like initiatives, helping utilities align innovation with cost recovery and regulatory requirements. Included cases often feature discussions on pre-approval, performance incentives, or other “innovation metrics,” enabling utilities to pilot non-traditional technologies or business models outside cost-of-service regulation.
 - *Benefits:* Implementing a sandbox-type mechanism as part of a broader ecosystem of innovation tools creates shared and ambitious objectives, can help create a culture of innovation, and may address more barriers to innovation than one-off programs.
 - *Challenges:* Rate cases are time- and resource-intensive, can be contentious, and may include negotiations amongst parties. These elements could mean that due to the breadth of topics considered there is less enthusiasm and time to spend on developing a sandbox-type mechanism, or it may get lost in the depths of negotiations and cost-cutting measures.
- **Regulatory Sandboxes:** These are mechanisms that provide a structured environment for testing new technologies and business approaches under modified rules to increase the speed of adoption. Regulatory sandboxes may also explicitly conduct regulatory experimentation to reduce regulatory barriers to innovation and adoption and scaling of advanced technologies and services. In our review of proceedings, those we identified as regulatory sandboxes reflect the spirit of open-ended testing, where commissions actively guide innovation outside more traditional regulatory paths. Sandboxes provide state PUCs with a framework to oversee innovation while managing risk for utilities and utility customers.
 - *Benefits:* Regulatory sandboxes explicitly modify or experiment with regulation to reduce barriers to innovation, which can have a market transformation effect.
 - *Challenges:* Stakeholders may lack understanding of these mechanisms and their benefits, which could create challenges in standing up a program that introduces some risk and costs to customers.

Each jurisdiction will want to consider the specific barriers to innovation that it faces when deciding which mechanism to use and how to adapt it to their needs.

4. Regulatory Sandboxes in an Ecosystem of Innovation

Regulatory sandboxes are an important tool to promote innovation in the utility sector, among other approaches that may be needed to address additional barriers. This chapter outlines other innovation vehicles in the utility sector, including those driven by utilities, regulators, and policymakers, as well as economy-wide initiatives and those that broadly create an environment that supports innovators. Innovation requires significant upfront investment, and innovators require some level of certainty that there will ultimately be demand for their product or service once it reaches an appropriate technology readiness level.

This chapter also discusses regulatory sandboxes in concert with other innovation vehicles to address specific barriers and alternative solutions decisionmakers can consider. Finally, the chapter identifies themes and elements of the ecosystem of innovation in states with sandbox-type mechanisms.

4.1 Other Innovation Vehicles

Innovation vehicles are programs or mechanisms designed to promote testing and acceleration of ideas that go beyond the status quo. These vehicles can be specifically targeted (such as seed funding for technology development) or they may support innovation broadly (such as by reducing biases towards traditional technology deployment). A broad variety of entities can implement innovation vehicles and may participate at different stages of the innovation and deployment chains. The innovation and deployment chains typically include basic knowledge creation, testing and refinement through prototypes and demonstrations, commercialization, deployment, and market transformation.⁴⁷

4.1.1 Utility-driven innovation vehicles

In exchange for a monopoly in their service area, utilities are required to meet certain state objectives such as safe, reliable, and affordable service. In a period of rapid load growth, technological change, and threats to grid resilience, innovation may be required. Figure 7 shows innovation tools at utilities' disposal.

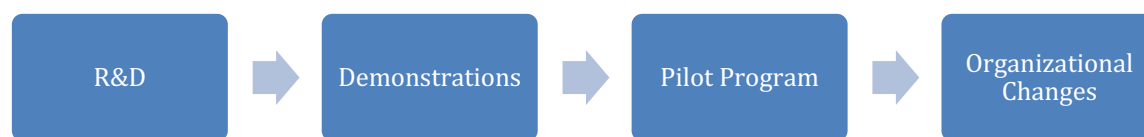


Figure 7. Utility Innovation Tools

⁴⁷ Costello, 2016; Ivo and Duff, 2020; U.S. DOE, ND.

R&D is a precursor to innovation that typically includes both basic and applied research.⁴⁸

Basic research attempts to create new knowledge that will lead ultimately to profitable commercial applications of new technologies. Applied research and development uses the new knowledge created by basic research and applies it to products or services that society values.

R&D often includes testing in a laboratory setting to prove a basic concept. Technologies at such early stages of development are considered to be at a low technology readiness level and have high risk.⁴⁹ Utilities largely conduct R&D by partnering with external organizations (e.g., Electric Power Research Institute, local businesses). But R&D budgets typically are small (0.1% of revenues in one analysis), particularly when compared to other industries.⁵⁰

Following R&D, **demonstrations** aim to evaluate the commercial feasibility and business case of a new technology or program, particularly with a view to how they will scale.⁵¹ Utilities are more likely to conduct demonstrations than basic R&D in order to test how a new technology or program will function within their system.

Defining **pilot programs** can be challenging. In the utility system of accounting, pilot programs fall under R&D, and the energy industry uses the term inconsistently. One interpretation is that pilots focus only on technical questions before moving toward business-focused demonstrations.⁵² Some use the term to mean an experiment that determines *whether* a new idea should move forward, while others mean an experiment to determine *how* a predetermined idea will move forward, which may be better described as a “phased rollout.”⁵³

The Hawaii PUC explored how to define a pilot program for the purposes of its Innovative Pilot Framework. The PUC stated that pilots should generally not focus on implementing or expanding proven programs and theories and instead should:

- “Reflect a small-scale model of a concept that is intended to be scaled up, if proven successful ...
- Have clear and unique characteristics that distinguish it as a distinct effort ...
- Be focused on testing new ideas and technologies which are not currently being pursued by other Company initiatives.”⁵⁴

Michigan PSC staff found that there was no consistent definition of a pilot across its utilities. PSC staff proposed to define a pilot as “a limited duration experiment to determine the impact of a measure on one or more outcomes of interest.”⁵⁵

⁴⁸ Costello, 2016.

⁴⁹ U.S. DOE, ND.

⁵⁰ Costello, 2016.

⁵¹ Costello, 2016 and Fairbrother et al., 2017.

⁵² Fairbrother et al., 2017.

⁵³ Cappers and Spurlock, 2020.

⁵⁴ HPUC, 2023(a).

⁵⁵ Michigan Public Service Commission Staff, 2020.

Traditional pilot programs remain an important and well-accepted method to promote innovation at utilities. Unlike regulatory sandboxes, pilots typically follow a traditional regulatory review process and do not include derogations as a standard practice. In any case, best practices for pilot design also generally apply to projects conducted through a regulatory sandbox.⁵⁶

Utilities also can create an internal ecosystem of innovation through **organizational changes**. For example, a utility may create a staff team that is focused on R&D and other innovation efforts and may even hire a Chief Innovation Officer. This broader innovation vehicle helps address a potential barrier to innovation associated with lack of focused leadership and resources.

4.1.2 Legislative or regulatory innovation vehicles

State lawmakers and utility regulators can implement innovation vehicles that are targeted or more broadly focused on long-term outcomes, such as:

- Topical explorations and information-gathering processes
- Performance-based regulation (PBR)
- Changes to legislative policies and utility regulations
- Track-then-act approach

State legislatures and utility commissions can undertake a **topical exploration and information-gathering process** related to innovative technologies or new utility business models. At the legislative level, this may include passing bills or resolutions that request studies from state agencies or that require the PUC to open a proceeding to consider specific innovation mechanisms. PUCs may open an exploratory docket or conduct an informal process on their own motion to hear from experts, collect information, and discuss challenges related to specific processes. For example, the Arizona Corporation Commission conducted a docketed exploration on “Innovation and Technological Development.” The Commission hosted six workshops as a part of the docket, posed questions to participants to gather information, and prepared a staff report with summaries and findings.⁵⁷

PBR is an important regulatory tool for promoting innovation.⁵⁸ PBR is a set of alternative mechanisms to align utility behavior and revenues/profit with achievement of state goals and desired outcomes. It can be implemented incrementally (e.g., establishing performance incentives) or holistically (e.g., moving away from the cost-of-service regulatory model). PBR tools that support innovation include:

⁵⁶ See Cappers and Spurlock, 2020.

⁵⁷ ACC Staff, 2014.

⁵⁸ In some cases, PBR is implemented following passage of legislation. For more information on state implementation of PBR, see RMI’s [Performance Incentive Mechanisms Database](#) and NARUC’s [PBR State Tracking Map](#).

- *Multi-year rate plans (MYRPs)*. These plans set a period of time in which the utility's rates will not change (a rate case moratorium for several years). MYRPs promote cost control by allowing utilities to keep a portion of realized savings until rates are reset. Coupling MYRPs with other innovation vehicles like sandboxes is helpful because utilities may either choose to innovate to maintain their services at lower costs, or may cut costs related to innovation.
- *Revenue decoupling*. Decoupling breaks the link between a utility's profits and electricity sales, reconciling the revenue actually collected from customers with the target level of revenues. Revenue decoupling can promote innovation by removing a disincentive for the utility to pursue advanced technologies, including those owned by customers or third parties, that will reduce retail sales.
- *Capex/Opex equalization*. Regulators can establish a rate of a return for operational and other non-capital expenditures to reduce bias toward traditional capital investments and promote investment in new technologies and services, regardless of ownership (e.g., Software as a Service).
- *Performance incentive mechanisms (PIMs)*. PIMs provide financial rewards or penalties for utility achievement of predetermined metrics. PIMs can focus on areas that promote innovation, such as new T&D technologies, system efficiency, and flexibility. Well-designed PIMs allow the utility to determine the best methods to reach desired outcomes, which can incentivize cost control and creative thinking to maximize utility rewards (or minimize penalties).
- *Performance tracking*. Regulators require utilities to track and publicly report on certain metrics, such as duration and frequency of power outages, either in comparison to a target or benchmark or as standalone data, without tying it to a specific financial reward or penalty. This is a relatively simple tool that drives utility focus on certain outcomes. For example, a Commission could require utilities to report annual R&D outcomes.⁵⁹

Changing legislative policies and regulations can be a highly effective tool to remove barriers hindering utilities' ability to innovate, mindful of the potential impacts and risks. Regulators also may reinterpret regulations under the appropriate conditions. Some states prefer a **track-then-act approach** to reduce risk by allowing others be first-movers and benefit from the information they gather before implementation in their jurisdiction.⁶⁰ This approach still allows jurisdictions to be early adopters of innovations with the benefit of an initial evidence bank.

4.1.3 Economy-wide or broader vehicles

Innovation vehicles can create a conducive atmosphere to attract and support innovators. A variety of tools can be implemented broadly (e.g., on a statewide level through a Governor's initiative) or more narrowly (e.g., utility-specific innovation webpages):

- Policy directives and vision statements
- Information sharing platforms and communication tools

⁵⁹ Rebane and Goldenberg, 2024.

⁶⁰ Ivo and Duff, 2020.

- Innovation hubs
- Incubators
- Forums to bring together innovators and investors (“pitch fests”)
- Technical assistance
- Innovative financing programs

Policy directives and vision statements promote an ecosystem of innovation by identifying a desired end state that stakeholders can rally around and drive towards. Examples include the following:

- New Jersey’s [Energy Master Plan](#) that identifies energy innovation as a desired outcome
- [2024 Inclinations on the Future of Energy in Hawaii](#) that identifies a roadmap for achieving ambitious goals in the utility sector
- [PowerPath DC](#) that identifies pilot projects as an important part of modernizing the District of Columbia’s energy grid and advancing the city’s ambitious energy objectives

Diverse stakeholders driving towards common and ambitious outcomes brings into sharp focus the need for innovative technologies and services to achieve those outcomes and helps to ensure that there will be demand for them.

A suite of tools (**information sharing platforms and communication tools, innovation hubs, incubators, pitch fests, and technical assistance programs**) help connect innovators with the resources they need to be successful. Information sharing platforms and communication tools can include webpages, newsletters, webinars, and other outreach efforts that aim to promote awareness of innovation programs and share outcomes and findings to advance the field of research. Innovation hubs, incubators, and technical assistance programs can connect innovators with other entrepreneurs, venture capital, and technical experts that provide support and help identify solutions when innovators face barriers.

Finally, **innovative financing programs**, such as through green banks and other loan programs, and grants for specific innovations or entrepreneurs, can provide financial support for risky, early stage, and capital-intensive projects.

4.2 How Innovation Vehicles Address Barriers to Innovation

Identifying barriers faced by a jurisdiction helps identify the appropriate tools to deploy. Regulatory sandboxes carry some risk and don’t address every barrier to innovation. Some types of sandbox mechanisms and innovation vehicles are more appropriate for addressing certain barriers than others. In the FinTech sector, researchers created a three-step flow chart for assessing whether to deploy a regulatory sandbox or a different innovation vehicle (Figure 8).

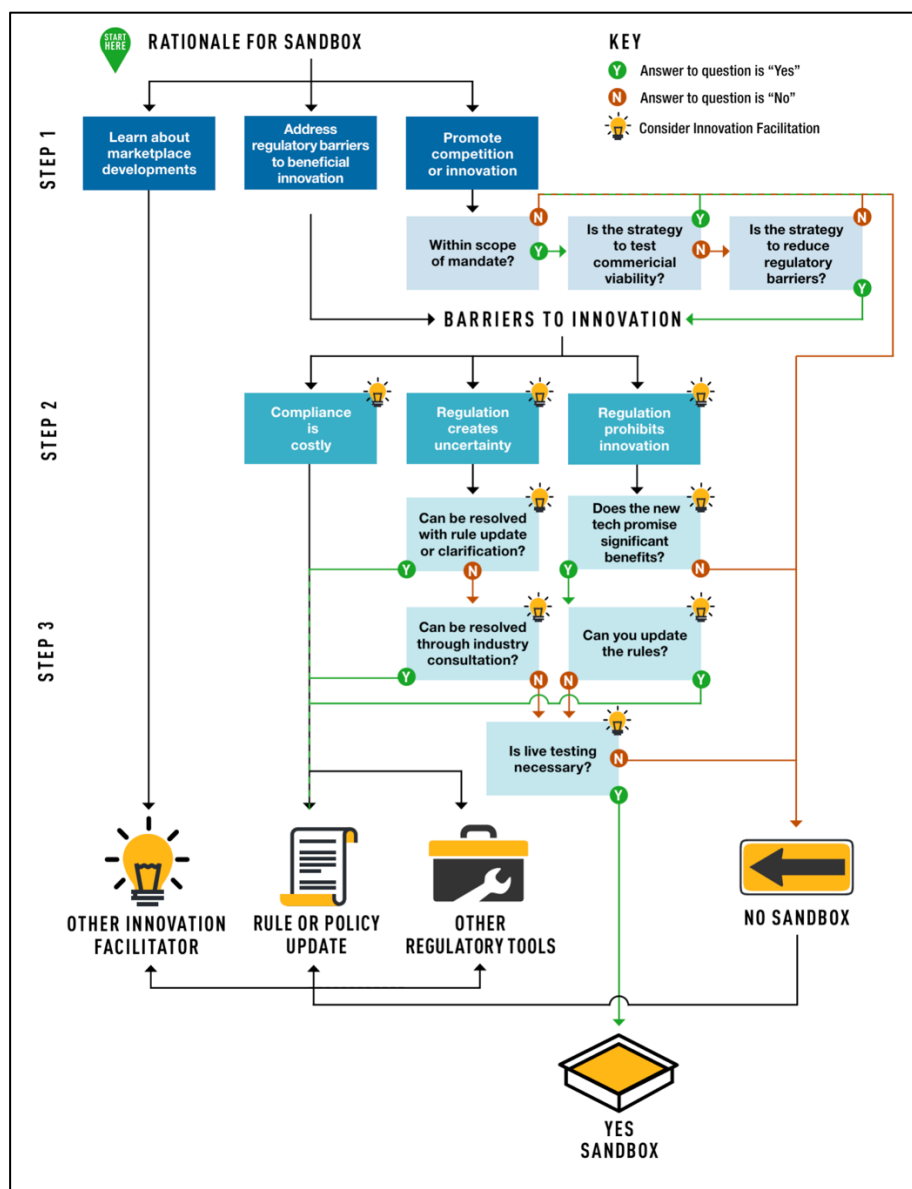


Figure 8. A Flowchart for Determining Whether to Use a Regulatory Sandbox in the FinTech Sector (Ivo and Duff, 2020)

This flowchart can be applied in the utility sector by asking similar questions and following a similar process:

- Why is a sandbox necessary?
- What are the barriers to innovation?
- Which innovation vehicle is most appropriate?

Table 8 revisits the barriers to innovation and technological change discussed in Chapter 2 and identifies how different innovation vehicles can help navigate them.

Table 8. Innovation Vehicles as Solutions to Regulatory Barriers to Innovation

Type of Barrier to Innovation	Disincentive to Innovation	Regulatory Sandbox Solutions	Other Innovation Vehicles
Cost of Service Regulation and Cost Recovery	Cost-of-service regulation incentivizes capital-intensive investments.	Sandboxes can place an explicit focus on certain non-capital investments and on innovation.	PBR can reduce capex bias and steer utility focus toward outcomes that may require innovation.
	Cost recovery practices disincentivize innovation.	- Sandboxes can create upfront assurances that cost recovery will be allowed for projects that conform to identified expectations. - Dedicated funding amounts (including for funding opportunity type mechanisms) create more certainty of funding availability. - Sandboxes may exempt utilities from traditional “used and useful” cost recovery practices.	Innovative financing programs can help to support riskier and costly upfront investments.
	Monopoly power reduces the incentive to control costs and creates an incumbent effect.	Sandboxes can invite third party applications, reducing the effect of utilities as gate-keepers to innovation.	- MYRPs incentivize cost control. - Policy directives and vision statements can encourage a focus on third-party solutions.
	The regulatory process is rife with barriers to innovation.	- Sandboxes can be designed with time-limited review periods for projects or may not require Commission approval for projects. - Upfront stakeholder engagement on sandbox objectives can reduce disagreement on specific programs or approaches. - Advisory councils and clear scoring criteria or go/no-go criteria can reduce process uncertainties.	- Policy directives and vision statements can reduce friction amongst stakeholders. - The track-then-act approach can lead to better understanding and consensus across parties.
	Traditional utility approaches to innovation have not resulted in transformative change.	Clear exit strategies from Sandboxes help to ensure that successes are carried through to full deployment.	Well-designed demonstrations and pilots lead to useful and actionable information.
Technological Risk	Utilities are first and foremost concerned about safety and reliability rather than innovation.	Sandboxes deploy technologies on a limited basis and aim to assess how more proven technologies will function in a specific jurisdiction.	- R&D includes early stage assessment of the capabilities of new technologies. - Demonstrations and pilots test the technical and commercial feasibility of new ideas.

			• The track-then-act approach leads to better information for decision-making.
	There are barriers to early replacement of existing technologies.	• Sandboxes collect data on new technologies to compare with status quo.	• Direct regulatory changes may include unique ratemaking treatment for stranded assets, such as securitization.
Education and Leadership	An organizational champion is often necessary to promote a culture of innovation and drive sandbox development.	• Not directly addressed.	• Utility organizational changes can create internal champions and allocate resources towards innovation • Policy directives and vision statements focus activities toward ambitious outcomes
	Lack of information sharing creates uncertainty and reduces the ability of other jurisdictions to capitalize on previous demonstrations and pilot findings.	• Regulatory sandboxes create an evidence bank for new technologies and services that can be cited in future innovation applications in the state as well as other jurisdictions.	• Innovation hubs, incubators, technical assistance, pitch fests, and information sharing tools are designed to support information sharing and relationship-building.

4.3 Elements of Ecosystems of Innovation in States with Sandbox-Type Mechanisms

Table 9 presents innovation vehicles we identified in our case studies that contribute to an ecosystem of innovation in the states that have explored or implemented sandbox-type mechanisms.⁶¹

Table 9. Innovation Vehicles in States with Sandbox-Type Mechanisms

State	Elements of an Ecosystem of Innovation	Type of Innovation Vehicle
American Public Power Association Program (National)	• DEED Project Library – an information-sharing system between projects that have received DEED grants. • DEED also hosts webinars and conferences to facilitate knowledge sharing.	• Information sharing platforms
Arizona	• 2013 and 2018 exploratory and rulemaking dockets were wide explorations of topics related to innovation, new technologies, resource planning, and energy policy for the state (such as retail electric competition and renewable energy standards). The rulemaking resulted in Commission policy statements on issues such as biomass, EVs, and alternative generation buy-through programs, but the Commission did not adopt new rules. • Arizona is exploring PBR and has performance mechanisms for demand-side management.	• Topical exploration • PBR
California	• California Energy Innovation Ecosystem: Launched by the CEC in 2016, this program supports emerging clean energy technology ventures aimed at meeting private sector demands.	• Information sharing platform

⁶¹ The table is not intended to provide an exhaustive list, but rather identifies innovation vehicles that are particularly relevant to the sandbox-type mechanism in that state. The online toolkit provides more detail.

	It connects entrepreneurs with essential resources, including networks, funding opportunities, mentorship, facilities, and expertise, to help transform their ideas into impactful solutions. • CalSEED: Founded in 2016, the program grew out of a partnership between the CEC and EPIC. Using EPIC funds, the CEC developed a pipeline of innovation clusters and funding to bring breakthrough technologies from lab to the market. CalSEED provides small grant funds to early-stage entrepreneurs and researchers to advance their concept or prototype. • CalTestBed: Created in 2019, this program assists innovators and entrepreneurs through vouchers and access to testing facilities that can accelerate the commercialization of clean energy technologies. The program also is funded by EPIC and supports projects aligned with EPIC ideas. • Climate Innovation Program: Established by Assembly Bill (AB) 209 in 2022, the program offers financial incentives to California-based companies to develop and commercialize technologies that support the state's climate goals. • The California PUC implements certain PBR elements, including multi-year rate plans, decoupling, and performance incentives.	• Innovative financing programs and grants • Technical assistance • PBR
Connecticut	• Connecticut's sandbox mechanism (Innovative Energy Solutions, or IES) has built-in Innovation Support Services that allow innovators to efficiently share information and feedback, ultimately striving to increase program accessibility. Services include information (provides a platform for open discussions between Authority staff, the Program Administrator, and the third-party innovator), pilot project regulatory support (enables innovators to request tailored support from Authority staff and the Program Administrator), the IES online portal (serves as the program's main public interface, improving accessibility for customers and facilitating participation for third-party developers unfamiliar with regulatory processes), and workshops (highlight program objectives and goals and emphasize specific areas of focus for innovators). The IES program also offers a pitch event to connect innovators with EDCs. • The Connecticut Public Utilities Regulatory Authority has an open exploration into PBR.	• Technical assistance (specifically, regulatory technical assistance) • Information sharing platforms • Pitch fest • PBR
Hawaii	• Hawaiian Electric has an Innovation Webpage, including a portal for outside parties to submit project ideas. • The Hawaii Innovative Pilot Framework was approved as part of the PBR Framework, which aims to holistically align the utility's financial incentives with performance towards desired outcomes and policy objectives.	• Information sharing platforms • PBR
Michigan	• The PSC has an online repository of data for all utility pilots. • Michigan has working groups to explore PBR mechanisms and is implementing performance incentives for demand-side management and reliability.	• Information sharing platforms • PBR
Minnesota	• Minnesota Energy Alley is a public-private partnership designed to support energy innovation and contribute to the transition to a clean energy economy. Minnesota Energy Alley involves multiple programs and services to support the growth of energy entrepreneurs and startups, to ultimately increase the state's market competitiveness.	• Innovation hubs • Innovative financing programs and grants • PBR

	• The Minnesota Climate Innovation Finance Authority is a green bank established to support the adoption of clean energy technologies, creation of more local clean energy jobs, and development of greenhouse gas reduction projects. • The Minnesota PUC suspended its exploration of PBR, but has performance incentive mechanisms in place for demand-side management.	
New Hampshire	• New Hampshire has performance incentives in place for demand-side management.	• PBR
North Carolina	• The state's sandbox-type mechanism grew out of a requirement for utilities to propose climate plans. • Following the enactment of HB 951, the NCUC adopted PBR mechanisms for both Duke companies, including multi-year rate plans, revenue decoupling, and performance incentive mechanisms.	• Policy directives and vision statements • PBR
New Jersey	• The 2019 Energy Master Plan identified expansion of the state's clean energy innovation economy as a primary objective. It included six sub-goals focused on growing R&D, workforce training, innovative financing, offshore wind opportunities, establishing an innovation center, and establishing a clean buildings hub. • New Jersey has performance incentives in place for demand-side management.	• Policy directives and vision statements • PBR
New York	• Demonstrations exist within the broader Reforming the Energy Vision (REV) initiative, which is composed of the following seven categories: Renewable Energy, Buildings and Energy Efficiency, Clean Energy Financing, Sustainable and Resilient Communities, Energy Infrastructure Modernization, Innovation and R&D, and Transportation. A number of related regulatory changes and initiatives support utility innovation and a broader ecosystem of innovation, including: ○ New York REV Connect (now New York Grid Connect): A platform that connects utilities with innovators on specific themes and issues, such as "Innovation Sprints," which included a time-limited series of activities where innovators and utilities could collaborate on ideas and partnership development to be developed into demonstrations, programs, and other activities. ○ Clean Energy Fund (CEF): A \$5 billion fund administered by the New York State Energy Research and Development Authority. The CEF supports four areas: a Green Bank (the nation's largest), NY-Sun (solar expansion), Market Development, and Innovation and Research. These initiatives reduce adoption barriers, stimulate private investment, and help shape policies and regulations. ○ PBR reforms: In 2016, the PSC issued an order stating that traditional cost-of-service ratemaking hinders overall innovation and discourages essential activities that utilities must pursue to implement REV. REV considered business model reforms such as new earning opportunities for utilities, reforms to markets and resource compensation, and metric tracking and reporting. ○ Advanced, coordinated grid planning efforts: REV included efforts to modernize and coordinate distribution system	• Information sharing platforms • Policy directives and vision statements • PBR • Innovative funding

	planning. These efforts are ongoing. The Grid of the Future proceeding is exploring a Proactive Planning Initiative to address inefficiencies in current grid expansion processes by standardizing planning assumptions, integrating electrification forecasts with grid planning cycles, and ensuring investments align with the state's climate goals. This will include a process to identify urgent grid upgrade needs before the framework is fully implemented.	
Oregon	• The Oregon Legislature directed the PUC to develop a framework for utilities to implement performance-based regulation before 2027. • Oregon has performance incentives in place for sharing variances in power costs.	• Policy directives and vision statements • PBR
Vermont	• Green Mountain Power has a Chief Innovation Officer, who may serve as an internal champion for innovation processes, including the Pilot Program. • The pilot process was adopted as part of a MYRP for Green Mountain Power.	• Organizational changes that focus on innovation • PBR
Washington, DC	• PowerPath DC was an innovation initiative spearheaded by the PSC, aimed at modernizing the city's energy grid and advancing the District's ambitious energy and climate objectives. Pilot projects were among the strategic initiatives established as part of this plan. • The District adopted some elements of PBR as part of its regulatory framework, such as revenue decoupling.	• Policy directives and vision statements • PBR
Wisconsin	• Wisconsin's state energy office is housed within the Office of Energy Innovation, which also administers the state's third-party energy efficiency programs. • Wisconsin is exploring PBR mechanisms such as performance metrics.	• Organizational changes that focus on innovation • PBR

Every state with a sandbox-type mechanism is supporting an ecosystem of innovation in some way. While there is significant variation, common innovation vehicles in states with sandbox-type mechanisms include PBR, policy directives and vision statements, and information sharing platforms. Each state has implemented or is exploring PBR in some way, most commonly with performance incentives for demand-side management. In Hawaii and the U.K., regulatory sandboxes complement comprehensive PBR frameworks as a means to ensure that utilities do not cut innovation programs when offered rewards for cutting costs to improve overall affordability, as well as to help meet ambitious goals and changing customer desires.

5. Case Studies: Sandbox Examples from Across the United States

This chapter presents specific examples of regulatory sandboxes and other sandbox-type mechanisms, including funding opportunities, pilot processes, and rate cases or rulemakings. The examples highlight diverse approaches to promoting innovative technologies and services, assessing regulatory structures, and aligning grid infrastructure with evolving energy market mechanisms so we've classified them by adoption mechanism, primary regulatory description, and programmatic outcomes related to the specific technology or service.

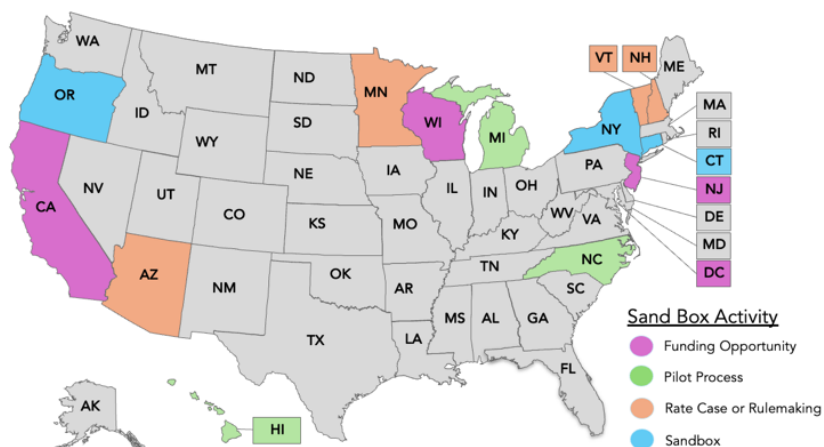


Figure 9. States Exploring and Implementing Sandbox-Type Mechanisms

infrastructure with evolving energy needs (Figure 9). There is often overlap in types of mechanisms so we've classified each state's mechanisms based on an assessment of the adoption mechanism, primary structure, and/or objectives. The chapter provides brief descriptions of each mechanism presented in Table 10, where relevant, examples of programmatic outcomes related to advanced grid technologies.⁶²

Table 10. Sandbox-type Mechanisms by State

State	Program
National	American Public Power Association (APPA) DEED Program
Arizona (not adopted)	Innovations and Technological Developments
California	EPIC Program
Connecticut	Innovative Energy Solutions
Hawaii	Innovative Pilot Framework
Michigan	New Technologies and Business Models
Minnesota (not adopted)	Rate Case Pilot Projects
North Carolina	Innovation Prototyping Process
New Hampshire (not adopted)	Grid Transformation and Enablement Program
New Jersey	Clean Tech Grant Programs and Future Regulatory Sandbox
New York	Reforming the Energy Vision Demonstration Projects
Oregon	Smart Grid Testbed
Vermont	Innovative Pilot Program
Washington, DC	PowerPath DC Pilot Project Fund
Wisconsin	Energy Innovation Grant Program

⁶² The accompanying online toolkit provides more detail for each program on key components, including scope, objectives, derogations, eligibility, application process, funding mechanism, oversight, reporting, timelines, scaling strategies, stakeholder engagement, challenges and modifications, broader innovation context, and programmatic examples.

5.1 Funding Opportunities

American Public Power Association | Demonstration of Energy & Efficiency Development (DEED) Program

The American Public Power Association's (APPA) long-running DEED program provides grants and scholarships to encourage energy innovation among public power utilities. It supports research, development, and demonstration for new technologies and programs to improve utility operations and services. DEED grants have funded projects aiming to improve reliability, deploy technology to improve distribution system management, increase worker and customer safety, heighten security, and reduce emissions impacts.⁶³ The DEED program has robust information sharing practices for funding recipients.

DEED projects focused on advanced grid technologies include:

- Support for municipal utilities in assessing the feasibility of deploying thermal microgrids including system-level optimized thermal services, distributed generation, and electric control and communications technologies
- Deployment of a non-communicating automatic feeder sectionalization and restoration scheme
- Non-wired fault and load transmitters for fault identification
- Advanced analytics to identify strategic locations for energy storage
- Use of drones to survey T&D assets and conduct minor repairs⁶⁴
- Smart Pole Solutions to explore potential for smart poles that can a) improve WiFi signals, b) heighten security (camera monitoring), c) offer level 2 EV charging, and d) display various messaging⁶⁵

California | Electric Program Investment Charge (EPIC) Program

The California Public Utilities Commission (CPUC) established EPIC in 2011 to fund scientific and technological research in support of California's clean energy goals: "EPIC investments advance precommercial clean energy technologies and approaches for the benefit of electricity ratepayers of California's three largest electric investor-owned utilities (IOUs)."⁶⁶

EPIC replaced the System Benefits Charge (also known as the Public Goods Charge) that supported efforts in energy efficiency, renewable energy, and research, development and demonstration. Subsequent volumetric surcharges for retail customers of the three IOUs (Pacific Gas and Electric [PG&E], Southern California Edison [SCE], and San Diego Gas and Electric [SDG&E]), fund EPIC investments that aim to benefit customers by supporting the development of precommercial clean energy technologies and strategies.⁶⁷

EPIC includes three distinct program areas: Applied R&D, Technology Demonstration and

⁶³ APPA, 2025.

⁶⁴ APPA, 2018.

⁶⁵ Delta, 2025.

⁶⁶ California Energy Commission, 2023.

⁶⁷ CPUC, 2011.

Deployment (TD&D), and Market Facilitation. Entities permitted to distribute funds include the California Energy Commission (CEC), PGE, SDG&E, and SCE. The CEC is authorized to make investments in all three program investment areas and receives 80% of the funds. The IOUs may only administer TD&D investments and split 20% of the funds. Each entity must submit an investment plan which is then approved by the CPUC.⁶⁸

Some exemplary outcomes from EPIC include:

- SCE is investing over \$23 million in the EPIC 4 period on T&D foundational technologies and situational capabilities to improve system flexibility, including adaptive protection schemes, ultra-low latency communication, and ubiquitous situational awareness.⁶⁹ SCE has also invested in next generation distribution automation to support system monitoring, analytics, and reliability, distributed optimized storage, and dynamic line rating projects.⁷⁰
- PG&E's Demonstration of Distributed Energy Storage for Reducing T&D Costs proved that distributed storage can provide autonomous peak shaving capabilities on a substation transformer bank, including during heat waves.⁷¹
- PG&E developed and demonstrated discrete series reactors, a technology used directly on transmission conductors to detect overloads and shift load to parallel equipment. The utility found that the technology can incrementally reduce line flow, learned about installation and engineering considerations, and that although they are not appropriate for every line and in every scenario, they could be less costly than traditional transmission upgrades in most cases.⁷²
- SDG&E ran a demonstration focused on smart distribution circuits, including testing advanced distribution automation control, dynamic feeder optimization, synchrophaser-based solutions, fault location, and modeling circuits to study voltage coordination between DERs and voltage regulators. SDG&E recommended that elements of the program move to commercial adoption.⁷³

New Jersey | Clean Tech Grant Programs and Future Regulatory Sandbox

New Jersey's 2022 Grid Modernization Study recommended development of a sandbox to promote and accelerate the deployment/testing ("fail or scale") of innovative technologies and methods outside of the current regulatory framework. The study recommended use of a regulatory sandbox particularly to help facilitate learnings for DER interconnection reform.⁷⁴ The Board of Public Utilities (BPU) has not yet specifically acted on this long-term recommendation, but has announced the formation of a Grid Modernization Forum that will consider

⁶⁸ CPUC, 2025.

⁶⁹ CPUC, 2023.

⁷⁰ EPIC Database, 2025.

⁷¹ PG&E, 2017.

⁷² PG&E, 2016.

⁷³ SDG&E, 2018.

⁷⁴ Guidehouse, 2022.

interconnection reform, propose pilots and demonstrations, and explore grid-enhancing technologies.⁷⁵

Additionally, the BPU is in the process of updating the state's 2019 Energy Master Plan, which served as a foundation for energy innovation funding programs.⁷⁶ In 2020, the BPU approved a Memorandum of Understanding (MOU) between the New Jersey Economic Development Authority (NJEDA) and the BPU that aims to advance New Jersey's clean energy goals, with a focus on clean tech innovation. To bolster New Jersey's Clean Energy and Clean Tech Ecosystem, and to support innovation within the State's growing green workforce/economy, the BPU provided the NJEDA with \$1.25 million in ratepayer funding. The MOU directs the NJEDA (in conjunction with the New Jersey Commission on Science, Innovation, and Technology) to leverage this funding to support two programs, one of which is the Clean Tech Seed Grant Program. This program supports early-stage clean tech companies for R&D and provides funding for proof of concept and prototyping stages to help attract investors and generate revenue. In 2023, the BPU agreed to provide the NJEDA with \$6 million more in clean energy funding to execute additional rounds of the Clean Tech Seed Grant program.⁷⁷

Grants have gone to a wide variety of recipients for technologies ranging from carbon capture and new battery types to plastic recycling technologies. One recipient, Grid Discovery, received funding to develop a "SaaS platform to automate and standardize the traditionally complex and time-consuming microgrid planning process."⁷⁸

Washington, DC | Pilot Project Fund

The PowerPath DC Pilot Project Fund is an initiative established by the Washington DC Public Service Commission (PSC) to support grid modernization, clean energy adoption, and innovative pilot projects that benefit ratepayers. The fund, created in 2016 as part of the utility merger settlement between Exelon and Pepco Holdings, is designed to advance DC's climate and energy goals by supporting pilot projects that improve energy efficiency, resilience, and affordability for ratepayers. Specifically, it finances projects that test new technologies, business models, and regulatory approaches to move the needle on these goals while ensuring compliance with the Clean Energy DC Act.⁷⁹

Governed by a Pilot Projects Governance Board, the fund follows a structured two-phase selection process: a Call for Papers, where stakeholders submit pilot project concepts, followed by a Request for Proposals (RFPs) for selected initiatives. Projects must demonstrate measurable benefits, including, for example, reductions in carbon emissions, integration of non-wires alternatives (NWA), deployment of advanced energy storage, or facilitation of greater energy data access. Ultimately, the Commission hopes that the Pilot Project Fund will facilitate

⁷⁵ New Jersey Board of Public Utilities (NJ BPU), 2024(a).

⁷⁶ NJ BPU, 2024(b).

⁷⁷ NJ BPU, 2023.

⁷⁸ New Jersey Economic Development Authority, 2024.

⁷⁹ District of Columbia Public Service Commission (DC PSC), 2016.

the deployment of projects that would “advance the District’s energy policies, providing direct and tangible benefits for District ratepayers and the environment.”⁸⁰

Projects underway include community heat pump deployment, use of advanced inverters to support grid stability, and deployment of a community microgrid.⁸¹

Wisconsin | Energy Innovation Grant Program

The Energy Innovation Grant Program (EIGP) is administered by the Public Service Commission of Wisconsin's Office of Energy Innovation (OEI). It is a federally-funded innovation program designed to support projects in energy efficiency, renewable energy, transportation, planning, and resilience, with a primary focus on public and nonprofit organizations.⁸²

One project funded through the EIGP is the Red Cliff Early Childhood Center Solar Energy System and Training Program, which installed a solar and battery microgrid system and integrates solar education into the school curriculum.⁸³

5.2 Pilot Processes

Hawaii | Innovation Pilot Framework

The Hawaii Innovation Pilot Framework, which was approved as part of Hawaii's PBR Framework, aims to promote innovation by creating a streamlined implementation process for pilots that explore new technologies, programs, and business models. The PBR framework's guiding principles are customer centricity, administrative efficiency, and utility financial integrity. The Pilot Framework includes two phases: the Workplan Development phase (project ideation and scoping) and Implementation Phase (proposal submission, review, and implementation). The Commission must act on filed pilot notices within 45 days of submission.⁸⁴

Projects approved through this process must advance decarbonization, customer resources and services, beneficial electrification, data sharing, access, and analytics, technology innovations, improved cybersecurity, heightened resilience and reliability, or increased equity, access, affordability, and sustainability.⁸⁵ Pilots underway through the Framework include multiple electric vehicle-related pilots and a utility data sharing application and have not yet focused on advanced grid technologies.⁸⁶

⁸⁰ Ibid.

⁸¹ DC PSC, 2025.

⁸² Public Service Commission of Wisconsin, 2025.

⁸³ Red Cliff Band of Lake Superior Chippewa Indians, 2023.

⁸⁴ HPUC, 2020.

⁸⁵ HPUC, 2022.

⁸⁶ HPUC, 2025.

Michigan | New Technologies and Business Models

The Michigan Public Service Commission (MPSC) approved an expedited pilot approval process (with a 90-day turnaround) under the MI Power Grid initiative. This framework is designed to "maximize the benefits of the transition to clean, distributed energy resources (DERs) for Michigan residents and businesses"⁸⁷ and supports rapid learning about energy innovation, emerging technologies, business models, and ownership structures to prepare the state for its energy future.

The process encourages collaboration between utilities, third parties, and stakeholders, ensuring that pilot projects align with Michigan's energy policy objectives while allowing for experimentation and learning. More broadly, the expedited pilot approval process is part of Michigan's Power Grid effort, which aims to modernize the energy system, enhance reliability, and support the state's clean energy and decarbonization goals.⁸⁸

While the vast majority of pilots in Michigan focus on energy efficiency, advanced grid technology-related pilots in Michigan include:

- DTE Energy's static conservation voltage reduction and volt-var optimization study, which ran for one year at two substations. The program cost \$900k and did not evolve into a full program.
- DTE Electric's Unified Plug-in Electric Vehicle to Smart Grid Integration pilot, which collected EV state of charge telemetry data to forecast charging station loading data and charging station constraints.
- Indiana Michigan Power's conservation voltage reduction pilot, and a pilot aiming to test and validate geotargeted energy efficiency (called energy waste reduction in Michigan) efforts for peak demand deferral (U-17353)
- Multiple non-wires alternative pilots by both DTE and Consumers Energy
- Consumer Energy's Undergrounding Low-Voltage Distribution (LVD) Lines pilot that sought to collect data on the actual reliability and cost impacts of undergrounding LVD lines.⁸⁹

According to the Michigan pilot database, these programs have not progressed to full-scale programs to date.

North Carolina | Innovation Prototyping Process

The Innovation Prototyping process aims to accelerate the review and approval process for prototypes that test emerging technologies, rate designs, new products, and innovative services to advance the development of cost-efficient solutions for reducing carbon emissions and to improve overall customer experience. The process is specifically designed to support Duke Energy in both efficiently testing new customer programs and rate designs and in scaling

⁸⁷ MI PSC, 2023.

⁸⁸ Ibid.

⁸⁹ Michigan Public Service Commission Pilot Directory:
<https://www.michigan.gov/mpsc/regulatory/reports/other/michigan-pilot-directory>.

successful projects. Utilities must file a letter of intent and a notice of innovation prototyping which the Commission may approve within 90 days.⁹⁰

No prototypes have gone through the process to date, however, a previous Hot Springs Microgrid project successfully demonstrated how a microgrid can support a full town's load from black start and provide other grid services. The project has spurred some momentum for potential future projects.⁹¹

5.3 Rate Cases or Rulemakings

Arizona | Innovations and Technological Development

In 2013, the Arizona Corporation Commission (ACC) opened its Innovation and Technological Development docket. The docket served as a platform for discussing the impact of emerging technologies on the electric utility industry and helping the commission anticipate regulatory challenges. It focused specifically on technologies that may disrupt traditional utility business models. In docketed correspondence, Commissioners stated they found the discussions and presentations informative. However, the docket did not result in any specific mechanisms for promoting innovation.⁹²

The ACC organized workshops to discuss the following topics: Interconnection, AMI Data, Microgrid, Voltage Optimization, Energy Efficiency, Energy Imbalance Markets, Rate and Integrated Resource Planning. These workshops were attended by a variety of industry experts and professionals. Following the workshops, ACC Staff filed a report recommending that the Commission identify an appropriate venue, specifically the integrated resource planning process, for considering emerging technologies.⁹³ In 2018, the ACC directed Staff to initiate a docket to consider changes to the Commission's energy rules, including those related to resource planning and emerging technologies. The docket would have modified resource planning rules such that resource plans should include development of new technologies, innovations, and pilot programs. However, the changes were not adopted, potentially due to the large number of complex issues considered at once.⁹⁴

Minnesota | Rate Case Pilot Projects

In 2023, as part of its final order in Xcel's 2021 Rate Case, the commission determined that initiating an investigation into the creation of a regulatory sandbox, "would not necessarily be more beneficial than continuing to develop these issues in individual dockets."⁹⁵ The commission cited its approval of numerous pilot programs over the years, recognizing their importance in innovation within the energy sector.

⁹⁰ North Carolina Public Utilities Commission, 2024.

⁹¹ Walton, 2023.

⁹² See, for example, Correspondence from Commissioner Bitter Smith, Docket No. E-00000J-13-0375, filed August 26, 2014, available at: <https://docket.images.azcc.gov/0000155569.pdf?i=1743395000240>.

⁹³ Arizona Corporation Commission (ACC) Staff, 2014.

⁹⁴ ACC, 2022.

⁹⁵ Minnesota Public Utilities Commission, 2023.

The Commission acknowledged the potential benefits of a regulatory sandbox but noted the resource efficiency of addressing these issues within existing dockets. Instead of establishing a sandbox, the Commission directed Xcel to collaborate with stakeholders and other utilities to improve pilot project effectiveness, accelerate successful program scaling, and foster energy sector innovation. The Commission found that this approach would be beneficial to both ratepayers and utilities, and it was supported by Clean Energy Organizations and Xcel.⁹⁶

New Hampshire | Grid Transformation and Enablement Program

Eversource New Hampshire proposed a Grid Transformation and Enablement Program (GTEP) as part of a rate case to promote innovation for Eversource's electric distribution system through: (1) accelerated investments in pole replacements, line reconductoring, and substation replacements, and (2) integration of advanced energy solutions via demonstration projects.

The program was envisioned to address growing customer expectations for fewer service interruptions, improve system resilience to severe weather events, and identify, plan, and test solutions that support operational efficiency and greenhouse gas reductions, including two resilience-focused demonstration projects – a non-wires alternative project and a microgrid project. The GTEP was designed to work in tandem with the company's base capital program to accelerate targeted infrastructure investments, including replacing aging distribution poles, reconstructing overhead lines, and upgrading substations. By modernizing these components of grid infrastructure, the program sought to create a more resilient and technologically adaptable electric grid for New Hampshire.⁹⁷

Through the rate case process, Eversource ultimately decided to propose its two planned demonstration projects in separate dockets. Additionally, due to party concerns over accelerated cost recovery treatment for part 1 of the GTEP, the Commission approved a settlement between Eversource and the parties that required the Company to pay for an engineering assessment of the distribution system's condition and costs and benefits of reliability and resilience investments that would be considered in a future least-cost integrated resource planning proceeding.⁹⁸ In 2020, Eversource withdrew its petition for Preauthorization of Westmoreland Clean Innovation Project, citing discussions with parties and a need to better understand the potential benefits of such a project.⁹⁹

Eversource's proposal faced challenges in that stakeholders were concerned about special ratemaking treatment for an "innovation" program that was not innovative enough (i.e., the program included business as usual distribution system investments). Additionally, parties requested more information on how to prioritize investments based on their costs and value with relation to resilience and reliability.¹⁰⁰

⁹⁶ Ibid.

⁹⁷ Eversource Energy, 2019.

⁹⁸ New Hampshire Public Utilities Commission, 2020.

⁹⁹ Eversource Energy, 2020.

¹⁰⁰ New Hampshire Public Utilities Commission, 2020.

Vermont | Innovative Pilot Program

In 2019, Green Mountain Power's (GMP) Multi-Year Regulation Plan (MYRP) established a framework for the Innovative Pilots Program, which allows GMP (and later expanded to other utilities) to design and run pilots outside of the traditional regulatory framework. The program encourages development of transformative products and services that can increase system reliability, reduce customer costs, and advance statewide clean energy goals. The program is designed to promote exploration of newer technologies that can be developed into mature programs offering lasting value and long-term benefits.

Pilot projects do not require Vermont Public Utility Commission (PUC) approval before being implemented. GMP must provide 15 days notice before beginning a Pilot project. This notice must be given to the Department of Public Service and the Public Utility Commission, with a copy to Efficiency Vermont.¹⁰¹

In 2021, the Innovative Pilot Program expanded to include cooperative and municipal utilities under 30 V.S.A. § 218d(o). Vermont municipal and cooperative electric utilities may "offer innovative rates or services to their customers as pilot programs without obtaining prior approval from the Commission if the rate or service." The objectives of the municipal and cooperative utility Pilot program broadly align with those established for the GMP Pilot program, with some additional stipulations. For example, Pilot projects may not increase company's net assets or overall cost-of-service by more than two percent. Additionally, a company must notify customers, the Department of Public Service, and the Commission (in written format) of an innovative rate or service at least 45 days prior to offering/implementing that innovative rate or service. The municipal or cooperative company then files a new report case with a report type of "Innovative pilot" to the Commission and Department.¹⁰²

Green Mountain Power's pilots have heavily focused on testing the business case for customer-sited resources, including incentives for residential EV chargers with managed charging, development of an all-electric resilience neighborhood, and incentives for efficient heat pump water heaters. One program deployed distributed batteries for frequency regulation services. The utility has scaled up multiple pilots to full-scale programs, including a flexible load management and battery incentive programs.¹⁰³

5.4 Regulatory Sandboxes

Connecticut | Innovative Energy Solutions

In 2022, the Connecticut Public Utilities Regulatory Authority (PURA) launched the Innovative Energy Solutions (IES) Program to act as a platform to foster electric sector innovation, ultimately supporting Connecticut's clean energy, climate, and public policy goals by

¹⁰¹ State of Vermont Public Utility Commission, 2019.

¹⁰² State of Vermont Public Utility Commission, 2022.

¹⁰³ All innovative pilots are available at:

https://epuc.vermont.gov/?q=node/87&_gl=1*19g5yga*_ga*MTMzODG5MzY5Mi4xNzMwODQyMzE4*_ga_V9WQW77KLW*MTc0MzY5MjNjQ3NS4yMjY4LjE3NDM0OTY1NDEuMC4wLiA..

introducing new products and services in a structured framework. The IES program's first cycle launched in 2023 and new cycles start every January. It follows a four-phase process: ideation and screening, prioritization and selection, project deployment, and assessment and scaling.

The IES program is designed to reduce barriers for deploying new technologies and to facilitate collaboration between product innovators and utilities. Projects can proceed via three distinct pathways: developer-led, electric distribution company (EDC)-led, and collaborative projects. This allows a range of stakeholders, from independent innovators to EDCs, to propose solutions. Parties submit proposals that are evaluated by an Innovation Advisory Council made up of stakeholders with diverse expertise and recommended to PURA for approval. To facilitate broader participation, PURA offers outreach, engagement, and educational resources for innovators. This includes an online portal, workshops, and tailored guidance to help applicants navigate regulatory requirements.¹⁰⁴

The first cycle of IES was focused on grid edge solutions. Exemplary programs underway include:

- Noteworthy's Artificial Intelligence (AI) program that mounts cameras to the utility vehicle fleet and uses AI to assess the state of the distribution grid based on data collected passively from the cameras.
- Rhizome's program that builds a digital representation of the distribution grid to assess asset vulnerability to hazards.
- Tantalus program that uses advanced metering infrastructure to collect granular power quality assessments and identify vulnerable distribution system assets.¹⁰⁵

These programs are still underway.

New York | Reforming the Energy Vision (REV) Demonstration Projects

Reforming the Energy Vision (REV) was an initiative aimed at transforming New York's energy system to be cleaner, more resilient, and more affordable through regulatory reform and market activation. REV was an ambitious and broad effort that worked to align utility practices and regulatory frameworks with advancing grid technologies. REV encouraged new utility business models and partnerships with third-party providers to integrate clean and distributed resources onto the electric system. The initiative worked to shape the regulatory system to drive innovation, technological progress, and private investment, ultimately expanding consumer choices and value while supporting a cleaner environmental future. In 2024, the Public Service Commission opened the Grid of the Future proceeding to build on REV to promote investment in flexible resources to support a reliable and more affordable system.¹⁰⁶

As part of REV, PSC staff issued a straw proposal for demonstrations that recognized the need for Demos to develop new business models that would allow utilities to effectively unlock new

¹⁰⁴ Connecticut Public Utilities Regulatory Authority, 2022.

¹⁰⁵ <https://ct-ies.com/>.

¹⁰⁶ State of New York Public Service Commission, 2024.

revenue streams and private investment in energy products and services. The memo set forward principles for Demos, including: flexibility, demonstrating innovation, value distribution, advancing partnerships, customer engagement, market creation, scalability and cost recovery. In demonstrating innovation, consideration was given to the diversity of projects and the relevant information they will provide to the overall REV initiative. In 2014, the Commission issued a memorandum and resolution, encouraging the utilities and third parties that had not already done so to begin working together at this time to develop potential demonstration projects (Demos).¹⁰⁷

Demos have included efforts to improve access to DERs, use storage as a virtual power plant, smart inverter functions, and curbside EV charging. A Demo related to advanced grid technologies is the New York State Electric & Gas (NYSEG) flexible interconnection demonstration to expedite interconnection of DERs and reduce costs through active network management to allow DERs to operate within distribution system constraints.¹⁰⁸

Oregon | Smart Grid Testbed

In 2017, the Oregon PUC issued an order on Portland General Electric's (PGE's) 2016 IRP. The order directed PGE to establish a Testbed to "explore ways to accelerate the development of cost-effective demand response to meet PGE's capacity need."¹⁰⁹ The commission also directed the utility to convene a Demand Response Review Committee to provide guidance in developing the Testbed.

Phase I of the testbed involved default (opt-out) enrollment of customers serviced by three distribution substations in a Peak Time Rebates pilot. These customers received a pay-for-performance incentive to reduce load on a voluntary basis, with 24-hour advance notice. Phase I allowed PGE to study the opt-out model and explore customer engagement with and attitudes about the program, recognizing that ongoing customer engagement and motivation are required for effectively acquiring demand response resources.¹¹⁰

In 2021, the PUC approved PGE's proposal for Phase II of the testbed. It includes six new demand response/flexible load demonstration projects over five years: (1) Flexible Feeder; (2) Managed EV Charging/Vehicle-to-Grid (V2G); (3) Solar Smart Inverter; (4) C&I and municipal Flexible Load and Resiliency; (5) Multifamily Bundle; and (6) Single Family New Construction Bundle.¹¹¹

¹⁰⁷ State of New York Public Service Commission, 2014.

¹⁰⁸ See Case No. 14-M-0101, at: <https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=14-M-0101&CaseSearch=Search>.

¹⁰⁹ Oregon Public Utility Commission, 2017.

¹¹⁰ Ibid.

¹¹¹ Oregon Public Utility Commission, 2021.

5.5 Notable Examples Abroad

Sandboxes in other countries have served as foundational examples for mechanisms developed in the U.S. and are the source of many of the design elements and best practices identified in this report. Compared to the U.S., mechanisms in other countries are more focused on third-party innovators and modifying or relaxing regulatory requirements identified as hindering innovation. Each of these mechanisms has adjusted over time to improve their effectiveness, included thematic calls, and is part of a larger ecosystem of innovation as part of a PBR framework or in partnership with separate innovation funding.

Ontario | Innovation Sandbox

The Ontario Energy Board (OEB) established an Innovation Sandbox in 2019 to support achievement of goals identified in its Strategic Blueprint and to better support innovation by introducing a simpler, less adversarial, and quicker way to trial new technologies and services in the electric and natural gas sectors. The sandbox offers two services – informational only and project-specific support.

The informational service allows innovators to meet with OEB staff on a confidential basis to better understand how regulations may affect an innovative product, business model, or service. Project-specific support begins with a meeting with OEB staff, followed by a formal application and determination of a path forward. To be eligible, projects should support consumer value and protection, maintain or enhance system reliability and resilience, facilitate reduced emissions, have the potential to economically scale, and identify a regulatory barrier that is hindering its viability.

The sandbox is focused on granting temporary exemptions from regulations, such as OEB codes, rules, and licenses.¹¹² In 2023, the *Ontario Energy Board Act, 1998* was amended to grant OEB specific authority to eliminate licensing requirements for pilot projects.¹¹³

In 2022, OEB reviewed the sandbox framework in consultation with stakeholders. In response, it found ways to more holistically support innovators and provided new dedicated funding for innovation through an [Innovation Sandbox Challenge](#). The challenge focused on two themes: (1) how to move pilots to broader implementation and (2) enhancing consumer awareness of their role in the energy transition.¹¹⁴ OEB also developed an [Innovation Handbook](#) to provide information to the market and partnered with the Independent Electricity System Operator (IESO) to administer a call for proposals to demonstrate how distributed resources could provide local and provincial grid services. Seven projects were selected by the IESO, five of which received additional regulatory specific support from the sandbox.

OEB does not report comprehensively on each pilot in its annual reports, but includes project examples and thematic information. Sandbox projects in Ontario have commonly focused on

¹¹² OEB, ND.

¹¹³ OEB, 2024.

¹¹⁴ OEB, 2023.

distributed resource aggregation and grid integration, community net metering, energy storage for resilience, and grid modernization. Many innovators relied only on the informational sandbox service than on project-specific support.¹¹⁵

Singapore | Regulatory Sandbox

The Singapore Energy Market Authority (EMA) created a regulatory sandbox in 2017 as a means of formalizing a previous effort to identify regulatory barriers to innovation on an ad hoc basis. The sandbox is a complement to basic R&D, allowing innovators in the electricity and gas industries to test projects on a broader scale with consumer safeguards. The sandbox also assesses how regulatory frameworks and rules may affect innovation. Key features of the sandbox include the following:

- Companies can seek temporary regulatory waivers for EMA to relax specific legal and regulatory requirements that would otherwise apply, including codes of practices (metering codes and codes of conduct), electricity market rules, and licensing conditions.
- Evaluation criteria are clearly defined (Figure 10), but in recognition of the experimental nature of the process, applicants are notified if they are not selected and may adjust and resubmit proposals.
- EMA may support concurrent sandbox treatment for similar technologies or services.
- The sandbox does not typically charge for participation, although EMA may seek to recover its costs from innovators.
- The sandbox does not provide funding support for proposals, though projects may receive separate R&D funding from EMA.
- Applicants must clearly define exit/transition criteria. Following the sandbox period and in consultation with the industry, EMA determines whether to permanently amend or relax regulations, extend the sandbox, or discontinue the sandbox (Figure 10.)¹¹⁶

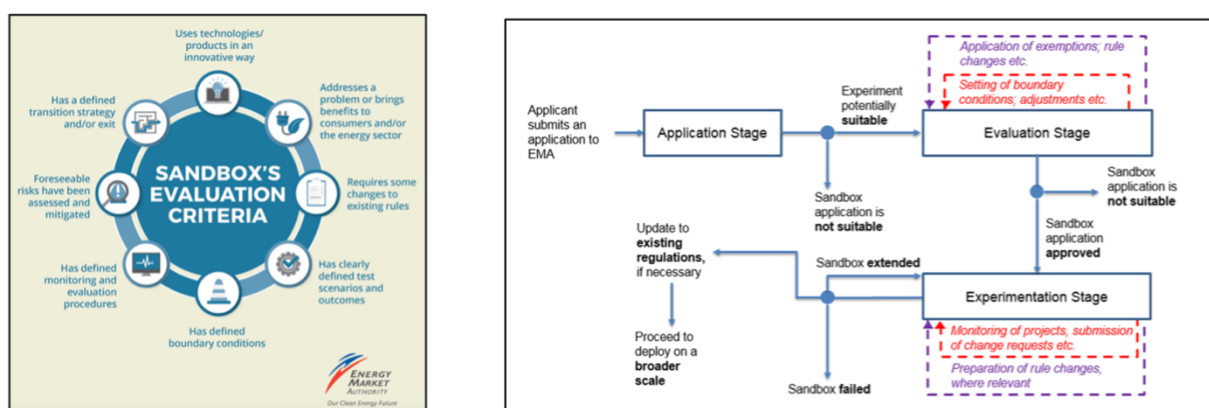


Figure 10. Singapore EMA's Sandbox Evaluation Criteria and Process Flow (EMA, 2019 and 2023)

¹¹⁵ OEB, 2024.

¹¹⁶ EMA, 2019.

After one year, EMA conducted a review of the sandbox framework and found that it could be improved by more holistically supporting companies throughout the innovation chain and better signaling EMA's priorities. In response, EMA created thematic calls for proposals, expanded the availability of R&D funding, and streamlined the application process for innovators.¹¹⁷

Complementary R&D funding calls have covered a wide range of themes such as cybersecurity, energy efficiency, and smart grid innovations.

United Kingdom | Energy Regulation Sandbox

The U.K. Office of Gas and Electricity Markets (Ofgem) developed an Energy Regulation Sandbox in 2017 as part of its PBR framework. The sandbox enables demonstrations and trials for regulated electric and gas companies that may require modified or reduced regulations in order to move forward, as well as activities that have already been through trials and are positioned for broader market entry, but may be limited by existing regulations. Ofgem offers guidance to help innovators navigate energy sector regulations and derogations to Ofgem codes. For trials, derogations are time-limited and may also include risk sharing with customers.

Innovators must report on results of their innovation, including customer responses, market insights, and experiences with the sandbox mechanism. Ofgem may explore parallel trials where appropriate and may use thematic calls for sandbox projects.

Sandbox projects have focused on energy-sector business model trials, including an innovative bilateral energy trading program, a price discovery program to encourage investment in EV charging equipment, and programs to improve the economics of microgrids and use of flexibility services from customer resources.¹¹⁸

¹¹⁷ Ibid.

¹¹⁸ Ofgem, ND.

6. Conclusion

Researchers identified 15 jurisdictions that have explored sandbox-type mechanisms for electric utilities. Twelve of these mechanisms were implemented and are still supporting deployment of innovative technologies and services today.

The majority of projects that participated in regulatory sandbox mechanisms focused on energy efficiency, demand-side management, and other customer-sited resources like energy storage and microgrids. Sandbox-type mechanisms commonly focus on integration of distributed generation—for example, through improved planning processes, DER management systems, rate design, non-wires alternatives, and electric vehicle initiatives. Customer resource pilots facilitate utilities learning how to manage and operate the distribution system more efficiently and cost-effectively. Interviewees for this report viewed customer-sited resources as low-hanging fruit because they often can be deployed at low cost.

With regards to advanced grid technologies, utilities and third-party sandbox participants have run sandbox-type mechanisms focused on T&D technologies and programs that increase reliability, such as testing equipment to provide grid support functions (such as through power quality monitoring, automated distribution system functionality, protection schemes, and situational awareness), undergrounding lines, and microgrid deployment. A few utilities are using sandboxes to test grid-enhancing technologies to increase T&D capacity. Future cycles of sandbox mechanisms could focus explicitly on advanced grid technologies to prove out their capabilities and value.

While sandbox-type mechanisms may include some scaling strategies by design, reporting is limited on whether and how projects scale following the trial phase. Utilities are commonly required to report on whether they recommend progressing to scale. Scaling decisions, however, are typically made outside of the sandbox mechanism, such as in rate cases or individual dockets, which can require a return to more traditional regulatory processes.

The Michigan pilot database indicates whether a project has scaled, and the California EPIC project database documents lessons on scaling. Connecticut is entering the assessment scaling phase for the first round of IES projects and is developing strategies to effectively move successful projects to scale. Challenges to scaling include:

- How to assess what individual projects will look like at scale
- Whether data collected as part of the trial is viable to assess a program at scale
- Whether to conduct a request for proposals for the project at scale or continue with the trial-phase vendor
- How to determine ratemaking treatment

In locales with sufficient experience, almost all interviewees indicated that they felt sandbox-type mechanisms in their state have been successful. While there are important learnings for individual projects and technologies, the benefits of sandboxes go beyond technological or service changes. Stakeholders expressed that sandboxes provide significant value through

relationship-building, dialogue, and increased openness to experimentation at utilities and regulatory bodies. Some sandbox-type mechanisms are in the early stages. More results will be available to draw from in the coming years for additional insights into their efficacy to speed adoption of advanced grid technologies to improve reliability, resilience, and affordability for the nation's electricity systems.

7. References

- American Public Power Association (APPA), 2018, *New Strides in Energy Innovation Through Public Power's Only Research and Development Program*.
<https://www.publicpower.org/system/files/documents/63%202018%20DEED%20Summer%20Completed%20Projects%20Flyer%20rev1.pdf>.
- APPA, 2025, *DEED R&D Funding*, Accessed March 30, 2025.
<https://www.publicpower.org/deed-rd-funding>.
- Appaya, S., H. Luskin Gradstein, and M. N. Haji, 2020, "Global Experiences from Regulatory Sandboxes", World Bank Group,
<https://documents1.worldbank.org/curated/en/912001605241080935/pdf/Global-Experiences-from-Regulatory-Sandboxes.pdf>.
- Arizona Corporation Commission Staff (ACC) Staff, 2014, Staff Report for the Innovation and Technological Development Docket, Docket NO. E-00000J-13-0375.
<https://docket.images.azcc.gov/0000158970.pdf?i=1730407354216>.
- ACC, 2022, *Decisions and Votes RU-00000A-18-0284*, <https://edocket.azcc.gov/search/docket-search/item-detail/21658>.
- Ayala, R., and A. Dewey, 2024, *Data Update: City Energy Burdens*, the American Council for an Energy Efficiency Economy, September, 11. <https://www.aceee.org/policy-brief/2024/09/data-update-city-energy-burdens>.
- California Energy Commission, 2023, *The Electric Program Investment Charge 2021 – 2025 Investment Plan – EPIC 4 Investment Plan*, July 25.
<https://www.energy.ca.gov/publications/2021/electric-program-investment-charge-2021-2025-investment-plan-epic-4-investment>.
- California Public Utilities Commission (CPUC), 2025, *Energy Research Development and Deployment*, Accessed March 30, 2025. <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/energy-research-development-and-deployment>.
- CPUC, 2011, *Decision 11-12-035 Phase 1 Decision Establishing Interim Research, Development, and Demonstration and Renewables Programs Funding Levels*, Rulemaking 11-10-003, filed October 6.
https://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/156050.PDF.
- CPUC, 2023, *Decision 23-11-086 Approving the Applications of Southern California Edison Company, San Diego Gas & Electric Company, and Pacific Gas & Electric Company for the 2021 – 2025 Electric Program Investment Charge Program Investment Plans*, filed November 30.
<https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M521/K242/521242549.PDF>.
- Cappers, P., and C. A. Spurlock, 2020, *A Handbook for Designing, Implementing, and Evaluating Successful Electric Utility Pilots*, Lawrence Berkeley National Laboratory,
https://eta-publications.lbl.gov/sites/default/files/pilot_best_practices_webinar_final_20200918.pdf.
- Ciulla, J. and C. Felder, 2021, *The Untapped Potential of Public Utility Commissions*, RMI, July 12. <https://rmi.org/the-untapped-potential-of-public-utility-commissions/>.
- Collins, M., M. Whiting, J. Schellenberg, and L. Schwartz, 2025, *Bridging the Gap on Data, Metrics, and Analyses for Grid Resilience to Weather Events: Information that utilities*

can provide regulators, state energy offices, and other stakeholders, Lawrence Berkeley National Laboratory. <https://emp.lbl.gov/publications/bridging-gap-data-metrics-and>.

Connecticut Public Utilities Regulatory Authority, 2022, *Innovative Energy Solutions Program Design Document*, Docket No. 17-12-03RE05, filed March 30. [https://www.dpuc.state.ct.us/2nddockcurr.nsf/8e6fc37a54110e3e852576190052b64d/da52e606ad2c1efe85258815005aa04f/\\$FILE/171203RE05-Attachment%20B-033022.pdf](https://www.dpuc.state.ct.us/2nddockcurr.nsf/8e6fc37a54110e3e852576190052b64d/da52e606ad2c1efe85258815005aa04f/$FILE/171203RE05-Attachment%20B-033022.pdf).

Consumer Financial Protection Bureau (CFPB), 2016, *Project Catalyst report: Promoting consumer-friendly innovation*, October. https://files.consumerfinance.gov/f/documents/102016_cfpb_Project_Catalyst_Report.pdf.

Costello, K., 2015, *Research and Development by Public Utilities: Should More be Done?*, National Regulatory Research Institute. <https://pubs.naruc.org/pub.cfm?id=4AA29DB3-2354-D714-51DB-4CFE5EFE50A7>.

Costello, K., 2016, *A Primer on R&D in the Energy Utility Sector*, National Regulatory Research Institute, May. <https://pubs.naruc.org/pub/FA85BA08-D94D-E40F-B7E1-98F834372877>.

District of Columbia Public Service Commission (DC PSC), 2025, *PowerPath DC Pilot Projects Governance Board*, accessed March 30. <https://dcpsc.org/Clean-Energy/Innovations/PowerPath-DC/Pilot-Projects-Governance-Board.aspx>.

DC PSC, 2016, *Order No. 18184*, FC 1119, filed March 23. https://dcpsc.org/PSCDC/media/PDFFiles/HotTopics/orderno_18148_FC1119.pdf.

Delta, 2025, *Smart Pole Solution*, Accessed March 30, 2025. <https://www.deltaww.com/en-us/solutions/Smart-Community/Smart-Pole-Solution>.

Electric Program Investment Charge (EPIC), 2025, *EPIC Database*, Accessed March 30, 2025. <https://database.epicpartnership.org/projects>.

Energy Information Administration (EIA), 2023, *Annual Energy Outlook*. <https://www.eia.gov/outlooks/aeo/narrative/>.

EIA, 2025(a), *Today in Energy: EIA extends five key energy forecasts through December 2026*, January 15. <https://www.eia.gov/todayinenergy/detail.php?id=64264>.

EIA, 2025(b), *Today in Energy: Solar, battery storage to lead new U.S. generating capacity additions in 2025*, February 24. <https://www.eia.gov/todayinenergy/detail.php?id=64586#>.

Energy Market Authority (EMA) of Singapore, 2019, *Framework for a Regulatory Sandbox for the Energy Sector in Singapore*, Version 2.0. <https://www.ema.gov.sg/content/dam/corporate/regulations/policy-papers/pdf-files/EMA-Regulations-Framework-for-Regulatory-Sandbox.pdf>.

EMA, 2023, "Regulatory Sandbox," Accessed April 22, 2025. <https://www.ema.gov.sg/regulations-licences/regulations/policies-frameworks/regulatory-sandbox>.

Energy Systems Integration Group (ESIG), 2024(a), *Charging Ahead: Grid Planning for Vehicle Electrification*, January. <https://www.esig.energy/grid-planning-for-vehicle-electrification/>.

ESIG, 2024(b), *Grid Planning for Building Electrification*, October. <https://www.esig.energy/grid-planning-for-building-electrification/>.

Eversource Energy, 2019, *Petition for Permanent Rates*, Docket No. DE 19-057, filed May 28. <https://www.puc.nh.gov/regulatory/Docketbk/2019/19-057.html>.

- Eversource Energy, 2020, *Petition for Preauthorization of Westmoreland Clean Innovation Project Withdrawal of Petition without Prejudice*, Docket No. DE 19-133, filed February, 28. https://www.puc.nh.gov/Regulatory/Docketbk/2019/19-133/LETTERS-MEMOS-TARIFFS/19-133_2020-02-28_EVERSOURCE_REQ_WITHDRAWAL_PETITION_WITHOUT_PREJUDICE.PDF.
- Fairbrother, C., L. Guccione, M. Henchen, and A. Teixeira, 2017, *Pathways for Innovation: The Role of Pilots and Demonstrations in Reinventing the Utility Business Model*, Rocky Mountain Institute. www.rmi.org/insights/reports/pathwaysforinnovation/.
- Forrester, S., A. Satchwell, G. Barbose, E. Cappers, C. Miller, and A. Alberg, 2024, *Retail Electricity Price and Cost Trends: 2024 Update*, Lawrence Berkeley National Laboratory. <https://emp.lbl.gov/publications/retail-electricity-price-and-cost>.
- Friend, A., 2021, *The Financial Conduct Authority's Innovative Journey: Moving Forward in the Face of Uncertainty*, Alliance for Innovative Regulation. <https://regulationinnovation.org/wp-content/uploads/2021/03/The-FCAs-Innovation-Journey-Moving-Forward-in-the-Face-of-Uncertainty-AIR-Final-2.pdf>.
- Guidehouse, 2022, *Grid Modernization Study: New Jersey Board of Public Utilities*, prepared for the New Jersey Board of Public Utilities, August 2024. <https://www.nj.gov/bpu/pdf/reports/NJBPU%20Grid%20Modernization%20Final%20Report.pdf>.
- Hawaii Public Utilities Commission (HPUC), 2020, *Decision and Order No. 37507*, Docket No. 2018-0088, filed December 23. <https://shareus11.springcm.com/Public/DownloadPdf/25256/39ae011d-700d-ee11-b83b-48df377ef808/389f3988-680e-ee11-b83b-48df377ef808>.
- HPUC, 2022, *Order No. 38654 Approving Hawaiian Electric's Pilot Framework Workplan*, Docket No. 2018-0088, filed October 19. Available at: <https://hpuc.my.site.com/cdms/s/search>.
- HPUC, 2023(a). *Order No. 40129*, Docket No. 2022-0212, filed July 28, 2023. Available at: <https://hpuc.my.site.com/cdms/s/search>.
- HPUC, 2023(b), *Decision and Order No. 39099*, Docket No. 2022-0212, filed March 22, 2023. Available at: <https://hpuc.my.site.com/cdms/s/search>.
- HPUC, 2025, *Docket No. 2022-0122*, accessed March 30. <https://hpuc.my.site.com/cdms/s/puc-case/a2G8z0000007ezuEAA/pc20247>.
- Hempling, S., 2021, *Regulating Public Performance: The Law of Market Structure, Pricing and Jurisdiction, Second Edition*. American Bar Association.
- Ivo, J., and S. Duff. 2020. "How to Build a Regulatory Sandbox: A Practical Guide for Policy Makers." Technical Guide. Washington, D.C.: CGAP. <https://documents1.worldbank.org/curated/en/126281625136122935/pdf/How-to-Build-a-Regulatory-Sandbox-A-Practical-Guide-for-Policy-Makers.pdf>.
- Lazar, J., 2016, *Electricity Regulation in the US: A Guide. Second Edition*, The Regulatory Assistance Project. <https://www.raponline.org/knowledge-center/electricity-regulation-in-the-us-a-guide-2/>.
- McDonnell, M., J. Gorman, and M. Field, 2022, *Regulatory Sandboxes: Program Design to Accelerate Innovation for an Evolving Electric Grid*, Strategen, May.
- McKinsey & Company, 2016, *What is fintech?*. <https://www.mckinsey.com/featured->

[insights/mckinsey-explainers/what-is-fintech](https://www.mckinsey.com/insights/mckinsey-explainers/what-is-fintech).

Michigan Public Service Commission Staff, 2020, *Utility Pilot Best Practices and Future Pilot Areas*, MI Power Grid: Energy Programs and Technology Pilots Workgroup.

https://www.michigan.gov/mpsc/-/media/Project/Websites/mpsc/workgroups/ep-tp/MPG_Pilots_Report093020.pdf?rev=848886c89b6c480eb024e2bbd5052d1d&hash=2F4B97FAF25D3C29B559BFF8834C34BF.

Michigan Public Service Commission, 2023, February 23 Order, Case No. U-20898, <https://mi-psc.my.site.com/sfc/servlet.shepherd/version/download/0688y000006tgUFAAY>.

Minnesota Public Utilities Commission, 2023, *Findings of Fact, Conclusions, and Order in the Matter of the Application of the Northern States Power Company, dba Xcel Energy, for Authority to Increase Rates for Electric Service in the State of Minnesota*, Docket No. E-002/GR-21-630, filed July 17. Available at: <https://mn.gov/puc/edockets/>.

National Academy of Sciences, Engineering, and Medicine, 2021, *The Future of Electric Power in the United States*, Division on Engineering and Physical Sciences; Board on Energy and Environmental Systems; Committee on the Future of Electric Power in the U.S. <https://nap.nationalacademies.org/catalog/25968/the-future-of-electric-power-in-the-united-states>.

National Association of Regulatory Utility Commissioners (NARUC) PBR State Working Group, 2024, *Tracking State Developments of Performance-Based Regulation*, NARUC. https://pubs.naruc.org/pub/D60DDEC2-A9AF-BB16-C824-86A5C2B2A13F?_gl=1*1umcl2r*_ga*NTE2NDk0OTQ2LjE3MjE5MjYyNDI.*_ga_QLH1N3Q1NF*MTcyMTkzMzk2MC4yLjAuMTcyMTkzMzk2MC4wLjAuMA.

National Association of State Utility Consumer Advocates, K. Lee, A. Cooper, A. Hoskins, C. Worley, K. Horton, K. Barbato, B. Kates-Garnick, M. McCafferty, and L. Schwartz, 2022, "The Role of Innovation in the Electric Utility Sector." Future Electric Utility Regulation Series FEUR Report No. 13, Lawrence Berkeley National Laboratory. <https://emp.lbl.gov/publications/role-innovation-electric-utility>.

New Hampshire Public Utilities Commission, 2020, *Revised Order No. 25, 433 Approving Settlement and Permanent Rates*, filed December, 17, 2020, Docket No. DE19-057. <https://www.puc.nh.gov/regulatory/Docketbk/2019/19-057.html>.

New Jersey Board of Public Utilities (NJ BPU), 2024(a), *Grid Modernization Forum Work Group Launch Notice*, Docket QO24030199, filed June 5. https://publicaccess.bpu.state.nj.us/CaseSummary.aspx?case_id=2112788.

North Carolina Public Utilities Commission, 2024, *Order Approving Guidelines with Modifications and Approving Deferral Accounting*, Docket Nos. E-2, Sub 1330 and E-7, Sub 1296, filed November 7. <https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=98523598-3864-4244-937d-d48dbdc00321>.

NJ BPU, 2024(b), *In the Matter of the 2024 New Jersey Energy Master Plan*, Docket QO24020126, opened February 28. https://publicaccess.bpu.state.nj.us/CaseSummary.aspx?case_id=2112714.

NJ BPU, 2023, *Clean Energy and Clean Tech Innovation Memorandum of Understanding Between the New Jersey Economic Development Authority and the New Jersey Board of Public Utilities*, October 25.

- [https://www.nj.gov/bpu/pdf/boardorders/2023/20231025/8B%20MOU%20between%20NJBPU%20and%20NJEDA%20\(Clean%20Tech\).pdf](https://www.nj.gov/bpu/pdf/boardorders/2023/20231025/8B%20MOU%20between%20NJBPU%20and%20NJEDA%20(Clean%20Tech).pdf).
- New Jersey Economic Development Authority, 2024, *Press Release: CSIT Awards \$3M to 41 New Jersey-Based Start-Ups Through Round 3 Catalyst and Clean Tech Seed Grant Programs*, October 15. <https://www.njeda.gov/csit-awards-3m-to-41-new-jersey-based-start-ups-through-round-3-catalyst-and-clean-tech-seed-grant-programs/#:~:text=CSIT's%20Round%203%20Catalyst%20Seed,%2C%20life%20sciences%2C%20non%2Dretail>.
- Ontario Energy Board (OEB), 2024, *Innovation Sandbox Annual Report*, June. <https://www.oeb.ca/html/sandbox/innovation-sandbox-annual-report-January-2023-to-December-2023.pdf>.
- OEB, 2023, “OEB Innovation Sandbox Challenge,” Accessed April 22, 2025. <https://engagewithus.oeb.ca/oeb-innovation-sandbox-challenge>.
- OEB, ND, “OEB Innovation Sandbox Process,” Accessed April 22, 2025. <https://www.oeb.ca/html/sandbox/process.php>.
- Office of Gas and Electricity Markets (Ofgem), ND, “Energy Regulation Sandbox,” Accessed April 22, 2025. <https://www.ofgem.gov.uk/energy-regulation-sandbox>.
- Oregon Public Utility Commission, 2017, *2016 IRP Acknowledged with Modifications and Exception*, Docket LC 66, filed October 9. <https://apps.puc.state.or.us/edockets/orders.asp?OrderNumber=17-386>.
- Oregon Public Utility Commission, 2021, *Staff’s Recommendation Adopted*, Docket UM 1976, filed December 2. <https://apps.puc.state.or.us/edockets/orders.asp?OrderNumber=21-444>.
- Pacific Gas & Electric (PG&E), 2016, *Electric Program Investment Charge (EPIC): EPIC Project 1.09C – Test New Remote Monitoring and Control Systems for T&D Assets, Discrete Series Reactors*, December 29. <https://www.pge.com/assets/pge/docs/about/corporate-responsibility-and-sustainability/PGE-EPIC-Project-1.09C.pdf>.
- PG&E, 2017, *Electric Program Investment Charge (EPIC): EPIC Project 1.02 – Demonstrate Use of Distributed Energy Storage for Transmission and Distribution Cost Reduction*, June 20. <https://www.pge.com/assets/pge/docs/about/corporate-responsibility-and-sustainability/PGE-EPIC-Project-1.02.pdf>.
- Public Service Commission of Wisconsin, 2025, *Energy Innovation Grant Program*, accessed March 30. <https://psc.wi.gov/Pages/ServiceType/OEI/EnergyInnovationGrantProgram.aspx>.
- PWC, ND, *EV charging growth: How can power and utilities prepare?*. <https://www.pwc.com/us/en/industries/energy-utilities-resources/library/ev-charging-power-and-utilities.html>.
- Rebane and Goldenberg, 2024, *How to Restructure Utility Incentives: The Four Pillars of Comprehensive Performance-Based Regulation*, RMI. <https://rmi.org/insight/how-to-restructure-utility-incentives-four-pillars-of-comprehensive-performance-based-regulation/>.
- Red Cliff Band of Lake Superior Chippewa Indians, 2023, *Grant Application: Red Cliff Comprehensive Energy Plan*, Docket No. 9709-FG-2022, filed January 30.

- <https://apps.psc.wi.gov/ERF/ERFview/viewdoc.aspx?docid=457830>.
- San Diego Gas and Electric (SDG&E), 2018, *Compliance Filing of San Diego Gas & Electric Company's (U 902 E) 2017 Electric Program Investment Charge Annual Report*, Docket U39E, filed February 28.
https://www.sdge.com/sites/default/files/EPIC_SDGE_Annual%20Report_Final_2-28-2018.pdf.
- Sheahan, B., and J. Zhang, 2019, *Experiment without penalty: Can regulatory 'sandboxes' foster utility innovation?*, Utility Dive, March 21.
<https://www.utilitydive.com/news/experiment-without-penalty-can-regulatory-sandboxes-foster-utility-innov/550950/>.
- Shreve, N., J. Selker, Z. Zimmerman, and R. Gramlich, 2024, *2023 Transmission Congestion Report*, Grid Strategies, September, 9. <https://gridstrategiesllc.com/2023-transmission-congestion-report/>.
- State of New York Public Service Commission, 2014, *Memorandum and Resolution on Demonstration Projects*, Case 14-M-0101, filed December 12.
<https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={A846946F-6C99-40A2-8CFC-B2EB0CC5AC9A}>.
- State of New York Public Service Commission, 2024, *Order Instituting Proceeding*, Case 24-E-0165, filed April 18.
<https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={202DF28E-0000-CF13-8DDF-8A223502E3B8}>.
- State of Vermont Public Utilities Commission, 2019, *Petition of Green Mountain Power Corporation for Approval of a Multi-Year Regulation Plan Pursuant to V.S.A. § 209, 218, and 218d*, Case No. 18-1633-PET, filed May 24. Available at:
<https://puc.vermont.gov/epuc-information/case-and-document-search>.
- State of Vermont Public Utilities Commission, 2022, *Order Adopting Standards and Procedures for Innovative Rates and Services Offered by Municipal and Cooperative Electric Utilities*, Case No. 21-2642-INV, filed January 20. Available at:
<https://puc.vermont.gov/epuc-information/case-and-document-search>.
- U.S. Department of Energy (DOE), 2023, *National Transmission Needs Study*,
https://www.energy.gov/sites/default/files/2023-12/National%20Transmission%20Needs%20Study%20-%20Final_2023.12.1.pdf.
- U.S. DOE, 2019, *Dynamic Line Rating*, June. <https://www.energy.gov/oe/articles/dynamic-line-rating-report-congress-june-2019>.
- U.S. DOE, ND, "Technology-to-Market," Accessed April 22, 2025.
<https://www.energy.gov/eere/buildings/technology-market>.
- Walton, D., 2023, *Keeping the Lights On*, The Assembly, September 20.
<https://www.theassemblync.com/business/hot-springs-microgrid-duke-energy/>.
- White, L., E. Agrawal, Dr. A. Bohman, A. Gopstein, C. Hua, I. Sepulveda, and L. Tian, 2024, *Pathways to Commercial Liftoff: Innovative Grid Deployment*, U.S. Department of Energy, https://liftoff.energy.gov/wp-content/uploads/2024/04/Liftoff_Innovative-Grid-Deployment_Final_4.15.pdf.
- World Bank Group, 2020, "Key Data from Regulatory Sandboxes Across the Globe," Accessed October 2, 2024. <https://www.worldbank.org/en/topic/fintech/brief/key-data-from->

[regulatory-sandboxes-across-the-globe](#).

Zetsche, D., R. Buckley, D. Arner, and J. Nathan Barberis, 2017, *Regulating a Revolution: From Regulatory Sandboxes to Smart Regulation*, University of Luxembourg Law Working Paper number 2017-006. <https://ssrn.com/abstract=3018534>.

Appendix A. List of Organizations Interviewed

Organization	Related Link
American Public Power Association (APPA)	https://www.publicpower.org/deed-rd-funding
Connecticut Public Utilities Regulatory Authority (PURA)	https://portal.ct.gov/pura/electric/office-of-technical-and-regulatory-analysis/clean-energy-programs/innovative-energy-solutions-program
Current Energy Group	https://currentenergy.group/
Duke Energy Corporation*	https://www.duke-energy.com/home
Hawaiian Electric (HECO)	https://www.hawaiianelectric.com/about-us/innovation
Hawaii Public Utilities Commission (HPUC)	https://hpuc.my.site.com/cdms/s/puc-case/a2G8z0000007ezuEAA/pc20247
Green Mountain Power (GMP)	https://greenmountainpower.com/
Public Staff – North Carolina Utilities Commission	https://publicstaff.nc.gov/
San Diego Gas & Electric (SDG&E)	https://www.sdge.com/epic
United Illuminating	https://www.uinet.com/
Vermont Public Utilities Commission (VT PUC)	Link to all innovative pilot dockets
Vermont Electric Power Company (VELCO)	https://www.velco.com/
WATT Coalition / Grid Strategies	https://gridstrategiesllc.com/

*Via written correspondence

Appendix B. Key Takeaways from Sandbox Case Studies

Sandbox-Type Mechanism	Key Takeaways	Example Advanced Grid Technology Projects
American Public Power Association DEED Program (National) [Funding opportunity]	APPA's R&D focused program supports smaller, public utilities that face different regulatory challenges than regulated utilities. The program invests significantly in outreach and information sharing.	Smart poles to improve WiFi, security, provide EV charging, and display messaging
Innovations and Technological Developments (AZ) [Rate case*]	Arizona's proceedings may have suffered from a lack of clearly defined objectives and attempting to address too many issues at once.	N/A
EPIC Program (CA) [Funding opportunity]	The EPIC program successfully supports utilities in pursuing technology demonstrations, but limits their ability to pursue other innovation areas like applied R&D and market facilitation.	- T&D foundational technologies and situational capabilities - Distributed Energy Storage for Reducing T&D Costs - Discrete series reactors for improving transmission performance - Smart distribution circuit demonstrations and modeling
Innovative Energy Solutions (CT) [Regulatory sandbox]	IES is in the early stages of project deployment, but can serve as an example of a well-designed a regulatory sandbox.	- AI for passively assessing distribution system health - Digital representation of the distribution grid to assess hazard vulnerability - Meter-based technology for assessing locational power quality
Innovative Pilot Framework (HI) [Pilot process]	Hawaii's pilot process effectively provides expedited project review and reduces cost recovery uncertainty.	None
New Technologies and Business Models (MI) [Pilot process]	Michigan's efforts to document challenges with pilot projects supported their development of an expedited pilot framework.	- Distribution-level conservation voltage reduction and volt-var optimization - Line undergrounding for reliability
Rate Case Pilot Projects (MN) [Rate case]	The Minnesota PUC did not believe that the added value from developing a sandbox would outweigh its costs, considering the already established process for consideration of individual pilots.	N/A
Innovation Prototyping Process (NC) [Pilot process]	Utilities have not yet proposed prototypes through the process, which could indicate that they are not yet prioritizing resources towards the effort.	None
Grid Transformation and Enablement Program (NH)	Stakeholders expressed hesitancy that Eversource's proposal was not innovative enough to warrant unique ratemaking treatment.	N/A

[Rate case]		
Clean Tech Grant Programs and Future Regulatory Sandbox (NJ) [Funding opportunity]	Stakeholders recommended a regulatory sandbox as a means to achieve specific desired outcomes for the state.	Platform software to expedite the microgrid planning process
Reforming the Energy Vision Demonstration Projects (NY) [Regulatory sandbox]	The REV Demos explicitly aim to address business model and regulatory hurdles to innovation and are part of a deep ecosystem of innovation in the state.	Active network management for flexible interconnection of DERs within distribution system constraints
Smart Grid Testbed (OR) [Regulatory sandbox]	PGE's Smart Grid Testbed has been an effective means of assessing different approaches to demand response, as evidenced by the program evolutions over the years.	Flexible Feeder demonstration aggregating customer resources for flexibility
Innovative Pilot Program (VT) [Pilot process]	Entities across Vermont have a strong culture of innovation, due to strong leadership and willingness to lead by Green Mountain Power. Green Mountain Power has conducted several successful pilots through the program that have later scaled.	Distributed batteries for frequency regulation
PowerPath DC Pilot Project Fund (DC) [Funding opportunity]	Multiple innovation vehicles have been the result of ambitious and consistent policy goals for the District.	Smart inverters for grid stability
Energy Innovation Grant Program [Funding opportunity]	This program supports entities outside of utilities to participate in the energy innovation landscape and does not rely on customer funds.	Resilient microgrid solution for an early childhood learning center

Appendix C. Literature and Resources

The authors reviewed literature and resources related to regulatory sandboxes and other approaches to expedite utility adoption of advanced grid technologies in the United States and abroad to inform this work. The cover the following categories:

1. **Utility Innovation and Technology** – This category covers literature related to utility pilot programs, scaling technology deployment, supporting a culture of innovation at utilities, and alternative mechanisms (other than sandboxes) for promoting innovation and includes case studies on particular innovative technologies.
2. **Utility Regulatory Sandboxes** – This category captures findings from research specifically on regulatory sandboxes in the utility industry.
3. **Lessons from Regulatory Sandboxes in Other Sectors** – This category includes literature on regulatory sandboxes deployed in sectors outside of the energy industry, largely the Financial Technology (FinTech) sector where regulatory sandboxes appear to be used more prominently.

Category	Resource
Utility Innovation and Technology	A Blueprint to Pilot Design: Best Practices and Lessons Learned (Sergici, 2020)
	A Handbook for Designing, Implementing, and Evaluating Successful Electric Utility Pilots (Cappers and Spurlock, 2020)
	A Roadmap for Advanced Transmission Technology Adoption (Deese et al., 2024)
	Case Studies on Agile Regulatory Governance to Harness Innovation: Civilian Drones and Bio-Solutions (Hernández and Amaral, 2022)
	Pathways to Commercial Liftoff: Innovative Grid Deployment (White et al., 2024)
	Pathways for Innovation: The Role of Pilots and Demonstrations in Reinventing the Utility Business Model (Fairbrother et al., 2017)
	Regulatory Experimentation: Moving Ahead on the Agile Regulatory Governance Agenda (OECD, 2024)
	Research and Development by Public Utilities: Should More be Done? (Costello, 2015)
	The Electricity Governance Toolkit (WRI, NIPFP, Prayas, 2007)
	Toward Methodologies for Multiple-Objective Based Energy and Climate Policy (Khosla, Dukkipati, Dubash, Sreenivas, Cohen, 2015)
	Utility Pilot Best Practices and Future Pilot Areas (Michigan Public Service Commission Staff, 2020)

Utility Regulatory Sandboxes	Energy Regulatory Sandbox: Guidance for Innovators (Ofgem, 2020)
	Innovative Regulatory Approaches with Focus on Experimental Sandboxes: Casebook (International Smart Grid Action Network, 2019)
	Regulatory sandboxes and pilot projects: Trials, regulations, and insights in energy transition (Aydin, Z., and O. Yardimci, 2024)
	Regulatory sandboxes: Do they speed up innovation in energy? (Beckstedde, et al., 2023)
	Regulatory Sandboxes in the Energy Sector (Publications of the Office of the European Union, 2023)
	Regulatory Sandboxes in the Energy Sector - Review and Learnings for the Case of Switzerland (Heymann, et al., 2021)
	Regulatory Sandboxes: Program Design to Accelerate Innovation for an Evolving Electric Grid (McDonnell, et al., 2022)
Lessons from Regulatory Sandboxes in Other Sectors	Efficiency vs. Equity Concerns in Regulatory Sandboxes (Crampes and Estache, 2023)
	Global Experiences from Regulatory Sandboxes (Appaya et al., 2020)
	How to Build a Regulatory Sandbox: A Practical Guide for Policy Makers (Jeník and Duff, 2020)
	Key Data from Regulatory Sandboxes Across the Globe (World Bank Group, 2020)
	Making Space for Innovation: The Handbook for Regulatory Sandboxes (German Federal Ministry for Economic Affairs and Energy, 2019)