PERSPECTIVES ON TRANSFORMING UTILITY BUSINESS MODELS

Paper 12 – Trials, Demonstrators, and Pathfinders

September 2024

INTRODUCTION

The journey to Net Zero is expected to see energy utilities transform their business models to help them in delivering good climate, economic, and social outcomes for their customers and the communities in which they live and work. Importantly, these new business models will also help secure the utilities' future as they balance complexity, uncertainty, and urgency in undertaking their central role in energy system change.

Traditional energy utility business models do not align with the emerging decentralized, distributed, digitalized system of the future and therefore may not serve the goals of decarbonization and sustainability well. Successful navigation of energy system transformation is anticipated to see utility companies pursuing innovative business models that prioritize low-carbon energy sources, energy efficiency, flexibility, and customer engagement. These will depend on innovation in new technologies, new processes and skills, and an encouraging and responsive policy and regulatory environment.

Taking good ideas through the innovation lifecycle and then into deployment as business as usual (BAU) will create many new opportunities but can be a difficult and time-consuming task characterized by substantial technical, operational, and commercial challenges. These challenges will vary depending on the nature and novelty of the innovation but in many cases will touch on the requirements and perspectives of a broad spectrum of stakeholders. This process is not just a technological one; the business models that allow the technology to respond to a market failure or a market opportunity should be an integral part of this activity.

Mitigating risk and accelerating achievement of good innovation outcomes can be significantly helped by a coherent, focused approach to testing and proving the value of the innovation. This includes not just the functioning of a particular technology application, but how that innovation can be deployed and provide a return on the investment made to create it, and how it can contribute to achieving other outcomes measured in terms of carbon, customer satisfaction, market position, and many other factors.

This paper explores the role of testing and trialing in developing and deploying business models that will see new energy solutions brought to BAU for the benefit of utilities, their customers, and other key stakeholders. It does not offer an exhaustive treatment of innovation testing; instead, it is intended to stimulate thinking about possible approaches and the benefits they can offer.

INNOVATION AND THE UTILITY

In earlier work undertaken by the Electric Power Research Institute (EPRI),[1] consideration was given to scenarios that describe possible futures for utilities and how these might be reflected in new or refreshed business models. These scenarios are illustrated in Figure 1.

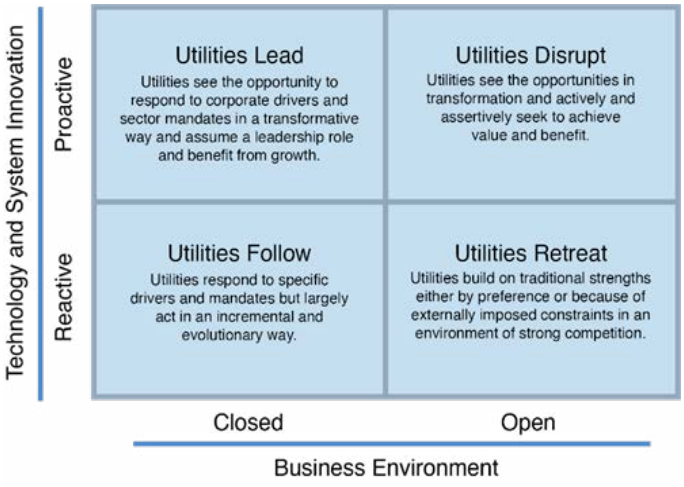

Figure 1. *Energy system transformation scenarios for utilities*

These scenarios provide a way of organizing and describing the context in which utilities are likely to be required to operate and reveal options for how they might choose to participate. They do this by showing possible relationships between the approach adopted for innovation and the extent to which the policy, regulatory, financial, and commercial environment creates opportunity or offers support for change. They reveal questions that require well-informed, timely decision making across key strategic areas:

- Possible responses to changes that are happening or could happen in the energy landscape, either in the commercial environment or the innovation environment
- Conditions that must be true in order for a utility to respond in a particular way
- Perspectives of other stakeholders and how they might align or conflict with those of the utility
- The transformation destination being sought
- Possible strategic options for reaching the destination successfully
- Framing for considering and responding to risk

Testing will play a critical role in helping utilities understand the implications of the decisions they make as they navigate the option landscape. Pathfinders can give initial insights. Trials and demonstrators will reveal risks and help develop mitigations, illuminate improvements, and give insight into how to develop them, enable engagement with key stakeholders, and identify critical success factors for responding well to their requirements.

The spectrum of testing approaches allows options in all quadrants to be explored, as well as paths to be identified for moving from one quadrant to another as business opportunities become better understood. Trials, demonstrators, and pathfinders are relevant to both axes of the quadrants— "Technology and System Innovation" and "Business Environment"—and both are equally important in decision making.

The form and nature of testing will vary across the quadrants, but it will play an important role in supporting and enabling operation in any of the quadrants. Testing may be more difficult to frame in "Utilities Disrupt" contexts, but its importance will be greater given the likelihood of disruption, meaning higher levels of uncertainty. In "Utilities Follow," the testing may be more oriented to optimizing core functions to achieve best-cost outcomes. In all cases, it will be supportive of allowing experimentation with different approaches to change.

A HIGH-LEVEL VIEW OF TESTING BUSINESS MODELS

Testing business models effectively requires a structured approach that allows for learning, adaptation, and validation of assumptions. A simplified high-level view is offered in Figure 2.

1 *Towards Net Zero: The Evolving Utility Business Model and Possible Future Scenarios*. EPRI, Palo Alto, CA: 2022. 3002025745.

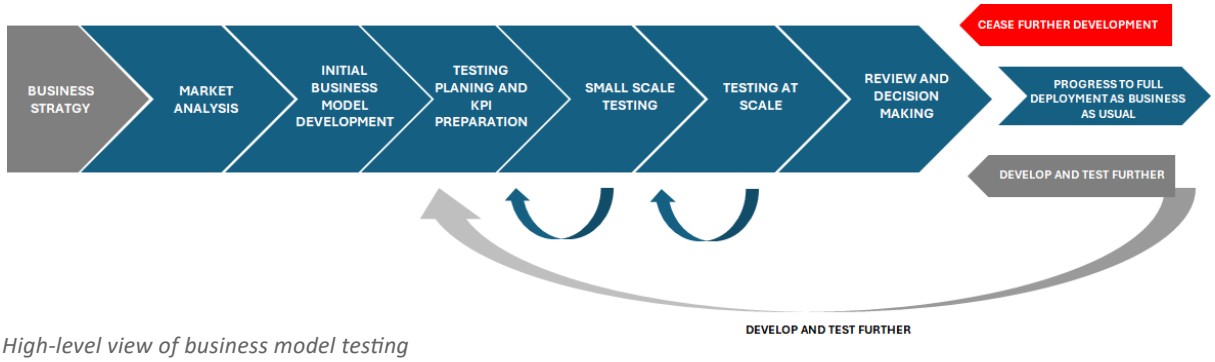

Figure 2. *High-level view of business model testing*

The business model needs to support and align with the utility's business strategy and support its plan for development and sector positioning. The relationship between testing and the strategy may be informed by the scenarios illustrated in Figure 1, placing the ambition in a particular quadrant or helping identify a potential journey in or across quadrants. This activity could include thorough analysis of the current market landscape to identify failures, inefficiencies, and emerging opportunities and involve engaging with customers, stakeholders, and industry experts to gain insights into their needs and preferences.

The regulatory landscape in which energy utilities operate may constrain the business model design and deployment. Any such constraints need to be understood to allow alignment with regulations and to determine if any regulatory approvals or modifications are needed. It may also be possible to use test environments to determine regulatory conditions that would have to be in place to enable a new business model and use the findings to influence change. Regulators may seek to play an active role in such testing.

The objectives of the business model test must be clearly defined, taking into account the specific challenges and opportunities identified. Testing may be focused on exploring the feasibility of a new revenue model, assessing market demand for a product or service, evaluating the scalability of a particular approach, increasing operational efficiency, or reducing carbon emissions; its purpose must be supported by well-articulated objectives and outcomes.

The testing process should start with small-scale pilot projects in a controlled environment to assess the feasibility and viability of the new business model. This is likely to minimize risk and maximize learning. This could involve testing the business model in a specific geographic area, targeting a niche market segment, or launching a limited-time pilot project. Starting small allows for experimentation without an initial commitment of significant resources.

it is important to engage with key stakeholders, including regulators, customers, industry partners, and internal teams, throughout the trial process and seek feedback, address concerns, and build support for the proposed business model by demonstrating its potential benefits and value proposition.

It is critical to define key performance indicators (KPIs) to measure the impact and performance of the business model test. These KPIs should align with the objectives and provide meaningful insights into the effectiveness of the model, and could include metrics related to customer engagement, energy savings, cost reductions, revenue generation, and environmental impact.

It may seem obvious but systematic data collection during the testing period is essential. This will enable assessment of the performance of the business model against the predefined metrics. The data is likely to be varied and could include customer feedback, sales data, operational metrics, and financial indicators that will permit trends and areas of improvement to be identified.

The learnings from the testing exercise should be used to iterate and adapt the business model based on the insights gained from the trial. This may involve altering pricing strategies, refining the value proposition, adjusting distribution channels, or modifying the target market. The goal is to continuously improve the model based on real-world feedback and gain insight in to how to optimize performance and scalability.

At the end of the testing period, the results should be evaluated against the predefined objectives and metrics. This will reveal if the business model achieved desired outcomes. It might also reveal that the business model failed, which is itself an important and valuable learning.

If the testing is successful, consideration should be given to scaling up the business model to broader customer segments or geographic regions. This would include developing a roadmap by identifying resource requirements, addressing operational challenges, and ensuring regulatory compliance. This may involve investing and scaling infrastructure to support growth. Lessons learned from the trial should inform strategic decisions moving forward.

Importantly, the learnings from the business model testing should be communicated with key stakeholders, including internal teams, investors, partners, and customers. Transparency and communication foster a culture of innovation and continuous improvement, while also building trust and alignment among stakeholders.

THE ROLE OF REGULATION

Regulation plays a crucial role in shaping the landscape for innovation testing, and in particular in establishing and defining the environment for business model change.

Regulations establish frameworks and guidelines that govern the conduct of innovation testing. They define the legal requirements, standards, and protocols that organizations must adhere to when testing new technologies or business models in real-world settings. The safety and well-being of participants and consumers involved in innovation testing is assured through the regulatory conditions that apply. These conditions include standards for product safety, data privacy, environmental protection, and consumer rights, mitigating risks and safeguarding against potential harm or exploitation.

Regulatory practices promote fair competition and market integrity by preventing anti-competitive practices, market manipulation, and unfair advantage. They establish rules for disclosure, transparency, and fair treatment of competitors, ensuring a level playing field for all participants in the innovation ecosystem. Regulations also address issues related to intellectual property rights, licensing, and patents, protecting innovation, and fostering a conducive environment for investment and collaboration.

Collaboration and knowledge sharing among stakeholders involved in innovation testing can be facilitated by regulations. They provide mechanisms for data sharing, intellectual property licensing, and collaboration agreements, enabling organizations to collaborate on research, development, and commercialization efforts. Regulations can also incentivize knowledge dissemination and technology transfer through funding programs, grants, and incentives for open innovation.

Regulations need to be flexible and adaptive to accommodate emerging technologies and business models. As innovation continues to evolve rapidly, regulations must be responsive to new challenges, opportunities, and societal needs. Regulators may need to engage in ongoing dialogue with industry stakeholders, experts, and policymakers to update and revise regulations accordingly.

TRIALS, DEMONSTRATORS, AND PATHFINDERS

The meaning of testing in the energy system can vary with a variety of different terms used—trials, demonstrators, pathfinders, and perhaps others. These serve different purposes and sit in different places in the innovation lifecycle. They each play distinctive but interconnected roles in the development and deployment of innovative technologies and business models as shown in Table 1.

Table 1. *The differences between trials, demonstrators, and pathfinders*

	TRIAL	DEMONSTRATOR	PATHFINDER
Purpose	Trials are small-scale experiments or tests conducted to assess the feasibility, viability, and potential impact of new technologies or business models in real-world settings.	Demonstrators showcase the capabilities, benefits, and value proposition of innovative technologies or business models to stakeholders, including customers, investors, regulators, and the broader market.	Pathfinders are pioneering initiatives or projects that explore new frontiers, break barriers, and set the direction for future innovation and development in a particular field.
Objectives	• Evaluate the technical functionality and performance of the innovation. • Assess customer acceptance, adoption barriers, and user experience. • Identify operational challenges, risks, and opportunities for improvement.	• Demonstrate the technical feasibility and performance of the innovation at scale. • Highlight the value proposition, benefits, and potential impact on stakeholders. • Build confidence, credibility, and trust among stakeholders.	• Pioneer new business models, technologies, or market paradigms. • Challenge conventional thinking and push the boundaries of what's possible. • Inspire and influence other stakeholders to follow suit and embrace innovation.
Key Characteristics	• Limited in scope and duration. • Target specific use cases, customer segments, or geographic areas. • Focus on gathering data, measuring performance, and validating assumptions. • Typically, low to mid technology readiness levels (TRL) but can be applied at all TRLs.	• Larger in scale and scope compared to trials. • Showcase real-world applications and use cases. • Often include interactive features, demonstrations, or showcases. • Typically, mid to higher TRLs.	• Visionary and ambitious in scope. • Explore uncharted territories or disruptive innovations. • Focus on setting precedents, shaping industry norms, and catalyzing change. • May sit outside the TRL structure but in the right circumstances could be applied at any TRL.
Examples	• Conducting a pilot project to test a new energy management system in a residential community. • Implementing a trial program to assess the effectiveness of demand response strategies for industrial customers.	• Establishing a demonstration site to showcase the integration of renewable energy sources and energy storage technologies in a microgrid. • Hosting a public event or exhibition to showcase the capabilities of a new electric vehicle charging infrastructure.	• Launching a groundbreaking project to develop a hydrogen-based energy system for transportation and industrial applications. • Establishing a flagship initiative to implement blockchain technology for peer-to-peer energy trading in a local community.

All of these—trials, demonstrators, and pathfinders—provide utilities with valuable data, evidence, and insights to inform strategic decision making about resource allocation, investment prioritization, and long-term planning. When used in combination with horizon scanning,[2] data analytics, scenario modeling, and other decision support tools, they can help utilities make more informed and evidence-based decisions,[3] reducing uncertainty and increasing the likelihood of achieving strategic objectives and performing well in dynamic and unpredictable energy markets.

Trials, demonstrators, and pathfinders also help utilities build stakeholder confidence by demonstrating their commitment to innovation, sustainability, and customer-centricity. By actively engaging customers, regulators, investors, and other key stakeholders throughout the project lifecycle, utilities can gain access to diverse perspectives, address concerns, align interests, and foster trust, transparency, and collaboration, thereby reducing uncertainty and resistance to change.

An important attribute of well-implemented testing following any of these approaches is to facilitate iterative learning and adaptation by allowing utilities to explore and iterate their thinking based on feedback and insights gained from previous experiences. By adopting agile development methodologies and rapid prototyping techniques, utilities can quickly adapt and adjust their strategies in response to changing market conditions, regulatory requirements, or technological advancements.

Pathfinders perform a specific role by helping utilities identify opportunities associated with new initiatives or investments by exploring different scenarios, assessing market dynamics, and evaluating potential impacts on business operations, regulatory compliance, and financial performance. By conducting thorough analyses, utilities can better anticipate and navigate complex and evolving energy landscapes.

Trials allow energy utilities to test hypotheses and assumptions about new technologies, business models, or market opportunities in a controlled environment. By conducting small-scale experiments and gathering empirical data, utilities can validate or refine their ideas, reducing uncertainty about the feasibility and potential impact of proposed solutions. By soliciting input from end-users and other participants, utilities can gain valuable insights into user preferences, behaviors, and needs, helping to refine solutions and address potential barriers or concerns.

By conducting trials, utilities can test new technologies, strategies, or business models on a smaller scale before full deployment. This allows them to assess performance, identify potential risks, and mitigate them early on, leading to more informed decision making when scaling up.

Pathfinders and trials together enable utilities to validate assumptions and hypotheses about new technologies or market opportunities. By testing these assumptions in a real-world context, utilities can verify their validity and adjust their strategies accordingly, reducing the risk of costly mistakes or misjudgments.

Demonstrators and trials provide valuable data and feedback from real-world implementation. Utilities can analyze this information to gain insights into customer behavior, system performance, and market dynamics, informing decision-making on future investments, regulatory strategies, and operational improvements. They allow utilities to evaluate the cost-effectiveness of different options before making large investments. By comparing costs, benefits, and performance metrics across alternative solutions, utilities can make more informed decisions about resource allocation and investment prioritization.

Demonstrators and trials also provide utilities with an opportunity to test new technologies or business models in compliance with regulatory requirements. By proactively engaging with regulators and seeking approval for pilot projects, utilities can ensure that their initiatives align with regulatory goals and constraints, reducing regulatory risk and uncertainty. The results of testing in this way may influence the direction of regulatory change as it seeks to support and enable decarbonization.

In summary, trials, demonstrators, and pathfinders help energy utilities to enhance their ability to innovate, adapt to changing market conditions, and deliver value to customers and stakeholders.

2 *Perspectives on Transforming Utility Business Models, Paper 1: Horizon Scanning and Forecasting*. EPRI, Palo Alto, CA: 2024. 3002028820.

3 *Perspectives on Transforming Utility Business Models, Paper 5 – Business Model Development: Information Inputs for Decision Making*. EPRI, Palo Alto, CA: 2024. 3002030494.

WHAT FACILITIES ARE BEST SUITED TO TRIALS, DEMONSTRATORS, AND PATHFINDERS?

Facilities for trials, demonstrators, and pathfinders in energy innovation should provide the necessary infrastructure, resources, and support services to facilitate testing, showcasing, and pioneering new technologies and business models.

Table 2. *Facilities best suited to trials, demonstrators, and pathfinders*

TRIALS	
Living Labs	Living labs are real-world environments where innovative technologies and solutions can be tested and evaluated in a controlled setting. These could be residential communities, commercial buildings, or industrial sites equipped with sensors, meters, and monitoring systems to collect data on energy consumption, performance, and user behavior.
Research and Development (R&D) Centers	R&D centers equipped with laboratories, test beds, and prototyping facilities provide a controlled environment for conducting trials on new energy technologies. Researchers can simulate various scenarios, test hypotheses, and refine prototypes before deploying them in real-world settings.
Field Test Sites	Field test sites, such as renewable energy farms, smart grids, or microgrid installations, offer opportunities to trial new energy technologies at scale. These sites provide access to real-world infrastructure and conditions, allowing researchers and practitioners to assess performance, reliability, and interoperability in a practical setting.
DEMONSTRATORS	
Innovation Hubs	Innovation hubs or technology centers serve as focal points for showcasing and demonstrating cutting-edge energy technologies and solutions. These facilities often include demonstration areas, exhibition spaces, and interactive showcases where visitors can experience the benefits and applications of innovative technologies firsthand.
Showrooms and Experience Centers	Showrooms and experience centers provide immersive environments where customers, investors, policymakers, and other stakeholders can learn about innovative energy solutions. These facilities feature demonstrations, product displays, and interactive exhibits that highlight the features, benefits, and value proposition of new technologies.
Test Facilities with Public Access	Test facilities with public access, such as energy research parks or innovation districts, offer opportunities for public engagement and education. These facilities may host open houses, tours, and outreach events to raise awareness, build community support, and foster collaboration around energy innovation.
PATHFINDERS	
Incubators and Accelerators	Incubators and accelerators provide support services, resources, and mentorship to early-stage startups and entrepreneurs developing disruptive energy technologies and business models. These programs offer access to funding, networking opportunities, and expertise to help startups navigate the path from ideation to commercialization.
Living Laboratories for Innovation	Living laboratories for urban innovation, such as smart cities or sustainable communities, serve as testbeds for pioneering new approaches to energy management, mobility, and infrastructure. These integrated ecosystems allow stakeholders to experiment with holistic solutions that address complex urban challenges.
Advanced Research Facilities	Advanced research facilities, such as national labs or research institutes, conduct cutting-edge research and development on transformative energy technologies. These facilities often collaborate with industry partners, academia, and government agencies to push the boundaries of innovation and drive breakthrough discoveries.

By leveraging these facilities, stakeholders in the energy sector can accelerate the pace of innovation, validate new concepts, and pave the way for the widespread adoption of sustainable energy solutions.

SUCCESSFUL ENERGY INNOVATION TEST FACILITIES

Several energy test and demonstration facilities worldwide have gained recognition for their contributions to advancing energy innovation and solution development. These include:

- **National Renewable Energy Laboratory (NREL) - United States:** NREL is a leading research institution focused on renewable energy and energy efficiency. It operates several test and demonstration facilities, including the Energy Systems Integration Facility (ESIF) and the National Wind Technology Center (NWTC), which facilitate research, testing, and validation of renewable energy technologies, grid integration solutions, bioenergy, geothermal energy, and energy storage systems. National Renewable Energy Laboratory
- **Energy Systems Catapult (ESC) Living Lab – United Kingdom:** The Energy Systems Catapult operates a Living Lab that provides a real-world testing environment for energy innovations—real consumers in real homes. It focuses on integrated energy systems and facilitates interdisciplinary collaboration among stakeholders. Energy Systems Catapult Living Lab
- **European Marine Energy Centre (EMEC) - United Kingdom:** EMEC is the world's first and leading test facility for wave and tidal energy technologies. Located in Orkney, Scotland, EMEC provides a unique testing environment for developers to validate and demonstrate marine energy devices in real-sea conditions, accelerating the commercialization of marine renewable energy. European Marine Energy Centre
- **Fraunhofer Institutes - Germany:** The Fraunhofer Society operates multiple research institutes in Germany, including the Fraunhofer Institute for Solar Energy Systems (ISE) and the Fraunhofer Institute for Wind Energy Systems (IWES). These institutes host state-of-the-art test facilities for solar PV modules, concentrating solar power (CSP) systems, wind turbines, and grid integration technologies. Fraunhofer Institutes
- **Offshore Renewable Energy Catapult (ORE Catapult) – United Kingdom:** ORE Catapult is the UK's leading innovation center for offshore renewable energy. It operates testing facilities such as the National Renewable Energy Centre (Narec) in Blyth and the Levenmouth Demonstration Turbine in Fife. These facilities support the testing and validation of offshore wind, tidal, and wave energy technologies. Offshore Renewable Energy Catapult
- **Offshore Wind Test Sites - Various Countries:** Several countries have established offshore wind test sites and demonstration zones to support the development and testing of offshore wind farms and associated technologies. Examples include the Østerild and Høvsøre test sites in Denmark, the Blyth Offshore Demonstrator Project in the UK, and the Fukushima Forward project in Japan. Østerild Test Site, Høvsøre Test Site, Blyth Test Site, Fukushima Forward
- **European Space Agency (ESA) Harwell Campus – United Kingdom:** The ESA's facility at Harwell Campus in Oxfordshire hosts testing facilities for space-related energy technologies, including solar panels and energy storage systems. These facilities support research and development in space-based solar power and other space-based energy applications. European Space Agency (ESA) Harwell Campus
- **Argonne National Laboratory – United States:** Argonne National Laboratory, located near Chicago, Illinois, conducts research in areas such as energy storage, transportation, nuclear energy, and grid modernization. Argonne operates facilities such as the Advanced Photon Source for materials research and the Center for Nanoscale Materials. Argonne National Laboratory

This small sample of test and demonstration facilities illustrates the variation and depth of capability needed to accelerate the development, validation, and commercialization of energy technologies and their associated business models.

The kinds of exploration that can be undertaken are suggested by some examples of trials and demonstrations that have been undertaken in a variety of contexts, such as:

- **Smart grid projects:** Many utilities around the world have initiated smart grid projects to modernize their infrastructure and incorporate advanced technologies for efficient energy management. For example, the Grid Modernization Initiative by the U.S. Department of Energy includes various demonstration projects aimed

at integrating renewable energy, energy storage, and advanced metering infrastructure.

- **Microgrid demonstrations:** Microgrids are localized energy systems that can operate independently or in conjunction with the main grid. Numerous trials and demonstrations of microgrid technology and business models have been conducted globally. One notable example is the Brooklyn Microgrid project in New York City, which explores peer-to-peer energy trading among participants using blockchain technology.
- **Energy storage pilots:** With the increasing penetration of renewable energy sources like solar and wind, energy storage has become crucial for grid stability and flexibility. Utilities are deploying energy storage systems and piloting different technologies such as lithium-ion batteries, flow batteries, and pumped hydro storage. For instance, Southern California Edison's "SCE 2nd Life" project repurposes retired electric vehicle batteries for energy storage applications. These pilots explore the role of business models in enabling storage solutions.
- **Demand response programs:** Demand response programs involve adjusting electricity usage in response to supply conditions or price signals. Utilities are conducting trials to incentivize customers to reduce or shift their electricity consumption during peak demand periods. Programs like Google Nest's Rush Hour Rewards and Oracle Opower's behavioral energy efficiency programs are examples of innovative demand response initiatives.
- **Advanced metering infrastructure (AMI) deployments:** AMI enables two-way communication between utilities and customers, providing real-time data on energy usage. Many utilities are implementing AMI systems to improve grid reliability, optimize operations, and empower consumers to manage their energy usage more efficiently. Pacific Gas and Electric Company's SmartMeter program is one such example.
- **Blockchain-based energy trading platforms:** Blockchain technology is being explored for its potential to enable decentralized energy trading platforms, allowing peer-to-peer energy transactions without intermediaries. Projects like Power Ledger in Australia and LO3 Energy's Brooklyn Microgrid mentioned earlier are pioneering blockchain-based energy trading initiatives.

The Incubatenergy Labs (IEL), run by the EPRI, is a startup demonstration initiative that collaborates with energy companies and global entrepreneurs to innovate solutions for electric power challenges. Since its launch in 2019, IEL has united energy companies, EPRI experts, and entrepreneurs to identify, test, and share solutions for critical challenges such as decarbonization, electrification, grid modernization, resilience, and sustainability. The program's collaborative model offers rapid evaluation of startup technologies by nearly 200 experts, co-funding opportunities to reduce costs and accelerate results dissemination, and broad sharing of outcomes to promote successful commercialization. IEL's annual cycle includes key phases like challenge identification, startup scouting and application, pitch events, and demo day showcases.

IEL also engages with the Incubatenergy Network, a consortium of clean energy incubators and accelerators, to support over 500 companies in accelerating the transition to a sustainable economy. Network members assist in sourcing startup applicants, joint communication on events, and resource deployment. Membership in IEL is available at two levels—Host and Participant. Hosts prioritize innovation challenges, select startups, and host events, while Participants contribute to challenge topics, assess startup applications, and engage in demonstration projects. The program encourages involvement from subject matter experts to review innovations and support startup selections.

Pathfinders take a perspective that is potentially more explorative in nature. Some examples that draw on UK experience include:

- The Distributed ReStart project was a world-first initiative involving £11.7 billion ($15 billion) of funding to explore how distributed energy resources (DER) such as solar, wind, or battery storage systems could in the future be used to create stable power islands as a step to restoring power to the transmission system in the unlikely event of a total system shutdown. Distributed ReStart
- The Voltage Pathfinder project sought to address the emerging issue on Great Britain's 40 kV and 275 kV

transmission system of high overnight voltages, created through reactive gain when power flows on the transmission network and demand on the downstream distribution systems are lower, particularly overnight. Voltage Pathfinder

- The Stability Pathfinder project sought to trial new technologies to generate important system characteristics, such as inertia. Previously these system characteristics were available only from synchronous generators associated with large power stations such as nuclear, coal, and gas. With the decline in thermal generating plant and synchronous generation, new sources of inertia and/or fast frequency response needed to be found. Stability Pathfinder

MOVING FROM INNOVATION TESTING TO BAU

Moving from innovation testing to integrating new practices into BAU involves several key steps to ensure successful adoption and sustainability:

- **Evaluate trial results:** Assess the outcomes of the innovation trials comprehensively. Evaluate both quantitative and qualitative data gathered during the trial period to determine the effectiveness, feasibility, and impact of the new business model or technologies.
- **Identify success factors:** Identify the key success factors and lessons learned from the trials. Determine what aspects of the business model were most effective and valuable, as well as any challenges or barriers encountered during implementation. Explicitly seek to understand any failures.
- **Engage stakeholders:** Engage with key stakeholders, including employees, customers, partners, regulators, and investors, to gather feedback and insights. Communicate the results of the trials transparently and solicit input on the potential integration of the business model and associated innovations into regular operations.
- **Develop implementation plan:** Develop a detailed implementation plan outlining how the business model will be integrated into existing processes and operations. Define roles and responsibilities, allocate resources including investment, and establish timelines for implementation.
- **Address barriers:** Identify and address any barriers or challenges that may hinder the adoption of the new business model or technologies. This could include addressing technical limitations, regulatory constraints, cultural resistance, or resource constraints.
- **Training and capacity building:** Provide training and capacity building initiatives to ensure that employees are equipped with the necessary skills and knowledge to implement and utilize the business model effectively.
- **Monitor and measure progress:** Establish monitoring and measurement mechanisms to track the progress and impact of the integration process. Define KPIs to assess the effectiveness and return on investment from the innovation over time.
- **Iterate and improve:** Continuously iterate and improve the integration process based on feedback and insights gathered from ongoing monitoring and evaluation. Make adjustments to the implementation plan as needed to optimize performance and address emerging challenges.

By following these steps and fostering a collaborative and adaptive approach, organizations can effectively transition from innovation trials and demonstrators to integrating new business models into BAU, enabling long-term success and sustainability.

LESSONS FROM OTHER SECTORS

Energy utilities can learn several valuable lessons from other sectors when it comes to business model innovation and testing. Some of these approaches will not translate directly but might inspire thinking that could be valuable in terms of insights gained, pace of testing, or mitigation of risks.

- **Retail Sector** Pop-up Stores: Retailers often use pop-up stores as trials to test new markets, products, or concepts before committing to a permanent location. Energy utilities could deploy similar temporary installations to showcase new energy technologies or services in different communities and gather feedback from customers.
- **Automotive Industry** Test Drives and Demonstrations: Car manufacturers frequently organize test drive events to allow potential customers to experience their vehicles firsthand. Energy utilities could host similar demonstrations or pilot programs to give customers the opportunity to try out new energy-efficient appliances, smart home devices, or electric vehicles.

- **Technology Sector** Beta Testing Programs: Software companies often invite users to participate in beta testing programs to provide feedback on pre-release versions of their products. Energy utilities could establish similar programs to engage customers in testing new energy management software, mobile apps, or smart grid technologies.
- **Healthcare Industry** Clinical Trials: Pharmaceutical companies conduct clinical trials to evaluate the safety and efficacy of new drugs or medical treatments. Energy utilities could design controlled experiments or pilot studies to assess the performance and benefits of innovative energy storage systems, renewable energy technologies, or demand response programs.
- **Financial Services** Fintech Incubators: Financial institutions often collaborate with fintech startups through incubator programs to develop and test new financial products or services. Energy utilities could establish similar innovation hubs or accelerator programs to support startups working on energy-related solutions and facilitate collaboration with industry experts.
- **Transportation Sector** Mobility Pilots: Cities and transportation agencies frequently launch pilot projects to test new mobility solutions, such as bike-sharing programs, autonomous shuttles, or electric buses. Energy utilities could partner with local governments and transportation providers to pilot electric vehicle charging infrastructure, microgrid systems, or renewable energy-powered transit options.
- **Manufacturing Industry** Factory Demonstrations: Manufacturing companies often host tours or demonstrations to showcase their production processes and innovative technologies. Energy utilities could organize similar events to highlight best practices in energy efficiency, renewable energy integration, or industrial automation for other businesses in their service area.

These examples demonstrate how trials, demonstrators, and pathfinders are utilized across various sectors to validate new ideas, engage stakeholders, and drive innovation. By adapting and applying similar approaches, energy utilities could innovate, not only in their business models but in the innovation process itself.

FUTURE OF ENERGY TEST AND DEMONSTRATION FACILITIES

The future for energy test and demonstration facilities is promising, with continued growth and evolution expected as the energy sector undergoes significant transformation. These facilities will continue to play a vital role in validating and integrating emerging technologies such as advanced renewables, energy storage, smart grids, electric vehicles, and hydrogen energy systems and their associated business models.

There will be an increasing emphasis on system-level integration and optimization within energy test and demonstration facilities. This includes testing the interoperability of different technologies, optimizing energy flows across multiple sectors (e.g., electricity, transportation, heating), and assessing the resilience and reliability of integrated energy systems. This will provide opportunities for new businesses, including those spanning multiple vectors for example.

An increasingly important trend will be to leverage digitalization, data analytics, and artificial intelligence (AI) to enhance testing capabilities, optimize performance, and derive actionable insights from testing and demonstration activities. This includes deploying sensors, IoT devices, and advanced modeling techniques to collect and analyze real-time data from testbeds including customers' premises. Is it reasonable to expect that exploiting digitalization and AI effectively will increase the volume of testing and enable testing to be conducted more quickly and at lower cost.

The value of this approach has already been demonstrated in facilities like Energy System Catapult's Living Lab which highlights the key role that consumer perceptions play in delivering valuable learnings to support not only technology and business model insights, but also to understand the interactions with changing policy and regulation. The Power Networks Demonstration Centre (PNDC) facility at the University of Strathclyde in Glasgow, Scotland is an established whole energy systems research, test, and demonstration environment, supporting the development and deployment of novel energy and transport technologies. Drawing these two facilities together in the Whole Energy System Accelerator (WESA) creates an even more powerful capability for innovators across the energy system as shown in Figure 3.

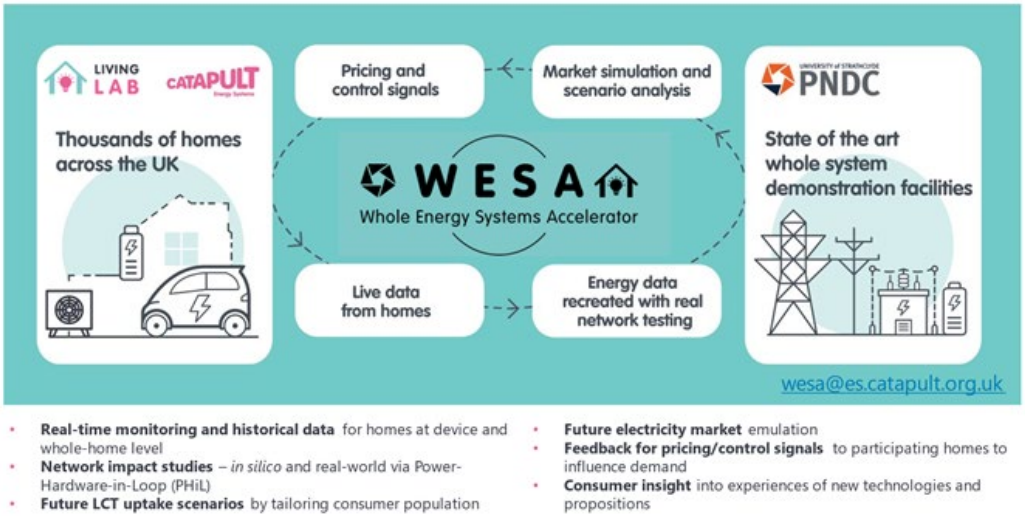

Figure 3. *WESA combines Energy System Catapult's Living Lab and PNDC capabilities in network emulation into a new facility enabling real-time simulations of future energy system scenarios, with real homes. This combination enables the modeling of the network impact of new innovations and understanding of how innovations might perform under future market conditions.*

It is expected there will also be a growing trend towards decentralized and community-based energy test and demonstration facilities, particularly where technology platforms such as microgrids, community energy projects, and distributed energy resources are involved. These facilities empower local communities to participate in energy innovation and decision-making processes.

It is also important that test and demonstration facilities seek to take a whole systems approach, and actively seek greater collaboration across sectors such as energy, transportation, buildings, water and industry to address complex challenges and unlock synergies between different technologies and systems. This includes partnering with stakeholders from adjacent sectors to explore integrated solutions and business models.

There will be increased international collaboration and knowledge sharing among energy test and demonstration facilities, facilitated by initiatives such as joint research projects, data sharing agreements, and collaborative networks. This global collaboration enables facilities to learn from each other, exchange best practices, and accelerate innovation on a global scale. One emerging initiative in the European context is the Network of Regional Energy Transition Labs (NoREST).[4]

Governments and regulatory authorities will continue to support energy test and demonstration facilities through funding, incentives, and regulatory frameworks that encourage innovation, collaboration, and investment in clean energy technologies. Clear policy signals and supportive regulations are essential for attracting private sector investment and driving innovation within these facilities.

The evolution of trial and demonstration facilities will be accompanied by new techniques for performing testing.

Innovating for testing innovation involves applying creative and strategic approaches to improve the effectiveness, efficiency, and outcomes of the testing process itself, and might include:

- **Digital twins allow** energy utilities to create virtual replicas of physical assets, such as power plants, grids, or buildings. By simulating various scenarios and testing new solutions in a virtual environment, utilities can optimize their operations, identify potential risks, and accelerate the deployment of innovative technologies and associated business models with greater confidence and efficiency.
- **Advanced analytics techniques**, including machine learning algorithms, enable utilities to analyze vast amounts of data from sensors, meters, and other sources to optimize grid performance and business models. By leveraging these insights, utilities can make informed decisions, detect anomalies, and proactively

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address emerging challenges, leading to faster and more efficient solution delivery.

- **Collaborative platforms and ecosystems** bring together utilities, technology providers, regulators, and other stakeholders to co-create, test, and scale innovative solutions. By fostering collaboration, knowledge sharing, and resource pooling, utilities can access expertise, leverage economies of scale, and accelerate the development and deployment of transformative technologies and business models.
- **Agile development and rapid prototyping** enable utilities to iteratively design, test, and refine new solutions in a shorter time frame. By involving end-users early in the design process, gathering feedback, and adapting to changing requirements, utilities can rapidly iterate and deliver solutions that better meet customer needs and market demands.
- **Modular and prefabricated components** enable faster deployment of energy infrastructure, such as solar panels, battery storage systems, or microgrids, in test environments. This helps reduce costs and quickly scale up small trials to be demonstration capable.
- **Integrated hardware-software solutions** combine hardware components, such as sensors, actuators, and controllers, with software platforms for data analytics, automation, and control. By integrating these technologies in testing environments, utilities can more easily tailor their evaluation programs to gain insights more quickly and effectively.

By embracing these innovations in trials, demonstrators, and pathfinders, energy utilities can enhance their agility, efficiency, and effectiveness in delivering solutions that address evolving energy challenges and opportunities.

WHO SHOULD PAY FOR AN ENERGY TEST AND DEMONSTRATION FACILITY?

The promising future of test and demonstration facilities is highly contingent on the availability of funding, both public and private. This will come from various sources, depending on factors such as the facility's objectives, ownership structure, operating model, and stakeholders involved:

- **Governments** at the local, regional, or national level often provide funding for energy test and demonstration facilities as part of their mandates to support research, innovation, and technology development in the energy sector. Funding may come from government budgets, grants, or research funding programs.
- **Private sector companies**, particularly energy technology developers, equipment manufacturers, or energy service providers, may contribute funding to energy test and demonstration facilities to validate and showcase their products, solutions, or services. Companies may invest in facility infrastructure, research projects, or collaborative programs that align with their strategic objectives and market interests.
- **Research institutions, universities and academic consortia** may provide funding for energy test and demonstration facilities as part of their research and education missions. These organizations may allocate resources from research grants, endowments, or institutional budgets to support facility operations, equipment purchases, or collaborative research initiatives.
- **Public-private partnerships (PPPs)** involve collaboration between government entities and private sector companies to finance, own, operate, or fund energy test and demonstration facilities. PPPs leverage public funding or infrastructure assets with private sector expertise, innovation, and investment to achieve shared objectives and maximize the impact of facility activities.
- **Industry consortia, trade associations, or industry-funded research** organizations may pool resources from member companies to support the establishment and operation of energy test and demonstration facilities. Consortia funding may come from membership dues, industry contributions, or collaborative research initiatives that address common industry challenges.
- **Philanthropic organizations, charitable trusts, or foundations** may provide grants or donations to support energy test and demonstration facilities that align with their philanthropic missions and priorities. Funding from philanthropic sources can help bridge funding gaps, support specific research projects, or advance social and environmental goals related to energy innovation.
- **International organizations, multilateral development banks, and bilateral aid agencies** may provide funding or technical assistance to support energy test and demonstration facilities in developing countries or regions. International collaboration and funding partnerships can leverage global expertise, resources, and best practices to address energy challenges on a broader scale.

- Energy test and demonstration facilities may generate revenue through **fee-based services, consulting fees, event hosting, sponsorship opportunities, or commercialization of research outcomes**. User fees charged to industry partners, startups, researchers, or other clients can help offset operating costs and contribute to the financial sustainability of the facility.

In summary, funding for an energy test and demonstration facility often comes from a combination of government support, private sector investment, academic resources, industry collaboration, philanthropic contributions, and user fees. By leveraging diverse funding sources and partnerships, energy test and demonstration facilities can maximize their impact and achieve long-term sustainability.

CONCLUSION

Trials, demonstrators, and pathfinders play a crucial role in accelerating the adoption and commercialization of energy system innovations by testing new technologies and business models in realistic, representative operational environments. They provide the opportunity to validate the performance and functionality of energy system innovations under real-world conditions. By deploying technologies or implementing new business models in actual market environments, stakeholders can assess how well they perform in terms of reliability, efficiency, scalability, and interoperability.

This approach allows for direct engagement with end-users, customers, and stakeholders, enabling feedback and insights on the usability, acceptability, and user experience. This feedback is valuable for refining and optimizing the design, features, and functionalities of the innovations to better meet user needs and preferences. The approach can also help utilities validate the market potential and demand for innovations by gauging interest, adoption rates, and willingness to pay among target customers and market segments. Demonstrating the value proposition and benefits of innovations in real-world contexts can attract investors, customers, and partners, and accelerate market penetration.

Well-structured testing provides a vital opportunity to identify and mitigate risks associated with energy system innovations early in the development process. By testing different scenarios, assessing performance metrics, and analyzing outcomes, stakeholders can gain valuable insights into potential challenges, barriers, and opportunities, allowing for course correction and iterative improvement.

Testing innovations within the applicable regulatory framework and demonstrating adherence to safety, environmental, and legal requirements, stakeholders can build trust and confidence among regulators, policymakers, and the public. Such testing also can provide insight into needed or desirable policy or regulatory changes.

Trials, demonstrators, and pathfinders serve as critical catalysts for advancing energy system innovation, driving commercialization, and accelerating the transition to a more sustainable, resilient, and efficient energy future. They provide a bridge between R&D and deployment, helping to bridge the gap between theory and practice and unlock the full potential of energy system transformation.

About EPRI

Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe. Together, we are shaping the future of energy.

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