SEPA snapshots

2024 SEPA Snapshots Series
EMERGING TECHNOLOGY

Smart Electric Power Alliance

Introduction

The 2024 SEPA Snapshots Series presents a series of focused, stand-alone chapters (Snapshots) aligned with SEPA's six focus areas: resilience, transportation, energy storage, emerging technology, policy, and energy equity. Each Snapshot offers a unique perspective on these critical topics within the energy industry. The series draws on insights from two key surveys—one targeting utilities and the other capturing input from broader energy industry participants—as well as project nominations for the 2024 Power Player Awards. With response rates varying across chapters, each section highlights findings and trends. Whether exploring a single Snapshot or engaging with the series as a whole, SEPA Snapshots delivers a versatile and insightful resource built on data-driven perspectives about how a diverse group of stakeholders is thinking about and acting on issues at the heart of the clean energy transition in 2024.

The Critical Role of Emerging Technology

Emerging technologies are critical to supporting the U.S. electric power sector's transition to a clean energy future. However, concerns about risks and limited awareness about the capabilities of newer technologies often delay adoption.

To inform this Emerging Technology Snapshot, a total of 148 respondents from 137 unique organizations across the clean energy industry shared insights on emerging technologies.[1] The Snapshots addendum provides detailed information about the respondents and SEPA's data collection methods.

2024 Emerging Technologies & Adoption Rates

Surveyed organizations listed their top emerging clean energy technologies in 2024 as:

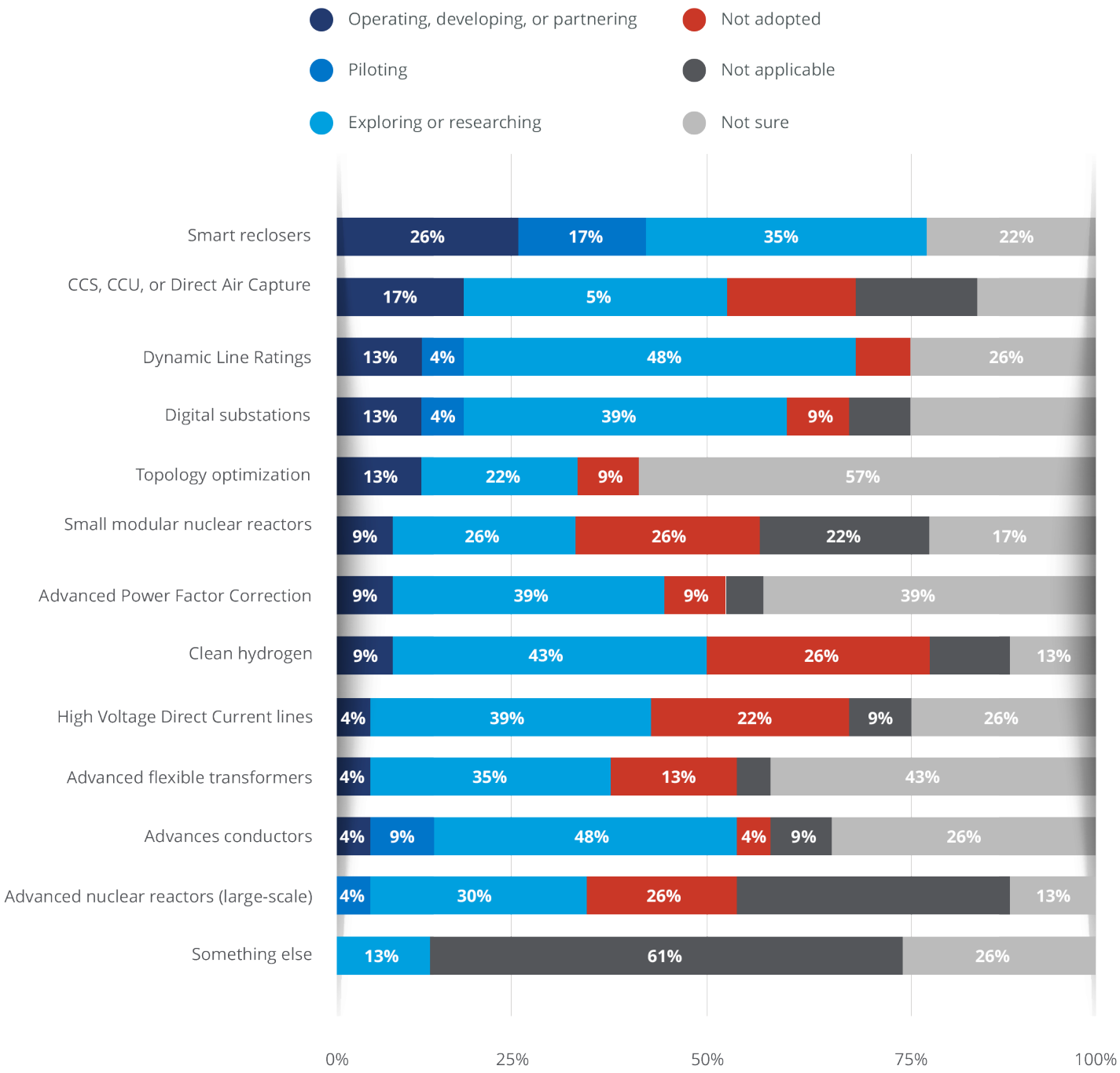
- Advanced or long-duration energy storage technologies
- Green hydrogen
- Virtual Power Plants (VPPs)
- Distributed energy resource management systems (DERMS)
- Artificial Intelligence (AI) applications
- Advanced nuclear power

Respondents expect that these technologies will play important roles in transforming the energy landscape by enhancing grid resilience, efficiency, and flexibility while supporting the broader goal of achieving a carbon-free future.

Surveyed utilities have different adoption rates for these and other technologies, but, in general, in 2024 implementation rates are low overall (Figure 1). Given that some of these technologies are not yet commercially available, slower adoption makes sense. Many respondent utilities were in the "research" phase for other technologies, including smart reclosers, dynamic line rating (DLR), digital substations, and carbon capture and storage (CCS). Respondents are also exploring novel technologies like advanced nuclear reactions and clean hydrogen. Utilities also are keenly exploring a broad range of technologies to enhance grid flexibility and resilience based on the survey results.

1 Individual sample sizes from the various audiences and data collection activities will vary in the results sections below.

Figure 1. Utility adoption of emerging technologies (n=23*)

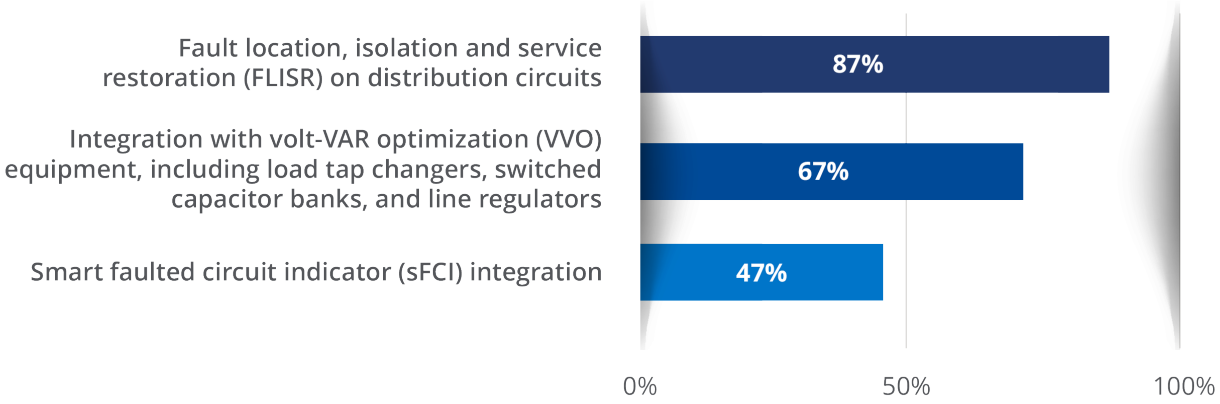


*The results presented should be considered directional rather than statistically significant, due to the sample size.

Advanced Distribution Management Systems

Among the 23 utilities surveyed, 43% are operating, developing, or partnering on an Advanced Distribution Management System (ADMS) project, with 39% are exploring or researching potential implementation, and 9% are piloting systems. The most common ADMS capability is Fault Location, Isolation, and Service Restoration (FLISR) on distribution circuits. Of utility respondents, 87% reported implementing or exploring this technology (Figure 2). Integration with Volt-VAR optimization (VVO) equipment—including load tap changers, switched capacitor banks, and line regulators—follows, with 67% of respondents planning to adopt these systems..

Figure 2. ADMS capabilities (n=15*)



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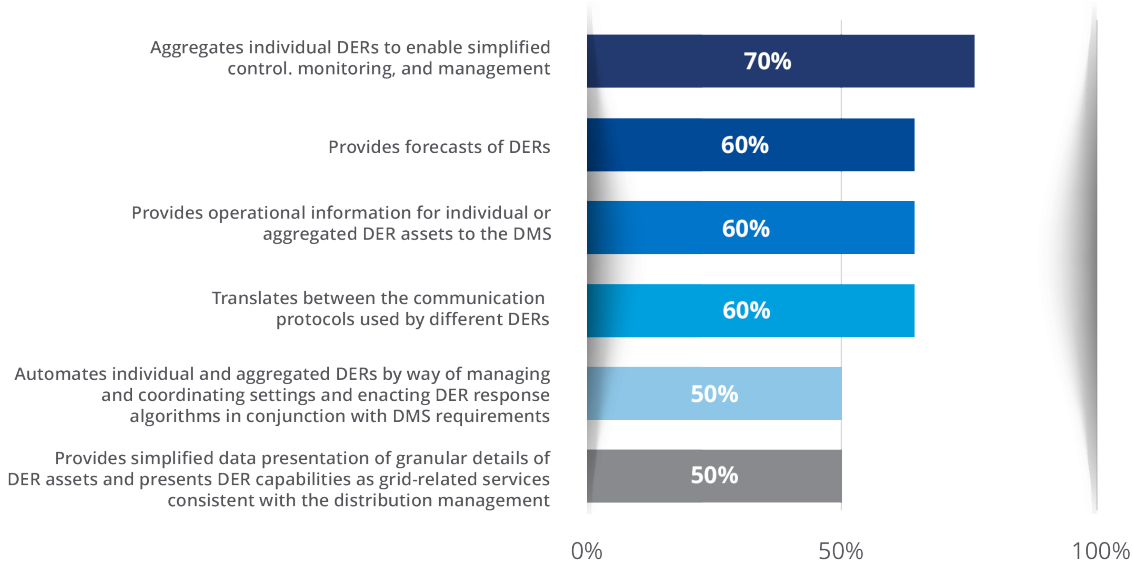
Eight surveyed businesses (14%) reported providing ADMS solutions to utilities. Other offered technology solutions focus on optimizing energy cost management and real-time load forecasting. Additionally, these companies provide innovative tools, such as automated design systems for electrified transportation and control enclosures for solar PV sites, with a strong focus on integration and cybersecurity to improve system reliability and security.

Distributed Energy Resource Management Systems

Distributed energy resource management systems (DERMS)—software platforms that manage energy flow from distributed resources—are increasingly of interest to utilities. Among utilities surveyed, 30% have fully implemented a DERMS, 9% are piloting, and 61% are exploring these systems or are planning to do so. And, 70% of utility respondents plan to use DERMS to aggregate individual DERs for simplified control and management. Other key capabilities highlighted by respondents include providing forecasts, operational information, and translating communication protocols. Additionally, half of the utility respondents plan to automate DER coordination and simplify data presentation. This highlights utilities' focus on improving DER management and integration.

Figure 3. DERMS capabilities (n=10*)



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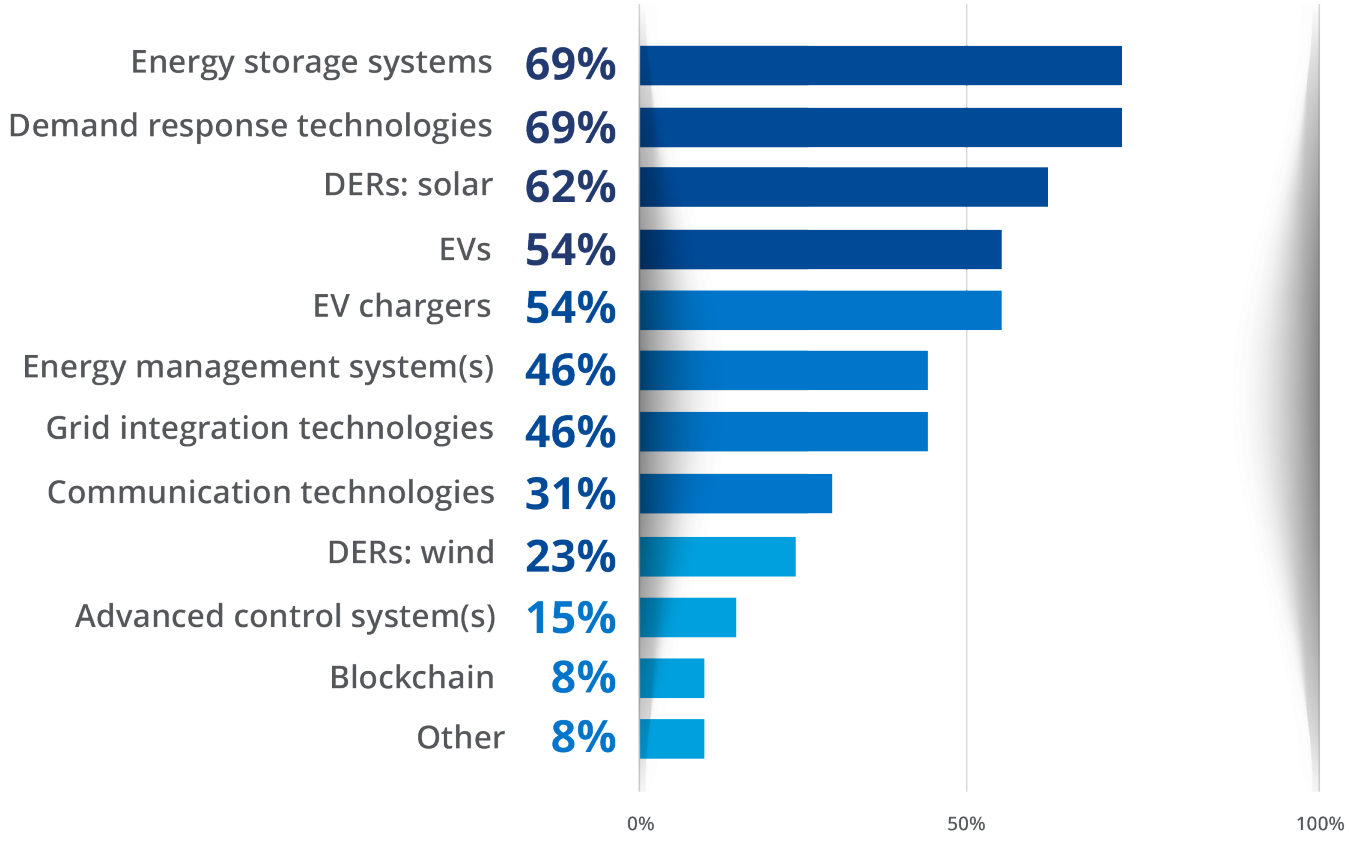
Virtual Power Plants

Virtual power plants (VPPs) are aggregations of DERs such as solar PV, batteries, EVs, and commercial and industrial loads that can provide energy and grid services similar to a traditional power plant. VPPs can be orchestrated to help manage energy supply and demand, optimize grid stability, and reduce the need for traditional, centralized power plants. Twenty-two percent of surveyed utilities (Figure 4) are implementing or partnering on VPPs and 57% are actively exploring or researching these solutions.

For the 13 utilities reporting current adoption of or planning for VPPs, these aggregations most commonly include energy storage systems and other demand response (DR) technologies. Almost two-thirds also incorporate distributed solar, while roughly half reported EVs and EV chargers. Less common VPP technologies include distributed wind, advanced control systems, and blockchain.

Figure 4. VPP technologies (n=13*)



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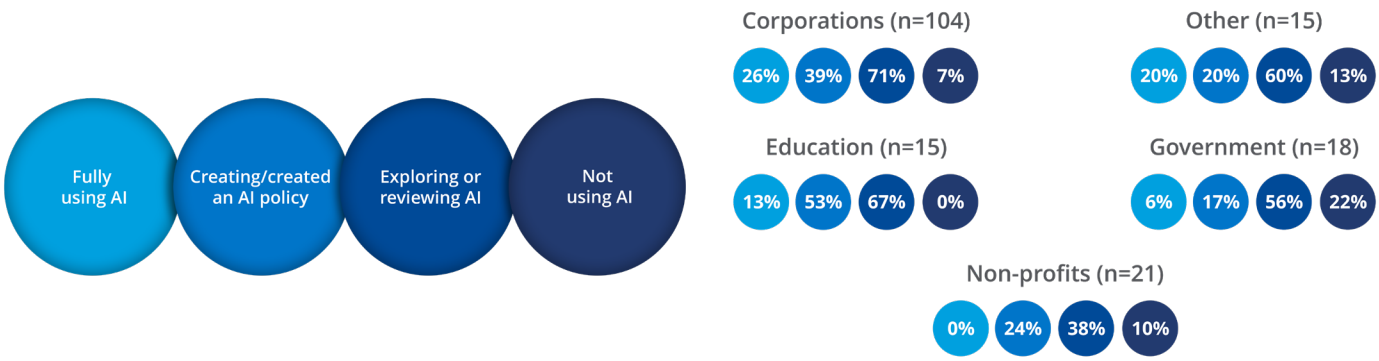
Artificial Intelligence

Based on the Snapshots survey, respondents are either very interested or have begun integrating artificial intelligence (AI) and machine learning (ML) applications into their operations, though the extent of adoption varies. Utilities, for example, are taking measured steps to incorporate AI into load forecasting, regulatory process efficiency, and optimizing grid management. Utilities are leveraging AI for operational efficiency gains, predictive maintenance, and enhanced system reliability through advanced technologies such as FLISR. Many surveyed utilities are concerned about cybersecurity related to AI deployment, including potential cyber threats that could disrupt grid operations.

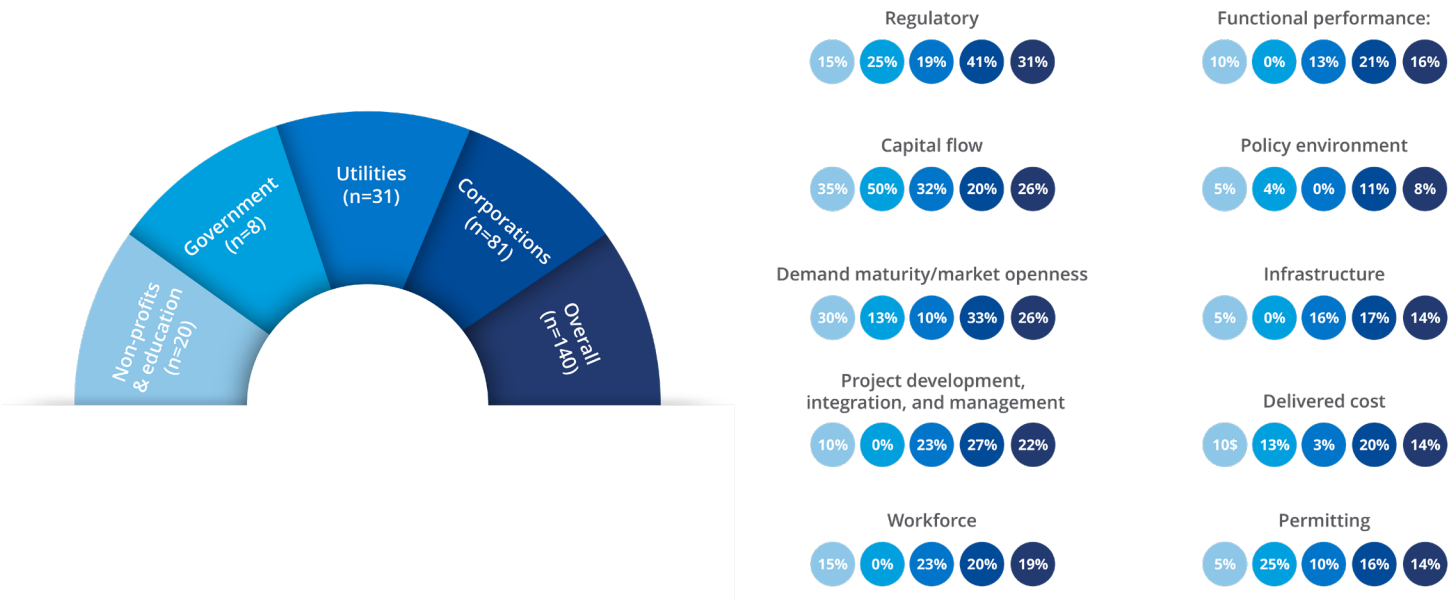
Figure 5. AI adoption among surveyed organizations (n=173)



Challenges & Barriers to Emerging Technology Deployment

Regulatory challenges are the most significant barrier to adopting and advancing new and emerging technologies across sectors (Figure 6). Responding businesses stated this as the most common barrier, at 41%. Access to capital is the second-largest barrier, particularly for government agencies (50%), and for utilities (32%), while it is less of a concern for businesses (20%). The market's maturity is another prominent challenge, affecting 26% of organizations across sectors. Additional barriers include project development, integration, management difficulties, workforce constraints, and concerns about the functional performance of new technologies.

Figure 6. Barriers to advancing or adopting emerging technologies (n=140)



These findings suggest that while organizations are interested in supporting the adoption and deployment of new technologies, regulatory frameworks, financial resources, and technological maturity are critical hurdles slowing their progress. The challenges related to project execution, workforce capabilities, and performance reliability further highlight the complexities organizations face in embracing emerging innovations. Overcoming these barriers will be key to accelerating the widespread acceptance and adoption of new technologies in various sectors.

Supporting Emerging Technologies & Moving the Industry Forward

Emerging technologies are critical to meeting increasingly ambitious clean energy goals. Access to new research and innovation, regulatory support, and efforts to mitigate cybersecurity concerns can allow us to scale emerging technologies. The path to a clean energy future depends on the successful adoption of emerging technologies like advanced storage solutions, AI, and virtual power plants. By fostering innovation, building supportive frameworks, and collaborating across sectors, we can drive the integration of these transformative solutions. Dive into SEPA's emerging technologies research to uncover more insights, best practices, and strategies to advance the technologies that will shape a sustainable and resilient energy landscape. Together, we can accelerate the adoption of transformative technologies and build a cleaner, more resilient energy future.

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For more information on Emerging Technology projects, initiatives, and partners please visit:

sepapower.org/our-focus/emerging-technology

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