EPRI

TECHNOLOGY INNOVATION

INSIGHTS AND INNOVATIONS

SECOND QUARTER, 2023

EPRI Technology Innovation (TI) *delivers strategic insights, serves as a global innovation hub, and drives early-stage R&D.* ***Insights and Innovations****, published quarterly, highlights TI products and webcasts to help transfer knowledge, new technology, practical guidance, and other results to EPRI members and additional stakeholders. The icons below identify TI resources by functional role, strategic research gap, and crosscutting technology area. Many resources are publicly available for free using the links provided.* All published TI resources are available for no-cost download by EPRI members after logging in to EPRI.com; webcasts are accessible on demand. Active interest groups are featured on p. 2.*

FUNCTIONAL ROLES

STRATEGIC RESEARCH GAPS

CROSSCUTTING TECHNICAL AREAS

**Resources marked with $ are publicly available for purchase. See p. 16.*

Strategic Response to Supply Chain Issues

A new 20-page brochure reviews the full scope of EPRI's supply chain R&D portfolio. The top 3 TI products listed below exemplify EPRI R&D in support of supply chain resilience across the energy sector: The reindustrialization white paper explores factors driving the siting of new factories and additional large "point loads" with potentially disruptive impacts on localized grids (see interactive summary for highlights). The April 2023 EPRI Insights introduces supply chain challenges, including workforce needs, for at-scale deployment of clean energy technologies and low-carbon fuels (see interactive summary for highlights). EPRI's equity guidebook identifies workforce development and job creation as opportunities for supporting underrepresented and marginalized communities (see the 2022 utility workforce study to review industry needs through 2050).

Highlighted Resources: Q2 2023

Reindustrialization, Decarbonization, and Prospects for Demand Growth (3002027930)
Industrial load growth trends and grid planning challenges

EPRI Insights—Supply Chain Considerations for the Energy Transition, April 2023 (3002026636)
Challenges, risks, and insights for meeting decarbonization goals

Equity and Environmental Justice Aspects Across the Energy System (3002027134)
Guidance for understanding issues and engaging communities

Space Solar Power for Global Decarbonization (3002027739)
Status and potential of satellite-based solar for terrestrial grids

EPRI Insights: Horizon Europe, July 2023 (3002027779)
Updates on EU R&D goals and engagement by EPRI Europe

Digital Transformation Maturity Model (3002027521)
New tool for digitization planning and implementation

OPPORTUNITIES FOR ENGAGEMENT

As a global innovation hub, TI supports collaborative interest groups that regularly convene for virtual information exchange and discussion. Typical webcasts feature domain experts, utility practitioners, and facilitated dialogues among participants. EPRI's Fusion Forum is free and open to public participation. Additional groups listed below are open only to employees of EPRI member organizations and at no additional cost.

Additional Resources

This quarterly newsletter facilitates access to TI products and webcasts. To get fresh insights, updates, and perspectives, check EPRI's ***Thought Leadership page***, listen to ***EPRI Current*** podcasts, sign up for TI's ***monthly newsletter***, join the ***EPRI Direct*** mailing list, and visit the ***online EPRI Journal.***

- **24/7 Carbon-free Energy Interest Group**
  Explores the development and implementation of load-matched carbon-free energy products for utility customers.
- **Digital Transformation Interest Group**
  Addresses the strategic and tactical aspects of enterprise-wide digitization, supporting beneficial technology implementations.
- **Fusion Forum**
  Explores the current state of fusion energy technology, reviews R&D activities and commercialization needs, and builds community among developers and end users.
- **Geothermal Energy Interest Group**
  Explores currently available technologies, future options, and their potential contributions to decarbonization goals.
- **Offshore Wind Interest Group**
  Explores offshore wind technologies and project development, interconnection, and grid integration issues and experiences.
- **Utility Business Model Working Group**
  Examines innovations for new utility business constructs and for integrating advanced technology into utility planning and operational processes.
- **Value of Resilience Interest Group**
  Explores tools for assessing customer-focused utility resilience needs and informing societal choices and investment decisions.

For program and registration information visit **electrification2024.com**.

CLEAN ENERGY

2023 TI Clean Energy Technologies Strategic Research Gap Portfolio Overview (June 06 Webcast; July 24 Webcast)

Q2 2023 The June webcast, led by EPRI's **Neva Espinoza,** introduces TI's Clean Energy Technologies Strategic Research Gap Portfolio, which focuses on offshore wind, advanced nuclear, long-duration energy storage, low-carbon fuels, and emerging technologies and applications. Featured presentations address TI projects on net-zero industrial clusters, redevelopment of existing power plant sites, fusion technology, and back-end fuel cycle management for advanced reactors. During the July webcast, EPRI domain experts highlight offshore wind turbine technology and grid integration R&D, long-duration storage technology scouting and assessment programs, and the Low-Carbon Resources Initiative and Low-Carbon Hydrogen Accelerator Program.

2023 Generation TI Portfolio Overview (April 19 Webcast)

Q2 2023 This webcast reviews R&D progress and next steps under the Generation TI strategy implemented in 2022, which focuses on building internal competencies and conducting 3-year programs in the areas of renewable energy materials, environmental aspects, water and land management, digital transformation, and carbon capture and storage implementation. Led by EPRI's **John Shingledecker,** the presentation highlights completed projects, new capabilities, ongoing R&D, active external collaborations, and planned outcomes in each of these TI program areas.

2023 Nuclear TI Portfolio Overview (April 25 Webcast)

Q2 2023 This webcast discusses the evolution of the Nuclear TI Portfolio over the past decade, illustrating how purposeful stakeholder engagement and targeted R&D have enabled EPRI to launch a substantial base-funded advanced reactor program and then highlighting specific 2022-23 projects. Led by EPRI's **Jeremy Renshaw,** the presentation includes R&D updates in the areas of digital transformation, AI-assisted ultrasonic testing, advanced reactor materials, automated diagnostics, fusion technology, advanced manufacturing, and use of reference signatures for hardware-based security.

EPRI Fusion Forum (April 19 Webcast; February 22 Webcast; June 21 Webcast)

Q2 2023 This forum brings together stakeholders from across the fusion community. The June 21 webcast, which explored fusion plant siting issues and opportunities, included talks by **Andrew Sowder,** EPRI; **Mark Denton,** Orano Federal Services; **Kevin Shoemaker,** Southern Ohio Diversification Initiative; and **Stephanie Howe,** Ohio University. The April webcast included a look at applications other than electric power generation by EPRI's **Jeremy Shook**, including grid support, hydrogen production, water supply, district heating, and industrial processing. **Kieran Fulton** of Realta Fusion provided focused perspective on fusion energy for industrial heat and power. The February 22 webcast featured presentations on fusion policy and regulation by **Mike O'Neil** and **Tim Peckinpaugh** of K&L Gates and on ongoing R&D at the EDF Innovation Lab by **Adam Levey** of EDF.

Space Solar Power for Global Decarbonization (3002027739)

Q2 2023 Unconventional technologies are needed to achieve worldwide decarbonization goals while meeting growing demand for affordable, reliable, secure, and resilient energy. This 2-page brief explores the status and potential of satellite-based solar power as a baseload generation option for terrestrial electricity grids. Key technology elements include PV modules designed for electricity generation in space, electricity-to-microwave converters, long-distance microwave power beaming, and large-area receiving antennas at the Earth's surface.

EPRI Insight: Horizon Europe, July 2023 (3002027779)

Q2 2023 This *EPRI Insights* begins with an introduction to Horizon Europe, the 9th in a series of major European Union (EU) research and innovation funding programs, covering 2021-27. The

21-page brief features updates on ongoing and new Horizon Europe projects involving EPRI Europe (EEU), an innovation hub centered in Ireland and engaging technical staff and utility collaborators in multiple EU states. EEU is an active contributor and project leader in areas such as distributed energy resource (DER) integration, localized energy community design and operation, interoperability testing, offshore wind turbine loading, and PV module recycling.

EPRI Insights—Supply Chain Considerations for the Energy Transition, April 2023 (3002026636)

Q2 2023 Building on a previously published review (3002023228), this 10-page *EPRI Insights* introduces supply chain challenges and risk management considerations associated with the transformation and decarbonization of US and global energy systems. Focus areas include raw materials requirements and manufacturing capacity for existing power generation and battery options; materials and manufacturing methods for future advanced technologies; and integration of environmental, social, and governance objectives in the sourcing of materials and products.

Incubatenergy Labs "Lunch & Learn" Series: Urban Electric Power (May 17 Webcast)

Q2 2023 This webcast features an update from Urban Electric Power, a 2021 Incubatenergy Labs participant focused on development of zinc manganese dioxide batteries. The company is working with EPRI and others on long-duration energy storage applications.

Energy Storage Tech Brief: RCAM Technologies (3002026994)

Q2 2023 RCAM Technologies, an energy storage company based in Boulder, Colorado, is developing a marine pumped hydro system for long-duration AC-to-AC electricity storage. The technology, introduced in this 4-page tech brief, uses a pump/turbine system to exchange ocean water with spherical concrete vessels located on the seabed. Vessels are fabricated using 3-D concrete printing technology, and the charge-discharge process exploits immense pressures at the bottom of the ocean. $

Energy Storage Testing Update: AquaNamic (3002027028)

Q2 2023 The Danish company AquaNamic, founded in 2018, is developing a novel flat-terrain pumped hydro storage system designed for expanding the geographic applicability of this proven AC-to-AC electricity storage option. This 6-page tech brief introduces the technology, which stores water under pressure in inflatable membranes concealed beneath mounds of soil and connected to an open reservoir. Water is moved between the membrane-based upper reservoir and the open lower reservoir by a pump/turbine system, providing AC storage with an expected round-trip efficiency of 75%. $

Hydrogen-Capable Gas Turbines for Deep Decarbonization (3002017544)

Q2 2023 This 7-page brief discusses progress in the development, demonstration, and commercialization of low-NOx combustion turbines capable of operating on hydrogen and other low-carbon fuels. These turbines could enable natural gas assets and infrastructure to be leveraged as a resource for decarbonization within the integrated energy network.

Current Global Barriers to the Deployment of Carbon Capture, Storage, and Utilization (CCUS) (3002027339)

Q2 2023 This 6-page *Quick Insights* discusses needs and methods for CCUS at fossil power generation and other carbon-intensive facilities, as well as for direct air capture. Current technology status, existing and near-term applications, and challenges and opportunities for future deployment are reviewed.

Technology Insights Brief: National Ignition Facility Reaches Net Energy Gain in Fusion Reaction (3002026196)

Q1 2023 On December 5, 2022, an experiment conducted at the National Ignition Facility managed by Lawrence Livermore National Laboratory yielded the first demonstration of a net energy gain in a fusion reaction. This 2-page brief characterizes the significance of this milestone in proving the scientific validity of inertial confinement fusion as a possible future source of zero-carbon energy, as well as describes the significant challenges ahead for this and other fusion technologies.

Technology Update: 24/7 Carbon-Free Energy (CFE): Matching Procurement to Hourly Electric Load (February 28 Webcast)

Q1 2023 During this webcast, EPRI's **Adam Diamant** highlighted key insights from a 2022 white paper (3002025290), which describes growing interest in procuring and supplying CFE 24 hours a day, 7 days per week and highlights opportunities and challenges facing electric companies considering development of products and services to meet this emerging need. In addition, **Craig Zamuda,** senior advisor for sustainability and climate at US Department of Energy (DOE), discussed the Biden Administration's CFE policy and plans, current utility engagement, and the need for expanded engagement.

Repowering Coal-Fired Power Plants for Natural Gas and Hydrogen-Fired Generation (3002025894)

Q1 2023 Repowering existing coal-fired plants with highly efficient combined-cycle gas plants that also have the capability to cofire an increasing percentage of hydrogen fuel offers several potential advantages. These include reducing onsite carbon and pollutant emissions immediately, achieving greater reductions over time, reusing existing site infrastructure and equipment, and leveraging existing permits, including for water withdrawals. This 18-page white paper summarizes key issues to consider and understand when evaluating such a repowering project.

Repowering Coal-Fired Power Plants for Hydrogen Production with Electrolysis (3002025895)

Q1 2023 This 20-page white paper summarizes key issues in evaluating the repurposing of a retiring coal-fired plant for hydrogen production using electrolyzers that also serve to balance intermittent renewable generation. The large area and relative remoteness typical of most coal plants are advantages, and repurposing offers potential to leverage site infrastructure, operating and environmental permits, and equipment and facilities, including for water access, supply and storage, and treatment. Grid interconnections require reconfiguration as the site transforms from a generator to a load.

ELECTRIFICATION & END USE

2023 Electrification and Sustainable Energy Strategy TI Portfolio Overview (June 15 Webcast)

Q2 2023 This webcast, led by EPRI's **Watson Collins**, provides a deep dive on ongoing TI projects seeking to accelerate EV adoption and charging infrastructure development, mitigate the impact of industrial refrigerants on climate, improve process efficiency in the pulp and paper industry, and develop the "Area of Vulnerability" power quality analysis tool. In addition, 2023 TI projects are introduced, several of which address equity, worker health and safety, and infrastructure for building and transport electrification.

2023 TI Electrification/End-Use Carbon Reduction Strategic Research Gap Portfolio Overview (June 7 Webcast)

Q2 2023 Presented by EPRI's **David Porter,** this webcast introduces two sample projects from each of four TI focus areas: industry (industrial heat pumps for steam production; controlled environment agriculture); transportation (GridFAST℠ tool for fleet operators and charging/fuel providers; state transport

electrification roadmaps); buildings (heat pump window units; retrofit window insulation) and customers (pricing innovation; valuing affordability, reliability, equity, and other measures). Increasing R&D emphasis on equity also is highlighted.

Flexible Control Strategies for Plug Loads to Mitigate Electricity Waste and Support Demand Response: Advancing Savings Strategies for Plug Loads (3002026411)

Q2 2023 This 114-page report describes R&D quantifying potential for energy and demand reduction from plug loads in commercial office buildings and laboratories. Smart outlet automation innovations were designed and tested on common-area appliances, chargers for mobile devices, and specialized equipment. Efficiency gains in real-world buildings depended upon device type and user setting with energy savings ranging from about 10 to 18% and demand reduction of 22% for one specific event. The report also provides recommendations for overcoming split incentives and other barriers to market acceptance.

Power and Presence Heatmap: Visualization Tool Demonstration (3002024751)

Q2 2023 EPRI's Power and Presence Heatmap Visualization Tool, designed to identify opportunities for plug-load energy and demand savings in commercial buildings, was extended in 2022 to integrate smart breakers for EV charging stations. This video reviews the tool's architecture and focuses on a demonstration for establishing a spatial and quantitative view of user presence alongside plug-load power consumption at EPRI's office building in Knoxville, Tennessee. The video highlights features, including defining zones for data visualization and download, identifying usage and presence patterns, and spatially monitoring power usage, aggregated presence, and energy-saving strategies. **$**

Development and Testing of an Energy-Efficient Ultra-Low-Charge Ammonia Refrigeration System in a Food Processing Plant: CEC EPC-16-048 Award (3002027734)

Q2 2023 This 132-page report documents development and performance testing of an air-cooled ammonia chiller for industrial applications. Field evaluation demonstrated its potential to reduce the needed charge of refrigerant, eliminate leakage at one of the most vulnerable points in the system, and thereby reduce regulatory barriers to use of zero-global-warming-potential ammonia refrigerant at industrial sites. The system also provided up to 40% efficiency improvement over a conventional water-cooled hydrofluorocarbon chiller at the same site. In addition, the innovative air-cooled chiller saved 3.38 gallons of water per kWh of electricity consumed.

Quick Insights: Charging Loads and Infrastructure Requirements for Electrification of Long-Haul Heavy-Duty Trucking (3002026104)

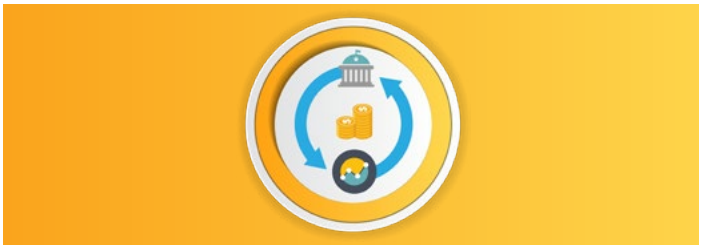
Q1 2023 This 8-page *Quick Insights* explores the grid and decarbonization implications of electrifying the most-energy-intensive over-the-road vehicles—combination long-haul heavy-duty trucks. Charging loads and infrastructure requirements are estimated based on real-world driver safety requirements and business goals, highway driving conditions, and requirements for en-route fast charging and post-workday recharging. Today's batteries can meet daily distance objectives. High-power charging stations—involving new service of more than 10 MW initially and up to 50 MW eventually—will be required to support significant penetration of long-haul electric trucking.

EPRI Highlights from the 2023 CES Convention (3002026149)

Q1 2023 A multidisciplinary team of EPRI experts attended the CES 2023 conference in Las Vegas on January 5–7, 2023 to apply an electric sector lens to innovations promoted by 3500 official exhibitors and many others. Products spanned the broad range of consumer applications, exploiting the latest advances in technology for individual, residential, commercial, and industrial uses. This 18-page brief provides a snapshot of innovations in areas such as worker performance and protection, sensing, robotics, machine vision, solar, battery, hydrogen, EV charging, communications, connectivity, and grid interactivity.

Incubatenergy® Labs (IEL) Lunch & Learn: WexEnergy (January 25 Webcast)

Q1 2023 A member of the IEL 2021 cohort, WexEnergy focuses on delivering easy and effective energy efficiency improvements using interior-mounted window retrofit kits. This webcast, introduced by EPRI's **David Lindsey**, features **Rachel Rosen** and **Ron Wexler** of WexEnergy talking about the company's progress since the IEL project, which included the first field installation of the SolarSkins™ product, designed to reduce air leakage year-round and solar gain during the cooling season.



MARKET TRANSFORMATION

2023 TI Market Transformation Strategic Research Gap Portfolio Overview (May 18 Webcast)

Q2 2023 EPRI's **Erik Ela** introduces key knowledge and capability gaps relating to the alignment of wholesale and retail markets, prices, and policies with environmental, decarbonization, renewable energy, reliability, and resilience goals. The webcast highlights ongoing research, outreach, and coordination activities supporting progress toward a "shared energy economy" vision. In addition, recent, ongoing, and planned 2023-24 activities in electricity market design and operations are described.

Estimating the Benefits of Cost-Reflective Pricing: Australia Case Study (3002025690)

Q2 2023 This 11-page tech brief describes an approach for estimating how accelerated adoption of cost-reflective electricity pricing and supporting technologies can—as enablers of load flexibility—deliver benefits to consumers, electricity providers, and society. It draws from an EPRI case study estimating the economic benefits for Australia associated with adoption of cost-reflective pricing tariffs and non-tariff incentives for end-use technologies and controllers that together allow customers to alter behavior and automate usage patterns in accordance with pre-specified parameters of comfort and economy. $

Reindustrialization, Decarbonization, and Prospects for Demand Growth (3002027930)

Q2 2023 This 21-page white paper estimates the electricity consumption of recently announced new or expanded US manufacturing facilities in selected sectors where onshoring is occurring to provide early perspective on demand growth driven by reindustrialization and to highlight the potential for new, large loads—referred to as point loads—that will need to be accommodated by the grid at specific locations. It also discusses the longer-term outlook for industrial demand in a decarbonizing economy, leveraging EPRI's recent Net-Zero 2050 modeling analysis.

The Impact of Industrial Onshoring on Electric Sector Demand Growth (3002027780)

Q2 2023 This 2-page brief, prepared to preview the study reported above, highlights developments, trends, and data suggesting that the US economy appears to be experiencing a revitalized manufacturing sector driven by the pandemic, conflict in Europe, disruptions in supply chains and energy markets, and policy responses. It also explores the potential impacts of industrial onshoring on electricity demand and regional load growth, alone and in combination with decarbonization and other drivers.

EPRI Inflation Reduction Act (IRA) Interest Group (January 19 Webcast; February 27 Webcast; March 27 Webcast; May 4 Webcast)

Q2 2023 The IRA Interest Group kicked off in January with an overview of the IRA and electric sector opportunities by **Carla Frisch** of DOE's Office of Policy followed by discussion involving **Shayla Manning,** DTE Energy; **Bobby Olsen,** Salt River Project, and **Clay Rikard,** Southern Company. The February webcast featured a presentation on "Equity and the IRA" by **Jessica Eckdish** of BlueGreen Alliance and panel discussion among **Tomas Green,** DOE; **Maddie Koewler,** National Association of State Energy Officials; **Liam Regan,** Guidehouse; **Kelli McCullough,** Southern Company; and **Michelle Nuttal,** Southern California Edison. The March webcast was keynoted by **Tim Ryan,** legislative assistant to Senator Chuck Schumer, discussing IRA power sector

incentives and national decarbonization goals, followed by EPRI's **John Bistine** discussing energy-economy modeling results exploring the impact of IRA provisions on technology transitions and progress toward US decarbonization targets. The May webcast featured **Keith Martin** of Norton Rose Fulbright detailing IRA provisions and incentives specific to stationary storage installations, followed by a panel discussion involving **Chico Hunter,** SRP; **Jennifer Poppler,** Duke Energy; **Carrie Bellamy,** Malta; **Gregg Noble,** KORE Power; and **Joshua Ryor,** Connecticut Public Utilities Regulatory Authority.

Utility Business Model (UBM) Working Group 2023 (February 22 webcast; April 25 webcast; June 27 webcast)

Q2 2023 The UBM Working Group, launched in October 2020, reconvened on a bimonthly basis in 2023. The February 22 session focused on the topic of "Energy as a Service" and featured an expert panel including **Andrew Dillon,** West Monroe Partners; **Sanem Sergici,** Brattle Group; **Steve Sunderhauf,** Exelon/PHI; **Brian Spak,** Consumers Energy Australia; and **Page Crahan,** Google X. The April 25 webcast, "Acquiring Business Model Transformation Management Best-Practices Knowledge," was kicked off by **Mark McGranaghan** of EPRI and **Ron Doades** of Ronald Doades & Company and included presentations on utility experiences by **Christian Arnold,** EWE Europe; **Colton Ching,** Hawaiian Electric; and **Larry Bekkedahl,** Portland General Electric. The June 27 event featured a conversation with **Peter Kelly-Detwiler** of Xcel Energy, author of "The Energy Switch - How Companies and Customers are Transforming the Electrical Grid and the Future of Power," along with an introduction to BEFLEXIBLE, a new Horizon Europe project engaging diverse stakeholders in supplying flexibility to facilitate continued integration of renewables.

Impacts of Inflationary Drivers and Updated Policies on US Decarbonization and Technology Transitions (3002026229)

Q1 2023 This 33-page white paper updates previous EPRI modeling to account for developments since the US announced goals of reducing economy-wide greenhouse gas emissions to 50% below 2005 levels by 2030 and achieving net-zero emissions by 2050. Results indicate that the core decarbonization pathways remain similar, that the rate of emission reductions must increase beyond historical trends by several times to meet 2030 targets, and that IRA and other policies could help offset some impacts of inflation and supply chain constraints on accelerated deployment of low-carbon technologies.

Global Innovation Effectiveness Project – 2022 Update (3002026252)

Q1 2023 In 2022, EPRI's Global Innovation Effectiveness Project, initiated in 2021 with a cohort of nine members, grew to include a mix of returning and new members, plus a sub-cohort of nuclear operators. This 35-page report leverages collective results of innovation effectiveness assessments performed with each member over 2 years to provide insights and practical approaches for all companies as they progress through their own innovation journeys. Recommendations for improving innovation span interviews with 200+ utility leaders, survey responses from 2000+ employees, reviews of 100+ documents, and countless conversations with and observations by innovation leaders. $

Utility Innovation Metrics: Assessing and Improving Innovation Measurement Capability (3002026253)

Q1 2023 The EPRI Global Innovation Hub (GIH) conducted a deep-dive effort in 2022, supplemented by discussions with individual utilities and roundtables with the cohort, to create tools for assisting companies in evaluating the efficacy and outcomes of their innovation programs and practices and in making strategic adjustments. This 22-page GIH report presents insights into innovation measurement challenges, a maturity framework for assessing measurement practice, and a step-by-step playbook for improving measurement capabilities. Also included are a case study detailing a pilot test of the playbook and appendices identifying useful readings and existing innovation metrics. $

Technology Update Series 2023- Utility Business Model Scenarios (January 9 Webcast)

Q1 2023 Across a landscape driven by trends such as digitization, decentralization, democratization, and decarbonization, utilities must evolve, transform, and play a leading role in accelerating the energy transition. This webcast, presented by EPRI's **Neil Hughes**

and **Eric Brown** of Grid Scientific and informed by a recent white paper (3002025745), introduces four possible future business scenarios—utilities follow, retreat, lead, and disrupt—to promote discussion and help individual companies advance their own corporate strategies.

RELIABILITY, RESILIENCE & FLEXIBILITY

2023 Integrated Grid and Energy Systems TI Portfolio Overview (July 31 Webcast)

Q2 2023 Led by EPRI's **Jeff Smith,** this webcast reviews TI projects supporting decarbonization, DER and renewables integration, reliability and resilience, grid modeling, and AI applications. Featured projects include energy planning approaches to decarbonization for developed, transitional, and developing economies; overhead costs of wholesale market access for DER participants; automated storm damage assessment; implications of capacity expansion and production cost modeling for market participants; and AI-based optimization of distribution automation control algorithms.

2023 Transmission and Distribution Infrastructure TI Portfolio Overview (May 25 Webcast)

Q2 2023 Led by EPRI's **Fabio Bologna**, this webcast reviews TI projects in the areas of interoperability and cybersecurity technology, distribution systems and the environment, and transmission and substation assets. Sample topics include DER interoperability, distributed sensor communications, grid model validation, life-cycle analysis of distribution pole materials, pollinator habitat improvement and biodiversity monitoring, robotics for insulator inspection and transmission tower painting, and rapid-response emergency transmission tower design.

Incubatenergy Labs "Lunch & Learn" Series: Switched Source (April 26 Webcast)

Q2 2023 This webcast features Switched Source, a 2020 Incubatenergy Labs participant. The company's Phase-EQ dynamic phase-balancing technology is now commercially deployed and successfully performing in the field with several more units being installed this year.

Demand Flexibility for Grid Reliability and Resilience: Planning Tool Integration of Demand Flexibility (3002025443)

Q1 2023 To support deeper integration of demand-side resources into grid planning for reliability and resilience, this 68-slide presentation proposes a framework for categorizing different types of flexible demand response (DR) behaviors. It also reviews how demand-side resources are currently being considered in the areas of capacity expansion, resource adequacy, transmission planning, and distribution planning. State-of-the-art modeling approaches are identified, and the challenges and future work needed to fully incorporate DR flexibility into grid planning are discussed. **$**

Understanding Risk Factors and Risk Management Practices related to DER-Provided Distribution Services (3002024840)

Q1 2023 This 9-page white paper provides a starting point for understanding whether wider participation of DER in delivering distribution services may require utilities to revisit or expand risk management practices. Risk factors in the planning and operational timeframes are reviewed, and potential revisions to existing contingency plans are discussed, along with liability terms for service providers. Considerations specific to community microgrids are also identified, and topical areas for additional research are reviewed. **$**

DER Management Systems Control Strategy Evaluator (3002024800)

Q1 2023 EPRI's Control Strategy Evaluator (CSE) software is used to test, evaluate, analyze, and quantify the benefits and the performance of control strategies implemented via Distributed Energy Resources Management Systems (DERMS). This 62-page

tech update describes the value and benefits of CSE v1.0, which includes the required downstream interface and the wrapping functions to host Aggregator-DERMS (ADERMS), Local-DERMS (LDERMS), Utility-DERMS (UDERMS), and/or distribution and transmission system operators. The tool uses EPRI's OpenDSS simulation software as a circuit simulator, while the upstream interface wrapper hosts the hierarchical control strategy under evaluation. **$**

ARTIFICIAL INTELLIGENCE & DATA ANALYTICS

ChatGPT and the Power Sector: What's Hype? What's Possible? (3002026468)

Q2 2023 This 4-page brief provides an initial assessment of the significance and the potential of ChatGPT, a commercially available AI-based chatbot that applies a large language model (LLM) to speed information gathering and delivery. It explores the following questions: What is it? What does it do? Why does it matter? How are others using (and not using) it? What to look out for? It also introduces EPRI's plans for reviewing LLMs, generating industry-specific use cases, and launching feasibility tests.

Artificial Intelligence for Distribution Analysis Using Advanced Metering Infrastructure Data (3002027392)

Q2 2023 This 94-page tech update presents a secondary circuit parameter estimation method to support development of secondary circuit models in cases where none exist, as well as identify issues and refine existing models. The new methods result from 3 years of exploring AI and machine learning based on AMI data for improving low-voltage secondary circuit models, meter phasing analysis, and distribution system state estimation and for identifying PV interconnection requests that may experience high curtailment due to volt-var function with var priority. The methods can support grid modernization and provide additional use cases for AMI and other emerging data sources. **$**

Incubatenergy Labs "Lunch & Learn" Series: PingThings (June 28 Webcast)

Q2 2023 This webcast provides an update from PingThings, an Incubatenergy Labs participant in 2020, working on a pilot project with Ameren, and in 2022, collaborating with Grupo Energia Bogota (GEB). Discussion focuses on the lightning-related challenges GEB was aiming to solve, how the company's PredictiveGrid platform was used to rapidly develop applications to provide a solution with greater insight and actionability, and successes and lessons learned.

Incubatenergy Labs "Lunch & Learn" Series: Pano AI (July 19 Webcast)

Q2 2023 This webcast provides an update from Pano AI, a 2021 Incubatenergy Labs participant that uses continuously rotating panoramic cameras to capture live images across broad areas and applies AI-based methods for automated smoke detection, incident location, mapping relative to utility infrastructure, fire risk assessment, and confirmation and alerting.

Visual Inspection and Surveillance Integrated Operations Network Roadmap (3002026475)

Q2 2023 This 65-page report presents an implementation roadmap for the automated Visual Inspection and Surveillance Integrated Operations Network (VISION) for nuclear power plants. It reviews current implementation, technology readiness, and gaps for reducing operations and maintenance costs, improving worker safety, and increasing security via automated, non-intrusive, area-wide monitoring and AI-based analysis of data from visual inspection, imaging systems, and acoustic, radiation, and other sensors. A plan for pilot VISION implementation is presented with focus on feasibility gaps, such as business case, leveraging existing camera networks, and cybersecurity, licensing, and union concerns. **$**

Artificial Intelligence for Energy Storage Operation: Energy Arbitrage (3002023924)

Q1 2023 This 10-page white paper explores data-driven reinforcement learning for operating energy storage to maximize revenue by buying and selling energy based on prices established through day-ahead auctions. A major advantage is that no complex forecasting models are needed. The effectiveness of a learning algorithm based on past market price signals is measured against output from DER-VET, an EPRI-developed tool offering perfect foresight optimization. In addition, results are presented from real-time AI algorithm implementation at an energy storage test facility located in Colorado.

Distributed Ledger Technologies in the Nuclear Industry: Examples of Application and Use Cases (3002025731)

Q1 2023 This 78-page report reviews viable use cases for distributed ledger technology (DLT) in the nuclear power industry. Data management is a commercial use that involves some customization for specific applications. Other promising use cases are linked to physical materials, which can have unique identifiers associating them with information that can be organized, queried, and shared. Examples include materials tracing, fuel tracking, and prevention of counterfeit and fraudulent materials or parts from entering the supply chain. DLT-based technologies for tracking nuclear plant materials and data are under development, creating opportunities for R&D collaboration. **$**

Incubatenergy® Labs Lunch & Learn: ThermoAI (February 23 Webcast)

Q1 2023 Since participating in IEL 2021, ThermoAI has partnered with the US Air Force Research Lab to develop advanced artificial intelligence (AI) models for crosschecking Internet of Things (IoT) systems. This webcast features EPRI's **Jeremy Lawrence** and ThermoAI's **Aiden Livingston** discussing how trusted AI models based on data collected from wireless IOT and other sensors can improve monitoring, diagnostics, and cyber security to enable greater levels of automation across energy and other industrial applications.

ENVIRONMENT, HEALTH & SAFETY

Current Events, Industry Forecasts, and R&D to Inform Energy Strategy—Water Resource Availability (3002026642)

Q2 2023 This 13-page *EPRI Insights* reviews water resource availability trends and highlights recent and possible future impacts of changes in water quantity and quality on the operation of nuclear, fossil, and hydroelectric power plants. EPRI guidance documents, assessment tools, and case studies supporting assessment and mitigation of water-related risks, including those associated with climate change, are also identified.

Advances in Photovoltaic Module Recycling: Life Cycle Inventory Assessment for Six Recycling Facilities (3002025345)

Q2 2023 Through a literature and patent review and survey of recyclers, EPRI identified industry trends and advances in PV recycling processes and collected life-cycle inventory (LCI) data for six leading recycling facilities. This 39-page tech update identifies feasible advances that have the potential to be affordable and environmentally responsible. LCI results provide insights on recovery rates and energy consumption for value-preserving, high-quality, and high-yield recycling processes that are at different levels of development and scaling. **$**

Fixed-Object Crashes Among Electric Utility Vehicles: Characteristics and Countermeasures (3002024763)

Q2 2023 Avoidable incidents from on-road and off-road vehicle operations, where utility vehicles strike fixed objects, continue to be reported. This 74-page report focuses on understanding and mitigating two types of fixed-object crashes—vehicles that run off the road and strike trees or utility poles; and vehicles that back into or strike objects on roadways, including overpasses. Based on a synthesis of literature, structured interviews with utility safety

managers, and analyses of crash data, detailed recommendations are provided to help drivers and fleet managers improve safety. $

Characteristics and Countermeasures of Fixed-Object Crashes Among Electric Utility Vehicles Key Findings and Recommendations (3002027501)

Q2 2023 This 2-page fact sheet summarizes findings and recommendations for helping understand causative factors and implement preventive measures for fixed-object crashes involving utility vehicles.

A Mixed-Methods Examination of Fixed-Object Crashes Among Electric Utility Vehicles (3002024764)

Q2 2023 The following peer literature article has been submitted to the Journal of Safety Research: St. Louis, R.M., Eby, D.W., Zakrajsek, J.S., Zanier, N., and Molnar, L.J. "A mixed-methods examination of fixed-object crashes among electric utility vehicles."

Review of Current Knowledge on Non-Exhaust Emissions from Conventional and Electric Vehicles (3002027445)

Q2 2023 Regulation of particulate matter (PM) emissions from vehicle exhaust has been effective, to the point where they are or will soon be lower in magnitude than non-exhaust vehicle PM from sources such as tire wear and brake wear. This has raised a concern that the transition to higher-mass EVs (driven by battery weight) could lead to higher non-exhaust emissions not offset by the elimination of exhaust emissions. This 12-page tech brief reviews the literature on PM emissions from conventional vehicles and EVs, concluding that despite considerable uncertainties, current EVs appear to provide a net benefit in PM emissions.

Technology Update Series - First Quarter 2023: Climate REsilience and ADaptation initiative (READi) (March 30 Webcast)

Q1 2023 As extreme events increase in frequency, EPRI's Climate READi is strengthening the collective approach to managing physical climate risk to the power system by convening global thought leaders and technical experts and conducting focused research. This webcast, led by EPRI's **Andrea Staid**, provides an update on Climate READi's three workstreams: physical climate data and guidance, energy system and asset vulnerability assessment, and resilience and adaptation planning and prioritization.

Universal Activity Patterns of Temperate Zone Insectivorous Bats (3002025950)

Q1 2023 This 9-page tech brief reviews field studies of bat activity at operating wind energy facilities and in areas proposed for turbine deployment in Europe and North America. The objective was to characterize relationships between bat activity/mortality and factors such as temperature, wind speed, wind direction, moon phase, barometric pressure, humidity, and precipitation. Available data, which represent the current state of knowledge, may allow predictive modeling of bat activity at wind energy facilities based on weather conditions, enabling development of operating strategies for optimizing energy production and bat conservation. $

NO_2/NOx Impacts on SCR Catalyst Performance (3002025924)

Q1 2023 New duty cycles and fuels can alter flue gas characteristics and NOx formation, challenging efforts to meet air quality compliance standards. This 24-slide presentation summarizes microreactor-based testing to characterize performance of a conventional selective catalytic reduction (SCR) catalyst using simulated flue gas samples representative of low-load gas-fired turbines and hydrogen-fueled turbines. Results generally validated previous work. NO_2/NOx ratios up to 0.5 allow increased catalyst activity, but higher ratios and low temperatures can result in markedly lower activity. $

EQUITY & SOCIAL JUSTICE

Equity and Environmental Justice Aspects Across the Energy System (3002027134)

Q2 2023 Across the energy system, opportunities exist to advance equity and environmental justice via proactive and intentional planning and community engagement supporting the execution of projects and implementation of programs key to a successful clean energy transition. This 29-page guide is designed to help utility planners and practitioners in identifying and addressing equity and environmental justice impacts and opportunities associated with power generation, transmission and distribution, and customer end use.

Equity and Environmental Justice Considerations for Coal-Fired Plant Repowering (3002026486)

Q2 2023 This 20-page white paper summarizes key equity and environmental justice issues to consider when evaluating repowering options for decommissioned coal plants—including gas, renewable, and nuclear generation plus battery storage and hydrogen production. Depending on the option, local jobs can be lost, retained, or transitioned; physical impacts can change; and other factors can have long-term effects on the local community and economy. Repowering creates opportunities for collaborating with community leaders to maximize benefits, minimize adverse impacts, address potential unevenness in the distribution of such effects, and implement novel partnerships and innovative mitigation measures.

Environmental Justice and Carbon Capture and Storage (3002026035)

Q1 2023 Deploying carbon capture and storage (CCS) at scale requires buildout of infrastructure, both around current power plants and in new areas, creating potential to address environmental justice (EJ) concerns in communities facing systemic inequities. This 14-page overview of EJ implications and opportunities associated with CCS technology includes leading practices that also support project development and operations. Meaningful engagement can help identify affected communities, increase their capacity, lead to workable mitigation strategies, and support benefits and solutions that might not otherwise be accepted or identified. $

INFORMATION, COMMUNICATIONS & CYBER SECURITY

2023 TI Information, Communication and Cyber Security (ICCS) Portfolio Overview (June 21 Webcast)

Q2 2023 Led by EPRI's **Matt Wakefield,** this webcast reviews EPRI's cross-cutting ICCS vision and strategy, identifies recent key products, and identifies 2023 TI priorities and projects in the areas of pervasive telecommunications, data centricity and interoperability, and cyber security.

Digital Transformation Maturity Model (3002027521)

Q2 2023 This 7-page white paper describes EPRI's Digital Transformation Maturity Model and how organizations can apply this tool in evaluating and advancing overall organizational readiness toward more digitized and data-centric environments. The tool leverages prior research to help organizations evaluate characteristics and considerations for enabling successful digital transformation and create high-level objectives and a roadmap toward their desired maturity level. The tool reflects leading practices in maturity model design vetted by EPRI subject-matter experts and will continue to be refined based on utility assessments. $

Cybersecurity Platform and Certification Framework Development for Extreme Fast Charging (XFC)-Integrated Charging Ecosystem (3002027649)

Q2 2023 No single entity is responsible for the data security of the entire EV charging infrastructure ecosystem, and there are currently no system-wide requirements. This 82-page report focuses on the XFC ecosystem, defined as 200 kW or above, summarizing pioneering EPRI-led efforts on cybersecurity requirements, assessment methodologies, and real-world functional verification. The entire process of EV infrastructure cybersecurity assessment is encapsulated in an online EV Charging Cybersecurity Management tool, expected to be released to the public.

Quantum Challenge Results: Quantum Technologies for AI-Enhanced Utility Cybersecurity (3002027693)

Q2 2023 In 2022, EPRI led an innovation challenge focused on how quantum technologies can address cybersecurity issues within the energy industry. The primary goal was to inspire and educate individuals, generate new enthusiasm and investment, and foster collaboration between the energy industry, quantum-focused companies, universities, US Department of Energy, national laboratories, and others. This 6-page white paper provides a summary of the challenge and features insights from the three winning proposals.

Interoperability in Grid Model Development for Distribution Operations and Planning (3002025956)

Q1 2023 This 8-page brochure highlights recent EPRI work enabling and demonstrating interoperability in grid model development for increasingly complex distribution operations and planning environments. Model interoperability has been identified as a key enabler of data availability and quality assurance—two important aspects in grid modeling. EPRI's efforts envision a grid model management business function as the centralized "bridge" between data repositories and data-consuming tools.

Cyber Security in Renewable Generation — Research Gaps and Priorities (3002026247)

Q1 2023 This 40-page tech brief considers the current and future states of renewable generation technologies and systems—as well as cyber security tools, processes, and technologies—to identify known vulnerabilities and attack surfaces and where risks and gaps exist. Identification of cyber security gaps and future vulnerabilities for each generation option will help inform investments by asset owners and assist EPRI in prioritizing research to enable future states. **$**

MATERIALS, MANUFACTURING & NONDESTRUCTIVE EVALUATION

2023 TI Nondestructive Evaluation (NDE) Portfolio Overview (May 03 Webcast)

Q2 2023 This webcast, led by EPRI's **Mark Dennis,** provides an overview of 2022 TI products and the vision and strategy underlying crosscutting 2023 NDE R&D activities. Featured 2023 projects address NDE 4.0 for the low-carbon future; laser acoustics for adaptive welding control and flaw detection; multi-sensor data fusion for controlling weld penetration; remote operated vehicles for underwater inspection; robots for steam turbine and generator inspection; NDE for fusion reactor materials; and AI-based image analysis for high-speed cameras.

Development of a Comprehensive Corrosion Database and Model for Flue Gas Desulfurization (FGD) and Wastewater Treatment Systems (3002023699)

Q2 2023 The corrosion behavior of the materials of construction is a key consideration for the reliability and resiliency of FGD and wastewater treatment systems at coal-fired power plants. Building on prior EPRI work, the focus of this 68-page report is on predictive modeling of critical localized crevice corrosion temperature as a function of process water and alloy chemistry and operating

conditions. A hybrid model, combining experimental and mechanistic modeling results, is proposed, and recommendations are provided for future improvements and applications. $

SiC-SiC Composites for Nuclear Applications (3002026565)

Q2 2023 This 12-page tech brief provides a quick guide to SiC-SiC composite materials that, based on high-temperature mechanical stability, are being considered for structural applications in molten salt, gas-cooled, and lead-cooled fast reactors. Qualification and deployment will require thorough understanding of how material performance can vary based on the manufacturing process and the advanced reactor operating environment. Avenues exist for SiC-SiC composite qualification, but knowledge and technology gaps will need to be overcome. Key SiC-SiC composite properties include those in as-manufactured, irradiated, chemical attack/oxidation, and stress-time-temperature states.

Spread Spectrum Time-Domain Reflectometry (SSTDR) - Study of SSTDR Technology for Monitoring of Energized Cables at Nuclear Power Plants (3002023863)

Q2 2023 Building on EPRI work identifying NDE techniques for field testing of de-energized and disconnected low-voltage cables during outages, this 108-page report discusses pilot testing of SSTDR for monitoring energized and operational cables to provide a complete picture of cable health. The pilot successfully demonstrated detection of possible cable aging in an experimental setting based on shifts in reflection peaks from the end of the energized cable due to changes in the velocity of propagation. In addition, the method was validated for use during operational cycling, with common cable configurations, and on installed equipment. $

Amorphous Metal Distribution Transformers—An Overview (3002026327)

Q1 2023 Proposed DOE efficiency standards could require almost all transformers to feature amorphous steel cores. This 9-page tech brief provides an overview of amorphous metal transformer (AMT) technology to improve understanding of the implications of changing from traditional silicon steel core materials. It discusses technical challenges associated with AMT deployment and use and identifies R&D priorities for better preparing the industry for potential widespread deployment. $

Hydropower Materials Research Roadmap (3002025926)

Q1 2023 In 2022, EPRI conducted its 1st EPRI Hydropower Materials Workshop and participated in related events hosted by DOE and University of Stuttgart that also engaged hydropower facility owner/operators and R&D organizations. Key repeated themes for further R&D include additive manufacturing challenges and benefits, *in situ* repair needs, materials selection recommendations, manufacturing best practice guidelines, surface degradation mechanisms and coating technologies, and collaborative field demonstrations. This 46-page tech update summarizes the major topic areas and identifies R&D priorities and collaborative opportunities.

ACCESSING INFORMATION RESOURCES

Individual TI resources featured in this publication can be accessed by clicking the links provided. Resources are available for download at no additional cost to EPRI members by logging in at www.epri.com.

Free and publicly available resources can be downloaded by other individuals and entities through EPRI's website. Resources available for purchase by non-members can be ordered by calling the EPRI Order Center at 800.313.3774 (Option 2) or 650.855.2121. You may also send an email to orders@epri.com.

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Visit EPRI's Thought Leadership page for the latest strategic insights: thoughtleadership.epri.com

For more information, contact the EPRI Customer Assistance Center at 800.313.3774 (Option 4) or askepri@epri.com.

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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