

Information, Communication Technology – P161

Program Description

This program is designed to promote innovation by identifying, evaluating, and applying emerging Information and Communication Technologies (ICT) for grid modernization and digital transformation efforts. These enabling technologies can be applied to drive radical change in the capabilities of a user or system.

The ICT program addresses these challenges by conducting research in the following functional research areas:

- **Interoperability:** Interoperability fosters innovation, future-proofing, efficiency, cost savings, and a better customer experience. The research accelerates the industry's migration toward interoperability by informing standards development, organizing interoperability tests, and collaborating with utilities on the demonstrations of emerging standards and case studies to communicate the value and lessons learned.
- **Telecommunications:** The research provides leadership in communications standards development, provides tracking and analysis of communications technologies, develops the tools and techniques to effectively plan and design communications networks, and conducts laboratory and field tests to evaluate the performance of evolving and emerging technologies.
- **Data-Centricity:** This research leads effort to an enterprise-wide extensible data model, understanding that specific applications will come and go while the data model remains constant. Data, not applications, are at the core of the enterprise, and they are valuable and versatile assets. Ultimately, the goal of data-centrism is to enable data to deliver maximum business value, improve operational outcomes, and facilitate innovation through data-driven insight.

Research Value

The ICT program is designed to promote innovation by discovering new and more effective solutions to current problems through interoperability, thereby guiding the industry towards highly connected, interoperable future grid value streams. The program is organized into six project sets which are coordinated as an integrated program to enable digital transformation and provide the following benefits to members and the public:

Emerging ICT and Technology Transfer (161A)

- Provides insights into emerging information and communication technologies and issues that could impact utility investments; also enables technology transfer to personnel who can use and benefit from it.
- DER Communication and Data Integration (161D)
- As the penetration of distributed energy resources (DER) on a section of the grid increases, the impacts on grid operations—both positive and negative—may increase. Careful planning and operations are needed to ensure that the growth of DER does not impact grid safety, reliability, and stability. Research conducted by utilities, DER solution providers, and power system researchers over the past decade focuses on what is required to realize the full value of DER. DER must become more visible and controllable. At the heart of these capabilities are information and communication technologies to address DER communication and data integration.

Enterprise Architecture and Integration (161E)

- Puts tools and techniques into the hands of enterprise architecture practitioners and others driving towards the same objectives, with an eye to the unique needs and operating environments of utilities. Informs IT/OT strategies to prioritize investments aligned with utility capabilities. Four primary areas of focus include 1) Organizational Alignment, 2) Information Availability, 3) Application Portfolio Optimization, and 4) Enterprise Architecture (EA) Maturity.

Advanced Metering Systems and SCADA (161F)

- This project provides information and tools for deploying advanced metering infrastructure (AMI) and SCADA protocols, aiding utilities in optimizing existing systems and maximizing data value. With these systems being crucial to performance and reliability, efforts focus on enhancing deployment, accelerating standards for interoperability, and identifying best practices for system operations and monitoring as for optimizing their utilization as AM and SCADA are evolving rapidly.

Telecommunications (161G)

- Provides insights, guidance, and tools to help utilities develop telecommunications strategies and apply emerging technologies and standards that play an increasingly critical role in the operation of the integrated grid. Areas of focus include: planning a scalable, multi-service network; evaluating new business models to make fiber deployment economically viable; addressing industry challenges with potential interference to licensed microwave links; stewarding the standards to enable interoperability and interchangeability; developing approaches to maximize the performance of wireless technologies; developing best-in-class telecom network management, visualization, and control systems while maintaining reliability, resilience, and cyber security; and many more related topics.

Geospatial Intelligence (161H)

- Provides leading practices for optimizing the value and innovative uses of geospatial systems and data in emerging applications such as augmented reality and digital twins. This project focuses on the science and technology of acquiring, storing, cleaning, modeling, analyzing, producing, presenting, and disseminating geospatial datasets as well as developing tools and insights that enable the next-generation GIS, including the support of immersive 3D environments. It also includes assessing emerging geospatial technologies that enable utilities to expand their GIS capabilities for advanced analytics, network management, and process automation.

Approach

The approach for providing value in the ICT program involves multiple strategies:

- Raise awareness of emerging and potentially disruptive technologies. Information and Communication Technologies such as artificial intelligence (AI), edge computing, cloud computing, augmented reality, virtual reality, 5G and more may create both opportunities and challenges. EPRI's staff identifies these technologies and provides guidance to inform decision makers on potential impacts.
- Tools and resources to enable adoption of emerging ICT. The program develops a variety of tools and resources to help utilities adopt emerging technologies either themselves or with EPRI assistance across all areas of the ICT program.
- Technology and standards evaluation, laboratory testing, and field demonstrations. The program conducts work in EPRI laboratories, where staff take part in assessment of emerging standards, equipment, and communications architectures. The program also

- performs field demonstrations of emerging standards and technologies in coordination with utilities.
- Industry case studies, best practices, and guidebook development. The program documents utilities' experiences as they implement early-generation technologies and applications. Experiences are captured through utility immersions, interviews, and case studies. The program also develops go-to reference books to help utilities plan for, design, deploy, and maintain new technologies or applications.
- Technology transfer. The program uses a variety of approaches to share and apply research results, including technical reports, white papers, software tools, webcasts, workshops, and application of ICT program resources directly for utilities.

Accomplishments

The ICT program delivers valuable information that helps its members, the industry, and the public in numerous ways. The following are select work products that each of the project sets has produced:

Annually, numerous webcasts and newsletters in 161A help utilities in their grid modernization and digital transformation journeys. Examples topics include:

- [Emerging Technology Webcast - Telecommunication](#)
- [Emerging Technology Webcast - GIS Solutions for Electric Grid 2045](#)
- [Connecting the Dots: Integrating DERs via Utility AMI](#)
- [DERMS Reference Architecture](#)
- [Data Management Collaborative - Surviving the Datavalanche](#)
- [Telecommunications - Evolution of Utility Private LTE Towards 5G - Roadmap, Benefits, and Pre-Requisites](#)
- [Emerging Technology Webcast - Enterprise Architecture and Integration](#)

Numerous guidebooks that help utilities apply emerging ICT practices, typically updated annually. Examples include:

- 161D: [DER Protocol Reference Guidebook - 8th Edition, Distributed Energy Resources Interoperability Guidebook – 2024 Edition: Information and Case Studies to Support Utilities in Achieving Interoperability with Distributed Energy Resources and Demand Response Technologies; DER Protocol Reference Guidebook - 8th Edition;](#)
- 161E: [Utility Enterprise Architecture Guidebook, 9th Edition; 2024 EPRI Utility Business Capability Model \(Public Version\); Cloud Integration Guidebook: A Guide for Enterprise Architects, 8th Edition; Utility Business Capability Model Guidebook 3rd Edition;](#)
- 161F: [DLMS/COSEM for North American Utilities; Guidebook for Integrating AMI into Outage Management, Revenue Protection Guidebook, Second Edition: Using Advanced Metering Infrastructure; Guidebook for Advanced Metering Infrastructure \(AMI\) Data Analytics: Second Edition](#)
- 161G: [Wide Area Network \(WAN\) Modernization Guidebook: 2024 H1 Edition; Strategic Fiber Guidebook 2024 Edition; Private LTE Guidebook – 2024 Edition; Satellite and Emergency Communication 2024 Update: Additional Testing of Starlink for Utility Use Cases Strategic Fiber Guidebook; Network Management Guidebook: 2024 Edition](#)
- 161H: [Geospatial Informatics Guidebook: Fifth Edition;](#)

Each project set produces relevant research results based on lab testing, demonstrations, and architectural practices to advance digital transformation. Examples include:

- 161D: [Understanding the Difference in DER Gateways and Plant Controllers](#)
- 161E: [LEAPWorx 5th Edition](#)
- 161F: [Continuous Meter Replacement in Heterogenous Systems](#)
- 161G: [Evaluation of Interference to 6- GHz Microwave](#)
- 161H: [EPRI Geospatial Intelligence Develops Innovation Lab – The Path Forward](#)

Key Activities

In 2026, the ICT program intends to deliver the following:

Emerging ICT and Technology Transfer (161A)

- Monthly webcasts - Emerging Information and Communication Technologies, and Technology Transfer
- ICT Newsletters

DER Data and Connectivity (161D)

- Maturity Assessment of DER Information and Protocol Standards
- DER Interoperability Guidebook
- Utility Experiences in DER Integration
- DER Protocol Reference Guidebook
- DER Data and Connectivity Technology Pipeline
- Promising Technologies report

Enterprise Architecture and Integration (161E)

- Utility Business Capability Model and associated guidebook
- IT-OT Convergence Guidebook
- Impacts of Disruptive Technologies
- Grid Modernization Playbook
- Grid Model Data Management Functional Architecture
- Grid Model Management (GMDM) Guidebook
- Data Management Guidebook
- Cloud Integration Guidebook: A Guide for Enterprise Architects
- Common Information Model Primer
- Utility Enterprise Architecture Guidebook
- Top Ten Indicators of EA Maturity
- LEAPWorx, reference architectures, metamodels, and accelerators

Advanced Metering Systems (161F)

- Advanced Metering Data Analytics Guidebook
- Head-end System Overview: Functions and Interfaces
- ANSI Meter Standards Utilization
- DNP Protocol Tutorial

Telecommunications (161G)

- Smart Grid Communications Intelligencer newsletters
- Telecom Standards Guidebook

- Evaluation of Interference to 6 GHz Microwave
- Network Management Systems Guidebook
- 4G and 5G Architecture approaches for resilient networks
- Emergency / Black Sky Communications Resilience and Planning
- Private LTE Guidebook
- Evaluation of Low Latency Wireless Technologies
- WAN Modernization Guidebook
- Strategic Fiber Guidebook

Geospatial Informatics (161H)

- Geospatial Analytics Use Cases
- Geospatial Innovations
- Geospatial Informatics Guidebook

Estimated Funding 2026

\$4.0M

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PS161A: Emerging Technologies and Technology Transfer

This project set is designed to promote innovation by providing strategic insights into emerging information and communication technologies (ICT) that may drive radical change in the capabilities of the grid by enabling interoperability, pervasive telecommunications, and data-centricity. The project set promotes technology transfer for the ICT program with monthly webcasts, periodic newsletters, and interactive forums on emerging topics. This will provide insights to inform utilities on efforts that help prioritize investments in people, processes, and technology to enable digital transformation.

P161.058: Emerging ICT and Technology Transfer

Objective

This project will provide technology transfer support for the Information and Communication Technology (ICT) program and will focus on providing frequent strategic insights into emerging information and communication technology through a combination of webcasts, interactive forums, and periodic newsletters.

Approach (The How)

This project will provide technology transfer by producing the following:

Monthly technology transfer webcasts. Webcasts are typically recorded on the third Thursday of the month and provide strategic insights on emerging ICT, program updates, and the opportunity for impromptu discussions on emerging topics.

A periodic program newsletter. The newsletter will provide program updates and short articles on emerging topics and program research results.

Information, Communication and Cyber Security (ICCS) Forum. The ICCS Forum (<http://iccsforum.epri.com>) is a utility member-only discussion forum where our members can ask questions of one another and EPRI, share experiences, and find answers related to information, communication, and cyber security.

An Annual Program Area Review. The annual Area Review summarizes the research results produced by the program each year and shares success stories on how members have used and benefited from the results.

Research Value

The value of this project is to provide frequent strategic insights on emerging ICT that are rapidly evolving and enabling engaging with EPRI subject matter experts (SMEs) and utility peers to accelerate learnings that could enable innovation, future-proofing, efficiencies, cost savings, and a better customer experience related to the ICT program project sets.

2026 Anticipated Deliverables

Title	Short Description		Date
Monthly Technology Transfer webcasts	Webcasts - Provide strategic insights on emerging ICT, program updates, and the opportunity for impromptu discussions on		12/31/2026

	emerging topics. – multiple(third Thursday of the month)		
ICT Program Newsletter	Periodic newsletter (typically bi-monthly) with brief articles on program activities and research project results – multiple		12/31/2026
ICCS Forum	Online Forum - The Information, Communication and Cyber Security (ICCS) Forum is a utility member-only discussion forum where our members can ask questions of one another and EPRI, share experiences, and find answers related to information, communication, and cyber security – continues		12/31/2026
Annual Program Area Review	Digital Summary - Provides a summary of the research results produced by the ICT program and success stories on how members have used and benefited from program results		12/31/2026

Past EPRI Research on Topic:

Monthly Technology Transfer Webcasts: The Monthly “Third Thursday of the Month” webcasts are recorded and accessible to members by logging into the [ICT Program “Events” web page.](#)

ICT Program Newsletter: ICT Program Newsletters are emailed to program members. Historical access to newsletters is accessible from the [ICT Program “Links” web page.](#)

3002032382	Summary of Interoperability Tracking and Reporting by the ICT Program in2025	Summary of the 3 rd Thursday’s ICT webcasts for 2025	12/31/2025
n/a	2025 Area Review: Information, Communication and Cyber Security	2025 Area Review: Information, Communication and Cyber Security. This digital review serves as a summary of research findings and showcases key successes while communicating project plans for the upcoming year.	12/31/2024
3002028804	ICCS Forum	The forum enables live interaction and maintains a history of questions and answers related to Information, Communication and Cyber Security (ICCS). ICT program members can access the forum by logging in here: http://iccsforum.epri.com	12/31/2024

3002028935	2024 Area Review: Information, Communication and Cyber Security	The 2024 Area Review on Information, Communication, and Cyber Security aims to keep members updated on research developments from the Information and Communication Technology (161) and Cyber Security for ED&CS (183) programs. It highlights achievements from 2023 and outlines plans for 2024, with a focus on identifying practical applications and preparing the industry for future challenges. This review serves to summarize research findings and showcase key successes while communicating project plans for the upcoming year.	2/24/2024
3002026076	2022-23 Area Review: Information, Communication and Cyber Security	The <i>2022-23 Area Review: Information, Communication and Cyber Security</i> is intended to help members stay informed of the past year's research activities and identify valuable results that can be applied to impact day-to-day operations. This <i>Area Review</i> summarizes research results and produces highlights of some of the key successes in 2022 and communicates 2023 plans for each membership project.	1/17/2023

PS161D: DER Communication and Data Integration

Objective

As the penetration of distributed energy resources (DER) on a section of the grid increases, the impacts on grid operations—both positive and negative—may increase. Careful planning and operations are needed to ensure that the growth of DER does not impact grid safety, reliability, and stability. Research conducted by utilities, DER solution providers, and power system researchers over the past decade focuses on what is required to realize the full value of DER. DER must become more visible and controllable. At the heart of these capabilities are information and communication technologies to address DER communication and data integration.

Currently, large numbers of DER worldwide continue to be connected to the grid without direct monitoring and control, or they simply use the internet and vendor systems as an interim solution. The goal of this project set is to conduct research on the evolving needs for DER data and connectivity, including tools and technologies, architectures, and methodologies to support DER and demand response (DR) technologies and services.

This project set can help utilities at any stage of DER/DR deployment and integration. This includes industry leaders targeting full integration (control and monitoring) of both in-front and behind-the-meter DER/DR or utilities more focused on reducing costs and improving efficiency of existing operations, such as the monitoring and operation of large-scale storage or solar plants and DR programs. The project set has activities that support both the immediate future (existing plans) and longer-term (strategic vision) value streams.

This project set has three recurring areas of focus:

- Interoperability, Information, Protocol, and Connectivity Standards
- Emerging Technologies
- Integration Experiences and Practices

The project set also hosts task force meetings throughout the year. Each call focuses on a particular topic. EPRI presents on new research and then attending members have an open discussion about their thoughts, concerns, and experiences to help inform future EPRI research projects and activities.

P161.049: DER Standards – Interoperability, Information, Protocol, and Connectivity Standards

Objective

Utilities, third parties, and utility customers are increasingly connecting distributed energy resources (DER) into the grid. As more DER and demand response (DR) are added, visibility and controllability of DER become key—or even critical—components for grid reliability, flexibility, and resiliency.

Information and communication technologies are core enablers for visibility and control of DER to facilitate the rapid, seamless flow of information among diverse assets and devices. These technologies must be capable of integrating and aggregating multiple types and brands of DER into a utility's various management systems. The key is standards.

In this project, EPRI evaluates today's information and protocol standards through a DER lens to evaluate how these standards can help utilities streamline integration and reduce both initial and ongoing costs.

Approach (The How)

EPRI's Information and Communication Technology (ICT) program team has experience working with utilities, manufacturers, and standards bodies to help develop the next generation of connected DER/DR. EPRI contributed to the development process by testing devices from manufacturers to identify barriers and potential solutions, and then provided this information back to the manufacturers and standards bodies. This process has been successful and can be credited for the creation of the first open-standards-based smart inverters and the development of the first interoperability test procedures (IEEE 1547-2018, IEEE 1547.1-2020), including the CTA-2045/EcoPort standard and subsequent devices.

EPRI will engage with standards organizations, review development, and update the *EPRI Protocol Reference Guidebook*. The Guidebook is a concise, stylized, digest-like overview of information and protocol standards that allows readers to make objective use of specific aspects of the protocol, including where a protocol fits into the greater communication architecture and the types of DER/DR it currently supports. The Guidebook also includes a model that evaluates the maturity of key traits of the protocols, which helps decision makers at utilities understand which standards are ready for their applications.

Research Value

Information and communications technologies will be critical for the success of utility grid modernization efforts and clean energy targets due to the degree of coordination required between distribution utility,

market operator, aggregator, and DER technology. As the industry orients to support utility clean energy targets, information about relevant standards and their maturity is important to inform decision making by utilities, manufacturers, solution providers, and regulators.

Examples of utility-impacting activities in the industry include:

- Regulators are seeing the need for interoperability, as evidenced by an increasing number of requirements in grid codes and state laws mandating adoption of these requirements.
- DER information and protocols are changing quickly. EPRI's *Protocol Reference Guidebook's* maturity tracking process saw an increase in maturity for almost every protocol tracked. This is the first time this has happened since the first version in 2017.
- Grid codes (e.g., CA Rule 21) and interconnection standards (IEEE 1547-2018) are driving an increase in maturity of generation-focused standards and protocols.
- Adoption of electric vehicle (EV) protocols and storage technologies is increasing, but adoption of information and protocol standards is low, preventing standardized management of these resources.
- Federal Energy Regulatory Commission (FERC) O2222 creates new opportunities and new integration challenges for DERs. Information and protocols will be critical to facilitate required coordination between distribution utility, market operator, aggregator, and DER technology.

Key Activities

Activity	Date	Completion Status
Maturity Assessment of DER Information and Protocol Standards		Not started

2026 Anticipated Deliverables

Title	Short Description	Date
EPRI Protocol Reference Guidebook – 10th Edition	<p>Guide: This deliverable is a concise, stylized, digest-like overview of communication protocols that allows readers to make 1:1 comparisons of specific aspects of information and protocol standards. Previous editions have covered protocols such as: EcoPort (ANSI/CTA-2045:2018), OpenADR, SunSpec Modbus, , IEEE 2030.5, OCPP, Matter, and more.</p> <p>The report content spans across demand response, EVs, energy storage, smart inverters, and DER group management. New protocols are considered annually.</p>	12/31/2026

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002032119	EPRI Protocol Reference Guidebook - 9th Edition	<p>The ninth edition of PRG updates includes the following information and protocol standards.</p> <p>SunSpec Modbus, SunSpec for IEEE 1547, MESA-Device, MESA-DER & IEC 61850-7-420:2021, IEC 61968-5:2020, Open Charge Point Protocol (OCPP), ISO/IEC-15118:2019, EcoPort (ANSI/CTA-2045-B), OpenADR / IEC 62746-10-1:2018, OpenADR 3.0, IEEE P1815.2 (DNP3) / DNP AN2018-001, IEEE 2030.5-2018, IEEE 2030.5 V2G-AC Profile, Common Smart Inverter Profile (CSIP), DER Group Management for IEEE 2030.5</p>	12/31/2025
3002031737	Distributed Energy Resources Non-Interoperability and How We Fix It:EPRI Findings and Action Plan	Technical Brief – to be published	12/31/2025
3002031737	Distributed Energy Resources Non-Interoperability and How We Fix It: EPRI Findings and Action Plan	Technical Brief - Over the past decade, the U.S. energy industry has advanced the integration of distributed energy resources (DERs) like solar and storage through evolving standards such as IEEE 1547, which now mandate communication capabilities and certification for interoperability. In 2024, EPRI launched the DER Interoperability Lab to investigate and resolve communication issues with DERs, aiming to improve system planning and ensure reliable grid support through collaborative testing and issue tracking.	2/20/2025
3002029064	EPRI Protocol Reference Guidebook – 8th Edition	The Protocol Reference Guide (PRG) serves as a comprehensive resource for	12/31/2024

		stakeholders involved in distributed energy resources and demand response technologies, providing concise briefs on various application-layer protocols to aid understanding of their maturity, current state, and applicability. Developed with input from industry leaders like American Electric Power (AEP), Duke Energy, and Salt River Project (SRP), the PRG is regularly updated to incorporate new protocols and changes, addressing common questions regarding industry drivers, data models, certifications, profiles, strengths, opportunities, and EPRI projects related to each protocol.	
3002026697	EPRI Protocol Reference Guidebook – 7th Edition	Annual update of this overview of communication protocols that allows readers to make 1:1 comparisons of specific aspects of information and protocol standards.	12/31/2023
3002024179	DER Protocol Reference Guidebook – 6th Edition: Assessment of Information and Protocol Standards for Distributed Energy Resources (DER), Electric Vehicles, and Demand Response Technologies	Annual update of this overview of communication protocols that allows readers to make 1:1 comparisons of specific aspects of information and protocol standards.	12/31/2022
3002023419	Distributed Energy Resources (DER) Protocol Reference Guidebook—5th Edition: Public Version	Public version of EPRI's Protocol Reference Guidebook.	12/31/2022
3002021352	DER Protocol Reference Guidebook – 5th Edition: Assessment of Information and Protocol Standards for Distributed Energy Resources (DER), Electric Vehicles, and Demand Response Technologies	Assists in communication and education of today's DER information and protocol standards.	12/31/2022
3002016144	Test Procedure for Validating DNP Application Note AN2018-001 in Distributed Energy Resources	Test procedure utilities and utility-partners can use when developing and validating DNP/MESA-DER implementations.	12/31/2019

3002015355	Open-Source DER Outstation for DNP Application Note AN2018-001	Reference implementation of DNP Application Note AN2018-001/MESA-DER.	12/31/2019
3002016335	Enhancing Grid Resiliency Through Improving Capabilities to Manage Communicating Energy Storage and Solar Systems	Summary of a \$1.2M study to address energy-storage and DER gaps in today's DER data and connectivity standards.	12/31/2019
3002013625	IEC 61850 Protocol Driver Agents: Open-Source Software to Support Testing and Development of IEC-61850 in Smart Inverters	Reference implementation of IEC-61850 for Smart Inverters.	12/31/2018
3002014087	EPRI IEEE 2030.5 Client User's Manual	Reference implementation of IEEE 2030.5 for DERs.	12/31/2018
3002013623	EPRI's Distributed Energy Resources Integration Toolkit: An Overview of EPRI Tools for Testing and Implementing Open Protocols	A summary of EPRI's evaluation tools for DER information and protocol standards.	12/31/2018

Related Research

The work in this project is coordinated with and designed to complement the work performed in EPRI's Cyber Security for Power Delivery and Utilization (P183), Electric Transportation (P18), Energy Storage and Distributed Generation (P94), Grid-Edge Customer Technologies (P170), DER Integration (P174), Distribution Operations and Planning (P200), Customer Insights (P182), and Advanced Buildings and Communities (P204) programs.

P161.051: Emerging Topics, Technologies, and Techniques

Objective

An industry focus on clean energy has further boosted the popularity of distributed energy resources (DER). In response, an ever-growing number of technology companies, standards groups, and utilities are all looking for the next big opportunity. This is causing an influx of new ideas and technologies.

This project is designed to assess these new technologies, characterize their applicability, and propose next steps for the industry.

Approach (The How)

EPRI will work with members to establish a pipeline of emerging technologies in the data and connectivity domain. These technologies will be characterized by technology readiness for the DER domain. Each year, EPRI will select one or two promising technologies for further study. EPRI will evaluate how these technologies will support the industry, the maturity of the technology, and what is required for it to be successful. This will be shared with members at task force meetings for further discussion about next steps for EPRI research on each topic.

Research Value

Tracking the continuously flowing pipeline of new data and connectivity solutions is an ongoing task. EPRI will make this process easier by working with members to collaborate and identify important topics, technologies, and solutions and discuss their benefits and challenges.

This may include the following topics:

- Emerging needs for a 2030 clean energy system
- Application of new connectivity technologies for DER
- Investigating industry buzzwords like *Internet of Things (IoT)*, *smart cities*, and *transactive energy*
- Understanding how artificial intelligence (AI) can unlock insights and opportunities in DER data
- New consumer technologies capable of providing grid flexibility
- Technology companies embracing the role of aggregator
- FERC O2222 opening energy markets to small-scale and behind-the-meter DER
- Electric vehicle proliferation and the concept of vehicle-to-grid
- An industry focus on resiliency at multiple levels of the grid
- New startups in the DER data and connectivity domain

Examples of past topics include:

- IEEE 1547 Revision: The Latest on Interoperability and Cyber Security
- Utility Integration with DER Aggregators: State of the Art
- EcoPort Demand Response Standard: From Utility Pilot to State Requirement
- Coming Soon to a Customer Near You: Overview of the Mandates for ICT Standards and What to Expect
- What's Up with MATTER: Utility Applications for Latest Protocol from IoT-Industry Heavyweights
- Understanding the Difference in DER Gateways and Plant Controllers
- Developing a Secure Format to Convey DER Settings
- When Worlds Collide: EV Protocol Landscape
- Who's On First?: The Interoperability of DER Certificate Management
- Wi-Fi Connectivity in Meters: An Opportunity for DERs?
- Interop Language for Utility Technical Interconnection and Interoperability Requirements (TIIRs)

Key Activities

Activity	Date	Completion Status
PS161D Task Force Meetings	12/31/2026	Ongoing

2026 Anticipated Deliverables

Title	Short Description		Date
DER Data and Connectivity—Technology Pipeline	Tech Update—EPRI will work with members to establish a pipeline of emerging technologies related to DER data and connectivity.		12/31/2026

Study results from one or two promising technologies	Tech Update—Each year, EPRI will select one or two promising technologies for further study. EPRI will evaluate how these technologies will support the industry, the maturity of the technology, and what is required for it to be successful. This will be shared with members at task force meetings for further discussion about next steps for EPRI research on each topic.		12/31/2026
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Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002031781	IoT Technologies for Distributed Energy Resources - 4th Edition: Information, Case Studies, and Lab Evaluations of IoT-Based Connectivity, Distributed Messaging, and Integrated Platform-As-A-Service Solutions	<p>This guide provides a high-level presentation of prevalent IoT protocols, including hardware, software, and messaging technologies, to build a baseline for understanding the potential of IoT protocols. The paper also defines the relationship between IoT protocols and existing DERs protocols assessed in the DER Protocol Reference Guidebook. Finally, it also includes deeper evaluation of specific IoT technologies including: LoRaWAN, Amazon Sidewalk, Integration with Utility AMI</p>	12/31/25
3002032120	Smart Meters with Internal Wi-Fi for DER Integration Challenges: Challenges and Research Needs for DER-Ready AMI Platforms Smart Meters with Internal Wi-Fi for DER Integration Challenges: Challenges and Research Needs for DER-Ready AMI Platforms	<p>This Technical Update explores the emergence of smart meters with built-in Wi-Fi as a new evolution in advanced metering infrastructure (AMI), highlighting how utilities are evaluating these capabilities to lower DER integration costs, improve visibility, and enable more dynamic grid-edge coordination. It assesses the technical capabilities, use cases, and integration pathways for Wi-Fi-enabled AMI meters, including whether Wi-Fi and IoT protocols like Matter could allow meters to function as low-cost DER gateways in support of utility flexibility and clean energy goals.</p>	12/31/25

3002032121	Interoperability Guidance for Utility Technical Interconnection Requirements	TechUpdate - IEEE Std 1547-2018 marked a major shift by introducing formal interoperability requirements for DERs, reflecting the grid's growing complexity and the need for reliable, scalable communication between DERs and utilities. This report shows that while IEEE 1547 provides a strong foundation, utilities often need additional TIIR specifications and practical guidance—across Clause 10 topics such as protocols, DER gateways, PKI, and commissioning—to achieve truly interoperable, secure, and operationally ready DER integration.	12/31/25
3002028805	Understanding the Difference in DER Gateways and Plant Controllers	Technical Brief - “Smart” distributed energy resources (DER) with grid-support capabilities and communication interfaces are now commonly available and being deployed throughout the world. With their arrival, utilities are developing the control systems required to integrate DER with power system operations using DER management systems (DERMS), distribution management systems (DMS), third-party aggregation, and communication networks.	12/31/24
3002029065	DER Data and Connectivity - Technology Pipeline	Technical Update - This report describes the communication requirements and related integration aspects of the standard. It provides an overall description of the technical requirements in the standard in the context of the broader IEEE 1547-2018 and UL 1741 standards which applies to all types of distributed energy resources (DER).	12/31/2024
3002029066	2024 study results from one of two promising technologies	Technical Update - Utilities are increasingly adopting advanced metering infrastructure (AMI) networks to improve grid reliability, efficiency, and sustainability. AMI networks enable real-time monitoring and management of energy consumption, allowing utilities to quickly identify and address outages, optimize energy	12/31/2024

		distribution, and lower operational costs. While AMI offers numerous benefits, its deployment involves significant upfront investment, with costs reaching hundreds of millions of dollars for large-scale rollouts, such as Ameren Illinois' projected \$417 million over 20 years.	
3002026698	Protocols to Support Group Management of DERs: ADMS to DERMS and Utility to Aggregator Interfaces	Tech Update - The necessity to aggregate DERs and oversee them at a group level has been acknowledged across various utility industry platforms. This recognition stems from different perspectives including bulk generation and transmission operators, DMS technology providers, distribution system operators, DERMS, aggregator service providers, and DER device manufacturers. This study initiates an exploration of information and communication protocols essential for implementing interfaces required to manage groups of DERs effectively.	12/29/2023
3002026699	IoT Technologies for Distributed Energy Resources – 2023 Guidebook: Information, Case Studies, and Lab Evaluations of IoT-Based Connectivity, Distributed Messaging, and Integrated Platform-As-A-Service Solutions	Tech Update – This paper provides a high-level presentation of prevalent IoT protocols, including hardware, software, and messaging technologies, to build a baseline for understanding the potential of IoT protocols. The paper also defines the relationship between IoT protocols and existing DER protocols assessed in the DER Protocol Reference Guidebook. Finally, it also includes deeper evaluation of specific IoT technologies.	12/29/2023
3002024100	Developing ICT Networks to Integrate Distributed Energy Resource Technologies	White Paper – Perspectives on the comm networks that integrate DERs. This paper highlights this changing paradigm and ongoing efforts to support the industry through this process.	12/8/2022
3002024195	DER Gateway Reference Architecture	Reference architectures based on EPRI's DER Gateway requirements specifications.	12/15/2022
3002024001	IoT Protocols to Integrate DERs	The Internet of Things (IoT) offers a broad spectrum of new	12/09/2022

		technologies with the potential to add significant capabilities to electric grid operation. Electric utilities have deployed a diverse collection of protocols to address the communication needs of these operational technology (OT) devices. This Technical Update explores IoT Protocols use to Integrate DERs.	
3002019424	Federated Architecture for Distributed Energy Resources Integration	As overall DER management systems become more advanced and more multi-level (federated), there is increased opportunity to build-in functional protection against potentially harmful control actions, both accidental and malicious. This white paper summarizes the concept of a federated architecture for DER Integration (FADER).	12/18/2020
3002017103	ICT for DER Case Studies— Business Justifications for DER Communications	In 2019, members of EPRI’s Project Set PS161D selected the topic of understanding utility plans for communicating DER and the business justifications that they are using to build out the infrastructure, programs, and technical capabilities to use DER’s flexibility and data.	11/22/2019
3002013624	The Economics of Customer and Grid Connectivity and Grid Interoperability: Evaluation of the Potential Impacts of Interoperability in Utility Economic Analyses and Program Design	This report answers two research questions: How connectivity and interoperability support the utility business needs? What interoperable communications considerations must be made to lower capital and operational expenses and reduce grid-asset risks?	12/31/2018

Past EPRI Research on Topic

The work in this project is coordinated with and designed to complement the work in EPRI’s Cyber Security for Power Delivery and Utilization (P183), Electric Transportation (P18), Energy Storage and Distributed Generation (P94), Grid-Edge Customer Technologies P170, DER Integration (P174), Distribution Operations and Planning (P200), Customer Insights (P182), and Advanced Buildings and Communities (P204) programs.

P161.052: Integration Experiences and Practices

Objective

Utilities are embracing new energy resources and services, with some companies moving to push centralized generation to distributed generation and other distributed energy resources (DER). To address the inevitable challenge of spatial and temporal variability, utilities are increasingly looking to flexibility systems and services from DER, including smart inverter-based DER and demand response (DR) for grid reliability and stability. The secure and reliable end-to-end integration of DER—including DER in the planning and operation of the electricity grid and expanding its scope to include DER operation—is an important research consideration. This capability provides utilities with visibility into DER/DR to enhance planning, the ability to control operating parameters in DER/DR to adjust to changing grid conditions, and dispatch capabilities to call on the flexibility of these systems when the need arises. As utilities develop their DER integration roadmaps to include communicating DER/DR and end-to-end integration of DER, it is important to step back and look at the bigger picture and understand the different technical and business elements that must come together to make it happen.

The research undertaken by this project seeks to understand how the many components of a DER/DR roadmap (including communicating DER/DR) come together—the technologies, processes, and systems that can streamline the end-to-end automation and integration and reduce long-term operation and maintenance costs.

Approach (The How)

EPRI has been advancing the building blocks for communicating DER/DR by working with stakeholder groups to update standards, provide guidance on managing groups of DER/DR, implement architectural references for the industry, and create simulation tools to emulate devices to encourage testability. This project intends to continue developing guidance and tools as needed to support the development and testing of communicating DER/DR.

Research Value

This project will create tools and guidance to help utilities integrate new transformative communication technologies in DER/DR and support the investment of these resources for integration into associated control systems and the grid. The goal is to support members in looking at the bigger picture to prepare for the end-to-end integration of DER/DRs.

Example research questions are:

- The complexity to operate, monitor, and configure large amounts of DER/DR scales as the number of DER/DR increases. How can DER/DR seamlessly integrate with aggregation platforms, such as third-party aggregator services, microgrid and advanced energy communities, campus management systems, distributed energy resource management systems (DERMS), or demand response systems?
- Communicating with large numbers of DER will require security and telecommunication technologies (customer-owned or utility networks) for communication capabilities. What are the requirements for these use cases?
- In response to this grid transformation, what training, digital workers, and automation are needed to complement existing industry practices?

A keystone of this project is the *DER Interoperability Guidebook*. It is a repository of previous EPRI research in this domain and provides stand-alone chapters on topics such as:

- ICT Requirements for Interoperability
- DER Architectures
- DERMS
- Cloud-based Systems
- Solutions to Common Interop Failures
- Network Technologies
- FERC O222 and ICT Systems
- IEEE 1547 Guidance
- Interoperability DER Data and Information

2026 Anticipated Deliverables

Title	Short Description	Date
DER Interoperability Guidebook	The guidebook leverages 10+ years of work developing and applying standards. Each year, EPRI will revise and add new sections to reflect the latest industry research needs. The 2026 version of the guidebook includes the following sections: Industry Requirements for DER Interoperability & Protocols, How to Validate Conformance: EPRI & Industry Test Tools, Example DERMS Communication Architectures, Cloud-Based Architectures to Support DR Programs and more.	12/31/2026
Utility Experiences in DER Integration	Tech Update - EPRI will work with member utilities to capture experiences, use cases, and other information to inform the member collaborative. EPRI will also host member task force meetings twice a year to discuss ongoing EPRI and utility research efforts in the industry.	12/31/2026

Past EPRI Research on Topic:

Product ID	Title	Short Description (link to new project)	Published Date
3002031779	Distributed Energy Resources Interoperability Guidebook - 2025 Edition: Information and Case Studies to Support Utilities in Achieving Interoperability with Distributed Energy Resources and Demand Flexibility	This guidebook covers the following topics: The Four Key Attributes of DER Interoperability, DER Information and Protocol Standards Landscape, Templates for Protocol Requirements, Validating Conformance, Protocol Mapping, Example Communication Architectures, Cloud-Based Architecture to Support Demand Response Programs, Integrating with Third-Party Aggregators, Common Interoperability Failures, Telecommunications for DERS,	12/31/25

		Qualitative Benefits of Interoperability, Key Decisions When Applying IEEE 1547-2018, Interoperability of Information for Operational Technology, ICT Resources to Support FERC O2222, Protocols to Support Group Management Of DER: ADMS To DERMS And Utility to Aggregator Interfaces, Understanding the Difference in DER Gateways and Plant Controllers	
3002032123	Where Small Worlds Collide: Navigating the EV Protocol Universe	This technical update examines how electric vehicles are evolving from passive loads into active DERs, requiring coordination across utilities, automakers, charge networks, aggregators, and buildings through shared architectures and interoperable protocols. By mapping business models, infrastructure, and standards such as ISO 15118, IEEE 2030.5, OCPP, and OpenADR, it highlights how aligning these domains can unlock EV flexibility to support grid reliability, renewable integration, and a more resilient energy ecosystem.	12/31/25
3002029062	DER Interoperability Guidebook 2024	Guide - This annually updated guidebook compiles knowledge to achieve interoperability and cost-effectiveness in demand response (DR) and distributed energy resource (DER) programs and technologies, including what elements of interoperability can be addressed by communication standards and which require utilities to act through updated program requirements.	12/31/2024
3002026702	Interpreting the Interoperability Requirements in IEEE 1547-2018: A Deep Dive into Clause 10	PowerPoint Presentation TechUpdate - IEEE 1547 serves as the primary standard in the United States for interconnecting Distributed Energy Resources (DERs), focusing on safety, performance, and information sharing. The 2018 revision marked a significant change, shifting from DER disconnection during grid disturbances to requiring them to remain online and offer grid-	12/29/2023

		supportive functions. This report outlines the new interoperability requirements, emphasizing information exchange, standardized protocols, and local communication interfaces. It also discusses key insights from the revision process and potential impacts for utilities, covering topics such as IEEE 1547 protocols, decision-making around interoperability, and necessary information and communication systems for integrating IEEE 1547 DERs into grid control systems.	
3002024196	Simplifying and Streamlining Interoperability of Distributed Energy Resources: Application-Specific Profiles for DER Information and Protocol Standards	Developing tools and resources for utilities to specify protocol requirements and validate their implementation.	12/12/2023
3002024909	Training Materials - ICT for Monitoring, Management, and Configuration of DERs	Technical Update – training materials created ICT for Monitoring, Management, and Configuration of DERs.	12/31/2022
3002024002	Decomposing FERC O2222	Technical Update – Assessment of the impact of FERC O2222 on utility IT and OT systems.	12/31/2022
3002018673	Applications of the Local Distributed Energy Resource (DER) Gateway – Low Cost, Secure DER Network Gateways for Integration of Smart Inverters	This report explores opportunities identified by utilities to use the DER gateway as a local platform housing features and logics that are valuable to the utility. The last section of the report covers different possible options for integrating the gateway with upstream utility communications.	06/11/2021
3002021863	Energy Storage Management Functions to Address Grid and Customer Services Phase 2 – Information and Communication Capabilities	This report presents set of high-value use cases for energy storage, proposes a functional specification to achieve the performance objectives relevant to each use case, and assesses the information and communication technology requirements to implement each use case.	12/30/2021

Past EPRI Research

The research on DER/DR spans multiple programs at EPRI, including information and communication technology (ICT), distribution and planning, solar, energy storage, and demand response. In this ICT project, the focus is enabling innovation and competition among providers of DER/DR integration applications by safeguarding interoperability and the ease of integration of these systems to support sustainability and scalability of utility systems.

PS161E Enterprise Architecture and Integration

Objective

Society demands a cleaner, more equitable, and more resilient electric power grid. This transformation requires:

- Organizational alignment: The organization focuses its resources on executing the strategic vision.
- Data management: All participants in the enterprise have access to the necessary information and toolsets.
- Application portfolio optimization: The systems required to run the business are optimized for performance and cost.
- Enterprise architecture (EA) maturity: EA practice is an integral part of the business, from strategy development to technology evolution.

The research of this project set aims to put the best tools and techniques into the hands of enterprise architecture practitioners and others driving toward the same objectives, with an eye to the unique needs and operating environments of utilities.

P161.029 Enterprise Architecture (EA)

Objective

Increase the maturity, influence, and impact of enterprise architecture (EA) practitioners and others who share the same goals at electric power utilities worldwide.

Approach (The How)

- Continually measure the maturity of EA at utilities, identify weaknesses, and develop improvement plans
- Identify successful practices of leading organizations and transfer them across the industry
- Accelerate the work of fellow architects by providing ready-to-use reference architectures and patterns gathered from collaboration across EPRI and with members
- Enable the exchange of priorities, challenges, and solutions via biannual task forces that strengthen the effectiveness of members' enterprise architecture capability

Research Value

This project helps members and the public by:

- Providing utility-specific guidance for the implementation of The Open Group Architecture Framework (TOGAF) and other architecture frameworks

- Measuring and benchmarking utilities' EA maturity against their peers and identifying areas of improvement for individual utilities and the industry
- Providing multiple opportunities—formal and informal—to exchange priorities, best practices, and innovative solutions with utilities around the world
- Accelerating the modeling of EA work by providing a library of enterprise architecture patterns (and much more) in a standard format
- Identifying and transferring leading practices that have been proven to increase the influence, effectiveness, and scope of EA capability at utilities

Key Activities

Activity	Date	Completion Status
EA Leadership Forum	Monthly	ongoing
EA and Integration Task Force	14-May-2026	Not started
EA and Integration Task Force	22-Oct-2026	Not started

2026 Anticipated Deliverables

Title	Short Description		Date
Utility Enterprise Architecture Guidebook, 11 th Edition	Technical Report – Annual update that incorporates leading research from the EA discipline and best practices and lessons learned from utilities to expand the effectiveness, scope, and influence of EA teams and those who share their objectives.		12/31/2026
Top Ten Indicators of EA Maturity: 2025 Survey Results	Tech Update – A yearly survey on the state of the EA discipline in the utility industry.		6/30/2026
LEAPWorx, 6th Edition	Technical Report – Reference architectures, metamodels, and other modeling accelerators.		12/31/2026

Past EPRI Research on Topic:

Product ID	Title	Short Description (link to new project)	Published Date
3002032383	Utility Enterprise Architecture Guidebook, 10th Edition	This guidebook bridges the gap between understanding enterprise architecture frameworks like TOGAF and applying them effectively in a utility context, especially for practitioners new to the	12/31/2025

		discipline. By grounding standards such as TOGAF, CIM, and ArchiMate in a realistic utility project example, it provides practical deliverables, best practices, and hands-on guidance for applying enterprise architecture both strategically and tactically.	
3002032386	Top Ten Indicators of Enterprise Architecture (EA) Maturity-2024 Results	The <i>Top Ten Indicators of Enterprise Architecture Maturity</i> is a survey instrument developed by the EPRI Enterprise Architecture Interest Group to provide a means to do a “back of the envelope” maturity assessment, and then use that assessment to benchmark against the average and range of responses for all participants. In 2024, data from 40 utilities were used to compile the results. Since 2015, the findings from this survey inform our enterprise architecture collaboration activities to determine how to best help utility enterprise architecture teams make improvements to their practices.	12/31/2025
3002032387	Library of Enterprise Architecture Patterns: LEAPworx, 7th Edition	Technical Report – to be published	12/31/2025
3002029889	Utility Enterprise Architecture Guidebook, 9th Edition	This guidebook seeks to address a gap between reading a leading enterprise architecture reference such as The Open Group Architecture Framework (TOGAF) and being able to apply it. While TOGAF is a valuable resource that generically describes the process of developing architecture, novice practitioners of enterprise architecture often do not know how to get started or how to apply the methods in TOGAF to develop an architecture in a utility context.	12/31/2024
3002029901	Top Ten Indicators of EA Maturity: 2023 Survey Results	Technical Update - The <i>Top Ten Indicators of Enterprise Architecture Maturity</i> is a survey instrument developed by the EPRI Enterprise Architecture	12/31/2024

		Interest Group to provide a means to do a “back of the envelope” maturity assessment and then use that assessment to benchmark against the average and range of responses for all participants. In 2023, data from 39 utilities were used to compile the results.	
3002029906	LEAPWorx, 6th Edition	Technical Report - The LEAPworx repository is an architecture “accelerator” that provides architects with reusable components, patterns, and technology-specific diagrams. It also provides guidance, via examples, on strategy and cyber security modeling. It contains editable diagrams that were originally used in EPRI architecture deliverables such as the <i>Enterprise Architecture Guidebook</i> and the <i>Utility Cloud Integration Guidebook</i> . An architecture practitioner at a utility can utilize these diagrams and modeling approaches to capture and communicate their local concerns and architectures.	12/31/2024
3002026848	Utility Enterprise Architecture Guidebook, 8th Edition	This guidebook seeks to address a gap between reading a leading enterprise architecture reference such as The Open Group Architecture Framework (TOGAF) and being able to apply it. While TOGAF is a valuable resource that generically describes the process of developing architecture, novice practitioners of enterprise architecture often do not know how to get started or how to apply the methods in TOGAF to develop an architecture in a utility context.	12/31/2023
3002026849	Top Ten Indicators of EA Maturity: 2022 Survey Results	The Top Ten Indicators of Enterprise Architecture Maturity is a survey instrument developed by the EPRI Enterprise Architecture Interest Group ¹ to provide a means to do a “back of the envelope” maturity assessment, and then use that assessment to benchmark against the average and range of responses for all participants.	12/31/2023

		In 2022 data from 38 utilities were used to compile the results. Since 2015, the findings from this survey inform our enterprise architecture collaboration activities to determine how to best help utility enterprise architecture teams make improvements to their practices.	
3002026850	LEAPWorx 4th Edition	LEAPworx, or the Library of Enterprise Architecture Patterns, serves as a comprehensive repository of architecture diagrams tailored for the electric utility industry. Developed over years of research and contributions, it offers architects reusable components, patterns, and technology-specific diagrams using ArchiMate®, an enterprise architecture modeling language. This resource provides utility practitioners with editable diagrams, strategy modeling examples, and cybersecurity guidance, facilitating the capture and communication of local concerns and architectures. Updates in the 5th edition include the Utility Business Capability Model 2023 Edition, the AMI Reference Architecture, DSO business capabilities, and ArchiMate meta-models and examples.	12/31/2023

P161.041 Enterprise Systems Integration

Objective

The transformation of the industry required to meet demands for a cleaner, greener, and more resilient grid will require the implementation of new enterprise systems in the operational and information technology domains. Interoperability is a key enabler to faster, cheaper, and more functionally complete implementation of these new systems. A clear understanding of the semantics and structure of standards-based data exchanges is foundational to systems interoperability and is also key to enabling innovative applications in the utility industry. As the industry evolves, so should the standards, which are unfortunately lagging behind in key areas such as cloud computing, cyber security, and data modeling. Additional semantics are required for new assets, analysis and business models, and exchanges need to be better defined so they can be automatically tested and validated to shorten the distance to integrate.

Approach (The How)

- Enable enterprise application interoperability through the application and extension of the International Electrotechnical Commission (IEC) Common Information Model (CIM), contributing proven interface specifications to the relevant working groups to inform and guide the evolution of standards
- Identify leading-edge best practices and tooling for the application and extension of the standards and utility experiences with the latest application integration techniques
- Research and develop solutions to utility industry challenges with cloud integration and deployment
- Define mappings to device control protocol standards, such as IEC 61850 and IEEE 2030.5, that are necessary to bridge from the enterprise to the grid control domains
- Develop application reference architectures that can accelerate problem definition and application solution architectures and support application portfolio rationalization and management

Research Value

The project helps members and the public by:

- Improving application interoperability by advocating for and extending the IEC CIM standard for information exchange standards and semantic understanding of utility data
- Educating utility practitioners on the use of the IEC CIM for standards-based integration and semantic model management and extension
- Enabling data exchanges across the enterprise domains and the grid measurement and control domains to support grid operations, asset health, distributed energy resources (DER) integration, etc.
- Accelerating the analysis and solution design of strategic domains by providing reference architectures that define application functions and the data exchanged, including Control Center of the Future, advanced metering infrastructure (AMI), grid model data management (GMDM), advanced distribution management system (ADMS), and DER gateways
- Defining the role of cloud-based services in an optimized application portfolio and effective methods for service governance and integration

Key Activities

Activity	Date	Completion Status
EA and Integration Task Force	16-May-2026	Not started
EA and Integration Task Force	10-Oct-2026	Not started

2026 Anticipated Deliverables

Title	Short Description		Date
Cloud Integration Guidebook: A Guide for Enterprise Architects, 11th Edition	Technical Report – How to utilize and connect to cloud-based services, securely utilize public clouds, manage capital expenditures/operating expenses (CAPEX/OPEX) considerations, and		12/31/2026

	provide guidance for information technology/operations technology (IT/OT) systems in the cloud.		
Common Information Model (CIM) Primer, 12th Edition	Technical Report – A reference for the IEC common information model, the associated data exchange standards, extending the model and building services as well as using the CIM and an enterprise information model for semantic understanding.		12/31/2026
Grid Model Data Management Functional Architecture, 2 nd Ed.	A reference architecture for the grid model data domain. This tech update highlights the outcome of vendor tool interoperability in using the CIM to support practical distribution grid model data exchanges.		12/31/2026
DER-AMI-Enterprise Testbed	Technical Update - A definition of the enterprise interactions between the distributed energy resource management system (DERMS)/DMS and the AMI headend for cases where DER are managed via AMI.		12/31/2026

Past EPRI Research on Topic:

Product ID	Title	Short Description (link to new project)	Published Date
3002032388	Cloud Integration Guidebook, 10th Edition: A Guide for Enterprise Architects	This guidebook explains why utilities were historically cautious about cloud adoption but shows how maturity of cloud solutions and operational realities have driven a shift toward cloud-based systems, especially among smaller utilities. It synthesizes practitioner experience and existing guidance to help utilities evaluate cloud solutions across technical, financial, change-management, and risk perspectives.	12/31/2025
3002032389	Common Information Model Primer: Eleventh Edition	The Common Information Model (CIM) Primer introduces how CIM is used in electric utilities, explaining its origins, core concepts, and modeling approach using Unified Modeling	12/31/2025

		Language through step-by-step examples. It also covers advanced topics such as extensible enumerations, and includes learning aids and case studies showing how utilities and vendors apply CIM for effective power system modeling and data exchange.	
3002029921	Cloud Integration Guidebook: A Guide for Enterprise Architects, 9th Edition	This guidebook was created to synthesize resources from the relevant literature, guidance where available from government sources, and most importantly the experiences of utility practitioners who have been on the leading edge of migrating applications to the cloud. This report guides the reader through introductory concepts. It considers cloud-based solutions from a variety of perspectives including technical, financial, and change management. It also provides guidance on how to evaluate any given solution for technical, business, and information risk.	11/7/2024
3002029927	Common Information Model (CIM) Primer, 10th Edition	The <i>Common Information Model Primer</i> helps readers understand how the Common Information Model (CIM) is used at electric utilities. The primer explains how the CIM originated and was developed through the years, with the support of working groups of Technical Committee 57 of the International Electrotechnical Commission.	11/4/2024
3002028913	Data Management Maturity Model	This white paper introduces a data management maturity model developed using the EPRI common maturity model framework. This enables as a strategic tool for organizations in the data management domain, enabling the identification of strengths and weaknesses,	02/02/2024

		and providing a roadmap for improvement.	
3002030340	Grid Modernization Playbook: A Framework for Developing Your Plan (Joint delivery with Program 200)	Grid modernization is an imprecise term, but at a very high level, it means making investments in people, processes, and technology to meet the future needs of the utility and its customers. Many modernization initiatives today involve a fundamental change in how grids are planned and operated. A grid modernization plan can touch on every aspect of a utility's operation. Every utility will also have a different vision of what a modern grid is and a different strategy and pathway for realizing that vision.	05/21/2024
3002028115	Leveraging the Standards in Formalizing EMS Alarms Data Structure	Making alarms available for automation and analytics	12/06/2023
3002026856	Enhanced Grid Model Validation: A SHACL Primer	Presents methodologies for data validation, specifically in the context of grid data. This report focuses on how SHACL can be used to define data validation rules specifically for grid data.	12/21/2023
3002026851	Cloud Integration Guidebook: A Guide for Enterprise Architects, 8th Edition	This guidebook synthesizes literature, government guidance, and utility practitioner experiences to provide comprehensive insights into cloud-based solutions, covering technical, financial, and change management perspectives, and offering guidance on evaluating solutions for risk factors.	12/31/2023
3002026852	Common Information Model (CIM) Primer, 9th Edition	The Common Information Model Primer serves as a guide for understanding the application of the Common Information Model (CIM) within electric utilities. It provides details on the structures of the information model, the data exchanges	12/31/2023

		standards and their use and extension.	
3002025383	A Functional Application Architecture for Grid Model Data Management (GMDM)	Application functions and data objects to accelerate portfolio analysis and solution definition for the grid model data domain.	09/30/2022
3002024195	DER Gateway Reference Architecture	Application and technology functions and data objects for DER Gateways.	12/15/2022
3002025527	Diagramming OT Cyber Security Threats, Vulnerabilities, and Impacts	A method for adding cyber security concerns to reference architectures.	10/06/2022
3002025385	Grid Model Data Management (GMDM) Architecture in Archimate	Utilizing the Archimate modeling language for the grid model data domain.	11/09/2022
3002025386	Common Information Model (CIM) Support for Distribution Grid Model Data Management	Latest re-organization and extensions to support the complexities of the distribution system.	11/10/2022

P161.062: Organizational Alignment

Objective

What frameworks and tools are best suited to ensuring that investments are aligned with organizations' strategic objectives and that the application and technology portfolios are capable of supporting today's business and its vision for the future?

This project seeks to provide enterprise architects, business architects, and strategic planners with the frameworks, tools, and processes necessary to capture the extent of the organization's alignment with current and future strategic objectives and to make a technology-agnostic plan to close any gaps.

Approach (The How)

This project will use and enhance the EPRI Utility Business Capability Model to create a series of frameworks that effectively capture and communicate objectives, outcomes, strategy, and roadmaps utilizing reference architectures that clearly define the functionality and data required to meet the needs of the grid without constraining the solution space prematurely.

The project will utilize generative artificial intelligence (AI) to extract ArchiMate motivation and strategy elements from strategic plans and use this data to automatically create models and diagrams in the SparxSystems Enterprise Architecture tool, also utilizing AI.

The project will provide a business-friendly approach to demonstrating application portfolio health, technology and security risks, redundancy, and underutilized or excessively expensive applications and technology. Capability assessments and maturity models are in high demand; an industry capability model can serve as a framework for assessments, scenarios that drive maturity targets, and industry architectures that can be used to reach the desired target.

Utilizing the same framework for both strategic and tactical decision making optimizes planning and helps ensure organizational alignment across information technology (IT) and business units and from strategy to execution.

Research Value

This project will help members and the industry at large by providing methods, frameworks, and tools that enable the conversation between business and IT in some or all of the following areas:

- Investment alignment with strategic objectives
- Accelerating capability assessments, gaps, and roadmaps from the current to the desired state
- Identifying strategic focus areas and outsourcing candidates
- Application portfolio health, risks, costs, and gaps
- Maturity assessments, target maturity and related capabilities, applications, and technologies

Business function reference architectures that accelerate strategic and tactical decision making by providing a platform of well-defined functions and data that are provided by the organization or required to realize the enterprise's strategic outcomes.

Key Activities

Activity	Date	Completion Status
EA and Integration Task Force	16-May-2026	
EA and Integration Task Force	10-Oct-2026	

2026 Anticipated Deliverables

Title	Short Description		Date
Utility Business Capability Model	Tech Update - Extensions and refinements to the model learned through its application across EPRI and utility projects.		12/31/2026
IT-OT Convergence, 9th Edition	Guide - Explores the drivers, the benefits, types and approaches for the convergence of information technology and operations technology.		12/31/2026
Architectural Impacts of Disruptive Technologies, 7 th Edition	Tech Update - Defines a process for selecting and assessing the potential impact of new technology to a utility.		12/31/2026
Business Capability Model Guidebook, 5th Edition	Guide - Provides guidance for building and using a business capability model for strategy development, roadmapping and assessments.		12/31/2026
Grid Modernization Playbook	Tech Update - Provides guidance on roadmapping for grid modernization. Joint deliverable with the Distribution Operations program (P200).		12/31/2026

Past EPRI Research on Topic:

Product ID	Title	Short Description (link to new project)	Published Date
3002032390	Utility Business Capability Model 2026	Technical Update - This business capability model defines what a utility needs to be able to do—focusing on capabilities rather than implementation—and supports use cases such as modernization roadmaps, investment alignment, and risk identification. The 2025 version, maintained by the Enterprise Architecture and Systems Integration project, provides a detailed four-level model with updated domains, reference examples, and multiple formats to support capability-based planning and enterprise architecture work.	12/31/2025
3002032391	Digital Transformation: Information Technology-Operational Technology Convergence Guidebook, Eight Edition	This guidebook explains how the convergence of IT and OT is reshaping electric utilities as grids become more digital and DERs extend operational systems to the grid edge. It defines key concepts, levels of convergence, and practical approaches—addressing technical, organizational, and cultural challenges—to help utilities choose the right integration strategy and mature their capabilities.	12/31/2025
3002032396	Architectural Impacts of Disruptive Technologies: Sixth Edition	Technical Update – to be published	12/31/2025
3002032397	Utility Business Capability Guidebook, Fourth Edition	This guidebook explains business capabilities and capability models and shows how they support strategy execution through capability-based planning. The third edition expands the guidance with a new focus on application portfolio management, including real-world examples from Exelon and Alliant Energy demonstrating how	12/31/2025

		capability management can streamline and rationalize application portfolios.	
3002033541	Grid Modernization Playbook: 2025 Update (joint project with P200)	This report explains how rapid changes—such as extreme weather, rising DER adoption, and emerging grid technologies—are increasing distribution system complexity and driving utilities to modernize planning and operations. It introduces EPRI’s grid modernization framework, which helps utilities develop company-specific strategies by aligning investments in people, processes, and technology to build a more flexible, reliable, and resilient grid.	12/08/2025
3002029931	Digital Transformation: Aligning Information Technology and Operations Technology, 7th Edition	The objectives of this guidebook are to: Clearly define concepts and terms to promote better understanding across both IT and OT domains. Provide additional context as to how business and technology changes are reshaping the IT-OT convergence challenge. Define three levels of convergence and how to decide which level is right for a particular capability. Share approaches to convergence, focusing on overcoming cultural differences that can lead to the appropriate level of convergence and a more mature and effective capability. Present EPRI research on IT-OT convergence in a format that can be updated and expanded annually. Provide guidance for selecting candidate business capabilities for three different levels of convergence. Identify areas for further research.	12/31/2024

3002029933	Architectural Impacts of Disruptive Technologies, 5th Edition	Tech Update - Disruptive technologies—such as the advanced metering infrastructure (AMI) or global positioning systems (GPS) that fundamentally alter how a business process is executed and may determine whether it is even performed at all—need to be considered regarding their impacts to utility application portfolios and roadmaps. This report provides an overview of the types of innovation, evaluates criteria for assessing disruptive technologies, and summarizes resources available to assist utilities in anticipating, evaluating, and implementing disruptive technologies.	12/31/2024
3002028114	EPRI 2023 Utility Business Capability Model	Business capability models are a tool for expressing what capabilities a utility may focus on in business terms. The focus is on the what, not the how. These models can be used in a variety of ways such as developing modernization roadmaps, creating heat maps that can show disparities in stated strategy versus where money is spent, or highlighting technology obsolescence or security risks.	10/25/2023
3002026854	Architectural Impacts of Disruptive Technology: Fourth Edition	TechUpdate - This research aims to demonstrate how utilities can assess the impact of disruptive technologies on their application portfolios and roadmaps, offering a practical framework for evaluating and preparing for such innovations.	10/27/2023
3002026853	Digital Transformation: Aligning Information Technology and Operations Technology, Sixth Edition	TechUpdate – The convergence of Information Technology (IT) and Operational Technology (OT) platforms is accelerating due to advancements in computing and communication technologies. This convergence is particularly impactful in asset-intensive industries, including electric utilities, where OT systems are crucial for monitoring and controlling production and capital assets. This guidebook aims to clarify concepts, provide context on how business and technology changes are shaping IT-OT convergence, define	12/29/2023

		levels of convergence, share approaches to overcoming cultural differences, present research findings, and identify areas for further research, ultimately facilitating effective integration of IT and OT applications.	
3002026985	Grid Modernization Playbook: A Framework for Developing Your Plan	TechUpdate – Joint deliverable with P200EPRI addresses the impact of disruptive technologies on utility application portfolios and roadmaps by leveraging business capability models, a tool that has gained recognition among architecture practitioners. Using an example of a potentially disruptive technology, Docker containers in a Distributed Energy Resource Management System (DERMS), EPRI compares its characteristics against a generic utility business capability model to derive an impact assessment. This research, based on a generic business capability model derived from the APQC Process Classification Framework (PCF)®, identifies evaluation criteria for disruptive technologies, examines utility readiness, demonstrates practical application of business capability models, and assesses technologies against local capabilities and technology roadmaps.	12/29/2023
3002026985	Grid Modernization Playbook: A Framework for Developing Your Plan	This report describes the EPRI framework and how it can be applied to develop company-specific strategies for grid modernization.	11/30/2023
3002021853	A Framework for Relating the Elements of Strategy Development through Implementation	This paper introduces a capability-based planning metamodel that can be used as-is or customized to meet the specific needs of a utility.	21/10/2021
3002021938	Business Capability: Motivations and Meta-Models	Provides the basis for understanding the link between stakeholders' concerns, objectives, outcomes, and strategy.	04/09/2021

P161.063 Data Management

Objective

The evolving utility industry is experiencing a surge in data sources such as grid and behind-the-meter sensors, weather data, and customer information. This influx, coupled with increasingly intricate grid operations and the widespread adoption of data analytics, underscores significant challenges in data management. These challenges encompass the sheer volume and diversity of data, its quality, and concerns regarding security and privacy. Additionally, the industry grapples with the legacy of siloed systems and inaccessible datasets.

To navigate these complexities effectively, the utility sector must possess robust capabilities to manage, comprehend, process, share, and appropriately dispose of data. Confidence in data relies on ensuring its provenance, quality, definition, location, security, and suitability for specific purposes.

Approach (The How)

Develop, implement, and enhance a data management maturity model tailored for the utility sector. This model, accompanied by an assessment framework, empowers utilities to gauge and enhance their own maturity levels while also benchmarking against industry peers.

Conduct thorough research to establish data quality metrics, measurement methodologies, and corrective procedures to uphold high standards of data integrity.

Articulate comprehensive data domain reference architectures for key utility domains, such as grid model data, to provide a structured framework for organizing and managing critical data assets.

Research Value

The project helps members and the public by:

- **Enhancing Enterprise Information Management (EIM) Capability:** Through measuring, benchmarking, and improvement initiatives, the project aids in elevating EIM capabilities across various industries. By identifying best practices and areas for enhancement, organizations can refine their information management strategies to better leverage their data assets effectively.
- **Streamlining Requirements Definition and Data Classification:** By accelerating the process of requirements definition and data classification for risk assessment and retention purposes, the project facilitates faster decision making and implementation of data management policies. This efficiency helps organizations promptly identifying and addressing potential risks while ensuring compliance with regulatory standards.
- **Analyzing Data Flows:** The project expedites the analysis of data flows across diverse business functions, applications, and stakeholders, including utilities, regulators, and market operators. This comprehensive understanding of data movement enhances transparency, facilitates regulatory compliance, and strengthens collaboration among various entities within the industry ecosystem.
- **Researching Data Sharing Approaches:** The project explores innovative data sharing approaches with global implications. By identifying and evaluating strategies for enabling secure and efficient data exchange, the project fosters the creation of new business opportunities on an international scale. This research encompasses legal, technical, and ethical considerations to ensure responsible and sustainable data sharing practices.
- **Promoting Collaboration and Knowledge Sharing:** Beyond specific initiatives, the project serves as a platform for collaboration and knowledge exchange among industry stakeholders. By facilitating dialogue, sharing insights, and disseminating best practices, the project fosters a culture of continuous improvement and innovation within the EIM community.

Key Activities

Activity	Date	Completion Status
EA and Integration Task Force	16-May-2026	Not started
EA and Integration Task Force	10-Oct-2026	Not started

2026 Anticipated Deliverables

Title	Short Description		Date
Data Management Maturity Model, 2 nd Edition	Tech Update - Specifies maturity levels of the components of enterprise information management capability and a corresponding assessment.		12/31/2026
Data Management Guidebook 2 nd Edition	Guide - The Data Management Guidebook will be designed to help utilities optimize their data management practices. It provides insights on aligning strategy with data management capability, measuring data quality, and implementing data governance principles. With practical guidance and frameworks, this guidebook empowers utilities to enhance their data management effectiveness and maximize the value of their data assets.		12/31/2026

Past EPRI Research on Topic:

Product ID	Title	Short Description (link to new project)	Published Date
3002032400	Data Management Guidebook 1.0	This guidebook bridges the gap between general data management frameworks like DMBOK and DCAM and their practical application in the utility environment, explaining why data management is both critical and challenging today. It provides a maturity model and assessment methodology, emphasizes data centricity and CIM-based integration, and offers detailed	12/19/2025

		guidance on data quality measurement and improvement.	
3002028913	Data Management Maturity Model	This White Paper introduces a data management maturity model developed using the EPRI common maturity model framework. This enables as a strategic tool for organizations in the data management domain, enabling the identification of strengths and weaknesses, and providing a roadmap for improvement.	02/02/2024
3002025786	Grid Model Data Management (GMDM) Information Architecture	Designing effective solutions for the management of data at an enterprise level requires an enterprise view of where data originates, how it flows, and where it is used. Business function-based information architectures can help by providing an organization and visualization framework. This report describes EPRI's Grid Model Data Management (GMDM) information architecture for the management of distribution grid model data for the electric utility industry.	12/05/2022
3002025387	Applying the Grid Model Data Management (GMDM) Information Architecture at the Distribution Utility	This Technical Brief analyzes the complexities surrounding the implementation of consolidated enterprise-wide management of grid model data at distribution utilities, highlighting existing challenges stemming from distribution system characteristics, software tool usage, and integration approaches. It identifies common obstacles hindering efficient data management and proposes a strategy, drawing from EPRI's decade-long experience with utilities, to advance towards effective grid model data management.	11/14/2022
3002025384	Introduction to Grid Model Data Management (GMDM): A Best Practice Approach to Managing Distribution Grid Model Data	This Technical Brief describes a future vision for grid model data management that reflects the complex reality of grid model data creation and use at the distribution utility. The vision is articulated by EPRI's Grid Model Data Management (GMDM)	11/16/2022

		information architecture, which provides a business function framework for organizing distribution grid model data flows which is intended for general use by any distribution utility.	
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Related Research

The EPRI contributions to the IEC CIM Standards inform data management, especially the industry reference data model that enables data classification and systems integration via the CIM profiles and API specifications.

PS161F Advanced Metering Systems and SCADA Protocols

Objective

Advanced metering infrastructure (AMI) and SCADA systems are being deployed by utilities worldwide. The performance of these systems, their reliability, and consumer trust in them, especially AMI, are crucial to the utility business, and many challenges must be addressed. Both metering and communication capabilities in AMI and SCADA are evolving rapidly, and the methods for optimizing their utilization and value are still developing. AMI assets exist throughout the full extent of a utility's service area, and replacing them can be disruptive to end users, resulting in a need for high-quality asset management throughout the system life cycle. Because many current systems are still largely custom-designed or proprietary rather than standards-based, the potential consequences are vendor lock-in, heightened risk of obsolescence, and poor interoperability.

This project set consists of the whole of EPRI research in metering, advanced metering systems, and SCADA protocols, bringing together communications and meter-specific research previously conducted in separate programs. This project set aids utilities in optimizing existing system utilization and in discovering the full value of AMI-collected data; accelerates and informs the development of emerging standards and architectures to enhance interoperability, innovation, and marketplace competition; and identifies best practices for the support of system operations and monitoring of systems. Finally, the project set will investigate AMI meters with regard to accuracy, reliability, and tamper resistance.

P161.032 Achieving Open, Interoperable Advanced Metering Systems

Objective

The present state of the advanced metering industry and advanced metering infrastructure (AMI) depends heavily on custom designs and proprietary systems. Although standards have been created, the maturity and quality of the standards and their application vary widely, and adoption has been selective. As a result, interoperability and interchangeability of devices have not occurred, leading to unnecessary costs and complexity in system design, selection, and integration. Another concern is vendor lock-in, which could inhibit innovation and limit functionality. Technology improvements and third-party communication systems are rapidly changing the landscape of available options and architectures, exacerbating the challenges in selecting next-generation technologies.

This project will assist utilities in designing, selecting, integrating, and deploying AMI systems based on standards, helping to reduce lifetime costs and improve performance. The research aims to improve the open options that are possible and accelerate availability in the marketplace. The project will provide technical references, performance assessments, and evaluation tools for AMI system components. Through software "upgradeability," existing assets can be more readily integrated with products and software from other manufacturers, and potential dependencies on existing vendors can be reduced.

Approach (The How)

In this project, EPRI will develop a comprehensive reference architecture and code implementation for open AMI. It tracks the industry status and monitors the key activities that are defining AMI technologies and system architectures and provides members with concise updates. This work informs the development of the most valuable standards by engaging experts in their respective fields and facilitating open working groups to develop consensus materials. Laboratory and field evaluations are conducted to assess the performance and interoperability of emerging system components. This project is coordinated in conjunction with the Power Quality (P1) and Distribution Systems (P180) programs

Research Value

The results of this project provide value by:

- Guiding AMI system changes and upgrades, aiding in the progression to open, interoperable AMI systems
- Migrating existing systems toward more open systems, reducing vendor dependency over time
- Reducing or avoiding vendor lock-in, thereby increasing competition and reducing procurement and operating costs
- Allowing stakeholders to collaboratively provide input to standards development

Key Activities

Activity	Date	Completion Status
Perform literature search	02/15/2026	Not started
Interview utility and standards personnel	03/25/2026	Not started
Interview vendors on their interfaces and functions	4/15/2026	Not started
Obtain new versions of manufacturers' meters and test	06/15/2026	Not started
Create final draft with latest status of standards	07/15/2026	Not started
Submit for publication	08/20/2026	Not started

2026 Anticipated Deliverables

Title	Short Description		Date
Metering Engineering Tutorial	Technical Update—Describes the current state of metering engineering, with particular attention to applications and standards of practice		12/31/2026

Past EPRI Research on Topic:

Product ID	Title	Short Description (link to new project)	Published Date
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3002032217	ANSI Meter Standards Utilization, 2nd Edition	This Technical Update analyzed a sample of twenty meters, both old and new, to assess their compliance with the ANSI C12.18 Standard (optical port protocol) and the ANSI C12.19 Standard (data table standard). While some quirks and anomalies were discovered, it appears that the level of compliance with these two standards is sufficient to read enough data in a standard form that would allow for the creation of a bill.	12/31/25
3002029969	Device Language Message Specification and Companion Specification for Energy Metering for North American Utilities	Technical Update - This work describes the DLMS/COSEM (IEC 62056) standard to give interested people an idea of what is included within this important metering communications protocol standard and how it works	11/26/24
3002024105	Standard Meter Communications Protocols Primer	Technical Update—describes the current state of the utilization of the American National Standards Institute (ANSI) standards in advanced metering systems available today.	12/31/21
3002021410	ANSI Meter C12 Communications Compliance Software	Pre-Software – implements an open source ANSI C12.18 reader.	12/31/22
3002013397	PRE-SW: DLMS/COSEM Reference Implementation (DLMS/COSEM), v1.0 Beta	To access DLMS/COSEM v1.0 to epri.com record 3002013397 Benefits and Values - Provides an open source implementation of an important metering protocol - Provides both server and client implementations - Runs on low-cost low resource embedded microprocessor Platform Requirements - C++11 compiler, Asio library.	Jan 21, 2019
3002008943	Revenue Protection Guidebook, 1st Edition: Utilizing Advanced Metering Infrastructure	With the introduction of advanced “smart” metering technology over a decade ago, utilities have been required to modify and broaden the methods and procedures they use to protect themselves from energy theft. A process that previously relied on physical visits, human labor, and training in inspection techniques is being replaced by one that is primarily based on digital sensors, remote readings, and analytic algorithms.	Dec 31, 2016
3002021413	Guidebook for Using AMI in Outage Management	This research describes the essential characteristics of a successful Advanced Metering Infrastructure (AMI) to Outage Management System (OMS) integration. It synthesizes some of the currently known best practices to	Dec 28, 2021

		ensure the success of such a project and gives practical examples.	
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P161.043 Advanced Metering Systems Operations and Management

Objective

Best practices for advanced metering infrastructure (AMI) system operations and management are not well-known or documented. Utilities are now preparing to launch their second AMI system. The newer AMI systems employ artificial intelligence (AI) in both the headend system and the metering devices. For many utilities, owning and operating large communications networks as well as using and training AI technology are new endeavors, and the requisite domain expertise is being developed internally.

AMI systems are made up of thousands—in some cases, millions—of nodes, each of which must remain reliably connected. Data must be collected frequently to satisfy billing requirements and support customer service. Despite this scale and performance, the total operating cost must be kept low compared to other communication systems. Service calls for even a small percentage of meters per year are not practical and would be cost-prohibitive on any scale.

This project provides insights into all aspects of AMI system operation and management by addressing processes throughout the life cycle, including new system acquisition, day-to-day management, and ultimate replacement. In many cases, this insight comes from best practice guidebooks that identify practices designed by industry experts and that are successfully employed by other utilities.

Approach

The aim of this project is to develop a comprehensive set of advanced metering operations and maintenance (O&M) best practices. Specific topics are prioritized to identify the areas of greatest and most pressing need. The products of this research are collaborative—representing the best of learning-by-doing and sharing results. EPRI engages experts and facilitates information sharing to identify and document the best practices in each area. In consultation with utility personnel who are directly involved with the O&M process at hand as well as AMI vendors, service providers, consultants, and domain experts, EPRI guides the development and documentation of the current best practices.

This research anticipates that utilities will apply the best practices, helping to refine the guidebooks as new methods are discovered. In this sense, the people with whom EPRI develops these guidebooks can continue as domain-specific communities with a common interest. The work being done in this project is coordinated with and designed to complement the work related to other distribution sensors being done in the Substations (P37) and Distribution Systems (P180) programs.

Research Value

This project helps utilities and their customers:

- Identify ways to reduce time and cost in operating and maintaining advanced metering systems
- Streamline AMI system procurement, deployment, and integration
- Identify processes that can reduce operating costs, such as distributed intelligence software applications
- Mitigate risks by providing insights into the system's health and remaining useful service life
- Reduce risk by proactively identifying and correcting meter issues

Key Activities

Activity	Date	Completion Status
Perform literature search	02/28/2026	Not started
Gather and analyze relevant standards	03/15/2026	Not started
Interview vendors on their interfaces and functions	4/15/2026	Not started
Catalog currently available head-end systems	05/15/2026	Not started
Create final draft	08/01/2026	Not started
Submit for publication	08/30/2026	Not started

Anticipated Deliverables

Title	Short Description		Date
Edge AI for Metering Applications	Technical Update—Describes some of the machine learning capabilities, distributed intelligence applications, for edge nodes in AMI systems and analyzes some of the implications of these functions.		12/31/2026
Meter Services Operations Overview	Technical Update – What are the purposes, methods, equipment, personnel, and training for a modern meter services department?		12/31/2026

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002032219	The Evolution of Advanced Metering Infrastructure System Functions	This paper traces the evolution of metering from mechanical systems to AMI and emerging AMI 2.0, emphasizing the Head-End System as the operational backbone for interoperability, data integrity, and reliable grid operations. It introduces an AMI maturity model to help utilities assess current capabilities, identify gaps, and prioritize investments toward a fully digital, resilient, and customer-centric grid.	12/31/2025
3002029970	Introduction to DC Metering for Utilities	Technical Update - This survey explores the progress in development and use cases involving DC metering equipment, highlighting its growing necessity for modern energy systems.	12/31/2024
3002026730	Testing Requirements for AMI Meters	This work documents the testing requirements for AMI meters but also extends this to the testing of the	12/29/2023

		entire AMI system. While meter accuracy, for example, is a critical cornerstone for accurate billing, other system components must also perform correctly for the system to function as expected.	
3002024106	Guidebook for Identifying and Mitigating AMI Communications	Guidebook that describes the current practice in identifying and resolving AMI system communications, including RF mesh and PowerLine Carrier (PLC) technologies.	12/31/2022
3002018630	Guidebook for Revenue Protection, 2nd Edition	This guidebook is aimed at helping utilities establish and improve revenue protection practices. <i>Revenue protection</i> refers to the broad set of processes that utilities employ to prevent, detect, and respond to energy theft and other energy unaccounted for. The first edition of this guidebook was developed through an open collaboration that brought together utility, manufacturer, and other industry experts over an eight-month period. This second edition updates some of the techniques that have been learned since the publication of the original edition in 2016 (3002008943).	02/26/2021
3002008943	Revenue Protection Guidebook, 1st Edition: Utilizing Advanced Metering Infrastructure	With the introduction of advanced “smart” metering technology over a decade ago, utilities have been required to modify and broaden the methods and procedures they use to protect themselves from energy theft. A process that previously relied on physical visits, human labor, and training in inspection techniques is being replaced by one that is primarily based on digital sensors, remote readings, and analytic algorithms.	12/31/2016
3002021413	Guidebook for Using AMI in Outage Management	This research describes the essential characteristics of a successful Advanced Metering Infrastructure (AMI) to Outage Management System (OMS) integration. It synthesizes some of the currently known best practices to ensure the success of such a project and gives practical examples.	12/28/2021

P161.044 Optimizing Advanced Metering System Value and Utilization

Objective

Advanced metering infrastructure (AMI) systems have the potential to support a wide range of uses. AMI data can provide value across the utility enterprise and can be processed in innovative ways to improve distribution operations, planning, distributed resource integration, customer service, and more. The industry is only beginning to study these ancillary uses. Performance and capabilities vary from system to system, making it difficult to know what options are practical for any individual system. Specific algorithms and system configurations that yield the best performance for each system need to be developed and published so that they can be freely and consistently implemented by manufacturers.

This project helps utilities optimize the use and value of AMI. The research is aimed at discovering the full range of applications that can be supported by a given system type, documenting optimal algorithms, and using them to transform AMI data into actionable information. The project also seeks to identify applications that cannot be effectively supported, saving members time and effort.

Approach (The How)

This project performs state-of-the-industry assessments to provide utilities and the public with insights into how AMI systems are being used successfully. It also identifies attempted AMI system uses that have been unsuccessful and seeks to understand why. This project develops data processing algorithms and simulation tools to help utilities and vendors implement new AMI functionality in an optimal way and to process AMI data for maximum benefit. This project's work is coordinated with and designed to complement work being done in the Electric Transportation (P18), Energy Storage and Distributed Generation (P94), Customer Technologies (P170), DER Integration (P174), and Distribution Systems (P180) programs.

Research Value

Applying the results of this project might help utilities:

- Make informed decisions about how to best use their company's AMI system and the data it produces
- Increase the overall benefits derived from AMI systems
- Identify advanced metering system applications that provide value to the public, consumers, utilities, and the grid overall
- Optimize the utilization of AMI data, recognizing additional benefits without additional cost
- Reduce the time needed to realize the benefits of AMI systems

Key Activities

Activity	Date	Completion Status
Perform literature search	1/31/2026	Not started
Survey industry personnel on current state and future expectations	2/28/2026	Not started
Analyze gaps between current and future state	5/15/2026	Not started
Write final version	9/1/2026	Not started
Submit for publication	9/30/2026	Not started

2026 Anticipated Deliverables

Title	Short Description		Date
Advanced Metering Data Analytics Guidebook, 4th edition	Guide - This updates the 2025 version to include the latest developments, including the use of machine learning in metering data analytics.		12/31/2026

Past EPRI Research on Topic:

Product ID	Title	Short Description (link to new project)	Published Date
3002032221	Advanced Metering Data Analytics Guidebook (AMI-Data-Analytics) v3.0	Utilities are increasingly using AMI data analytics to extract more value from the large volumes of AMI data they collect, and successful programs emphasize organizing data, systems, and staff around clear use cases, architectures, data characteristics, and data policies. The report also highlights eight free open-source tools (with utility-centric usage scenarios) and adds coverage of machine learning methods and algorithms to support more advanced analytics. To access AMI-Data-Analytics v3.0, click here: https://ami-data-analytics.epri.com	12/31/25
3002029971	Continuous Meter Replacement in Heterogenous Systems	Tech Update - In an increasingly interconnected world, the proliferation of advanced metering devices from multiple vendors creates challenges for seamless communication and interoperability. This paper explores how standardization across multiple levels, from hardware to protocols to user applications, enhances interoperability and device integration within AMI systems.	12/31/24
3002026731	Business Cases for Replacement AMI Systems	This research describes business cases for the replacement of AMI systems. While original AMI deployments were often justified solely on the basis of the efficiency improvement realized by not having to send out meter readers to gather data every month, the replacement of existing and deployed AMI systems typically needs a different approach. Benefits of new systems, including customer and utility benefits, are sometimes harder to quantify but often are just as compelling.	12/29/23

3002026784	Advanced Metering Data Analytics Guidebook	Many utilities are gathering large amounts of data from their Advanced Metering Infrastructure (AMI) systems and are embarking on or have already begun AMI data analytics activities to maximize the value of this data. This report describes how utilities that have successfully used AMI data analytics have learned to effectively organize their data, systems, employees for that purpose, including use cases, system architecture, data characteristics and data policies. It also describes eight free open source software tools that can be useful in AMI data analytics and gives utility-centric scenarios for how each might be used.	12/29/23
3002024107	Analyzing and Categorizing Momentary Outages from AMI	This technical report describes methods for analyzing momentary outages reported by AMI meters and how to interpret and categorize the results.	12/31/22
3002021412	Integrating Non-meter Sensors and Devices into AMI—AMI Sensor Integration	This Technical Update describes how sensors other than meters are integrated into AMI networks and considerations for doing so.	12/31/2021
3002018631	AMI Data Analytics Survey	This report describes the management of AMI data after it has been received by the Head End system. Based on a series of meetings with industry experts, this guidebook describes aspects of AMI data management, including use cases, system architecture, data characteristics and data policies.	3/31/2021

P161.045 SCADA Protocols

Objective

Many utility systems use SCADA protocols, and increasingly, disparate devices such as distributed energy resources (DER) that may or may not be owned by the utility have begun to use these protocols. Performance characteristics, interoperability, security, and the usability of these protocols over different underlying physical media are all of interest to utility personnel. The effective use of such protocols as well as their interoperability contributes to more efficient use of resources, benefitting the general public. The focus of this research is to examine SCADA protocols to better understand all the aspects listed above.

Approach (The How)

This research will study SCADA protocols and contribute to their better understanding and utilization within the utility arena by creating such material as tutorials, guidebooks, software, webinars, and white papers. Some sources of information that may be employed to produce this research includes standards

documents, open-source software, other published research, and examination of the communications of existing manufactured devices in either field or lab environments.

Research Value

The value of the research is that it helps to deepen and broaden knowledge of SCADA protocols in the utility industry. This allows utility personnel to be better informed when purchasing, configuring, testing, deploying, updating, replacing, and retiring SCADA devices and software. In turn, the more effective and secure use of such resources benefits the public by enabling the efficient use of resources.

Key Activities

Activity	Date	Completion Status
Do literature search for background	1 March 2026	Not started
Interview utility people for interests	14 May 2026	Not started
Create first draft	1 June 2026	Not started
Finalize draft for publication	1 August 2026	Not started

2026 Anticipated Deliverables

Title	Short Description		Date
SCADA vs. AMI Protocols: A Comparison	Technical Update – Describes some of the defining characteristics of both SCADA and AMI protocols to help utility personnel from either realm to better understand commonalities and differences.		12/31/2026

Past EPRI Research on Topic:

Product ID	Title	Short Description (link to new project)	Published Date
3002032222	DNP tutorial	Tutorial - A short, modern tutorial that describes the operation and features of the DNP protocol.	12/31/25

PS161G Telecommunications

Telecommunication is essential to utilities and has an increasingly critical role in the operation of the integrated grid. In grid modernization, telecom supports higher penetrations of distributed energy resources (DER) and a greater reliance on sensors to provide situational awareness. No single technology can meet all the widely varying requirements, resulting in complex and heterogeneous telecom networks that are challenging to manage.

The project set addresses challenges that utilities face with respect to telecommunications:

- Planning a scalable, multi-service network that meets current and future needs.
- Leveraging technologies and best practices from commercial telecom operators (both wireline and wireless).

- Resolving barriers to complete the transition of the wide area network (WAN) to packet technologies.
- Evaluating new technologies, including artificial intelligence (AI), business models, and partnerships to make fiber deployment in more locations economically viable.
- Addressing industry challenges with potential interference to licensed microwave links.
- Enabling wider use of wireless networks by identifying suitable licensed wireless spectrums and optimizing the use of available spectrum with AI and machine learning (ML).
- Stewarding the standards to enable interoperability and interchangeability.
- Identifying the options available with commercial wireless and shared networks and navigating the transition to 5G networks.
- Evaluating wireless technologies and network configuration approaches to deliver low-latency communications to support DER protection and other latency-sensitive use cases.
- Developing approaches to maximize the performance of wireless technologies in unlicensed spectrums and developing strategies for alternatives when unlicensed bands can no longer support desired utility applications.
- Evaluating the role of AI in improving telecom network operational efficiency.
- Leveraging AI to improve telecom project risk management.
- Developing resilient telecommunications infrastructure and evaluating satellite and other technologies for backup and emergency operations.
- Developing best-in-class telecom network management, visualization, and control systems that take advantage of advances (such as AI, software-defined networking, software-defined WAN, and network functions virtualization) while maintaining reliability, resilience, and cyber security.

P161.053 Wide Area Networks

Objective

The wide area network (WAN) is the backbone of the utility telecommunications infrastructure. As new requirements and applications are deployed to support grid modernization, the WAN must expand in capacity and geographic presence.

The WAN physical plant is increasingly built on fiber, while microwave links and leased services continue to play an important role in many networks. With the opening of the 6-GHz band to unlicensed devices, maintaining the reliability of licensed utility microwave systems poses an increasing challenge. For many utilities, the long-term goal is to migrate the WAN to incorporate more fiber, but the economics are challenging. New approaches are needed to enable a viable business case for fiber. These approaches involve innovative materials and construction techniques, leveraging opportunities with other entities that also need fiber-rich metropolitan networks, predictive maintenance with artificial intelligence (AI), and providing capacity for broadband services. Leased dark fiber and bandwidth from communications service providers will likely remain necessary for some portion of many utility WANs for multiple reasons. The next-generation optical network architecture becomes possible when the physical plant is fully fiber. Regardless of ownership, similar challenges and best practices apply.

In the network architecture, the transition to fully packet-based networks is still underway. There is a need to understand the available technologies, best practices, and the role of AI for network architecture, configuration, and operation. These include the use of packet networks for protection and evaluating the use cases for software-defined networking (SDN) and network function virtualization in the WAN for information technology (IT) and operations technology (OT) networks, as well as evaluating the role of AI across the various system life cycle stages.

The objectives of the project include:

- Identify and mitigate interference to 6-GHz microwave systems from Automated Frequency Coordination (AFC)-controlled standard power and very low power (VLP) outdoor, and Low Power Indoor (LPI) unlicensed equipment
- Understand trade-offs between private and leased WAN circuits
- Ensure that latency requirements for teleprotection and precision time synchronization are met when running over packet networks under normal and abnormal circumstances
- Identify, analyze, and quantify business cases for expanded fiber deployment, including opportunities arising from IT/OT convergence, AI tools and techniques, and broadband service opportunities
- Identify, analyze, and evaluate best practices for WAN operation and management and for improving WAN reliability, availability, and optimizing service provisioning and orchestration via AI/machine learning (ML)

Approach (The How)

- Lab and field testing of 6-GHz microwave systems with unlicensed devices to understand potential impacts and mitigations. Engagement with standards-setting organizations to improve incumbent protection.
- Evaluation and assessment of opportunities and partnerships for fiber deployment, including fiber-to-the-home technology, fronthaul for distributed antenna systems, and 5G small cells and smart city applications.
- Evaluation of life cycle and failure rates in overhead and underground fiber cables and evaluation of AI-based tools for predictive maintenance.
- Evaluation of hybrid fiber-wireless architecture and deployment models.
- Testing and evaluation of new technologies for time synchronization, teleprotection support, and transport for operational networks (carrier Ethernet [CE] and time-sensitive networking), including: 1) approaches for quality of service and link layer cyber security; 2) evaluation of synchronous Ethernet and related time synchronization methods; 3) evaluation of the meshing of multi-protocol label switching (MPLS); and 4) CE in a system.
- Assessment of recent advances in WAN technologies, such as segment routing.
- Evaluation and case studies about best practices for operating and maintaining the WAN and fiber plant, including AI applications and best practices for fiber restoration programs.
- Evaluation of AI tools to assist in project and resource scheduling for WAN modernization.
- Evaluation of non-fiber WAN technologies—high-capacity microwave, new satellite technologies, and others.

Research Value

- Cost savings and risk avoidance resulting from strategic network planning and adoption of standards, leveraging best practices from the industry.
- Increased operational effectiveness for telecommunications and reduction of outages through better situational awareness.
- Preparing the utility WAN for an AI-centric future.
- Improved reliability and lower cost for teleprotection circuits, enabling more advanced protection schemes.
- Improved ability to plan and deploy an expanded, higher-density, fiber-based WAN while creating new economic and business opportunities.
- Ability to leverage new technologies and AI to more rapidly scale and expand the telecommunications network to meet business requirements.
- Information needed to develop a long-term microwave system strategy.
- Delivery of public benefit from telecommunications' enablement of grid efficiency improvements, increased use of distributed energy resources (DER), and improved reliability of electricity delivery.

Key Activities

Activity	Date	Completion Status
6-GHz Microwave Interference	12/31/2026	Not started
WAN Modernization Guidebook	12/31/2026	Not started
Strategic Fiber Guidebook	12/31/2026	Not started

2026 Anticipated Deliverables

Title	Short Description		Date
Evaluation of Interference to 6-GHz Microwave	Tech Update - Analysis and field testing of interference to 6-GHz microwave links from increasing consumer adoption of unlicensed devices, including VLP devices and increased adoption of Wi-Fi 7		12/31/2026
WAN Modernization Guidebook 2026 Edition	Technical Report—Annual Guidebook Update		12/31/2026
Strategic Fiber Guidebook: 2026 Edition	Technical Report—Annual Guidebook Update		12/31/2026

Past EPRI Research on Topic

Product ID	Title Auto fill from POF system from Product ID	Short Description	Published Date
3002032228	6 GHz AFC Protection: Field Test Results - 2025	This report summarizes EPRI's role in the WInnForum 6 GHz AFC Functional Specifications work group, including consensus changes with AFC operators to address under-protection of fixed service microwave links. It presents results from DOE-funded, INL-administered field testing at Southern Company Georgia Power and investigates real-world unlicensed interference affecting a Salt River Project fixed service link in Arizona.	12/31/2025

3002032229	Wide Area Network (WAN) Modernization Guidebook: 2025 Edition	This guidebook explains the critical role of wide area networks in supporting modern utility operations as grid modernization drives new, mission-critical applications and the replacement of aging legacy technologies with packet-based, virtualized networks. The 2025 edition outlines why WANs are essential, how underlying technologies are evolving, and shares best practices and lessons learned from utility WAN migration experiences to ensure resilient, reliable communications.	12/31/2025
3002032231	Strategic Fiber Guidebook 2025 Edition	This guidebook focuses on electric utility-specific fiber optic networks, explaining why utilities adopted fiber early and addressing key questions around installation best practices, lifecycle tradeoffs, shared network models, and strategic justification. The 2025 edition updates industry practices and adds a new Southern Company long-haul fiber case study based on direct utility experience.	12/31/2025
3002029958	Strategic Fiber Guidebook: 2024 Edition	<p>Guide - The objective of this project is relevant case studies as examples. Information on all case studies was gathered from meetings with principal individuals directly responsible for the fiber initiatives at each company.</p> <p>Updates in this 2022 edition are primarily in the area of information and guidance on the fiber</p>	12/31/2024

		lifetime issue. All other content was reviewed and revised were necessary to be current with updated standards and industry practices.	
3002029953	WAN Modernization Guidebook: 2024 Edition	Tech Report - This 2024 H1 edition introduces readers to the topic of telecom wide area networking in electric utilities, focusing on why WANs are needed by utilities, and the rationale behind the evolution of the underlying technologies. Best practices and lessons learned from network migration experiences of utilities are also included.	12/31/2024
3002029950	Evaluation of Interference to 6-GHz Microwave	TechUpdate - Preliminary results of 6 GHz AFC testing at Southern Company Georgia Power Columbus fixed service microwave station are detailed. This real-world field-testing effort was funded by Department of Energy CESER program and administered by Idaho National Laboratory (INL). This report also presents other EPRI work on this topic in 2024, including participation and findings from the FCC AFC Public Trial and WInnForum AFC Functional Specification change request. The report concludes with a summary and potential next steps.	12/31/2024
3002027046	AFC Protection—Field Test Results	Preliminary results of EPRI participation in the 6 GHz AFC public trial is presented. None of the AFC operators that	12/31/2023

		started public trials had completed them at time of publication. The presentation covers the EPRI strategy in creating an industry stakeholder test vector list, the responses from the AFC operators, analysis of the responses, overview of challenges submitted, operator replies, and potential next steps.	
3002027068	WAN Modernization Guidebook: 2023 Edition	Wide area networks have a central place and play a critical role in the utility telecommunications infrastructure and operation. There are several challenges brought on by the obsolescence of existing solutions. This issue is forcing a migration from TDM and serial to packet-based WAN technologies. In addition, the rise of cloud computing along with other even recent technology advances such as software defined networking further complicate the transition process. This 2023 edition contains an overview of the topic and content drawn from previous EPRI Information and Communication Technology (ICT) research in the WAN subject area. Four of these previous reports are provided in the appendix.	12/31/2023
3002027080	Strategic Fiber Guidebook 2023 Edition	The guidebook highlights the significance of fiber optic communications for electric utilities due to its safety and reliability advantages over copper-based wireline systems. The 2023 edition primarily focuses on updates	12/31/2023

		regarding fiber lifetime issues, while ensuring the overall content remains current with updated standards and industry practices. Case studies, sourced from meetings with key personnel responsible for fiber initiatives at various companies, are provided throughout to offer practical examples.	
3002023623	Strategic Fiber Guidebook 2022 Edition	Electric utilities were among the first adopters of fiber optic communications because of the dielectric nature of the media that provides increased safety and reliability over copper-based wireline telecommunications. This annual guidebook update focuses on utility owned fiber optic networks.	12/31/2022
3002023622	Wide Area Network (WAN) Modernization Guidebook	This document contains information to provide guidance on the main drivers impacting the Wide Area Network (WAN) resulting from the trend in utilities towards convergence of the IT and OT networks. One is cloud computing, and the other is sunseting of traditional service provider dedicated private line services as they migrate customers to undifferentiated Internet as the primary service offering and away from specifically provisioned services with guaranteed service level agreements (SLAs).	12/31/2022
3002023621	Assessment of AFC System Protection of 6 GHz Microwave Links	Technical Update that provides further assessment of the upper and lower 6 GHz (U6/L6) fixed service (FS) microwave radio bands extensively used by	12/31/2022

		<p>utilities for wide-area operational communications, including protection and control of the bulk electric system. A recent report and order by the Federal Communications Commission (FCC) opens these bands to unlicensed operation of radio local area network (RLAN) devices. This operation is of two types. The first is operation of standard-power access points and clients in the U-NII-5 (coincident with L6) and U-NII-7 (coincident with U6) bands under control of an automatic frequency coordination (AFC) system. The second is low-power indoor (LPI) operation without an AFC in the U-NII-5 through U-NII-8 bands.</p>	
3002020361	Integrating and Orchestrating WAN Services	Technical Update exploring integrating and orchestrating WAN services.	12/31/2021
3002020360	Reliable Operation of 6 GHz Microwave Links	Technical Update documenting testing of reliable operation of 6 GHz microwave links.	12/31/2021
3002020359	Strategic Fiber Guidebook 2021 Edition	Electric utilities were among the first adopters of fiber optic communications because of the dielectric nature of the media that provides increased safety and reliability over copper-based wireline telecommunications. This guidebook focuses on utility owned fiber optic networks.	12/31/2021
3002018509	Teleprotection Over Packet Guidebook: 2020 Edition	Review of equipment vendors' products (SEL VSN) and service provider roadmaps for leased circuits. Surveys and case studies of best practices	11/23/2020

		and challenges in packet transition.	
3002018508	Evaluation of Interference Potential for 6 GHz Microwave links	Evaluates susceptibility of equipment used in the band to interference from unlicensed systems. The FCC R and O 20—51 allows unlicensed device operation in the upper and lower licensed 6 GHz fixed service (FS) microwave radio bands. EPRI conducted field testing to determine if unlicensed devices are operating in compliance with the FCC R and O and can cause harmful interference to incumbent FS systems.	08/17/2020
3002019705	Unlicensed Use of the 6 GHz Band	Fixed Service Incumbent Protection: Excerpts and Analysis of Federal Communications Commission (FCC) Report and Order (R and O).	08/17/2020
3002019712	Unlicensed Use in the 6 GHz Band: Field Interference Test Results	<p>The Federal Communications Commission (FCC) Report and Order (R and O) 20-51 allows unlicensed device operation in the upper and lower licensed 6 GHz fixed service (FS) microwave radio bands. This research conducted field testing to determine if unlicensed devices operating in compliance with the FCC and O can cause harmful interference to incumbent FS systems.</p> <p>This report shares key findings with industry stakeholders that may not be EPRI members. This is a summary report and detailed results are available to utilities participating in EPRI's</p>	07/24/2020

		Telecommunications 161G project set.	
3002015939	Telecommunications Data Isolation Techniques NERC-CIP Standards Requirements	<p>This report investigates guidelines and best practices for telecommunications data isolation in utility networks and is a resource for understanding and evaluating different approaches to North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection Standards (CIP Standards) compliance in the wide area network (WAN). It provides answers to questions such as what are valid technical approaches for isolating information technology (IT) and operational technology (OT) networks, critical and non-critical, and bulk electric system (BES) and non-BES data? It includes explanations and evaluations of several means and methods of accomplishing the above, such as physical layer techniques including optical transport networking (OTN), and different types of virtual circuits at Layers 2 and 3 such as Carrier Ethernet virtual local area network (VLAN) and Multiprotocol Label Switching (MPLS). Finally, it addresses the important issues around NERC CIP Standards requirements and how they map to the approaches.</p>	11/25/2019

Related Research

- [3002017804](#) Fiber Optic Primary Power Cable Feasibility Analysis, Literature Survey and Analysis, January 2020
- [3002013919](#) Black Sky Communications Evaluation
- [3002018519](#) Latest issue of *Smart Grid Communications Intelligencer* newsletter

P161.054 Field / Neighborhood Area Networks

Objective

Utilities are faced with demands to provide communication to an increasing number of field devices, and the average amount of data from each device is also increasing. At the same time, there is a critical shortage of suitable spectrum to operate a field area network (FAN) using wireless technologies. Unlicensed spectrum is crowded and unpredictable, and there are ongoing concerns about the cost and availability of commercial cellular services. Utility FANs must continue to perform at a high level, especially during man-made or natural disasters. This highlights the question of the appropriateness of relying on commercial service providers versus a utility's investment in its own communications infrastructure.

Private long-term evolution (LTE) and 5G are emerging as leading solutions for the integrated FAN. The standards-based technology has an extensive product ecosystem. For operating a FAN in spectrums not suitable for LTE, there is a wide variety of appropriate wireless products available, but standards and interoperability are more limited. Because of the wide range of cost, reliability, and performance requirements, no single FAN technology can be considered universal. Multiple-tier architectures and ongoing development of standards for specialized FAN requirements provide a path forward, but the tradeoffs of the overall system architecture are still challenging. As 5G technology matures, commercial network operators are able to offer new capabilities on the spectrum between public and private networks, such as 5G network slicing, which expand the set of options to utilities.

The objectives of this project include:

- Understand and define the tradeoffs and various technologies and service offerings between private wireless networks and commercial cellular
- Achieve reliability and resilience in a multi-technology wireless network
- Improve interoperability and coexistence (understanding how wireless technologies work together, identify potential conflicts) in the FAN
- Research the role of artificial intelligence (AI) in each stage of the FAN system life cycle; help utilities develop and implement an AI strategy as part of FAN deployment efforts
- Understand the specific communication requirements for distributed energy resources and the related systems for protection, such as direct transfer trip (DTT)
- Evaluate options for licensed and shared spectrum for FAN applications and private (LTE) networks
- Understand the role of AI to manage prioritization and quality of service (QoS) on constrained or impaired wireless networks
- Utilize the unlicensed spectrum, understanding current capacity limits and future trends that could impact capacity
- Understand low-power, wide-area sensor networks (LPWANs); Internet of Things (IoT) networks; and 5G networks—and their effectiveness and fitness for utility purposes

Approach

- Evaluate performance, cost, and reliability factors for private wireless networks and commercial cellular.
- Advance standards and testing for certification of interoperable FAN technologies.
- Define and test methods for achieving reliability and resilience in a multi-technology wireless network. Evaluate and test combinations of private utility FAN, commercial cellular, advanced metering infrastructure (AMI) networks, and customer broadband. Examine techniques for hybrid solutions, failover, connection sharing with forwarding, and meshing. Examine the scalability of networks, including optimal addressing approaches for internet protocol.
- Evaluate the value of AI in network anomaly detection and response.
- Evaluate and test licensed and shared spectrum for FAN applications, including options for implementing private LTE networks.
- Identify best practices and strategies for deployment of private LTE, including the role of AI in optimizing and scaling up the network, and migration from legacy systems.
- Develop case studies and models (including AI/machine learning (ML)) to enable economic and business justification for the value of private wireless networks and support the business case and value to ratepayers to regulators.
- Create and test AI-based approaches to evaluate and manage prioritization and quality of service in normal operation and in constrained or impaired wireless networks.
- Develop and assess AI-based techniques for optimizing operation in the unlicensed spectrum, including analysis of data sets of spectrum occupancy and noise.
- Appraise technologies for LPWAN, IoT, and 5G networks for their effectiveness and fitness for utility use.
- Evaluate and test wireless technologies and network configuration approaches to deliver low-latency communications to support DER protection and other latency sensitive use cases.
- Conduct end-to-end simulation and testing of communication networks to support DER and DTT.
- Understand the role of AI across all life cycle stages in the transition of legacy wireless technologies to the FAN.
- Coordinate with other EPRI programs and project sets to determine telecommunications requirements to support grid applications in the field.
- Apply Wi-SUN test bed and related testing tools to develop a data set to enable AI modeling of AMI 2.0 scenarios. Evaluate utility networks in the field for support of multiple applications, such as combining DER and AMI.

Research Value

The following benefits can be achieved from the results of this project:

- Cost savings and risk avoidance resulting from strategic network planning, adoption of scalable network architectures, and leveraging AI tools and best practices from the industry
- Understanding of how to use AI to improve operational effectiveness for telecommunications and reduction of outages through better situational awareness and anomaly detection
- Enhanced interoperability and longer life cycles for installed FAN equipment as well as reduced vendor lock-in
- Improved knowledge and ability to select the optimum type of spectrum for the FAN and AI techniques to obtain maximum performance and value from the spectrum and the network

- Enriched knowledge and ability to select the optimal technologies for FAN implementation, based on test results and industry case studies
- Understand how to use AI to improve network performance, reliability, and availability to serve critical applications
- Public benefit derived from telecommunications' enablement of grid efficiency improvements, increased use of distributed energy resources (DER), and improved reliability of electricity delivery

2026 Anticipated Deliverables

Title	Short Description		Date
Guidebook on Cellular Communications for Utilities – 2026 Edition	Technical Update - Annual update of the previous “Private LTE Guidebook” expanding the scope to include private, public, and intermediate technologies. It provides an overview of the technology and architecture and identifies current and potential spectrum options for private LTE network deployment.		12/31/2026
Evaluation of Low-Latency Wireless technologies	Technical Update – Ongoing evaluation and assessment of the 5G predecessor technologies Ultra-Reliable Low-Latency Communication (URLLC), including lab and field testing as technologies become available.		12/31/2026

Past EPRI Research on Topic:

Product ID	Title	Short Description	Published Date
3002032232	Private LTE Guidebook - 2025 Edition	<p>This report examines why utilities are pursuing private LTE networks to improve reliability, resiliency, and support grid modernization, outlining the underlying technology, architectures, and available spectrum options such as Anterix 900 MHz, Ligado 1.6 GHz, and CBRS. It also evaluates the business value of private LTE as an integrated platform through multiple utility use cases and illustrates lessons learned through four utility case studies spanning pilot to mature deployments.</p> <p>Digital version available here: Private Long-Term Evolution Guidebook – A</p>	12/31/2025

		Guidebook on Cellular Communications for Utilities	
3002032233	Evaluation of 5G for Low Latency Use Cases.	This Technical Update describes due increased cost of fiber optic cable to support Direct Transfer Trip, many utilities are interested in low-cost cellular options to fulfill the requirements of this use case. EPRI worked with three member utilities to conduct latency performance testing of their networks. These networks included a private LTE network with a hosted core, a completely standalone private LTE network that is owned and operated by the utility, and 5G and LTE commercial networks that one utility utilizes. This document covers the testing methods, testing results, and the future work planned for this area of research.	12/31/2025
3002029961	Private LTE Guidebook: Sixth Edition 2024	Guide - The report contains four case studies of utility private LTE projects. Ameren's case study captures a project in the pilot stage. Southern Company's Southern Linc case study highlights a mature private LTE network. New York Power Authority highlights a focus on transmission asset inspection as a use case, and San Diego Gas and Electric's case study highlights operation in Citizen's Broadband Radio Service (CBRS) spectrum.	12/31/2024
3002029962	Low-Latency and Performance Assessment of 5G for Utility Use Cases	Tech Update - Due to the increased cost of fiber optic cable to support direct transfer trip and other low-latency use cases, many utilities are interested in low-cost cellular options to fulfill the requirements of this use case. EPRI worked with ConEd to conduct latency performance testing of one commercial 5G	12/31/2024

		service provider at several important ConEd locations.	
3002027090	Private LTE Guidebook – 2023 Edition	Annual update of this guidebook that provides an overview of the technology and architecture and identifies current and potential spectrum options for private LTE network deployment.	12/31/2023
3002028191	Communication requirements for DER	Technical Update that explores Ultra-Reliable Low-Latency Communication (URLLC) field testing and evaluation.	12/31/2023
3002023627	Communication Requirements for DER: Initial Steps in Evaluating Wi-SUN for DER Communications	Technical Update that evaluates the telecommunications requirement for distributed energy resources (DER).	12/31/2022
3002023624	Private LTE Guidebook 2022	Annual update of this guidebook that provides an overview of the technology and architecture and identifies current and potential spectrum options for private LTE network deployment.	12/31/2022
3002020373	Private LTE Guidebook 2021	The report contains four case studies of utility private LTE projects. Ameren's case study captures a project in the pilot stage. Southern Company's Southern Linc case study highlights a mature private LTE network. New York Power Authority highlights a focus on transmission asset inspection as a use case, and San Diego Gas and Electric's case study highlights operation in CBRS spectrum.	12/31/2021
3002020364	LTE Inter-Network Operation and Roaming	The value derived from the research are optimize cost and reliability by enabling operation on multiple networks and leveraging the value from 5G network with dual connectivity.	12/31/2021

3002020363	LTE Shared Spectrum and Flexible Frequency Operations	This presentation explored LTE Shared Spectrum and Flexible Frequency Operations.	12/31/2021
3002020362	Frequency Planning and Interference Management for Licensed Spectrum FANs	The 700 MHz Upper A Block spectrum has been widely deployed by utilities for a Field Area Network (FAN). These radio technologies use various methods for frequency planning and coordination over the coverage area. As utilities desire to increase the capacity and density of their networks, the process for frequency planning becomes a greater challenge.	12/31/2021
3002019357	Communications Architecture Requirements for Near-Term Smart Inverter Use Cases - 2nd Edition: Study of the Communications Requirements for Utilities to Realize the Benefits from Grid-Ready Smart Inverters.	The process to develop these requirements involved mapping telecommunications technologies to a range of selected smart inverter use case scenarios.	12/17/2020
3002018511	Evaluation of Commercial and Private NB-IoT for Field Area Networks (FAN) Use Cases	Analysis and testing of commercial and private NB—IoT with selected FAN use cases to determine applicability and available performance.	12/18/2020
3002018510	FAN Capacity Offload	Selective use of higher-band spectrum evaluates FAN augmentation with bands such as Citizens Broadband Radio Service (CBRS), public safety, and industrial, scientific, and medical (ISM) for selective capacity expansion while maintaining a primary licensed control channel.	12/20/2020
3002019977	Private Long-Term Evolution (LTE) Guidebook: Second Edition 2020	Provides an overview of the technology and architecture and identifies current and potential spectrum options for private LTE network deployment.	12/09/2020

3002015943	Private LTE Guidebook (Volume 1)	Contains four case studies of utility Private LTE projects. Ameren's case study captures a project in the pilot stage. Southern Company's Southern LINC case study highlights a mature Private LTE network. New York Power Authority and Consolidated Edison case studies introduce companies in the planning process.	12/31/2019
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Related Research

- [3002017359](#) Communications Connectivity Technology Newsletter, January 2020
- [3002017804](#) Fiber Optic Primary Power Cable Feasibility Analysis, Literature Survey and Analysis
- [3002016411](#) The 5G Technology Roadmap for the Utility FAN: Staying Ahead of the Technology Adoption Curve
- [3002016412](#) Business Case for Telecommunications December 2019

P161.055 Telecommunications Planning and Management

Objective

Modern utility telecommunication networks are heterogeneous and complex. Various types of network technologies are used to implement different network tiers and to optimize for application- or location-specific requirements. Long-term success requires best-in-class processes, systems, and tools for management and planning, which are continually evolving. Utility telecommunications managers need an understanding of the best approaches for network planning and management. This includes incorporating visualization techniques and identifying actionable network performance metrics as part of ongoing reliability management efforts.

New networking technologies developed for commercial carriers (such as software-defined networking [SDN] and network function virtualization [NFV]) can play a role in multi-service utility information technology (IT) and operations technology (OT) networks. The strategic planning processes must be considered carefully to ensure that network expansion and upgrade cycles are aligned with grid infrastructure and operational upgrades that rely on the telecommunications network. Similarly, ongoing advancements in artificial intelligence (AI) and machine learning (ML) is expected to have a significant impact on the operational efficiency of critical communications infrastructure.

The objectives of this project include:

- Understand the current status of telecom network planning and operation in the utility industry.
- Develop insight and analysis on best practices for utility telecommunications network management.
- Research network planning, engineering, and operation developments and practices recommended by telecommunications industry forums and investigate applicability to the utility industry.
- Investigate the rapidly evolving AI/ML landscape and explore how it can help utilities improve the operations efficiency of their telecommunication networks.

- Investigate the role AI/ML can play in helping utilities address skills shortage challenges in the field of telecom network planning and operation.
- Investigate the roles that tools, techniques, and processes for fault management, performance management, geospatial informatics, dispatch management, etc. play in managing the “operational availability” of a utility telecom network.
- Identify how SDN and NFV can be applied to improve flexibility and resilience and reduce costs, without sacrificing cyber security.
- Build more accurate network modeling, planning, and simulation tools.
- Explore techniques and develop frameworks to quantify the economic value derived from the integrated telecommunications network.
- Explore techniques to quantify the value to be gained from investments in telecom network operation. This includes both financial value as well as technical value in terms of system effectiveness and reliability management.
- Identify and implement best tools for automation and documentation (logical network inventory as well as physical), including identification of naming conventions from carrier best practices.
- Evaluate communications requirements and technology solutions for digital worker, augmented reality/virtual reality (AR/VR), and related use cases for training, inspection, and remote workers.
- Understand best practices for utility telecommunications organizational capabilities, structures, and life cycle management.

Approach (The How)

- Create survey(s) to collect and analyze data on the current status of telecom network planning and operation in the utility industry.
- Test and evaluate (through case studies) best practices and approaches for telecommunications network availability, monitoring, and management.
- Investigate broader frameworks, such as TOGAF, ITIL and TM Forum's eTOM, to derive utility-specific guidelines.
- Develop cost-benefit analysis tools to analyze approaches to telecommunications modernization in the context of larger grid modernization.
- Develop financial and technical evaluation tools to analyze approaches to build new and/or improve existing network operation capabilities.
- Develop more accurate planning, modeling, and simulation tools.
- Develop frameworks to quantify the value to be gained from investments in telecom network operation, including a dedicated network operations center (NOC).
- Develop quality-of-service methodologies that securely configure, monitor, predict, and adapt prioritization of data across the network, regardless of the specific technology mix.
- Evaluate and test SDN in integrated hybrid networks involving multiple communications technologies.
- Evaluate AI/ML-based tools, techniques, and technologies for improving operational efficiency of utility telecom networks and productivity of network operation teams.
- Evaluate AI/ML-based methods for self-configuration, zero-touch provisioning of devices.
- Evaluate multi-tier networks and capabilities for autonomous operation, self-forming networks, and islanded communications networks to support resilient microgrids.
- Develop frameworks to provide guidance on key system life cycle management activities such as requirements engineering and project risk management.

Research Value

The following benefits may be achieved through the results of this project:

- Cost savings resulting from strategic network planning, adoption of standards, and leveraging best practices from the industry
- Improved operational effectiveness for telecommunications, reduction of outages through better situational awareness, and higher availability of telecommunications networks
- Higher internal customer satisfaction through high-reliability telecommunications services, with performance and reliability that meet application requirements
- Improved ability to plan and deploy advanced networks, creating new economic and business opportunities
- Ability to accurately plan telecommunications network expansion and growth in conjunction with grid expansion
- Ability to leverage modern technologies (such as AI/ML) to address skills shortage challenges faced by utilities
- Improved ability to rapidly scale and expand the telecommunications network to meet business requirements
- Public benefit derived from telecommunications' enablement of grid efficiency improvements, increased use of distributed energy resources, and improved reliability of electricity delivery.

2026 Anticipated Deliverables

Title	Short Description		Date
Network Management Systems Guidebook	Technical Update –		12/31/2026
4G and 5G Architecture Approaches for Resilient Networks	Technical Update – 4G and 5G research and technology evaluation to enhance security and resiliency of utility critical infrastructure.		12/31/2026
Emergency/Black Sky Communications Resilience and Planning	Technical Update – Update on best practices for ensuring communications availability in emergency scenarios, assessment of new technologies for non-terrestrial networks, and longer-term test results for Low Earth Orbit satellite systems.		12/31/2026

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002032234	Network Management Systems Guidebook	This guidebook explains how communications networks supporting the power system are expanding and becoming more	12/31/2025

		<p>complex, making effective telecom network management essential to utility resilience. It introduces the evolution of telecom network management—including the growing role of AI and machine learning—and explains its relevance for utilities managing modern, mission-critical communications infrastructure.</p>	
3002032235	<p>Security and Resiliency of Utility Critical Communications Infrastructure for Microgrids</p>	<p>This technical update examines the security and resilience of critical communications infrastructure for utility microgrids, focusing on the use of private LTE to support secure, reliable operations in both grid-connected and islanded modes. Using a Zero Trust Architecture lens, it assesses LTE security capabilities, identifies gaps, and provides guidance informed by EPRI research, DOE/NREL testbeds, and real-world cyber incidents to help utilities mitigate cyber-physical risks.</p>	12/31/2025
3002032236	<p>Satellite and Emergency Communication: Phase 3 - 2025</p>	<p>This report evaluates Low Earth Orbit (LEO) satellite communications as a promising solution for connecting remote and hard-to-reach grid assets, highlighting their lower latency, higher throughput, and reduced costs compared to traditional geostationary satellites. It presents 2025 field and lab testing of Starlink—including performance monitoring, failover use cases, and new non-terrestrial network</p>	12/31/2025

		services—and assesses the viability of LEO systems for reliably supporting modern grid operations.	
3002029963	Network Management Guidebook: 2024 Edition	Tech Update - The role of communications networks underlying the power system is changing. To fulfill the new role, these networks are expanding in size and increasing in complexity. The resilience of these transforming networks depends upon the telecom network management capabilities of the utilities building, operating, and maintaining the power grid. Utilities must be prepared for managing the expanded footprint and complexity of the telecom systems their critical infrastructures depend upon. This guidebook introduces the audience to the field of telecom network management with a focus on the field's evolution and relevance for the utility industry.	12/31/2024
3002029964	Integrating Islandable Communications Networks into Resilient Microgrids: Lab Test Results	Tech Update - The Islandable Communication network was integrated into the simulation environment, allowing both a commercial cellular carrier and a private LTE network to be evaluated. The microgrid simulation showed differences in performance and behavior when operating over the wireless networks (compared to operating over wired Ethernet in the lab). These	12/31/2024

		differences point to further research opportunities to better understand how microgrid communication carried over real-world or impaired networks affects the microgrid system behavior.	
3002029965	Satellite and Emergency Communication 2024 Update: Additional Testing of Starlink for Utility Use Cases	Tech Update - Assessing the viability of Low Earth Orbit (LEO) networks to reliably and affordably connect grid assets in remote locations and effectively manage the evolving electric grid demands significant research.	12/31/2024
3002027107	Network Management Guidebook	The role of communications networks underlying the power system is changing. To fulfill the new role, these networks are expanding in size and increasing in complexity. The resilience of these transforming networks depends upon the telecommunications network management capabilities of the utilities building, operating, and maintaining the power grid. Utilities must be prepared for managing the expanded footprint and complexity of the telecommunications systems their critical infrastructures depend upon. This guidebook introduces the audience to the field of telecommunications network management with a focus on the field's evolution and	12/31/2023

		relevance for the utility industry.	
3002027112	Applicability of Low Earth Orbit Satellite for Utility WAN and Emergency Communication	Satellite communication is widely used by utilities to provide connectivity in remote areas and for emergency backup communication. Downsides include high cost of service, low throughput, and high latency. New Low Earth Orbit satellite systems have recently been deployed and promise improvements in all these metrics. This introductory investigation provides initial assessment and sets up plans for longer term testing and evaluation.	12/31/2023
3002023629	Telecom Site Planning and Practices for Resilience and Backup Power	Technical Update that describes resilient networks with islanded operation capability evaluation.	12/31/2022
3002023628	Integration of Device Provisioning into the Network Management System	Technical Update that describes the evaluation of integration of provisioning in the Network Management System.	12/31/2022
3002020375	Design and Planning of a Scalable IT Network	Approaches, best practices, and case studies for optimizing the IT network for unforeseen circumstances, such as mass work-at-home. Application of SD-WAN, VPN, and other technology to support business IT, telecommunications, and workforce requirements.	12/31/2021
3002020376	Integration of the Telecom NMS with GIS	Evaluation of tools, systems, and processes to integrate the Telecom NMS with GIS data (logical and physical circuits, wavelengths, and related equipment).	12/31/2021

		Also planning and management (non-real-time) that can capture telecommunications circuit assets for life-cycle management.	
3002018513	Telecom Network Management and Manager of Manager Systems (NMS): Metrics and Opportunities for Interconnections	Examines (NMS) tools used by utilities, future NMS system requirements identified through future research and proposed development of electric power industry telecommunications metrics to measure the "health" of the network, including specific case studies.	12/18/2020
3002018512	Optimizing Provisioning and Device Management, Phase 2	Explores the adoption of elements of the Remote SIM Provisioning Architecture that may be able to be used in non-3GPP networks. Also presents a means to configure attached grid equipment using Zero-touch Provisioning.	12/23/2020
3002018515	IP Architecture and Planning for IPv4 and IPv6	Provides an overview of the development, documentation, and evaluation of the best practices for IP network planning and architecture to support the concurrent use of IPv4 and IPv6.	12/31/2020
3002015946	Optimizing Provisioning and Device Management	This study examines some of the features of the Groupe Spécial Mobile Association (GSMA) eSIM standard that details remote SIM provisioning architecture. In addition, the report discusses some current utility practices and details next steps in the research, which will examine remote	11/25/2019

		provisioning systems for non-3GPP networks.	
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Related Research

[3002016411](#) The 5G Technology Roadmap for the Utility FAN: Staying Ahead of the Technology Adoption Curve

[3002016412](#) Business Case for Telecommunications

[3002011409](#) Persistent Wi-Fi™ Platform for Connected Devices Demonstration.

[3002013919](#) Black Sky Communications Solution Evaluation (05-31-2018)

P161.056 Telecommunication Standards Engagement

Objective

Although standards such as long-term evolution (LTE) and Wi-Fi have revolutionized consumer and commercial wireless service, many utilities remain constrained by proprietary communications systems. Standards development is an ongoing process because existing standards continue to evolve, and new standards are proposed and developed. A two-way flow of information is needed to ensure a desirable outcome for utilities and their telecom needs. First, the standards groups need input from participants who can contribute and articulate the requirements and desires of the utility industry. Second, the utility industry needs to be informed of the standards development pipeline and its relevance and impact to their own planning cycles and procurement.

Utility telecom networks use a combination of wireless, copper, and fiber media and operate wireless networks in both licensed and unlicensed spectrums. The licensed spectrum may be utility-owned or accessed through a commercial cellular operator. Standards-based communications technologies enable interoperability, vendor choice, a broader product ecosystem, and, ultimately, lower costs. Of the wide range of wireless communications technologies that are deployed today or might be deployed in the future, many originate from standards development activities that this project participates in and tracks.

Approach (The How)

- Identify and participate in the development of new standards with impact and relevance to utility telecommunications.
- Represent the needs and requirements of electric utilities through leadership and contribution to the standards process.
- Propose new standards developments when a gap or need is identified.
- Enable coordination between multiple standards supporting utilities and other vertical applications through the IEEE 802.24 Technical Advisory Group.
- Inform members of activities and the standards development pipeline through regular newsletters. Provide context and explanation of how the standards can be applied and their potential impact.
- Develop and maintain an annually updated guidebook with a high-level description of telecom and communications standards, their roadmap, utility applications, and interrelationships.

Research Value

The following benefits can be achieved through the results of this project:

- Cost savings resulting from strategic network planning, adoption of standards, and leveraging best practices from the industry
- Standards development outcomes that incorporate utility needs and requirements, resulting in cost-saving and life-cycle benefits, for example, contributions to work items in Third Generation Partnership Project (3GPP) related to requirements for 6G
- Understanding available standards and the pipeline of future standards, which enables informed discussions with vendors regarding procurement decisions
- Improved ability to plan and deploy advanced networks, creating new economic and business opportunities
- Ability to accurately plan telecom network expansion and growth in conjunction with evolution of network technologies and grid expansion
- Improved ability to scale and expand the telecom network to meet business requirements
- Public benefit derived from telecom's enablement of grid efficiency improvements, increased use of distributed energy resources, and improved reliability of electricity delivery

Key Activities

Activity	Date	Completion Status
Telecom Standards Engagement in IEEE 802, IEEE PES, 3GPP, IEC, IETF, and CIGRE Committee D2 (Telecommunications)	Ongoing	

2026 Anticipated Deliverables

Title	Short Description		Date
Smart Grid Communications Intelligencer, 1H 2026	Technical Newsletter – This biannual newsletter highlights issues of relevance and interest to utility communications engineers and managers. The focus is on developments in communication technologies and standards, as well as business issues that can affect the design, deployment, or operation of utility communications infrastructure.		12/31/26
Telecom Standards Guidebook Vol 8 (2026)	Technical Report – The annual update of this guidebook incorporates previous work performed and adds individual utility policies and practices, including placeholders for future research results.		12/31/26

Past EPRI Research on Topic

Product ID	Title	Short Description	Published Date
3002032239 and 3002032241	Smart Grid Communications Intelligencer 1H 2025 Smart Grid Communications Intelligencer 2H 2025	The Smart Grid Communications (“Comms”) Intelligencer, is a bi-annual newsletter. Our mission is to highlight issues of relevance and interest to utility communications engineers and managers. Our focus is on developments in communication technologies and standards, and business issues that can affect the design, deployment, or operation of utility communications infrastructure.	12/31/25
3002032240	Telecom Standards Guidebook Vol 7 2025	This guidebook provides an overview of standards relevant to telecommunications in the electric power industry. The focus is on the purpose and relevance of the standards as well as the development status and roadmap of the standards development organizations.	12/31/25
3002029966	Smart Grid Communications Intelligencer, 1H 2024	This biannual technical newsletter provides context-rich updates on long-term standards development and communication technologies relevant to utility communications professionals, focusing on both technical and business impacts.	6/18/2024
3002029967	Telecom Standards Guidebook V6 2024	This guidebook provides an overview of standards relevant to telecommunications in the electric power industry. The focus is on the purpose and relevance of the standards as well as the development status and roadmap of the standards development organizations.	12/31/2024
3002029968	Smart Grid Communications Intelligencer, 2H 2024	This biannual technical newsletter provides context-rich updates on long-term standards development and communication technologies relevant to utility communications professionals, focusing on both technical and business impacts.	12/31/2024
3002027122	Smart Grid Communications Intelligencer, 1H 2023	This newsletter highlights issues of relevance and interest to utility communications engineers and managers. Utility telecommunications networks use a variety of technologies out of necessity, since no single	7/18/2023

		<p>technology can meet all requirements. Many networks use a combination of wireless, copper, and fiber media, and operate wireless networks in both licensed and unlicensed spectrum. The licensed spectrum may be utility-owned or accessed through a commercial cellular operator. Standards-based communications technologies enable interoperability, vendor choice, a broader product ecosystem, and ultimately lower costs. Many of the wide range of wireless communications technologies that are deployed today, or may be deployed in the future, originate from the standards development activities that are covered in this newsletter.</p>	
3002027156	Telecom Standards Guidebook Vol 5	<p>This guidebook provides an overview of standards relevant to telecommunications in the electric power industry. The focus is on the purpose and relevance of the standards as well as the development status and roadmap of the standards development organizations.</p> <p>Each section describes the current standards, with emphasis on the following: Purpose and function, Relevance to utility telecommunications, Adoption and maturity, Roadmap and amendments. The intent is to update this information annually.</p>	12/31/2023
3002027150	Smart Grid Communications Intelligencer, 2H 2023	<p>This newsletter highlights issues of relevance and interest to utility communications engineers and managers. Many networks use a combination of wireless, copper, and fiber media, and operate wireless networks in both licensed and unlicensed spectrum. The licensed spectrum may be utility-owned or accessed through a commercial cellular operator. Standards-based communications technologies enable interoperability, vendor choice, a broader product ecosystem, and ultimately lower</p>	12/31/2023

		costs. Many of the wide range of wireless communications technologies that are deployed today, or may be deployed in the future, originate from the standards development activities that are covered in this newsletter.	
3002023633	Comms Intelligencer Newsletter 2H 2022	Twice published yearly technical newsletter relevant to utility telecommunications.	12/31/2022
3002023632	Comms Intelligencer Newsletter 1H 2022	Twice published yearly technical newsletter relevant to utility telecommunications.	12/31/2022
3002023631	Standards Guidebook - 2022 Edition	Annual update of this guidebook provides an overview of standards relevant to telecommunications in the electric power industry. The focus is on the purpose and relevance of the standards as well as the development status and roadmap of the standards development organizations.	12/31/2022
3002020378	Telecom Standards Guidebook - 2021 Edition	This guidebook provides an overview of standards relevant to telecommunications in the electric power industry. The focus is on the purpose and relevance of the standards as well as the development status and roadmap of the standards development organizations.	12/31/2021
3002020379	Comms Intelligencer Newsletter 1H 2021	Twice published yearly technical newsletter relevant to utility telecommunications.	12/31/2021
3002020380	Comms Intelligencer Newsletter 2H 2021	Twice published yearly technical newsletter relevant to utility telecommunications.	12/31/2021

PS161H Geospatial Intelligence

Objective

This research focuses on providing utilities with leading practices for optimizing the performance of geospatial systems and data. Geospatial technologies provide unique capabilities utilities can leverage to integrate data from multiple systems to make better-informed decisions, create operational efficiencies, reduce costs, and increase safety and grid resiliency. Geographic information systems (GIS) are an essential tool for the electric utility industry's transition to net zero by 2050.

The Geospatial Intelligence project set focuses on the science and technology of acquiring, storing, cleaning, modeling, analyzing, producing, presenting, and disseminating geospatial data sets. Collaborative research in this project set will help enable utility GIS professionals to:

- Expand the enterprise value of GIS data, geospatial systems, and platforms at electric utilities
- Develop effective geospatial analytic capabilities
- Effectively manage large geospatial data volumes
- Enhance GIS data quality and develop consistent processes
- Deliver new geodata services for advanced planning and operations applications

P161.059 Geospatial (GIS) Data Practices

Objective

This project focuses on optimizing geospatial data performance for electric utilities worldwide. Geographic information systems (GISs) consolidate data from multiple disparate systems, internally and externally, based on location. Developing a comprehensive data strategy that includes geospatial data is imperative for electric utilities to rely on their data portfolio as an asset.

Approach (The How)

EPRI engages with utilities, vendors, and stakeholders to continue the development of the *Geospatial Informatics Guidebook*. The Guidebook began as a collection of many years of GIS research at EPRI. Today, it is transitioning into a body of knowledge for GIS professionals at electric utilities. Valuable content is added annually based on member collaboration on common challenges and priorities from the task force and advisory meetings.

Research Value

The Geospatial Data Practices research provides GIS professionals at member utilities with an indispensable resource guidebook for managing and optimizing their geospatial data and systems.

This research also contributes a societal benefit by enabling better-informed decisions surrounding grid decarbonization, improving worker safety, and enhancing grid reliability and resiliency.

2026 Anticipated Deliverables

Title	Short Description		Date
Geospatial Informatics Guidebook: 7 th Edition	Technical Update - A digital reference for best practices in geospatial data management, updated annually.		12/31/26

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002032160	Geospatial Informatics Guidebook: Sixth Edition	Technical Update - Guidebook reorganization providing leading practices for GIS department operations. New chapter addressing	5/16/2025

		utility geospatial intelligence use cases and challenges.	
3002029155	Geospatial Informatics Guidebook: Fifth Edition	Technical Update – Case study on utility network migration project. (New product microsite.)	12/31/2024
3002026827	Geospatial Informatics Guidebook: Fourth Edition	<p>Technical Update – A digital reference for best practices in geospatial data management, updated annually. The objective of this guidebook is to provide an industry resource for geospatial data practices and begin to lay the groundwork for the development of a maturity model for geospatial data management. This project consolidates EPRI research insights into a valuable resource for electric utility GIS professionals. The project team worked with the Geospatial Informatics task force to establish their priorities for geospatial data management. The third edition of the guidebook includes:</p> <ul style="list-style-type: none"> • additions to the data quality management. • Geolocating underground infrastructure • The geospatial data standards sections. <p>Digital Version of Fourth Edition:Geospatial Informatics Guidebook EPRI Micro Sites</p>	12/31/2023
3002024796	Geospatial Informatics Guidebook: Third Edition	A digital reference for best practices in geospatial data management, updated annually.	12/31/2022
3002021995	Geospatial Informatics Guidebook: Second Edition	Annual update that aims to prepare electric utility GIS professionals to deliver improved geodata services to an expanding spectrum of utility individuals and systems. The project also helped GIS professionals understand how trends in the geospatial industry are affecting their management of geospatial information and investments.	12/31/2021
3002019291	Geospatial Informatics Guidebook (Version 1)	Consolidated key content from past EPRI reports into a format suitable for annual updates in the future. This report aims to prepare electric utility GIS professionals to deliver improved geodata services to an expanding	12/09/2020

		spectrum of utility individuals and systems. The project also helped GIS professionals understand how trends in the geospatial industry are affecting their management of geospatial information and investments.	
3002018992	Enhanced Grid Modeling Data for Planning and Operations (shared deliverable with P200)	This report begins the process of transformation by providing clarity amongst GIS professionals that maintain grid data and distribution engineers that consume that data for grid models. The report was a shared deliverable with P200.	12/09/2020

Related Research

This research spans multiple EPRI programs as geospatial technologies can be applied in multiple utility areas such as Transmission, Distribution, Generation, Security, Environmental, Resilience, Data Analysis, Electric Vehicles, Distributed Energy Resources, Energy Storage, and Customer Insights.

P161.060 Geospatial Innovations

Objective

Utilities are facing significant challenges in reducing fossil fuel generation, escalating the growth of distributed energy resources connecting to the grid, and the electrification of transportation. The grid transition requires adding new network devices, sensors, and data feeds. This unprecedented change in the industry will require more advanced tools and methodologies to manage a successful transition. Geographic information system (GIS) applications provide utilities with a common operating picture by integrating numerous systems into a single view.

This project provides insights into innovative geospatial applications that electric utilities can leverage to optimize the value of their geospatial investments.

Approach (The How)

This project collaborates with utilities, vendors, universities, and national labs to define the highest value geospatial applications for the industry. EPRI’s goal is to provide leadership on evolving GIS and geospatial technologies by conducting research, pilot projects, and test cases that utilities can implement to provide immediate value.

Research Value

This research provides utility members with proven and next-generation geospatial applications that improve worker safety, increase business process efficiencies, and reduce operations and maintenance costs. The public will benefit from this research as it informs utilities about enhanced methods to generate locational intelligence on utility matters for their area.

2026 Anticipated Deliverables

Title	Short Description		Date
Geospatial Innovations	Tech Update - Leading practices for leveraging GIS technologies within electric utilities.		12/31/2026

Past EPRI Research on Topic:

Product ID	Title	Short Description (link to new project)	Published Date
3002032162	GIS Data Quality – State-of-the-Art Machine Learning and Artificial Intelligence	EPRI has provided detailed research on techniques for improving GIS data quality for many years. This white paper compiles these leading practices as well as investigates machine learning and artificial intelligence techniques for improving GIS data quality.	12/31/2025
3002032165	Digital Twin Case Studies and Takeaways from Industrial Immersive 2025	The Industrial Immersive conference brings together leading practices in extended reality (XR), spatial computing, 3D, reality capture, digital twins and AI solutions. The report provides an overview of presentations of digital twin implementations and XR.	12/31/2025
3002029157	Geospatial Innovations	Technical Report -- Technical article series on the rapidly expanding geospatial technologies in the electric utility industry.	12/31/2024
3002026787	Geospatial Applications and Management	Geospatial integration with work management systems, low code GIS applications and management strategies.	12/31/2023
3002026839	Geospatial XR Demonstration	Digital twin 3D model presentation.	12/31/2023
3002024797	Geospatial Requirements for XR Applications - 2022 Update	Annual Technical Update that provides digital twin frameworks and application roadmaps to support evolution toward spatial computing.	12/31/2022
3002021996	Geospatial Requirements for XR Applications	Provides guidance on development of digital twin frameworks and application roadmaps to support evolution toward spatial computing.	12/31/2021

3002018703	Standing Up the Real Digital Twin	Describes new machine-readable, digital twin representations and the emergence of spatial computing.	11/30/2020
3002019370	Multi-Dimensional Worlds Converge: Exploring BIM and 3D Modeling at Electric Utilities	Surveys electric utility funders of EPRI projects to understand the state of the art regarding development of digital-twin representations of utility infrastructure from various possible sources and provides the results from this survey.	05/01/2020
3002016147	Geospatial Data Integration in Augmented Reality Solutions for Electric Utilities	Examines the status of and barriers to the ingestion of geospatial data into AR-enabled solutions for utility professionals.	09/10/2019
3002013117	Reality Computing: A Guide to Augmented Reality, Mixed Reality, Virtual Reality, and Extended Reality	Explores augmented, mixed, and virtual reality and the necessary tools to create higher-fidelity applications.	12/13/2018
3002014696	Augmented and Mixed Reality Training for the Smart Grid	Evaluates augmented reality and mixed reality for a just-in-time training solution.	12/17/2018
3002011490	Detection and Geolocation of Power Distribution Infrastructure Using Public Domain Photographic Imagery	Provides a foundational understanding of methods for improved asset georeferencing using low-cost imagery and neural networks.	09/06/2017

Related Research

This research spans multiple EPRI programs as geospatial technologies can be applied in multiple utility areas, such as transmission, distribution, generation, security, environmental, resilience, data analysis, electric vehicles, distributed energy resources, energy storage, and customer insights.

161.061 Geospatial Intelligence Analytics and Visualization

Objective

Geographic information systems (GIS) at electric utilities support many grid operations and planning applications by providing a spatially accurate network model and detailed facility information that is valuable for planning studies and operations. GIS arose from the need to support facilities management, design, construction, and work management. The power industry will need to develop effective geospatial network analysis techniques to meet the growing grid challenges utilities face.

The focus of this project is on developing innovative geospatial analysis techniques to support multiple utility business processes.

Approach (The How)

EPRI will research, develop, test, and apply innovative geospatial analytic and visualization techniques to help utilities meet their highest priorities and challenges. New approaches include investigating the value of machine learning, artificial intelligence, and GeoAI.

Research Value

Project members will gain practical insight into the best practices and innovative geoanalysis methodologies drawn from multiple areas. This research provides utilities and the public with the opportunity to address grid transition planning, discover data patterns, automation, and resource optimization, and provide a foundational visualization tool to present complex subjects.

2026 Anticipated Deliverables

Title	Short Description		Date
Geospatial Analytics Use Cases	Presentation—Update to 2023 pilot demonstration extending geospatial analytics into new use case areas. Delivered via interactive web-based format (Story Maps).		12/31/2026

Past EPRI Research on Topic:

Product ID	Title	Short Description (link to new project)	Published Date
3002032163	Geospatial Intelligence Use Cases, Qualitative Benefits, and Challenges	This overview describes how utilities use geospatial intelligence to turn data from GIS, utility systems, and emerging sources like drones and IoT into insights that improve safety, efficiency, and situational awareness. It highlights the role of the EPRI Geospatial Innovations Lab in helping utilities integrate these tools into a unified, modern data environment.	12/31/2025
3002029158	EPRI Geospatial Intelligence Develops Innovation Lab – The Path Forward	This research explores how integrating geospatial intelligence (GEOINT) into utility GIS systems can transform them from static asset repositories into dynamic tools that enhance operational efficiency, resilience, and decision-making in the face of modern utility challenges.	12/31/2024

3002026841	Geospatial Analytics Use Cases for Efficiency, Resiliency, and Decarbonization	Pilot demonstration building dataset of rooftop solar using machine learning and EV fleet vehicle clusters delivered via interactive Web-based format (Story Maps).	12/31/2023
3002024818	Dynamic Geospatial Informatics Can Model Grid Operating Conditions	Geospatial informatics, organized around geographic location, help acquire, maintain, analyze, and visualize data. They represent spatial phenomena as points, lines, and polygons. Points indicate discrete places, polygons describe boundaries, and lines show connections. Complex data representations include connected networks, vital for electric utilities to represent power flow from generation to customers. These networks are crucial for grid planning and management, serving as essential data sources for enhanced grid models. Geospatial informatics have been widely adopted across various industries, though more extensively in some than others.	12/31/2022
3002021521	Enhanced Grid Modeling: A Collaborative Framework for Model Verification, Validation, and Quality Tracking	Update to the 2020 document, provides clarity for GIS professionals who produce data for grid models and for distribution engineers who consume the data needed for their analysis. The document explores both GIS and engineering perspectives and explains modeling requirements in depth.	12/31/2021
3002021753	Distribution Modeling Guidelines: Distributed Energy Resource Modeling Recommendations for Distribution System Assessments: 2021 Edition	Practical recommendations and guidance are provided on modeling DER within the most common distribution assessment methods used today, such as instantaneous power flows, quasi-static time series assessments, fault analyses, harmonic studies, dynamic studies, electromagnetic simulation, and reliability assessments.	12/22/2021

		Additionally, forward-looking DER modeling needs, and impact assessments are considered.	
3002018992	Enhanced Grid Modeling Data for Planning and Operations	This document provides clarity for GIS professionals who produce data for grid models and for distribution engineers who consume the data needed for their analysis. The document explores both GIS and engineering perspectives and explains modeling requirements in depth.	12/09/2020

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