ELECTRIC POWER
RESEARCH INSTITUTE

Smart Grid

Executive Summary





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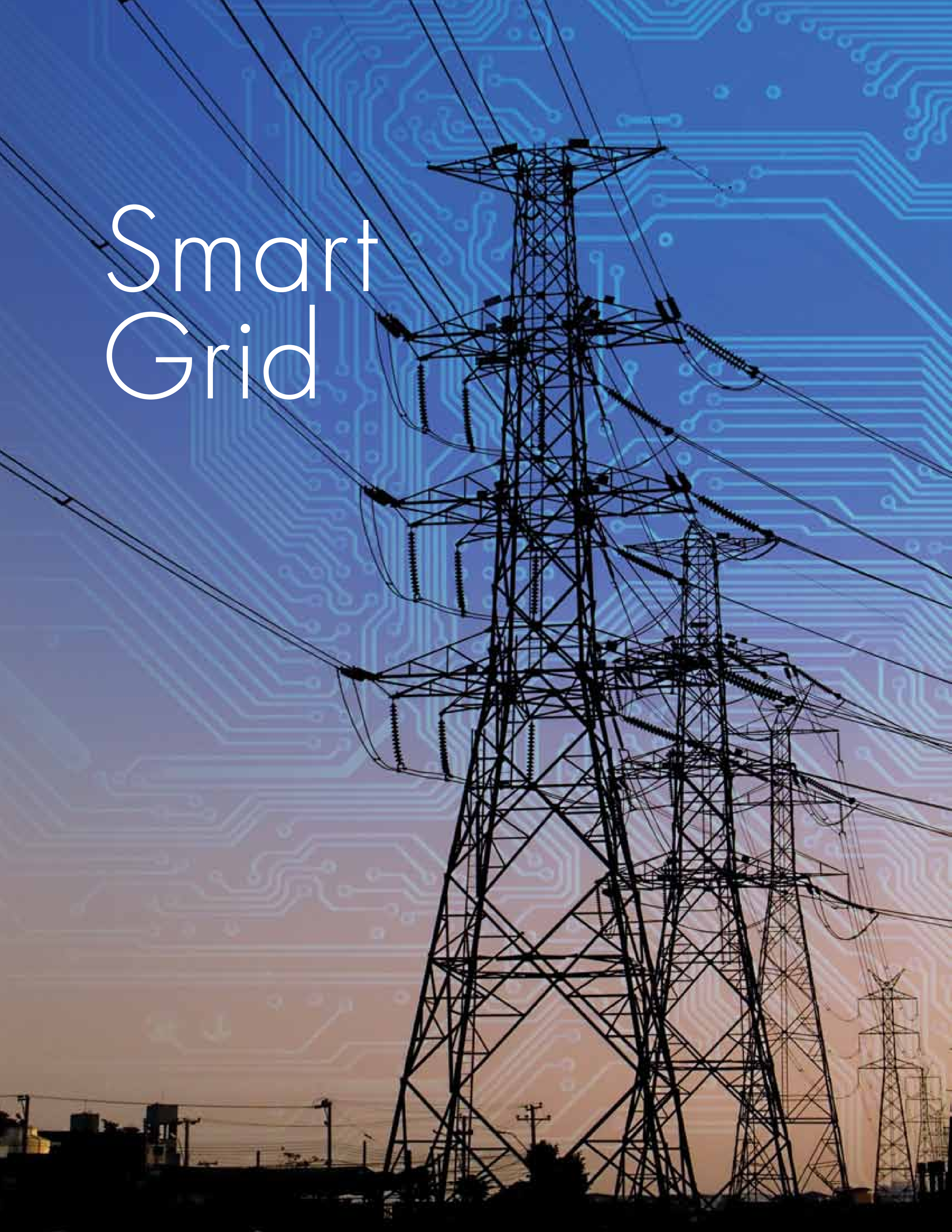


Smart Grid

The smart grid's potential is generating momentum for innovation in technology and operations. Utilities, technology companies, and government agencies are investing in smart grid technologies, and they are joined by industry other stakeholders, regulators, and policymakers in working to understand both its potential and its challenges. Smart metering, communications and technologies to help automate the power grid more fully are just some of the areas receiving new levels of investment and scrutiny. Momentum for the smart grid springs from several value propositions:

- With more energy use choices, customers progress from passive consumers to energy managers.
- Utilities can continue to operate the grid reliably with increased penetration of intermittent renewable generation and various forms of demand response. These in turn can help utilities reduce carbon emissions while meeting long-term demand growth.
- New technologies and infrastructure can be brought on line to maintain and improve reliability — especially important as today's grid is operating close to its limits, many of its components reach the end of their service life, and new devices and equipment (including electric vehicles) connect to the grid and add to the load.

High Expectations

Industry stakeholders expect a smart grid to help resolve a variety of issues, including reducing fossil-fuel-fired generation investment, and creating new ways for customers to become active participants in energy consumption, storage, or even production.

In making this happen, questions have emerged regarding who will carry the cost, who will benefit, and how public and stakeholder expectations will be met.

The Risks

As with any innovation, smart grid investments carry certain risks. Smart grid functional requirements, interoperability and cybersecurity standards are still evolving, and premature technology obsolescence could strand some investments even as transitional technologies need to be replaced before their expected end-of-life. This could become necessary when such technologies become incompatible with adopted standards or cannot meet future requirements for smart grid functionality.

As smart grid standards are developed, they will affect technology selection, functionality, effectiveness, and costs. Understanding these impacts requires risk and economic analysis, but this, in turn, can provide for fully informed decision making and help balance costs, risks, and benefits.

There is a significant opportunity to apply smart grid technology to optimize distributed resources, including those on the demand side. It is important, however, to understand the limits of relying on demand-side resources, to invest effectively in smart technology, and, when necessary, to build new generation, transmission, and distribution capacity.

Integration and Standards for a Smart Grid

One important way to mitigate the risks of integrating the power grid with information and communication technology is to employ an architecture that supports an array of applications. These applications will have to consider consumer interaction, increased reliability, asset optimization, and operational efficiency. In addition, they will need to enable more robust and dynamic markets. Standardized interfaces for smart grid components will be necessary for achieving interoperability, but they must not create barriers to innovation or delays for coordination.

A critical objective of a smart grid is to enable new technologies and support new business models. Like the Internet, a smart grid needs to be created as a system of interoperable, layered systems that can integrate diverse technologies, operators, and connections. The nature and function of these systems will evolve with the technology, generating new businesses and new interactions. To support this evolution, smart grid systems must include the following characteristics:

- Layered systems are proven characteristics of high-performance architectures (such as the Internet), increasing the likelihood and speed of integration and reuse and presenting opportunities for innovation.
- Integrating only the required functions expands the reach of each standard. The market operations and load curtailment for electricity and natural gas might be the same.

- Everything developed for the smart grid must come into play with the inherent capacity to be scaled up effectively. Smart grid applications, components, and participants are expected to grow rapidly as standards mature and infrastructure is modified or added.
- Cybersecurity is critical and must be managed over the life of the systems deployed. Security must anticipate and respond to the rapid evolution of threats, vulnerabilities, and exposures for any given application.

The EPRI IntelliGrid program has focused on identifying the communications and information technology requirements of a smart grid. In 2009, the program's principles were used to lead utilities and other stakeholders in developing an interim roadmap for smart grid interoperability standard development for the National Institute of Standards and Technology (NIST). This work continues, and EPRI continues to provide feedback and analysis of expected impacts of proposed standards.

Research Expanding Smart Grid Applications

Various domains within the grid have evolved to different levels of maturity. To a large extent, generation scheduling and transmission operations are already automated and organized as markets. Distribution feeders are partially instrumented and employ various automation and control schemes — some integrated and some stand-alone. Energy use metering and communications technologies have evolved from technology that captured simple cumulative usage data to technologies that will capture the time when energy is used and communicate price signals and other data to users. This captures the real-time value of the energy being consumed.

One of the most profound benefits of a smart grid will be its capacity to transform data into actionable information.

Smart Grid in Distribution

As new loads and resources are connected to the distribution system, changes to operational practices might be required. To address these, EPRI research in distribution focuses on such things as integrating distributed photovoltaic solar resources, understanding the charging characteristics and impact of plug-in electric vehicles, and optimizing distribution voltage to reduce distribution losses and increase end-use energy efficiency savings. To meet the grid's changing requirements, it will be essential to expand the capability to model the characteristics and simulate the behavior of distribution.

Enabling Active Consumer Participation

Equipping consumers to manage their energy use remains a key focus of research. Consumers will have many options to respond to energy and pricing information provided by a smart grid. They will be equipped to adapt their energy use to changing conditions and to create programmed responses by smart devices and appliances. Consumers and system operators can join forces to optimize locally generated or stored energy with energy that is being delivered from the grid.

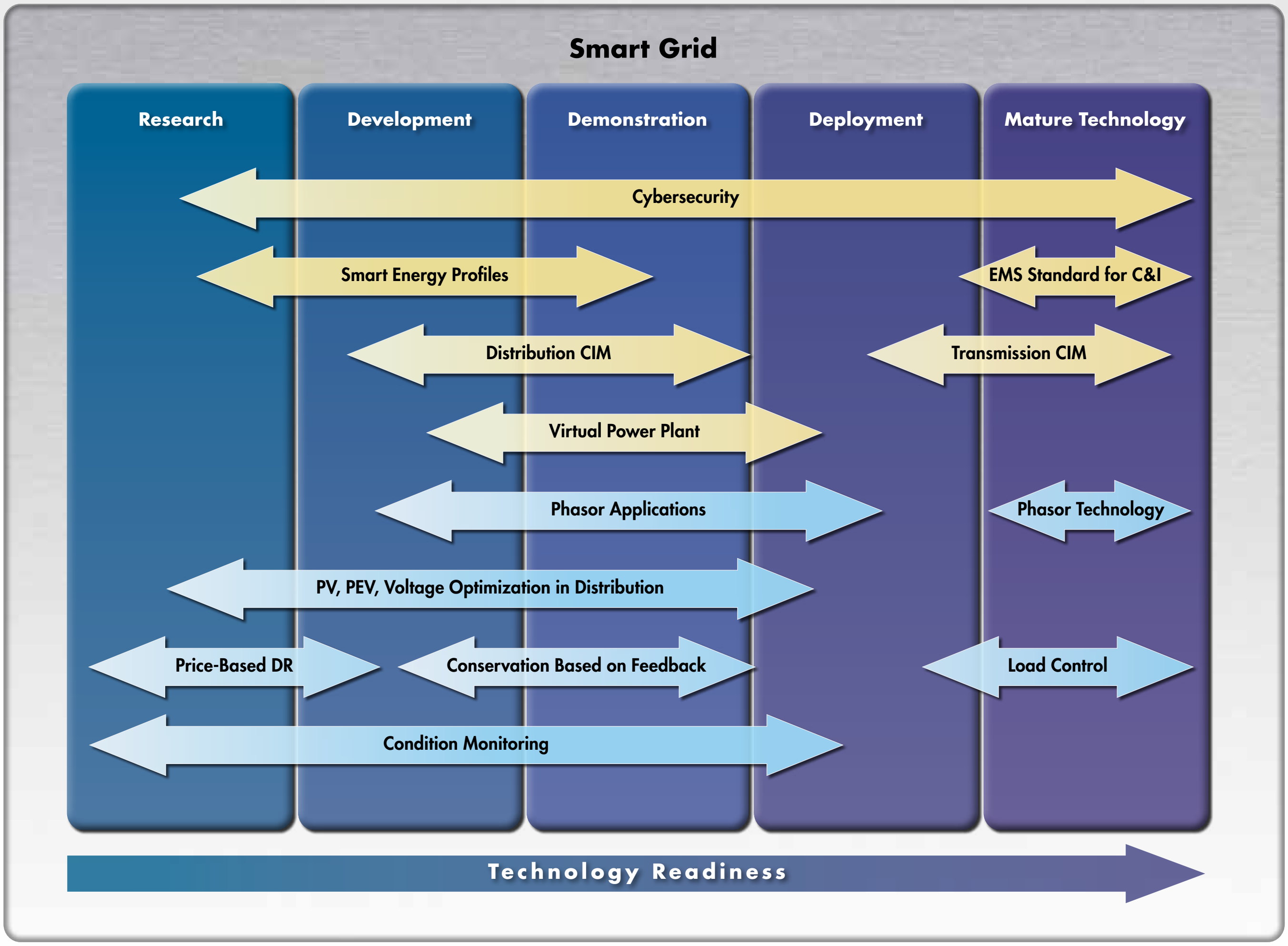
EPRI's smart grid demonstration projects integrate such distributed energy resources as demand response, photovoltaic generation, and energy storage, working across the energy value chain — from distribution operations to market clearing — which is essential for enabling the wide adoption of these resources. Other research efforts focus on demand response technologies and understanding how consumer behavior changes and responds to more dynamic market options.

Expanding the Smart Grid in Transmission

If grid operators are to maintain reliability while relying increasingly on more variable generation sources, they will require additional transmission investment and expanded grid reliability applications. These can be accomplished by using information derived from synchro-phasor data. EPRI research is focusing on applications that might offer utilities the capability to detect dynamic stability indicators and voltage security issues in wide area systems in real time as well as to minimize losses while increasing transmission grid utilization.

Because utilities will continue to rely heavily on existing infrastructure, EPRI research is developing and demonstrating on-line condition monitoring of key grid components, equipping utilities to anticipate reliability events and take mitigating actions. At the heart of such monitoring is a new family of sensors, designed to detect degradation and impending failure of power equipment. This smart grid application can help transmission owners correct situations before components fail.

The scope of EPRI research spans a range of communications and information technology research including common interface models and communications and security interoperability standards. In addition EPRI collaborates with various stakeholders to define functional requirements specifications for smart grid applications from interfacing to consumers to managing new loads and resources on distribution to increasing reliability in transmission.



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