# NuIDEA

## ACTION PLAN

FEBRUARY 2023

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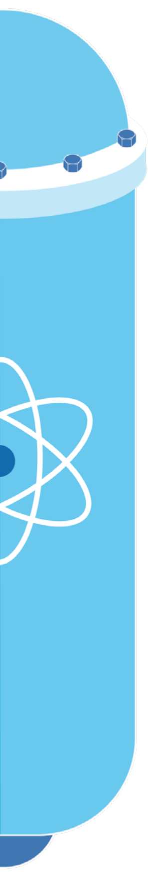
# INTRODUCTION

District energy systems connect multiple heating and cooling energy users to central energy sources. These plants utilize equipment such as boilers and chillers to produce steam, hot water, and chilled water.

In addition to thermal energy, district energy facilities can cogenerate electricity utilizing equipment such as combustion turbines paired with heat recovery steam generators.

Traditionally, district energy systems have used either fossil fuel or electricity from the grid as an energy source. Fossil fuel use started with coal as a primary fuel, which has been largely replaced by natural gas. Fuel oil is often used as a backup fuel in critical applications.

In recent years, there has been a growing demand in the district energy market to decarbonize energy sources to help address climate change. This presents significant technical and financial challenges in making large scale changes to existing infrastructure necessary to achieve decarbonization.



The industry is considering a variety of different technical options to address these challenges. These options include transitioning from steam to hot water, electrification, heat pumps, and switching to low-carbon fuels.

Another potential option is to utilize a new nuclear technology: microreactors. These reactors are much smaller reactors than traditional plants, but can still provide reliable and carbon free energy located directly on site. Although microreactor based district energy systems have significant potential, several challenges need to be overcome to fully realize this potential.

While it is recognized that larger nuclear plants have been used for district heating, the focus of this work is on the use of microreactors due to their potential to serve a much larger portion of the market.

To address these challenges, more than 20 organizations have come together to form the Nuclear in District Applications (NuIDEA) Initiative. The NuIDEA Initiative has worked for the last year to develop this action plan, which defines the work necessary to fulfill the NuIDEA mission.

## The NuIDEA Mission

**Enable nuclear energy as an option for the district energy market by 2026**

# OVERVIEW OF THE DISTRICT ENERGY MARKET

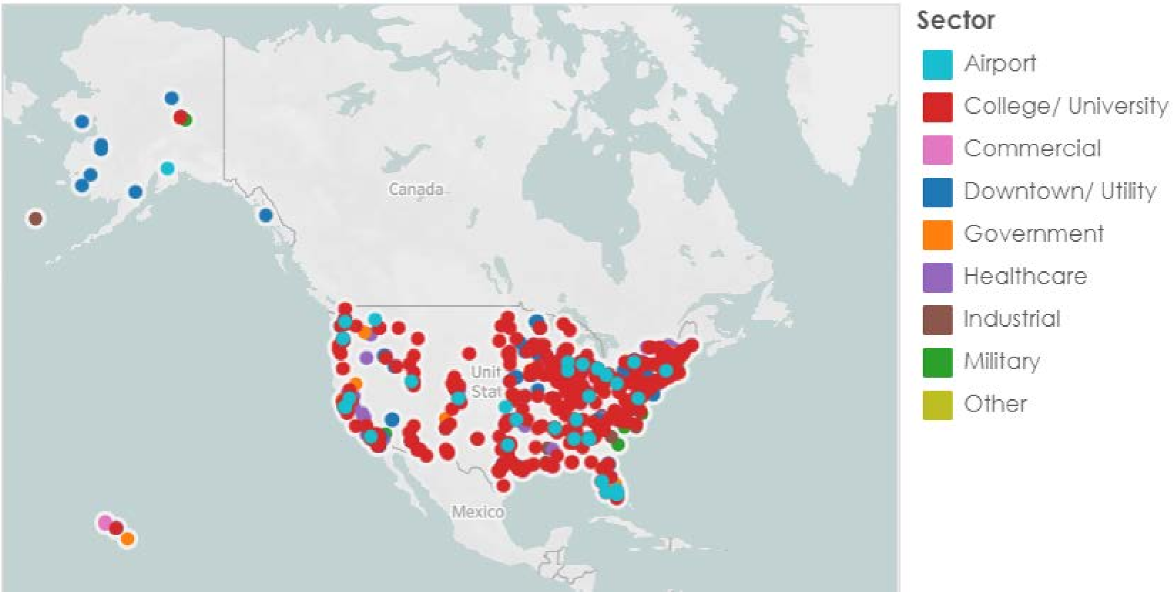
District energy systems produce and distribute steam, hot water, and/or chilled water through dedicated piping networks to heat or cool connected buildings.

By centralizing production equipment and utilizing economies of scale, energy costs and environmental impacts are reduced while freeing up valuable space in customer buildings. Also, electricity can be cogenerated to capture additional benefits.

Classically, district energy plants employ a combination of boilers, chillers, and generators, but more systems are now deploying more advanced and efficient technologies, including thermal energy storage, geoexchange, and waste heat recovery.

District energy systems in North America typically serve "clusters" of buildings. These clusters can be found in the following markets:

- College and university campuses
- Urban districts
- Healthcare facilities
- Government facilities
- Military facilities
- Airports




District Energy Systems Operated by International District Energy Association Members

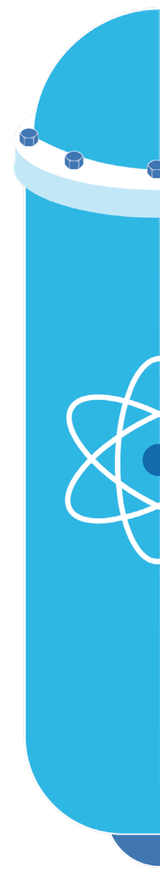
In systems such as college campuses and healthcare facilities, the utility plant and buildings are under the same ownership. In other systems, such as municipal systems, the customer buildings have distinct and separate owners. The number of customer buildings served by a district energy system range from as few as 3 or 4 in the initial stages of new system development to more than 1000 for mature systems. For example, the Con Edison Steam Business Unit in Manhattan serves more than 1,800 customer buildings, making it the largest district steam system in the world.

Recently, the International Energy Agency published a report projecting that district energy systems will provide heat for 20% of global space heating needs by 2030, up from 15% in 2020. It also estimates that the industry will have 350 million connections in 2030, as it gains market share in urban areas.

The benefits of district energy systems for plant operators and end-users include the following:

- Ease of use and simplified building operations
- Avoided capital costs for in-building heating and air conditioning equipment
- Additional space within a building for alternative uses and other income activities
- Reduced labor, repair, and maintenance expenses
- Reduced $CO_2$ emissions

District energy has been used for nearly 150 years, and its use continues to grow around the world.



# DISTRICT ENERGY MARKET DRIVERS

Until very recently, few federal policy drivers existed for district energy in the United States. District energy systems are eligible for accelerated depreciation, and many large campus utilities upgrades are funded, in part, by state and federal grant programs.

At the state and local level, states and municipalities have the authority to determine whether district energy systems are regulated as utilities, and to incentivize development through rebate structures or other development initiatives.

Since federal and state policies have not traditionally been strong drivers for district energy adoption or upgrade, individual system operators and managers tend to be the primary decision-makers when it comes to technology decisions. Those operators are primarily motivated by users' priorities. Currently, key user priorities include decarbonization and increased reliability and resiliency.

However, the passage of the Inflation Reduction Act in the United States in 2022 has the potential to be the most consequential energy and climate legislation in decades. Notably, it includes $369 billion in new spending for energy security and climate change measures. The energy and climate provisions can benefit district energy systems by reducing the cost of upgrading and decarbonization. The major opportunities lie in tax incentives or direct payments to tax exempt and governmental entities in lieu of a reduction in tax liability. The legislation also establishes funding for climate-related grants and technical assistance.

User goals of decarbonization and increased reliability and resiliency, as well as opportunities created by the Inflation Reduction Act, have created a strong incentive to upgrade district energy systems. New microreactor technology is well positioned to address these district energy market drivers.

## Key Market Drivers

- **Decarbonization**
- **Increased Reliability and Resiliency**
- **Inflation Reduction Act**

# OVERVIEW OF MICROREACTOR TECHNOLOGY

To meet the diverse needs of a decarbonizing society, nuclear technology developers around the world are pursuing alternatives to the gigawatt-scale nuclear power plants seen today.

The current operating fleet of nuclear power plants primarily produces electricity for the grid. These plants are often sited on hundreds of acres of land, generating thousands of megawatts of electric energy. This can be enough electricity for a whole city, but an overwhelming amount of energy for a university, hospital, or federal campus.

Microreactors are an emerging option for producing thermal and electric energy. This innovative technology can be tailored to occupy less than an acre and produce a few tens of megawatts of energy. These miniature nuclear reactors can be added as needed for a wide variety of applications.

For example, consider a typical district energy plant that serves a system with a peak steam load of 300,000 lb/hr at 150 psig. With a microreactor design of 30 megawatts- thermal producing approximately 90,000 lb/hr, 5 microreactors can be utilized to meet the peak load with N+1 reliability.

Many of the microreactor designs provide high-temperature steam (e.g., 1200˚F). This enables the efficient production of chilled water and electricity using steam driven chillers and steam turbine generators. By producing multiple energy products, the utilization of the plant can be optimized.

A few prominent microreactor technologies are currently available on the market. The most common is the high-temperature gas reactor (HTGR). These designs use trisostructural isotopric (TRISO) fuel, small kernels of uranium enclosed by graphitic materials for protection. This fuel form can withstand temperatures high enough that it is essentially impossible to melt the fuel. Helium is typically used as the coolant to transfer the heat to a steam generator.

Another common microreactor type is the liquid metal cooled reactor. This reactor commonly uses liquid metal heat pipes for passive heat removal.

Current designs utilize passive safety concepts. This approach allows the reactor to cool itself independently of off-site power, as the physics of natural convection are able to return the core to a safe state.

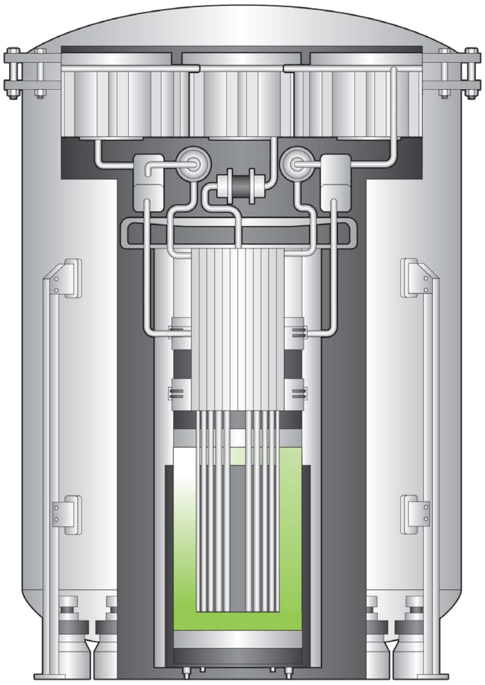


*Illustration of Microreactor*

# NuIDEA INITIATIVE

Based on the evolving drivers of the district energy market, as well as the development of new microreactor technology, EPRI formed the NuIDEA Initiative in the spring of 2022. The mission of the NuIDEA initiative is to enable the use of nuclear energy in the district energy market by 2026.

More than 20 organizations have already joined the NuIDEA Initiative. The participants include a wide variety of organizations such as district energy utilities, universities, hospitals, government agencies, architect-engineers, and non-profit advocacy organizations.

After establishing its mission, the participants of the NuIDEA Initiative focused on developing an action plan to address the market need. This action plan is initially focused on the North American market. Future engagement will be explored in other international markets.

The subsequent sections of this document describe the objectives of each area and the associated actions. The NuIDEA Initiative will work over the next three years to address the actions identified for completion by 2026.

## NuIDEA ACTION PLAN AREAS

**Policy**

**Public Awareness**

**Ownership Models**

**Finance**

**Insurance**

**Project Development and Execution**

**Technical**

**Regulatory**

**Permitting**

**Operations and Maintenance**

**Security**

## EPRI’s Role in the NuIDEA Initiative

EPRI is a U.S. Internal Revenue Code Section 501(c)(3) non-profit scientific research organization, which conducts independent and objective energy research, development, and demonstration, for the benefit of the public. Consistent with its mission, EPRI has incubated this initiative to provide an open forum for interested organizations and individuals and plans to contribute independent and objective insights in areas of EPRI’s expertise. Initiative stakeholders are invited to lead or participate in the 11 action areas that align with their respective business objectives and interests. Since EPRI does not take a position on legislation or policy, EPRI will not participate in actions that are related to Policy, Public Awareness, Insurance and Regulatory.

# POLICY

## OBJECTIVE

The objective of this area is to support the adoption of federal, state, and local policies that would encourage the use of nuclear energy in district energy applications.

## ACTIONS

| ACTION ID | DESCRIPTION | RESPONSIBLE |
|---|---|---|
| POL-1 | Identify sources of funding for pilot projects using nuclear energy in district energy facilities. | NuIDEA Policy Team [1] |
| POL-2 | Identify opportunities in existing policies (e.g., the Inflation Reduction Act) that provide financial incentives to encourage the adoption of nuclear energy in district energy facilities. | NuIDEA Policy Team [1] |
| POL-3 | Encourage procurement and/or production of fuel for microreactors beyond the amount dedicated for high-assay low enriched uranium (HALEU) fuel in the IRA. | Nuclear Energy Institute (NEI) |
| POL-4 | Develop policies and processes for radioactive waste disposal for the use of microreactors used in district energy facilities, similar to processes for research reactors. | NEI |

*[1] Due to EPRI's role as a 501(c)(3) non-profit scientific research organization as described on page 9, EPRI will not be a member of the NuIDEA Policy Team.*

# PUBLIC AWARENESS

## OBJECTIVE

The objective of this area is to encourage and develop public awareness of nuclear energy in district applications.

## ACTIONS

| ACTION ID | DESCRIPTION | RESPONSIBLE |
|---|---|---|
| PA-1 | Perform surveys to identify a baseline public understanding of the use of nuclear energy in district energy applications. | NuIDEA Public Awareness Team[2] |
| PA-2 | Develop NuIDEA fact sheet that describes the potential use and benefits of nuclear energy in district energy applications to inform public opinion. | NuIDEA Public Awareness Team[2] |
| PA-3 | Communicate the NuIDEA fact sheet to the public through the use of various channels such as press releases and social media. | NuIDEA Public Awareness Team[2] |
| PA-4 | Develop partnerships with organizations to engage with on the use of nuclear energy in district energy facilities. These organizations include but are not limited to the American Society for Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), American Public Power Association (APPA), and the International District Energy Association (IDEA). | NuIDEA Public Awareness Team[2] |

[2] *Due to EPRI's role as a 501(c)(3) non-profit scientific research organization as described on page 9, EPRI will not be a member of the NuIDEA Public Awareness Team.*

# OWNERSHIP MODELS

## OBJECTIVE

The objective of this area is to develop guidance on various ownership models that can be used to deploy microreactors into a district energy system.

## ACTIONS

| ACTION ID | DESCRIPTION | RESPONSIBLE |
| --- | --- | --- |
| OWM-1 | Develop a guideline on ownership models for the use of nuclear energy in district energy facilities, including the following topics:<br><br>• Description of ownership model options available for deployment to the industry, including advantages and disadvantages of each<br><br>• Delineation of ownership and operation responsibilities, including licensing, incentives, fuel disposal, and others<br><br>• Guidance on risk allocation options among stakeholders for each ownership model<br><br>• Challenges and barriers for each ownership model due to new microreactor technology<br><br>• Standard contractual agreements/templates, along with the procurement structures and criteria recommended for each ownership model<br><br>• Guidance on potential ways to manage nuclear projects from a governance perspective<br><br>The ownership models should be based on general understanding of the expected capital and operations and maintenance (O&M) costs. | EPRI |

# FINANCIAL

## OBJECTIVE

The objective of this area is to support the ability to finance the utilization of microreactors in district energy applications.

## ACTIONS

| ACTION ID | DESCRIPTION | RESPONSIBLE |
|---|---|---|
| FIN-1 | Identify and characterize options that could be utilized for financing microreactor district energy projects. | EPRI |
| FIN-2 | Develop objective informational material on utilizing nuclear energy in district energy environments, including but not limited to market size, microreactor technology, current policy drivers, and environmental, social, and governance (ESG) impacts. | EPRI |

# INSURANCE

## OBJECTIVE

The objective of this area is to develop guidance for obtaining insurance coverage related to using nuclear energy as part of a district energy application. This includes but is not limited to the following types of insurance:

- Nuclear liability coverage
- Physical property damage coverage
- Transportation coverage
- Coverage for long-term operability interruption
- Coverage for expenses associated with stabilization and decontamination resulting from a nuclear event

## ACTIONS

| ACTION ID | DESCRIPTION | RESPONSIBLE |
|---|---|---|
| INS-1 | Develop a white paper on nuclear insurance for district energy facilities that includes the following topics:<br>• A description of the intended use of nuclear energy in district energy applications<br>• Analysis of current regulations for nuclear liability and property insurance compared to the intended use of microreactors in district energy applications<br>• If necessary, develop a list of recommended regulatory changes to support nuclear in district energy for consideration by the Nuclear Regulatory Commission (NRC) | NuIDEA Insurance Team[3] |
| INS-2 | Submit the white paper to the NRC. Engage NRC on the white paper. | NEI |
| INS-3 | Develop a guideline on nuclear insurance for district energy facilities. | NuIDEA Insurance Team[3] |

*[3]Due to EPRI's role as a 501(c)(3) non-profit scientific research organization as described on page 9, EPRI will not be a member of the NuIDEA Insurance Team.*

# INSURANCE

| ACTION ID | DESCRIPTION | RESPONSIBLE |
|---|---|---|
| INS-4 | Develop a list of other non-traditional coverage items that may need to be considered in a district energy application. | NuIDEA Insurance Team[3] |
| INS-5 | Determine additional risks and insurance requirements for transportation coverage of non-traditional equipment (e.g., pre-fueled reactor). | NuIDEA Insurance Team[3] |

*[3]Due to EPRI's role as a 501(c)(3) non-profit scientific research organization as described on page 9, EPRI will not be a member of the NuIDEA Insurance Team.*

# PROJECT DEVELOPMENT AND EXECUTION

## OBJECTIVE

The objective of this area is to develop guidance and solutions for the development and execution of a project to implement a microreactor in a district energy system.

## ACTIONS

| ACTION ID | DESCRIPTION | RESPONSIBLE |
|---|---|---|
| PDE-1 | Develop a process that determines and documents owner operator project requirements. | EPRI |
| PDE-2 | Develop typical roles of key parties, including but not limited owner/operator, architect-engineer, reactor original equipment manufacturer (OEM), and contractor. | EPRI |
| PDE-3 | Develop a contracting options guideline. | EPRI |
| PDE-4 | Develop typical guidance for selecting a site. | EPRI |
| PDE-5 | Develop guidance for selecting reactor technology. | EPRI |
| PDE-6 | Develop a project development and execution roadmap for implementing microreactors at district energy facilities. | EPRI |
| PDE-7 | Develop a guide to identify and characterize potential risks that are unique to using microreactors in district energy facilities. | EPRI |

# TECHNICAL

## OBJECTIVE

The objective of this area is to develop technical guidance and solutions to integrate a microreactor into a district energy system.

This area does not include technology development of microreactors. It also does not include any on-site refueling systems, as it is assumed that any microreactor used for district energy will not be refueled on-site.

## ACTIONS

| ACTION ID | DESCRIPTION | RESPONSIBLE |
|---|---|---|
| TEC-1 | Develop typical owner requirements for microreactors, including thermal load requirements. | EPRI |
| TEC-2 | Develop conceptual system designs for using microreactors to supply steam, hot water, chilled water, and electricity. | EPRI |
| TEC-3 | Develop guidance on radiation monitoring and protection. | EPRI |
| TEC-4 | Develop automation strategies, including load following. | EPRI |
| TEC-5 | Develop interfacing signals and methods to interface microreactor control systems with district energy plant control systems. | EPRI |
| TEC-6 | Develop a methodology to physically and functionally separate nuclear facilities from adjacent facilities. | EPRI |
| TEC-7 | Develop new or repurpose existing technical methodologies that would support the consideration of smaller emergency planning zones. | EPRI |

# REGULATORY

## OBJECTIVE

The objective of this area is to address nuclear regulatory barriers to using nuclear energy in the district energy market.

EPRI and NEI are working on an Advanced Reactor Roadmap that is separate from the NuIDEA Initiative. This roadmap will address generic regulatory issues, including those affecting microreactors. As such, this action plan does not repeat those actions, and only includes actions specific to district energy applications.

## ACTIONS

| ACTION ID | DESCRIPTION | RESPONSIBLE |
|---|---|---|
| REG-1 | Develop a fact sheet to describe the roles of the NRC, other regulatory bodies, the Institute of Nuclear Power Operations (INPO), and the roles of the owner/operator, licensee, architect engineer, and reactor vendor for district energy owner- operator awareness. | NEI |
| REG-2 | Develop resources for high-level district energy end-user understanding of NRC regulatory approval pathways (Part 50/52/53) and associated requirements. | NEI |
| REG-3 | Encourage a nuclear regulatory framework that is appropriate for the size and risk of microreactors applied in district energy systems. | NEI |

# PERMITTING

## OBJECTIVE

The objective of this area is to develop guidance on the development of the expected permitting tasks that can be anticipated for a new nuclear project in district energy facilities. This includes federal, state, local and construction permitting that is outside the NRC's scope.

## ACTIONS

| ACTION ID | DESCRIPTION | RESPONSIBLE |
|---|---|---|
| PER-1 | Develop a guide for planning permitting activities for nuclear energy projects in district energy facilities. The guide will include the following information:<br>• A permitting matrix for planning the permitting process for intended sites<br>• A process to modify existing permits<br>• A 'fit for purpose' process for the permitting of projects at the expected district energy scale<br>• Templates for the permitting process<br>• Potential opportunities to centralize the permitting process with a specific agency<br>• A typical permitting cycle for an example project | EPRI |

# OPERATIONS AND MAINTENANCE

## OBJECTIVE

The objective of this area is to identify the needs and requirements associated with operating and maintaining a microreactor within the bounds of a district energy system.

## ACTIONS

| ACTION ID | DESCRIPTION | RESPONSIBLE |
|---|---|---|
| O&M-1 | Develop a generic concept of operation for utilizing a microreactor in a district energy system. This would include but is not limited to desired operational concepts, level of automation, maintenance strategies radiation monitoring and protection, hazardous waste management, and O&M staffing. | EPRI |
| O&M-2 | Develop generic training concepts for operators of nuclear district energy facilities. | EPRI |
| O&M-3 | Identify, generically, the O&M procedures and strategies that need to be provided by the OEM and/or architect-engineer (A/E). | EPRI |
| O&M-4 | Develop generic concepts for engineering and licensing to support nuclear district energy facilities. | EPRI |
| O&M-5 | Develop a report on workforce alignment and needs to support transition from current district energy systems to future inclusion of nuclear energy. | NEI |

# SECURITY

## OBJECTIVE

The objective of this area is to develop approaches to physical and cyber security that are right-sized for district energy facilities using microreactor technology.

## ACTIONS

| ACTION ID | DESCRIPTION | RESPONSIBLE |
|---|---|---|
| SEC-1 | Develop a security (physical and cyber) white paper to cover the following topics:<br>• A security concept of operations for district energy facilities<br>• Current regulatory security compliance and inspection requirements for microreactors<br>• Opportunities within existing regulations that allow for exemptions and/or alternative measures to current requirements<br>• Potential new regulatory language or changes to existing regulation that are appropriate to the use of micro reactors within district energy systems<br>• Potential new security program inspection criteria for district energy systems | NEI |
| SEC-2 | Submit the white paper to the NRC. Engage the NRC to address the industry input identified in the white paper. | NEI |
| SEC-3 | Develop a security-by-design guideline (physical and cyber) for reactor OEMs and A/E's. | EPRI |

# NuIDEA INITIATIVE TEAM

The following individuals supported the development of this action plan.

## NUIDEA INITIATIVE LEAD

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## About EPRI

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

### CONTACT INFORMATION

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

### EPRI RESOURCES

EPRI members interested in engaging in and supporting this effort should contact EPRI for further discussion.

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