

# Solving the EV Charging Dilemma



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Land of Opportunity

Graceful Aging

How Reindustrialization Is Boosting  
U.S. Manufacturing – and Challenging Utilities

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## Land of Opportunity

*How rights-of-way in the southeastern U.S. can benefit pollinating insects.*

**By Chris Warren**

There's nothing ambiguous about the mission of electric company vegetation managers. Above all, their job is to ensure that the growth of trees, bushes, and other vegetation doesn't negatively impact the reliable production and delivery of electricity.

In the case of high-voltage transmission lines, the Federal Energy Regulatory Commission (FERC) [approves](#) reliability standards that, among other things, specifies maintaining a certain distance between vegetation and the lines themselves. As a result, utilities develop and implement a tree trimming and vegetation management strategy to keep electricity flowing reliably.

Though reliability will always remain the top priority for vegetation managers, there is a growing awareness that there are opportunities to simultaneously bolster reliability while also benefitting biodiversity and, more specifically, pollinators like birds, butterflies, bees, and other insects. Researchers have found that pollinator populations are in decline because of habitat loss, climate change, invasive species, and the use of

pesticides. This is a societal challenge because about one-third of all the food we eat and thousands of medicinal plants depend on healthy pollinator populations.

### The Benefits of Integrated Vegetation Management (IVM) and Rights-of-Way (ROW)

Many utilities and landowners acknowledge the potential to manage vegetation in ways that both ensure reliable supplies of electricity and benefit pollinators. Electric companies use integrated vegetation management (IVM) to promote low-growing vegetation that doesn't risk damaging grid infrastructure, like transmission lines, or potentially cause power outages, wildfires, or soil erosion.

EPRI's Transmission & Distribution (T&D): Environmental Issues [Program](#) conducts extensive research into the environmental issues related to the design, construction, operation, and maintenance of T&D infrastructure. This has included reports such as and research into the potential pollinator benefits of transmission line rights-of-way (ROW) in [Arizona](#), a

five-year [project](#) with American Electric Power (AEP) highlighting the value of installing prairie habitat for bees, butterflies, and birds, and [video](#) about the biodiversity value of rights-of-way in the Southeast U.S.

The opportunity to support pollinator habitat in rights-of-way for high-voltage transmission lines largely depends on how much land they cover. A widely cited estimate calculates that approximately nine million real estate acres are occupied by electric power transmission lines and another 12 million acres occupied by pipelines, meaning there is a total of 21 million real estate acres potentially available for establishing and maintaining habitat. While there is an opportunity to utilize rights-of-way to bolster the populations of flowers and vegetation pollinators depend on without negatively impacting reliability, more research is needed. Little is known, for example, about whether southeastern U.S. rights-of-way have the potential to provide pollinator habitat and what impact integrated vegetation management can have in unlocking that potential.

## A Southeastern Focus

Between 2018 and 2021, EPRI collaborated with Southern Company to investigate the potential of

right-of-way integrated vegetation management practices to support pollinators and pollinator habitat. Plant and pollinator data collected over a five-year [study](#) highlights the value of implementing and selecting IVM practices that can protect and preserve pollinators.

The transmission lines and rights-of-way that Southern Company manages provided a potential opportunity to benefit pollinators. “One motivation for this study was to better understand the importance of rights-of-way in the southeast to pollinating insects. The second was to understand the impacts of integrated vegetation management in terms of herbicide treatments,” said Joe Drumm, natural resources manager at Southern Company. “Our role in the environmental department is not to restrict or tell the vegetation management professionals what to do or not do. But we do want to understand the impact of different management regimes to ultimately inform the best decisions.”

Together with Southern Company subsidiary Alabama Power and Auburn University, EPRI selected four rights-of-way in central Alabama to study. Each of the test sites were a minimum of 1000 meters long and just over 45 meters wide.



To compare the impact of various integrated vegetation management practices on both plants and pollinator insects like bees, wasps, and flies, each of the four plots was divided into three sections. Researchers first established a baseline of the vegetation cover in each of the plots by quantifying the grass, forbs, woody vegetation like brambles and pine trees, and bare ground present when the project began in 2018. Additionally, researchers pinpointed all the flowering plants in each of the test plots and measured their floral blooms to gauge how the frequency and density of the blooms changed over time in response to tested integrated vegetation management practices.

Researchers also established a baseline of pollinating insect populations by collecting information about bees, flies, and wasps in each of the rights-of-way research sections as well as in adjacent forested areas slightly removed from the rights-of-way. After the initial data collection phase, three different herbicides were applied in each of the research areas using either ground or backpack sprayers. The three herbicides used were a high-volume, broad-spectrum herbicide (T1); a low-volume broad-spectrum herbicide (T2); and a low-volume, grass-friendly herbicide (T3). Over the course of 2019, 2020, and 2021, researchers collected vegetation and insect pollinator data monthly during the

summer and fall flowering seasons to understand any potential treatment differences on the right-of-way vegetation and pollinator communities.

## Lesson Learned: Rights-of-Way Can Benefit Pollinators

The main takeaway of the research was clear: rights-of-way provide habitat that uniquely supports insect pollinators.

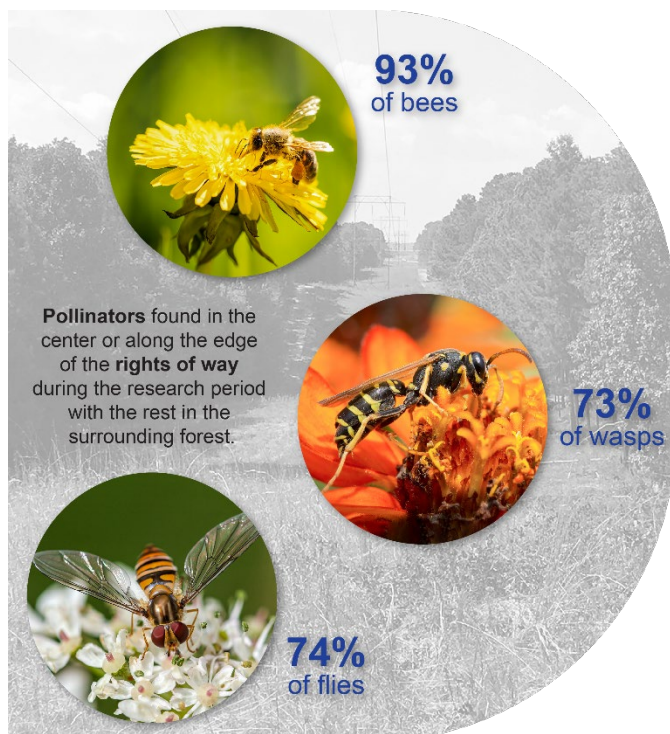
“One of the really exciting outcomes of this research was we found a much higher abundance of bees, wasps, and some groups of flies on the rights-of-way compared to off the rights-of-way,” said Dr. Ashley Bennett, an environmental research scientist at EPRI who spearheaded the project. “This suggests that the integrated vegetation management practices Southern Company was using, regardless of the treatment, was providing habitat and resources for those pollinating insects on the right-of-way.”

It is not entirely surprising that rights-of-way offer superior habitat for insect pollinators than the surrounding forestland during the summer and fall. Pollinating insects need flowers for pollen and nectar. In forests, most trees typically flower in the spring. Having floral resources available in the forest in spring and later in the season, having flowers blooming in the rights-of-way can be particularly beneficial for pollinators. “It’s nice to have a forest with early season spring resources adjacent to the right-of-way, where we typically don’t have a lot of flowers blooming early in the season,” Bennett said. “But once we get into the summer and fall season, the right-of-way has a lot more perennial flowers blooming than the adjacent forest.”

## Validating Southern Company’s Approach

The results of the research also confirmed that Southern Company’s existing integrated vegetation management practices support pollinating insects. “It’s gratifying that the research shows that our current integrated vegetation management practices are working,” said Jesalyn McCurry, environmental stewardship manager at Southern Company.

The research also deepened the utility’s understanding about available herbicides it could use in its integrated vegetation management. For



example, land treated with the low-volume grass-friendly herbicide (T3) had more forbs and less bare ground than land managed with the other two treatments. Areas treated with that same herbicide, T3, also had greater bloom density, and both treatments 2 and 3 resulted in higher bloom frequencies compared to treatment 1.

While there were differences in the impact on vegetation, it was also clear that no single herbicide treatment was significantly more supportive of pollinating insects. This was helpful in confirming that vegetation managers have several options that can both enhance grid reliability and support pollinator habitat. “We want to ensure they have as many tools as necessary in their toolbox that they can deploy to accomplish their mission,” Drumm said.

While the research has practical value by informing the integrated vegetation management of Southern Company, it is also helpful in demonstrating just how real the utility’s commitment to biodiversity and environmental conservation is. “We are proud of our company’s public commitments to protecting and conserving the environment as we serve our customers,” Drumm said. “Biodiversity-focused research, and implementing the findings, is central to demonstrating this commitment.”

The research is also valuable outside of the southeastern U.S. to showcase to other electric companies the potential benefits of pursuing integrated vegetation management practices that support pollinator habitat. EPRI is currently pursuing research to quantify and explore biodiversity supported on rights-of-way outside of the southeastern U.S., including the midwest, northeast, and western United States.

“One area of research we are currently pursuing is demonstrating the overall biodiversity value of rights-of-ways compared to off right-of-way habitat. We can really start to build an exciting story in different regions of the country about the conservation value of rights-of-way if we are able to document groups of conservation concern such as pollinators, birds, and bats are utilizing right-of-way habitat,” Bennett said. EPRI’s T&D Environmental Issues Program will be initiating new research in 2024 evaluating the conservation potential of rights-of-way compared to other off right-of-way habitats.

### **EPRI Technical Expert**

Ashley Bennett



## Graceful Aging

*EPRI research and pilot programs demonstrate how risk insights can enhance nuclear aging management programs.*

**By Chris Warren**

Whether they acknowledge it or not, every human being is in the risk assessment business. For example, you perform a risk assessment every time you cross a street, decide to go on a trip, or consider a big life decision. Opting for a lightly trafficked route to school or work over a more crowded but quicker commute is a common daily dilemma. Another typical risk assessment is taking a vehicle for a routine tune-up or to diagnose a problem.

“There’s a ranking that goes on,” said Fernando Ferrante, who leads the Risk and Safety Management Program at EPRI. “You’re not going to let your brakes wear out. You’re not going to let your tire treads go bald. There are other things that you’re not going to ignore, like a broken mirror or your oil level, that could cause problems if they go unaddressed for a long time. But risk insights help prioritize where mechanics should focus their time and attention first.”

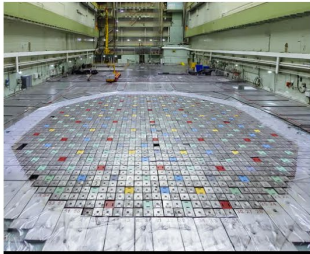
Risk assessments are part of everyone’s everyday life. When it comes to complex systems such as the electrical grid, sending astronauts to Mars, or operating commercial nuclear reactors, this work is done by risk analysts. They provide insights that can help make informed decisions when faced with competing priorities, costs and benefits, and uncertainties.

### Long Operating Lives Elevates the Importance of Aging Management

Since 2019, EPRI has collaborated with the Nuclear Energy Institute (NEI) and member utilities Ameren and Constellation Energy to research and pilot the use of risk insights to improve aging management programs (AMPs) at nuclear power plants. One of the results of the ongoing work is the EPRI report, [Leveraging Risk Insights for Aging Management Program Implementation](#).

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Aging management programs have always been important in the nuclear power industry, but they are particularly important today.



Initial License 40 Years



20-Year Extensions



U.S. Reactors



Worldwide Reactors



In the U.S., the Atomic Energy Act authorizes the Nuclear Regulatory Commission (NRC) to license reactors to operate for 40 years.

Once a reactor has been in operation for four decades, the NRC can renew its license for an additional 20 years at a time.

The vast majority of nuclear reactors in the U.S. were built in the 1970s and 1980s, and most have already had their initial 40-year license extended by two decades.

Similar extensions have been granted to nuclear power plants in operation worldwide, thanks in part to the important role nuclear power plants play in generating carbon-free electricity.

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As nuclear power plants operate longer, the role of AMPs in ensuring their safety and performance is elevated. Historically, AMPs have been guided by a deterministic philosophy, which was the common approach when most plants were built. A deterministic AMP is a prescriptive set of requirements directing how maintenance on plant systems, structures, and components (SSCs) is performed.

The deterministic philosophy worked well, particularly when large nuclear power plants had relatively little operating experience. However, because most plants have operated for decades, they have accumulated insights into how operations and design impact SSCs.

Those insights consider the frequency and impact of challenges to plant safety and performance and can complement deterministic approaches. For example, risk insights based on operational data and modeling give plant operators more flexibility to prioritize maintenance and other efforts on reactor components, systems, and operator actions based on their impact on safety and performance. Instead of being prescriptive, approaches informed by risk insights provide multiple approaches to achieving performance and safety objectives.

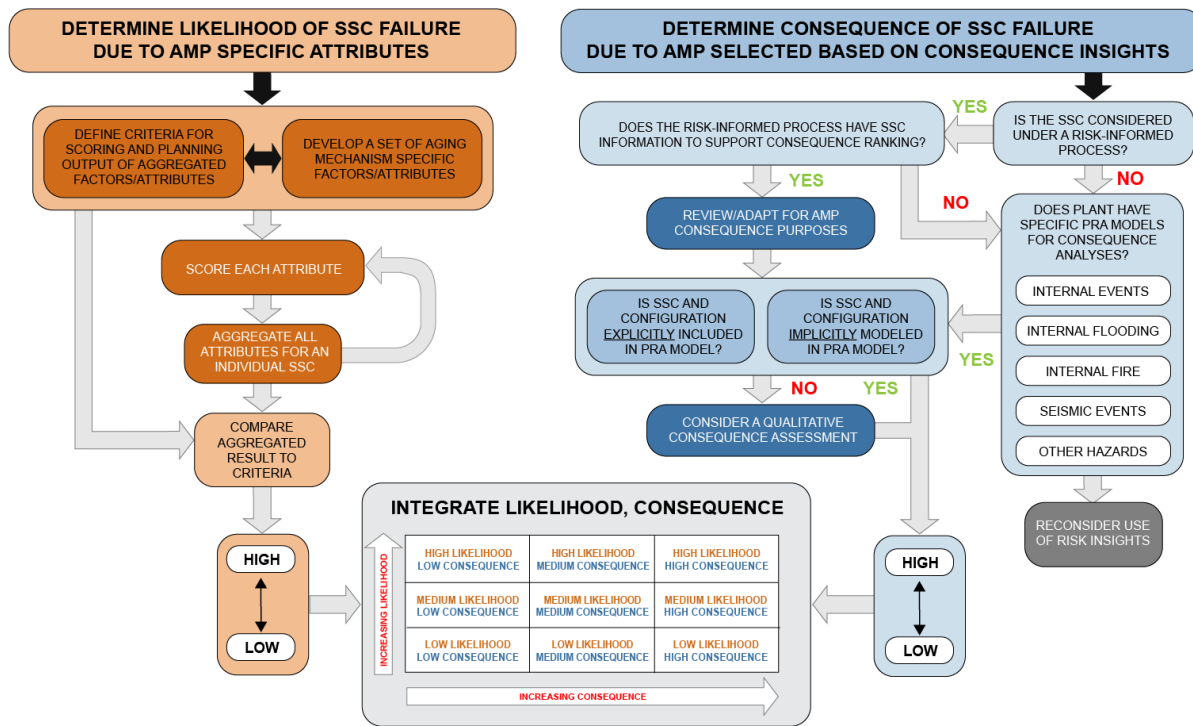
The fact that so many reactors have been operating for decades provides an opportunity to take advantage of risk insights. “It’s important to realize that when the first aging management programs were put together, there was limited information available about how many of these components may age,” said EPRI principal technical leader Emma Wong. “With limited information, it is reasonable to be more prescriptive, which led to more deterministic aging management programs.”

Decades of operating experiences and research have changed that, ushering in the possibility to translate that experience into risk insights that can be incorporated into AMPs. Indeed, Ferrante sees the work EPRI and its partners are pursuing not as a criticism of the deterministic AMPs that have worked so well but as opportunities to bolster them with research and real-world experience.

“We have all this engineering knowledge in terms of challenging areas for aging mechanisms in nuclear power plants,” Ferrante said. “We’re gathering that information and making it more risk prioritization oriented. You can use insights to shift your program from looking at everything the same way to asking what it will cost the plant if one component fails.”



## Framework for Leveraging Risk Insights for Aging Management



And some components and structures are more important than others.”

The importance of integrating risk insights into AMPs is also underscored by the resource constraints nuclear power plant operators face today. While there is increasing interest in the potential for sensors and other technologies to monitor the aging of components in real-time, that capability has not yet been widely implemented or may not even exist for commercial use. “If you look at power plants today, they have fewer people and fewer resources but need to be able to manage more,” Wong said. “So, you need to be smarter about where you target your resources and time.”

### A Framework to Apply Risk Insights

Risk insights have the potential to improve the efficiency and effectiveness of AMPs. However, applying insights consistently can be challenging. This is particularly true because different nuclear power plants’ SSCs vary considerably, which is why one of the most important outcomes of the research

that went into the [Leveraging Risk Insights for Aging Management Program Implementation](#) report was the development of a framework to guide the application of risk insights in AMPs.

“The scenario at each plant will always be different, but the framework provides a guideline to follow,” Wong said. “You can move down the flow chart approach to see if this works for you. It won’t work for everyone because not everyone will have enough information to use the framework. But the framework provides a tool that lets you gather information to see if it’s possible to use risk insights and benefit from them.”

For example, the framework involves collecting plant-specific information about SSCs and any existing knowledge about aging mechanisms and risk insights. The framework also leans heavily on operational lessons learned at the plant. This can result in a better understanding of the likelihood that there will be an SSC failure due to an aging effect and the potential consequences of a failure.

All this information can then be used to inform AMP decisions and strategies, including the performance of maintenance, equipment replacement, and inspections.

There are several unique features of the framework. One is that it is focused on both safety and plant performance. This is a paradigm shift. “When you look at aging management for a license renewal, it’s all based on safety,” said Wong. “They don’t look at whether your plant will run optimally. We’re looking at the enterprise risk management of the whole system. Safety is paramount, but operational performance is also up there.”

Another unique aspect of the framework is that it is built to continuously incorporate new risk insights that are developed because of ongoing operational experience and research. Indeed, the framework acknowledges that AMPs should include a constantly refreshed feedback loop that integrates an improved understanding of how SSCs age and what can be done to mitigate the risks of aging.

### Applying Risk Insights in the Real World

Developing a framework that can be applied at any nuclear power plant was an important first step in seizing the benefits of risk insights. But it was also essential to apply it in real-world scenarios. This was done in a pilot project at Constellation Energy’s Limerick Generating Station in Pennsylvania, where the framework was applied to the utility’s selective leaching AMP. It was also incorporated into the AMP for medium-voltage cables at Ameren’s Callaway Energy Center in Missouri.

The results were encouraging. At a high level, researchers estimate that implementation of the framework could save Constellation \$2 million and Ameren \$600,000 over 20 years of extended plant operations.

At Constellation’s Limerick Generating Station, applying the framework resulted in a more holistic asset maintenance and management approach. For example, the framework utilizes information about component degradation and existing risk tools to create a technical basis to modify the testing and inspection

recommendations that plant owners committed to secure a 20-year license extension.

The pilots utilized a component-specific approach versus the more standard general risk analysis that would be used in a deterministic AMP. This resulted in a component-specific analysis of degradation risk that built a technical justification for AMP action.

For example, at Limerick, the utility recognized the need to integrate components not traditionally associated with safety into the AMP. “They looked at everything to see what would degrade and impact plant operation, not just safety,” said Drew Mantey, an EPRI senior principal project manager. “The framework led them to look at ways to better their asset and aging management.”

At Ameren’s Callaway Energy Center, the framework helped build a justification for testing cables less frequently than what would be dictated by a deterministic AMP. “We did this pilot to show that there was potentially a rationale for extending testing frequencies that are set at six years to 10 years,” Mantey said.

As helpful as the pilots were in validating the relevance and value of the framework in the two plants, they also helped confirm its versatility. That’s because one pilot applied selective leaching risk insights to the framework while the other used insights specific to medium-voltage cables. “It allowed us to look at different risk tools, which was good because it shows how the framework can be applied with different inputs,” Mantey said.

Now that the potential of risk insights to improve AMPs has been demonstrated, lessons from the pilot projects and EPRI’s research are being incorporated into a how-to guide for other utilities to use. The work is being led by EPRI and the NEI’s License Renewal Task Force. Additional pilot projects are also under consideration.

One of the most important lessons from the pilots was about the importance of communication. “Sometimes silos can arise where engineers and risk analysts may not fully understand the benefits of using risk insights,” Wong said. “Sometimes the experts involved may feel like they don’t speak the

same language. But we saw in both pilots that one way to overcome this hurdle is to successfully communicate by sharing the information transparently and clearly with each other.”

## **EPRI Technical Experts**

Emma Wong, Fernando Ferrante, Drew Mantey



## How Reindustrialization Is Boosting U.S. Manufacturing – and Challenging Utilities

*A new EPRI report documents ways decarbonization efforts drive regional industrial growth and “point load” electricity demand.*

**By Chuck Ross**

Industrial electricity demand has been flat for most of the last 25 years at [25% of total U.S. demand](#), with many companies moving their production overseas. But that’s changing in some regions of the United States, where manufacturing activity has started growing again. A range of contributors, from supply chain insecurities arising from the COVID pandemic and the war in Ukraine to rapidly growing investments in technologies related to decarbonization, are driving new factory construction. While this reindustrialization offers broad economic advantages, it could pose challenges for electric companies as they work to deliver the power these high-demand facilities need to keep their lines running.

### Decarbonization Driving Growth

While some early examples of this growth were related to low U.S. natural gas prices, the trend has quickened as companies have sought to regain

control over their supply chains. Additionally, federal incentives underwritten by 2021’s Infrastructure Investment and Jobs Act and 2022’s CHIPS Act and Inflation Reduction Act are [sparking construction](#) in sectors related to semiconductors, solar panels, electric vehicles, and batteries. As a result, more than 155 new or expanded manufacturing facilities were announced, began construction or operation between January 1, 2021, and March 1, 2023, and factory construction spending doubled between January 2022 and April 2023.

These plants may have a limited impact on total U.S. industrial power demand, boosting consumption by about 0.65% compared to 2022’s level. But, with annual demand ranging up to more than 1,000 gigawatt-hours (GWh) annually, they pose big challenges for local utilities – especially given the difference in time required to build a new factory and to develop the transmission and distribution capacity needed to serve that plant. Rob Chapman,

EPRI's Senior Vice President, Energy Delivery and Customer Solutions, notes that challenges are more significant than simply getting power to a service entry.

"A large portion of this new load is going to be 24/7," Chapman said. "Some may operate Monday through Friday and shut down on weekends. As such, there may be different peaks and valleys, but a large portion will operate 24/7. That can pose a challenge."

## Defining the Issue

Meeting manufacturers' expectations of power availability could grow challenging for utilities, especially given the difference between the two to three years it might take to develop a manufacturing plant and the three to five years typically needed to extend distribution resources – with up to a decade necessary for building new transmission.

"Companies that are reshoring don't want to be told they must wait two, three, four years to receive the power needed to support manufacturing development," Chapman said, adding that the issues don't stop with power availability. "Another issue that may come into play is power quality. We have seen a resurgence of requests around power quality to help ensure that manufacturing facilities are being properly supported."

EPRI has been researching just how big an impact this reindustrialization and onshoring trend might have on utility operations. It recently released "[Reindustrialization, Decarbonization, and Prospects for Demand Growth](#)," a report documenting the increase in "point loads" created by new manufacturing facilities that will need to be accommodated by the grid at specific locations. It also covers the longer-term outlook for industrial demand in a decarbonizing economy, leveraging EPRI's recent [Net-Zero 2050](#) modeling analysis.

Among the study's findings are these significant data points:

- New load for the more than 155 new plant and expansion projects totals more than 13,000 GWh/yr (not including data for about 20 facilities with insufficient data for estimating usage).
- Two-thirds of these facilities are scheduled to open by 2025.
- Power availability is likely less significant to affected utilities than the concentrated nature and the potential for rapid emergence of these point loads, which might also cause higher peak demand.
- Many companies want access to 100% renewable energy, 24/7 carbon-free energy, and extremely high service reliability and power quality levels.



Emerging large point loads aren't a new issue for utilities. However, they often develop over time, like large, planned communities that might eventually house thousands of residents but take years to build out fully. That's not the case with a new manufacturing plant.

"If they know ahead of time there is a new community that's going to be built, utilities can plan for it and get all of the approvals," said Poorvi Patel, manager of strategic insight in EPRI's Technology Innovation program. "Now, because of all the policies for fast-tracking decarbonization, we don't have the five to 10 years' foresight – it's more like two years' foresight, which makes it more challenging."

Patel's team worked with third-party consultants to gather and collate publicly available data on new plant and expansion announcements. These contributors also interviewed corporate managers on their expansion plans. Since data collection stopped in March 2023, a number of additional projects have been announced, making this a "very dynamic" trend, Patel said.

Among the surprises for Patel in the data was the degree to which new industries behind today's decarbonization efforts – boosting production of solar panels, electric vehicles, and battery systems for both stationary and transportation uses – are driving manufacturing growth. Also notable is the highly regional nature of where load growth is happening.

"If you look at load growth over the entire U.S., industrialization is just a tiny piece of it. But you can go down to the state level in Arizona and see they're going to have 10% to 15% load growth because of reindustrialization or industrialization, which means a lot to that area," Patel said, targeting one particularly impacted state as an example.

### Emerging Data Center Concerns

Data centers are becoming another important point load source for grid planners, but so far, it's been difficult to know their impact on an affected utility's operations. And hyperscale data centers are becoming more common to support the machine



learning efforts required to develop artificial intelligence capabilities. However, we're still learning just how large their demand might be. Again, the grid impact for utilities in these expansions will be highly regional, and EPRI is also researching where such hot spots might be located.

"If you dive down to the regional base in a state like Virginia, they may see about 35-45% of their load being consumed by data centers in 2030," Patel said. "That is going to be a big chunk and will be very constraining to them."

Given the current reindustrialization and data center construction trends, EPRI is working with regional utilities to help advance their planning efforts. The recent completion of the Integrated Strategic System Planning (ISSP) initiative and the launch of the Integrated System Planning (ISP) Interest Group are two examples, according to Chapman.

"The ISSP Initiative developed a new resource planning framework and supporting analytical toolbox that may be used for planning reliable resource portfolios across the system," Chapman said, adding that the related ISP interest group will give electric companies options for exchanging best practice information with their peers. "The hope is to help members identify next steps for implementing and improving an integrated system plan within their companies."

### EPRI Technical Expert

Poorvi Patel



## Solving the EV Charging Dilemma

*EPRI research identifies the fundamental barriers to mainstream EV adoption and kickstarts collaborative solutions*

**By Chris Warren**

In the International Energy Agency’s (IEA) most recent [World Energy Outlook](#), a couple of technologies stood out for their unprecedented growth rates. Despite the lasting disruptions of the energy crisis sparked by Russia’s invasion of Ukraine and lingering supply chain and economic challenges from the COVID-19 pandemic, the IEA said that the rapid emergence of solar photovoltaics (PV) and electric vehicles (EVs) were quickly becoming a foundation of a new clean energy economy.

According to the IEA, one in 25 cars sold globally in 2020 was electric. By 2023, that number had risen to one in five cars. In the U.S., a similar story of rising demand for EVs has taken shape despite a rash of [news stories](#) about slowing demand. In each of the first three quarters of 2023, EV sales broke records, and annual sales were forecast to [surpass one million](#) for the first time ever. In California, [one in four new car sales](#) are now EVs, and the state beat its target of 1.5 million new EV sales almost two years early.

### Rapid Growth, But Lots of Room for Improvement

While the IEA’s description of EV sales as “exponential” seems apt, it is also true that the brisk pace of adoption is not enough to achieve the federal government’s goal that 50 percent of all new vehicles sold in 2030 be EVs. What may also be surprising to some is the fact that although EV sales are continuously growing, we must sustain and expand adoption efforts significantly over many years because vehicles on the road have an average age of about 12.5 years (source).

Here’s why. There are five phases in the typical customer journey leading up to and following a purchase: awareness, familiarity, consideration, purchase, and loyalty. Even though EVs are a relatively new product, they have nearly universal awareness. According to a survey of new vehicle consumers, 94 percent were aware of EVs. Exactly half of consumers, 47 percent, who were aware of EVs took the next step and became familiar with EV

options. Of the 47 percent who learned more about EVs, 33 percent considered purchasing an electrified car or truck. Only 1.5 percent ultimately decided to buy an EV.

“What’s unique with EVs is that awareness is very high, but the conversion rate is not,” said Watson Collins, an EPRI senior technical executive whose work focuses on electric transportation. “So, closing that gap becomes increasingly important as we are looking to create long-term and sustainable growth in EV adoption.” This matters to automakers producing EVs, but it also matters to policymakers eager to achieve ambitious decarbonization goals.

Energy companies seeking to engage customers about EVs can also benefit from a deeper understanding of the factors inhibiting purchases. Many companies currently focus on outreach and education about EVs, initiatives that are designed to raise awareness and promote EV familiarity. “If you only have so many dollars to spend to help increase adoption, how do you prioritize your focus?” Collins said. “This is a complicated vehicle purchase process,

and it’s not a simple marketing fix of raising awareness and getting sales. You must identify the main barriers preventing consumers who are considering and investigating an EV from buying one and then use that knowledge to come up with solutions to overcome the barriers.”

## How Can We Excite and Inspire EV Adoption?

EPRI is spearheading a root cause analysis to identify the underlying barriers to greater EV adoption. The analysis involved a comprehensive review of existing research about EV adoption barriers and multiple subject matter interviews. The result was an identification of six underlying barriers to widespread EV adoption.

The goal is to use these findings to inform key stakeholders and galvanize industry collaboration on solution-driven action items.

### CHARGING FAMILIARITY

After many decades of operation, the infrastructure to fuel internal combustion engine vehicles is ubiquitous and reliable. The same is not true of EV charging, particularly charging that takes place away from home. Not only do 78 percent of Americans believe that it’s difficult to locate a charging station, but over 20 percent of EV drivers have arrived at a public charger to find that it doesn’t work.

### CONSUMER NEEDS

Many vehicle shoppers have found that the features they prioritize are not available in the current selection of EVs and that the process of buying an EV is overly complicated.

### OWNERSHIP EXPERIENCE

Owning an EV is different from owning a gas-powered vehicle. This means that EV drivers must learn new things, like understanding the range of their car or truck, who can perform maintenance, and where to find public chargers.

### CONSUMER INERTIA

Humans are creatures of habit. Many consumers will repeatedly purchase the same product, even if superior options exist. Resistance to change is especially acute with products used daily, like vehicles.

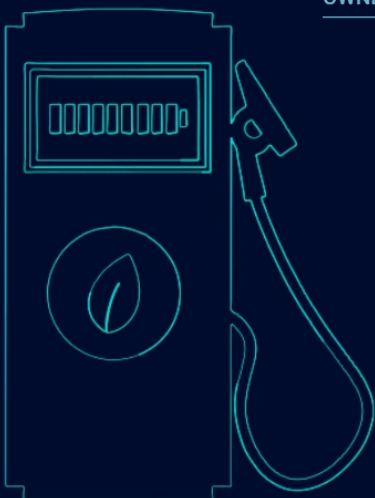
### SUPPLY CHAIN INERTIA

It is a significant undertaking to retool, reinvest, and refocus the multi-trillion-dollar vehicle supply chain. Auto manufacturers must reinvent many of their existing processes and supply chains to be able to meet the growing demand for EVs.

### COSTS

EV prices are falling, and the total cost of owning an EV (including fuel and maintenance) is lower than for gas-powered vehicles. Nevertheless, the still high upfront cost of EVs deters some drivers from a purchase.

## Barriers to Widespread EV Adoption





## EV Charging Unfamiliarity



**CONNECTOR CONFUSION.** Drivers of ICE vehicles never have to worry that the nozzles at a gas station won't work to fuel their car or truck. The same is not true of the connectors that deliver electrons into EVs at public charging stations. Because there are four different connector types—and because the connectors are not interchangeable—EV drivers can't be confident that they can charge at any station.

**VARIETY OF AT-HOME CHARGING PRACTICES.** Because 80% of EV charging takes place at a driver's home, it is essential that all home types have charging options. This is not straightforward because optimized charging at an apartment complex, off-street parking, and other vehicle accommodations looks very different from single-family home charging.

**VARIETY OF PUBLIC CHARGING OPTIONS.** Driver uncertainty about the type of connectors available is just one of the concerns EV owners may have about public charging. Public chargers also vary in their charging speeds, and some are only available to drivers of EVs made by individual companies like Tesla and Rivian. This uncertainty lowers the confidence of prospective EV owners, who worry about refueling on road trips and when they forget to charge at home.

**PRICE AND PAYMENT COMPLEXITIES.** Some public EV chargers require drivers to download an app. Others demand a membership fee in addition to charges for the electricity that goes into the EV. There are also over 350 cost structures in place for public charging across the U.S. Potential EV owners may be dissuaded from a purchase when the seemingly simple act of refueling their vehicle is varied and hard to grasp.

**AVAILABILITY AND VISIBILITY.** This is not enough to give confidence to everyone considering an EV purchase that they'll be able to refuel no matter where they are. A lack of visible signage and charging locations away from heavily trafficked areas also contributes to worries that public charging is not sufficiently ubiquitous.

**CHARGER EDUCATION.** Charging is a significant piece of the EV ownership experience. Not enough is being done to educate potential EV owners about home and public charging options and proactively address their concerns. Because the EV ecosystem is so diverse—including groups ranging from electric utilities to automakers to nonprofits—coordinated and targeted education initiatives could help alleviate the anxiety that prevents many from enjoying the many benefits of EV ownership.

### Tackling the Charging Familiarity Barrier

EPRI recently released the first of six white papers, each about the six systemic barriers to mainstream EV adoption. The papers provide in-depth descriptions and analysis of each barrier and prioritize actions to overcome them, including where EPRI is taking a leading role.

The first white paper focuses on the nettlesome charging issue at home and on the road. The research dug into the sources of charging unfamiliarity and found that it is rooted in six realms.

### From Diagnosis to Solutions

The purpose of identifying charging-related barriers is to kickstart efforts to address them. Prioritization of which barriers to tackle is also important, and EPRI's research included assessing each of the six barriers on a five-point scale. The assessments were based on these factors:

**Impact.** A score of one meant that EV consumers would not experience a clear unmet need, while a score of five translated into a large group of potential EV buyers experiencing an unmet need.

**Simplicity.** A score of one indicated that potential EV customers would encounter challenges that a single stakeholder could solve. A score of five, however, indicated that multiple stakeholders would need to work together to solve the challenge.

**Affordability.** A score of one meant EV consumers would not face an additional financial burden due to the barrier. In contrast, a score of five indicated the barrier represented a significant financial burden.

Different EV stakeholders will attach varying levels of importance to each barrier to adoption. For example, price and payment complexity and connector confusion will be a significant concern to the providers of public fast chargers, while charger education and the variety of public charging options

may be a higher priority for energy companies. While the report provides the results of EPRI's scoring, different EV stakeholders can use the five-point scale to prioritize their own work addressing barriers.

What's clear from the research is that no single entity can develop solutions to address all six barriers. Industry collaboration will be needed to provide ways to remove barriers preventing vehicle shoppers from choosing an EV. EPRI will be spearheading collaborative research focused on two barriers:

- **Variety of at-home charging practices**  
Addressing this barrier includes examining charging standards and also understanding that home charging isn't always at a single-family dwelling. EPRI and members are exploring potential charging solutions for EV owners living in multi-family dwellings.
- **Price and payment complexities**  
EPRI is tapping its extensive study of public charging cost structures across the U.S., including collaboration with energy companies and technical experts.

"EPRI is already doing work in these spaces or has a body of work to build on," said Mariela Arceo, an engineer scientist whose work focuses on electric transportation. "We have research looking at bringing charging to hard-to-reach places, like multi-family dwellings, and we are deeply engaged with

the standards bodies. These are areas where it makes sense for EPRI to lead because they are barriers that score high and because we have insights and research that can help inform solutions."

The collaborative research aimed at tackling barriers to EV adoption is part of a holistic strategy. Many stakeholders are engaged to help EVs deliver their maximum economic and environmental benefits to individual drivers, businesses, and society. This includes [EVs2EV chargeingScale](#), a three-year initiative launched earlier this year to coordinate and optimize the efforts of energy companies, regulators, charging providers, consumers, fleet operators, and EV manufacturers to achieve the 2030 goal that EVs constitute 50 percent of all new vehicle sales.

"Accelerating EV adoption is at the heart of all that we are doing, all that [EPRI's Electric Transportation [program](#)], and EVs2Scale," Collins said. "Together, these activities increase engagement with stakeholders in diverse segments of the industry. This activity is unique because it complements and expands these efforts by focusing on consumer drivers."

## EPRI Technical Experts

Mariela Arceo, Watson Collins



### **About EPRI**

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

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