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EPRI JOURNAL

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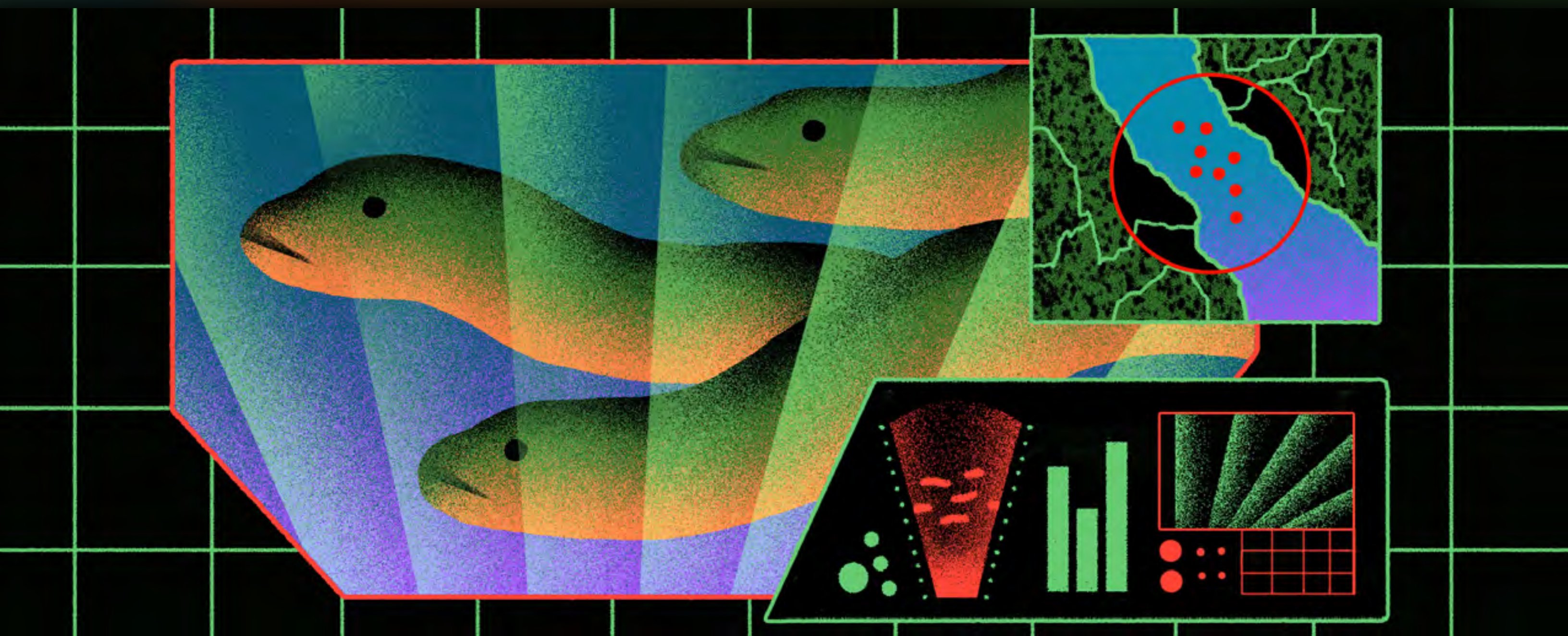

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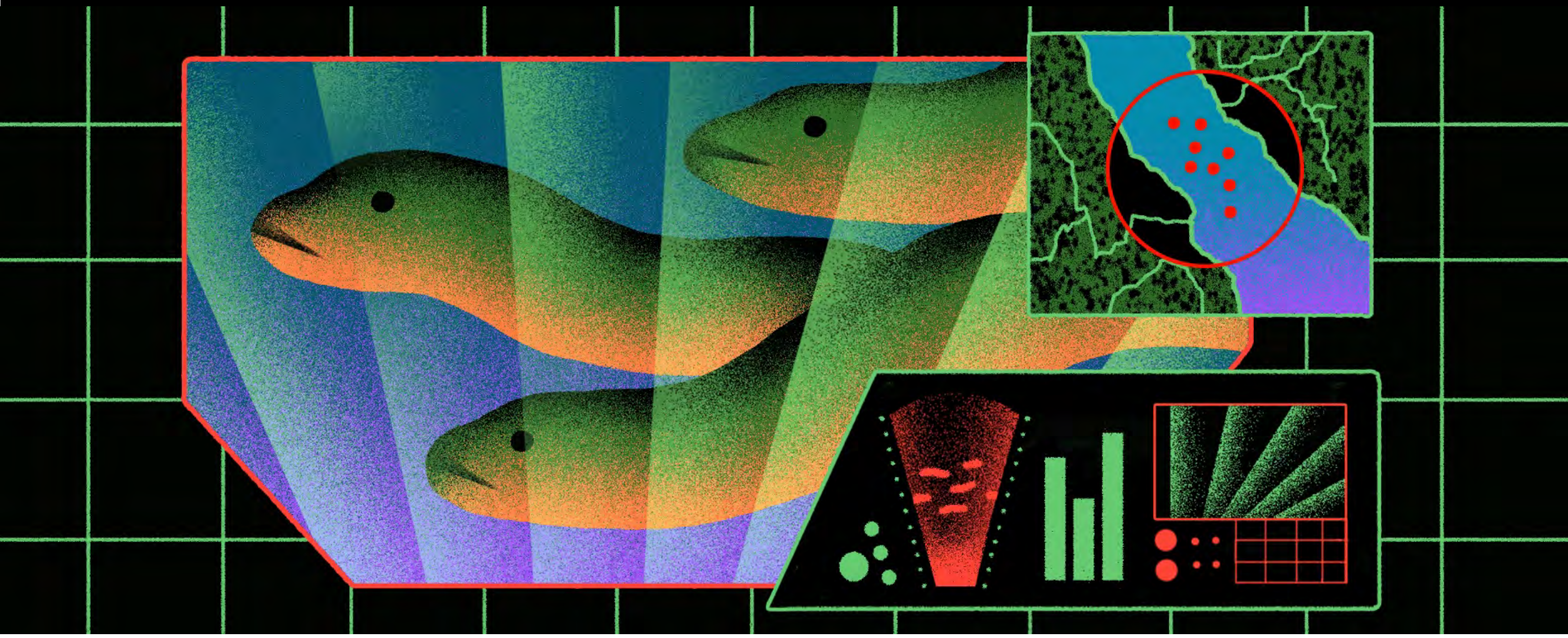


A New AI Tool to Track Eels

EPRI Uses Deep Learning for Eel Conservation in the Saint Lawrence River

By Mary Beckman

Young salmon swim down rivers through hydroelectric dams to the ocean. As adults, they swim upstream to spawn, using fish ladders to bypass the dams. American eels also navigate dams when it's time to reproduce but do so in reverse. After maturing upstream, they swim downstream to ocean breeding grounds.

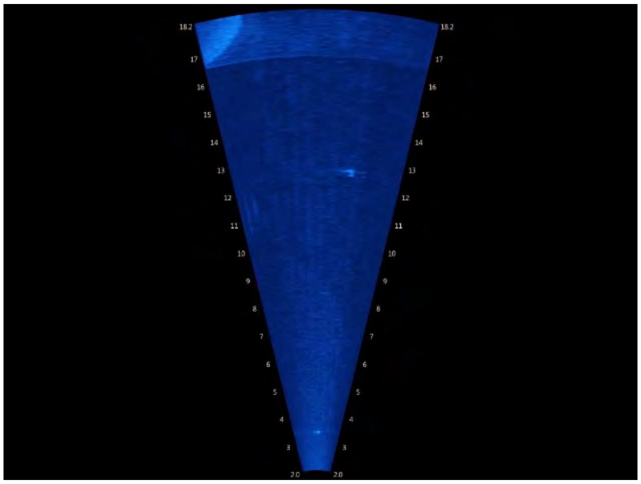
Unlike salmon, eels are fully grown—up to three feet long—when they pass through dams. This makes them particularly vulnerable to turbine blades. Less than 80% of eels survive passage through a single dam, and far fewer survive passage through multiple dams. Since 2014, EPRI's Eel Passage Research Center has been investigating how to guide eels around the two hydropower facilities along the Saint Lawrence River, which connects the Great Lakes with the Atlantic Ocean. Promising methods include using light or sound to direct eels away from the turbines.

An important part of this research is tracking eel movements. For migrating salmon, researchers use acoustic tags to track movement and can observe them through windows at the top of fish ladders. Eel tracking methods are less advanced.

"To develop technologies to prevent eels from entering turbine intakes, we first need to observe and understand their downstream movement," said EPRI Principal Technical Leader Paul Jacobson.

This is not easy in the Saint Lawrence River. The river is wide, deep, and fast-moving, and eels migrate primarily at night. The Eel Passage Research Center examined the use of sonar to monitor eels as they migrate downriver. Sonar sends out sound waves that bounce off underwater objects (such as eels) and return to a detector, generating images of the objects.

Along the upstream side of the Iroquois Dam on the Saint Lawrence River, Jacobson's team set up sonar systems with a range of 30 meters. The devices scanned for eels swimming normally through the dam as well as for eels tethered to floats (to produce images certain to contain eels). Eels, sticks, vegetation, and other fish species appear in the sonar images as bright areas. Human analysts examined the sonar images to distinguish eels from other objects. Because eels are relatively rare, false positives can easily skew eel counts.



A series of sonar images showing an eel in the Saint Lawrence River. Look for the moving object near '13.'

"Humans are very good at image analysis and can easily classify images of familiar objects," said Jacobson. "For example, most people have no trouble identifying brands and models of cars."

The sonar analysts correctly identified 88% of the eels in the images and never mistakenly identified other objects as eels. However, the process is time-intensive and requires analysts familiar with eel sonar images.

With funding from the U.S. Department of Energy, EPRI and Pacific Northwest National Laboratory are investigating the use of deep learning algorithms known as convolutional neural networks to analyze the large sonar data sets. Researchers trained the algorithms using images of eels and other objects from the St. Lawrence River and the laboratory. They tested the algorithms using similar data not used during training and assessed the accuracy. The algorithms achieved accuracy equal to or better than that of the human analysts.

The technology has potential to quickly provide the consistent, reliable data that dam operators may need to satisfy licensing requirements. Ultimately, data could be processed in real time, improving facility operations and making data storage unnecessary.

Jacobson sees an opportunity to improve the algorithms' performance. With the current approach, the algorithms classify consecutive images of the same eel independently, ignoring the swimming motion revealed by image sequences. By including motion analysis, Jacobson expects the algorithms to yield accuracy far superior to that of human analysts. EPRI and Pacific Northwest National Laboratory plan to examine this in a follow-up study.

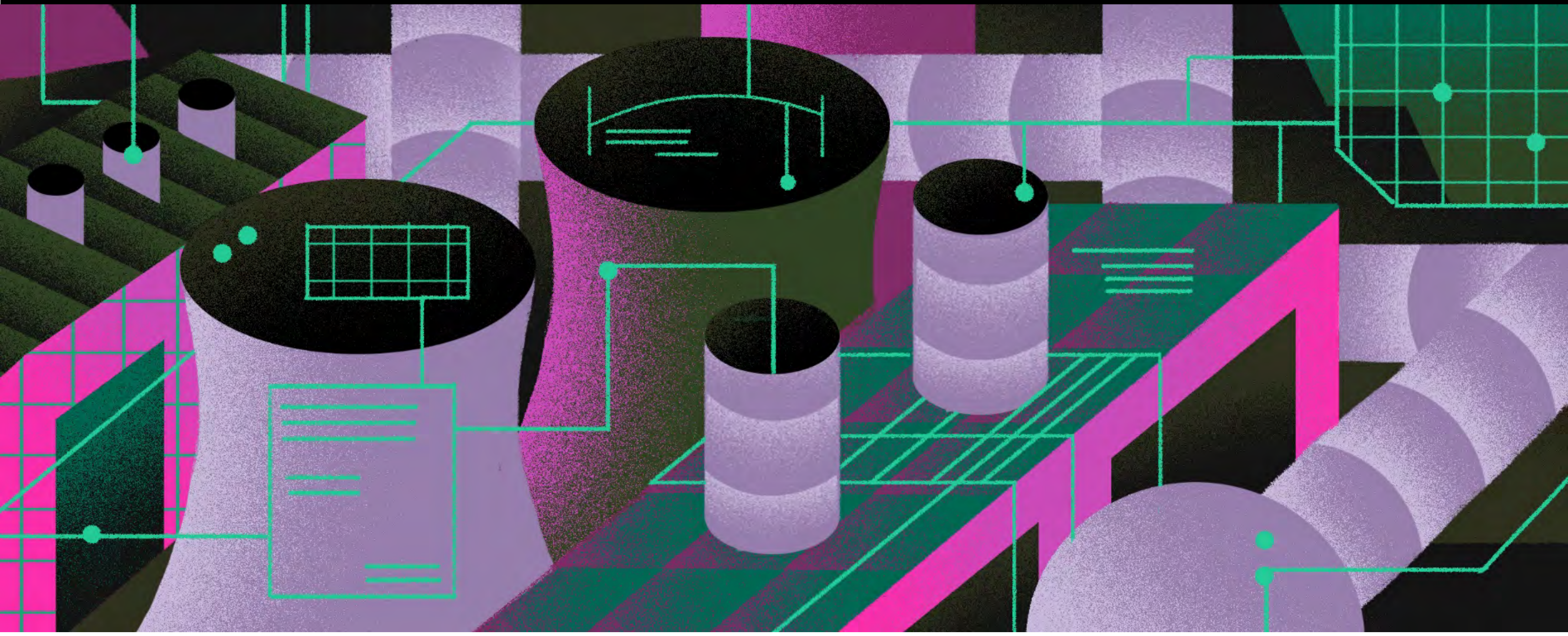
Jacobson says that automated eel monitoring tools can help researchers at the Eel Passage Research Center develop technologies to steer eels away from turbines. The deep learning software is open-source and available for others to use.

"We hope the technology will be widely adopted," said Jacobson. "It can be useful for power companies facing similar eel management challenges in Europe, New Zealand, and Australia. It can also be adapted to track other kinds of fish such as lampreys and sturgeon."

KEY EPRI TECHNICAL EXPERTS

Paul Jacobson

EPRI JOURNAL



EPRI, Southern Company Create 'Avatar' of Tomorrow's Digital Power Plant

By Steve Kerekes

Think of Alabama Power's James M. Barry Electric Generating Plant as a power plant version of actress Zoe Saldana in the groundbreaking film *Avatar*. Saldana and other actors in the movie wore suits covered with sensors to record body movements and facial expressions—technology that equipped the production team to make the computer-generated characters come alive on screen. Like Saldana, Plant Barry is fitted with hundreds of sensors that record and relay data to provide operators with a detailed view of component behavior at the 2,370-megawatt facility powered by coal and natural gas.

Plant Barry has become a demonstration site where EPRI and Southern Company (Alabama Power's parent company) are examining various digital technologies and techniques to optimize fossil plant operations. This work builds on EPRI's I4GEN® initiative to equip power companies to achieve comprehensive digital plant operations.

Although utilities such as Southern Company are deploying more renewable energy, conventional power plants are expected to remain a part of the energy mix for many years to come. According to U.S. Energy Information Administration data, 100 gigawatts of coal-fired generating capacity in the United States have been retired over the past decade, and approximately 350 coal-fired plants with a combined capacity of 250 gigawatts continue to operate. To accommodate intermittent renewables, coal plants designed for baseload operation increasingly operate in flexible modes, such as load-following and cycling. This can take a physical toll on plant components, and new monitoring and maintenance measures are needed to keep facilities cost-competitive.

Digitalization can equip Plant Barry and other Southern Company generation facilities to transition from schedule-based maintenance to more cost-effective condition-based maintenance. Sensors throughout the plant provide real-time or near-real-time data about the conditions and performance of components and systems. Diagnostic software can analyze the data to identify anomalies, which can be addressed by digital controls.

Alabama Power's James M. Barry Electric Generating Plant. Photo courtesy of Southern Company.

"When fossil plants operate in flexible modes, different components are going to wear out and break in different ways and at different rates," said EPRI Program Manager Susan Maley. "If you have the right information at the right time, plant staff can make better decisions on difficult questions. Should a piece of equipment be taken offline for maintenance? Or is a certain amount of damage acceptable for that equipment in order to keep the plant fully operational and economically viable?"

Southern Company views digitalization as a key element of its strategy to decarbonize its generation fleet. EPRI expects that these digital technologies can be applied to hydroelectric, wind, and solar power plants.

"This demonstration facility will accelerate emerging technologies and enable digital transformation of a power plant," said Chethan Acharya, the Southern Company principal research engineer leading the Plant Barry digitalization project. "Instead of conducting several small projects at different sites, EPRI and Southern Company determined it would be more effective to develop a research center where various stakeholders can collaborate. Partnering with EPRI makes it possible to engage additional technology developers and examine a full-scale plant digitalization."

The hardware, software, and other digital technologies for the five-year demonstration project at Plant Barry are under development. These include:

- Advanced controls to automate plant operations
- Advanced equipment sensors, such as those that can be immersed in a machine's lubricating oil to provide continuous data on oil quality
- Wireless communications in the plant
- Communications to off-site data processing centers that can alert operators to abnormal conditions
- Prognostic tools for operations and maintenance
- Cyber security for the installed technologies

Hundreds of additional sensors are expected to be deployed over the course of the Plant Barry demonstration.

"We are starting with a pilot-scale demonstration to validate findings before full-scale technology implementation," said Acharya. "We expect this research to reduce our generation fleet's operations and maintenance costs and increase reliability."

"Whether it's new sensors, augmented reality headsets for field technicians, or data analytics, digital technologies can work together to improve plant processes," said Maley. "With the Plant Barry demonstration, we're taking an integrated approach, examining the benefits of deploying a suite of techniques and technologies in a systematic way."

EPRI seeks to work with utilities large and small to launch other full-scale digital demonstration facilities.

A TARGET TO MONITOR 120,000 POWER PLANT PARAMETERS IN NEW YORK

New York Power Authority (NYPA) is collaborating with EPRI on digital transformation of its generation and transmission assets. Paul Tartaglia, NYPA's chief technology and innovation officer, says that the value of data from digitalization comes not from collecting more of it but from using it effectively.

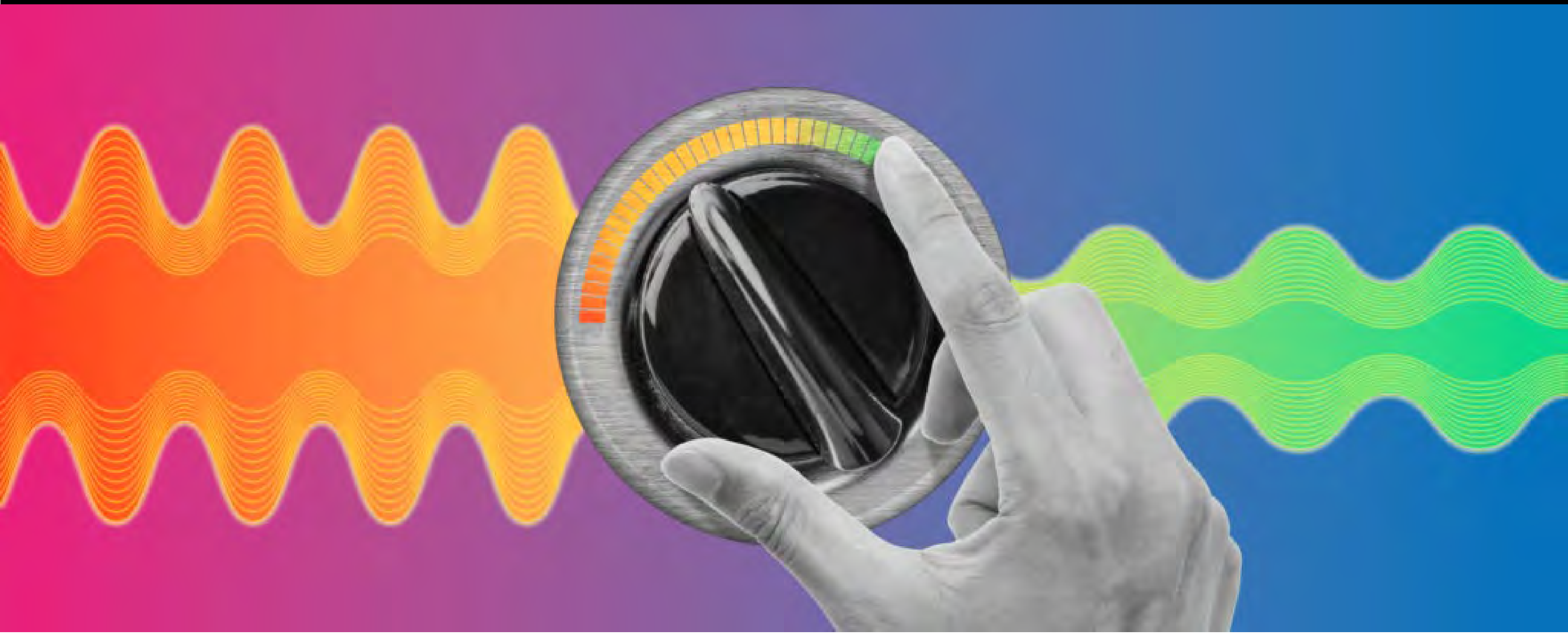
"By analyzing power plant data with advanced pattern recognition software, we can observe changes and trends across thousands of pieces of equipment in more than a dozen generating facilities that are monitored 24 hours a day, 365 days a year," said Tartaglia. "We are able to identify abnormal equipment behaviors and address them well before failure. Without these digital technologies, you would need thousands of analysts to look at all the data."

NYPA aims to increase the number of data points in its fleet operations from 45,000 to 120,000. This can better position NYPA to cycle its fossil plants, integrate renewable energy generation, and prepare for other changes, Tartaglia said.

"We're using data analytics not only to extract value out of our fleet's existing operating modes, but also to prepare us for new operating paradigms that emerge in the future energy grid," he said.

KEY EPRI TECHNICAL EXPERTS

Susan Maley



Energy Efficiency: It's Time to Reach Above the 'Low-Hanging Fruit'

By Tom Shiel

For decades, utilities have implemented successful programs to promote more efficient electric appliances and devices and their more efficient use. According to EPRI Technical Executive Chris Holmes, energy efficiency programs yielded a 3.9% reduction in U.S. electricity consumption between 2013 and 2018.

While these impressive results may lead some to de-emphasize the need for further gains, an EPRI study on energy efficiency potential finds otherwise.

"These initiatives have been extremely successful—so successful that there is a growing belief that the well of remaining efficiency potential has dried up," said EPRI Technical Executive Chris Holmes. "Although most of energy efficiency's 'low-hanging fruit' has been harvested, our study reveals that there is still plenty of fruit. We just have to extend our reach a bit higher."

Researchers examined the remaining efficiency potential of numerous electric devices in the residential, commercial, and industrial sectors in the United States, gathering data on:

- The number of utility customers deploying the devices
- The most efficient commercially available technologies and their cost-effectiveness
- Market barriers to adoption (such as high upfront costs and lack of consumer awareness)

EPRI found that energy efficiency programs can reduce annual electricity use in 2040 by 365 terawatt-hours. For reference, the U.S. Energy Information Administration (EIA) reported that California retail electricity sales in 2017 totaled 257 terawatt-hours.

In 2018, EIA forecast that total U.S. electricity consumption would increase from 3,683 terawatt-hours in 2017 to 4,272 terawatt-hours in 2040 for an average annual growth rate of 0.62%. EPRI's estimate of energy efficiency potential translates into a 10.2% reduction in electricity consumption over the next 23 years—and a 26% reduction in the annual growth rate to 0.45%.

The areas with the biggest efficiency potential were:

- Residential central air conditioning
- Electronics in commercial facilities, such as printers, copiers, phones, and networking equipment
- Industrial facilities' HVAC, water heating, and lighting

The greatest U.S. potential is in the Southeast and South Central regions, driven by residential space cooling. In other regions, commercial facilities offer the most potential.

"The technologies where we see the greatest potential in the residential, commercial, and industrial sectors are air conditioning systems, heat pumps, and water heaters that use variable-speed compressors," said Holmes. "These technologies are engineered to run at the optimal speed to meet comfort needs while minimizing energy consumption."

IMPLICATIONS FOR POWER COMPANIES

The conclusion that there is still significant efficiency potential is supported by a 2015 EIA survey, which found that only 7.5% of homes have conducted audits to identify energy efficiency opportunities.

"The potential energy savings for the 92.5% of homeowners who have not had an energy audit is huge," Holmes said.

Holmes points to several ways that utilities can reach beyond energy efficiency's low-hanging fruit.

"They can address the barriers that prevent consumers from deploying these technologies," he said. "This can include financial incentives and education."

Utilities can develop tools for evaluating advanced metering data and identifying inefficiencies in their customers' energy use.

"Utility customers can use these tools to examine the performance of their devices and pinpoint the reasons for high utility bills," said Holmes. "Such tools could recommend more efficient technologies."

Emerging technologies can help find efficiency potential. Customers can deploy smart sensors that track consumption of individual appliances and adjust their operation to optimize efficiency. EPRI and power companies are field-testing the energy management circuit breaker in residential and commercial service panels and are evaluating its performance in continuously monitoring specific appliances' power consumption.

"Utilities can work with HVAC and appliance manufacturers, wholesalers, installers, and other stakeholders to make the process of deploying new technologies easier for consumers," said Holmes.

THE QUESTION OF AVOIDED COSTS

For decades, utilities had a strong economic incentive to pursue energy efficiency programs because they reduced the capital and operational costs of generating, transmitting, and delivering electricity. These "avoided costs" have diminished in recent years with the wider use of low-cost natural-gas-powered electricity, rooftop solar, and wind power. This has shifted the threshold for justifying efficiency investments.

"It's unclear whether these avoided costs will continue to decline," said Holmes. "Cheap natural gas may not be available forever, and we could see greater avoided costs in the future. That would make efficiency investments more cost-effective."

KEY EPRI TECHNICAL EXPERTS

Chris Holmes

Pandemic Drives Human Connections, With Lasting Energy Impacts

Nuclear utilities big and small face financial challenges as electric load growth slows, renewable The COVID-19 pandemic will leave indelible imprints on society well beyond its physical toll. A physiological crisis with broad economic impacts, the pandemic also carries with its genuine psychological effects. Remarkably, a global challenge requiring social distancing and isolation has, in many ways, reignited human connections. Around the world, there are countless accounts of neighbors joining in song, communities cheering their frontline heroes, and families spending a little more time connecting in person and online.

If the same pandemic had struck just 20 years ago, society would have been far more limited in its opportunities to connect. The significant technological innovations over the past three decades have presented us with incredible new ways to cope. Today, we have the option of being physically isolated yet socially connected. We can communicate face-to-face with family in real-time, collaborate seamlessly with co-workers around the world, and students can engage in remote learning from almost anywhere on the globe.

Mike Howard, President and Chief Executive Officer, EPRI

As we increasingly come together through technology, how will the innovations that make virtual human connections possibly impact our energy system and the environment?

The energy system is an extension of the society its supports. Technology-enabled social interactions require a vast amount of energy. A two-way video webcast consumes many times more energy than a phone call – but the resulting increase in social value is even more significant.

As technology helps us overcome a world of separation and strengthen our social connections, it illuminates a future that we can help shape. It helps bring human stories to life, delivers hope through shared expressions, and connects us across the globe like never before. Technology brings us closer to our communities and helps satisfy curiosities about the world around us. Through this crisis, many have grown to appreciate the real value of the environment and the energy that keeps us connected. With this perspective, the value of transitioning to a cleaner energy system and a cleaner environment — for our future and that of future generations – is increasingly apparent.

COVID-19 has forced each of us to reflect on what is most important — to ourselves, our families, our communities, and our future. The lasting impact of this enlightened perspective will enable a generation of thought leaders who will design, build, and shape a cleaner energy system that will lead to a more pristine environment. For an industry that touches all corners of society, the pandemic will shape more than how we interact; it will transform the energy system on which the world's social interactions depend. Long after the pandemic has ended, sustainable advancements built on social connections will lead to environmentally impactful energy solutions benefiting generations to come.

Mike Howard

President and Chief Executive Officer, EPRI

ELECTRIC POWER RESEARCH INSTITUTE

The Electric Power Research Institute, Inc. (EPRI, www.epri.com) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, affordability, health, safety and the environment. EPRI also provides technology, policy and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI members represent 90% of the electricity generated and delivered in the United States with international participation extending to nearly 40 countries. EPRI's principal offices and laboratories are located in Palo Alto, Calif.; Charlotte, N.C.; Knoxville, Tenn.; Dallas, Texas; Lenox, Mass., and Washington, District of Columbia.

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