



February 2022

EPRI

EFFICIENT ELECTRIFICATION

The global clean energy transition will require more flexible and reliable energy systems. This month's *Efficient Electrification* looks at how long-term investments and advances in industrial electrification and green hydrogen production may help scale flexibility and advance aggressive decarbonization goals. In a new report, researchers investigate the requirements in system planning, market design, and operations.

In our second article, we explore how research has advanced the ability of distributed energy resource management systems (DERMs) to operate a more reliable grid. With new software advances and successful modeling demonstration, today's DERMs are ready to unlock numerous value streams for utilities, including increased visibility to updating smart inverter settings.

We hope you enjoy this edition and appreciate your ongoing support.

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ELECTRIFICATION 2022

INTERNATIONAL CONFERENCE & EXPOSITION

Building a Net-Zero Future for All

June 28-30, 2022
Charlotte, North Carolina



How Hydrogen Production and Industrial Electrification can Provide Power System Flexibility

There is no question that a decarbonized power system that relies on variable renewable resources like wind and solar photovoltaics (PV) will need plenty of flexibility. In order to achieve the grid reliability society depends on – which will increase as we electrify transportation and other sectors – flexible demand side management will be increasingly important to balance supply and demand.

In the National Renewable Energy Laboratory's (NREL) most recent [Electrification Futures Study](#), researchers examined scenarios that included high levels of electrification accompanied by significant renewables penetration. In one scenario analyzed, 66 percent of generation came from renewables in 2050. "We find that demand-side flexibility – especially from newly electrified loads – can enhance operational efficiency by reducing VRE (variable renewable energy) curtailment and increasing utilization of generators that have lower operating costs," wrote the report's authors. [EPRI's National Electrification Assessment](#) also models potentially robust growth.

Thinking long-term

Today, most of the focus around flexibility from the demand side is centered on DER. One key example is incentivizing electric vehicles (EVs) to charge when demands on the grid are low and renewable generation is particularly high.

While DER is a near-term priority for flexibility, a new report takes a longer view about the importance of other resources in achieving aggressive decarbonization goals. In February by the Energy Systems Integration Group (ESIG), of which EPRI is a member, released [Increasing Electric Power System Flexibility: The Role of Industrial Electrification and Green Hydrogen Production](#) looks at the power system planning and modeling that will need be needed to take full advantage of green hydrogen and emerging electrified loads

in energy-intensive industries, such as steel, fertilizer, and cement production.

The report assumes that both the cost declines and performance improvements necessary for green hydrogen and industrial electrification to be viable will occur over the next decade-plus. The analysis also assumes generation from variable renewable sources will increase significantly to around 70 percent of annual energy penetration.

"There's a lot of talk in the various decarbonization pathways about how you reach the mid-2030s and beyond and need a huge flexibility resource to replace the thermal resources that provide flexibility today," said Aidan Tuohy, a lead author of the report, chair of the ESIG System Operations and Market Design working group, and an EPRI program manager. "This is a reality check from a power systems perspective. We need to start to understand the market designs and planning processes and models that will be needed to ensure system reliability. That involves understanding the electrical characteristics of new technologies such as hydrogen electrolyzers and other resources and doing the work to ensure that the system that emerges has the energy, capacity, and flexibility that will be needed. We are starting that work now because these things take time."

Improved planning requires detailed knowledge of resources

Much research and collaboration is still required to commercialize green hydrogen at-scale and enable electrification to deliver the heat required for energy-intensive manufacturing. While the report assumes these resources will become cost effective as envisioned by the U.S. Department of Energy (DOE) and others, it also outlines numerous considerations that will shape their future role in the power system.



As the report highlights, the questions that need to be answered are nuanced. For example, utilizing hydrogen to support the power system depends in part on how many hours electrolyzers operate each year, the capital costs of the electrolyzer, and the price of electricity. When electrolyzers operate frequently, for instance, electricity costs are more important than capital costs. But when they are running less frequently, capital costs and electricity prices are equally important.

The authors outline specific needs and advances required in system planning, market design and operations. One of the important needs identified is to better integrate electrified industrial loads and hydrogen production into power system planning processes. Today, when utilities perform resource planning to ensure they will be able to provide reliable electricity to customers in the future, they do so with the benefit of a deep understanding and accurate models of how different technologies function. Because green hydrogen and many forms of industrial electrification are so nascent, those planning and forecasting tools are not as mature. Nor is it clear how those two potentially powerful sources of flexibility interact with one another.

“We need to be sure we are properly characterizing these resources without oversimplifying how they work,” Tuohy said. “One concrete example is if you think you are going to produce hydrogen for use in another industry by making it when there is excess wind. To plan for that you have to properly characterize how often there is excess wind and make sure the hydrogen demand is there. You don’t want to get into a situation where it’s very windy but for some reason you are not producing hydrogen or that the economics don’t work because you only produce for a few hours a year. You need more details.”

Transmission and market design considerations

Transmission system planners also need a more granular understanding of electrified industrial loads and hydrogen production. A long-term question for transmission system operators is whether it’s necessary to build out additional capacity to transport clean energy from locations where wind and solar are abundant to places where demand is high. Transmission infrastructure is expensive and time consuming to permit and construct. Hydrogen production could potentially eliminate the need for new transmission assets by producing electricity in the location where it’s needed. Another possibility: Additional transmission can potentially enable added flexibility from hydrogen and industrial electrification.

Another need identified in the report is an improved understanding of whether hydrogen production and industrial electrification necessitate changes in how the electric system operates and how markets function. Both potential sources of flexibility deliver that value in a variety of ways, including shifting demand to off-peak times, potentially across weeks or months, providing grid services like ramping and fast frequency response or even hydrogen providing capacity and energy directly. However, these potential benefits have implications for how the grid operates that need to be understood.



Similarly, markets may need to be redesigned to incentivize and leverage the full flexibility potential of hydrogen production and industrial electrification. The experience of accurately representing energy storage is instructive. “The market redesign initiatives to integrate batteries are an example of how new resources have been added that are not typical generators and loads,” Tuohy said. “If you now start thinking about similar things with industrial loads that could shift energy over days or weeks, we have to think about changes to capacity, energy and ancillary services markets as well in order to better represent them.”

The report also identifies the need for additional work to improve the performance and lower the costs of industrial electric technologies, particularly for those that need to provide high temperatures. Policies will also be needed to support low-carbon and renewable powered industrial heating.

Additionally, hydrogen production and industrial electrification solutions need to be tested in real world conditions through pilot and demonstration projects. “Take how an electrolyzer works, for example,” Tuohy said. “Even if we know how to function and reduce its costs, how do you actually integrate that into the system and then go out and deploy those resources? Demonstration projects help you understand whether these resources deliver the flexibility we think they will.”

ESIG is following up with a high-level study showing how to integrate these resources into generation and transmission planning tools. This can further identify gaps and research needs. EPRI is also continuing to focus on advancing both the technologies themselves through work related to efficient electrification and the Low-Carbon Resources Institute, as well as the integration of the technologies into operations and planning tools.

How Research Enhances the Ability of DERMS to Manage a Reliable Grid

At the end of 2021, a flurry of data was released that reinforced just how mainstream distributed energy resources (DER) have become in America's power system. For example, in December the consultancy Wood Mackenzie and the Solar Energy Industries Association (SEIA) issued a [report](#) showing a record 5.4 gigawatts were installed in the fourth quarter, including robust demand for residential, commercial and community solar.

Similar stories of growth were also apparent in numbers reported about other DER, like [electric vehicles](#) (EV) and [energy storage](#). These end-of-year numbers only accentuate the larger story about the accelerating growth of DER. In fact, Wood Mackenzie recently released its annual U.S. DER Outlook [report](#), which noted that 78 gigawatts of DER were installed in America between 2017 and 2021. The report also forecast that another 175 gigawatts would be installed between 2022 and 2026 – an amount equivalent to the installed capacity of PJM, the largest power market in North America.

For utilities, there are many challenges and opportunities that come with navigating this DER influx. That is particularly true in states where DER growth has already been strong and demand continues to rise. In New York, for example, DER growth is being primarily driven by public policy, particularly the Climate Leadership and Community Protection Act, which establishes the goal of reducing carbon emissions 85 percent below 1990 levels by 2050.

That statewide policy has also been augmented by federal action where Federal Energy Regulatory Commission (FERC) orders mandate independent system operators (ISOs) develop plans to enable DER participation in wholesale energy markets.

To fully leverage the potential of DER to achieve aggressive clean energy and decarbonization objectives, utilities need to be able to efficiently, equitably, and cost-effectively interconnect large amounts of DER. Utilities also need to maintain grid reliability and resilience, as large numbers of intermittent resources with bi-directional power flows connect to the distribution grid. There are numerous issues to be addressed, including grid constraints due to thermal violations and over-voltage, as well as other power quality issues.

Advancing the potential of DERMS

Over the past few years, EPRI and many member utilities located in regions where DER growth is particularly brisk have been exploring the use of advanced software to manage and control DER. Known as the distributed energy resource management system (DERMS), the software has the potential to speed interconnection of new DER without the need of expensive grid infrastructure upgrades. DERMS also has the capacity to boost the amount of DER that can be interconnected while maintaining grid power quality and reliability.

Modeling [research](#) by EPRI has validated the potential of DERMS, particularly as a way to cost-effectively integrate solar photovoltaics (PV) by curtailing their generation at times when voltage levels got too high or reverse power flows neared a transformer's rated capacity. Last year, EPRI teamed up with Central Hudson Gas and

Electric Corporation of New York in a two-year project funded by the New York State Energy Research and Development Authority to develop and test algorithms that equitably curtail the generation of DER connected to the grid.

As that real world demonstration has progressed, EPRI has released new research aimed at helping utilities understand both the opportunities and limitations of DERMS. Importantly, the work has resulted in detailed guidance utilities can use to assess and implement the software.

"There is no reason to wait to install a DERMS, as it unlocks a number of value streams for utilities. The value of DERMS ranges from increasing visibility of DER to updating smart inverter settings to reliable operation of the grid under high penetration of DER," said Ajit Renjit, a smart grid engineer who has been working closely with Central Hudson and spearheading EPRI's DERMS research, along with his colleague Summer Fabus. "Even those utilities that aren't immediately challenged by the level of DER on their systems today should consider building their infrastructure to manage DER as the levels of DER are predicted to rise everywhere in the country."

Assessing DERMS starts with understanding DERMS

Education about DERMS, its function, capabilities, limitations, and potential use cases are the primary topics of the white paper, [Implementing DERMS to Manage Grid Constraints](#). Based in part on lessons learned working with Central Hudson, the paper is a primer on the drivers of DER growth, the grid implications that result when large numbers of solar generators, energy storage systems, and other DER are interconnected, and how DERMS can help manage a reliable grid. The research helps illuminate two different options when it comes to DERMS, each of which has its own benefits and drawbacks.

One version of the grid management software is DERMS with corrective controls. The software utilizes controls that monitor the grid in real-time and, when a constraint or some other grid violation occurs, corrective DERMS adjusts DER dispatch to address the



problem. To implement corrective DERMS effectively, a grid impact study must first be undertaken to pinpoint the specific grid locations the software will monitor and control. In general, the locations that DERMS should monitor are those that face constraints as a result of unmanaged DER operation.

Another important aspect of implementing DERMS with corrective controls is specifying the methodology that will dictate which DERs are curtailed when a grid constraint arises. In other words, if there are 10 or 20 PV plants operating, which assets will be curtailed, how much of their capacity will be limited, and for how long?

There is a range of curtailment methods. They include prioritizing the dispatch of certain DER based on how and when the resource was interconnected, spreading curtailments equally across a number of DERs contributing to the constraint, or curtailing in such a way that minimizes the negative economic impact to all DER.

There are potential challenges to utilizing corrective DERMS, notably that grid conditions will evolve after a grid impact study is complete and that DER participation in wholesale markets depends on day-ahead or hour-ahead functionality. This would need to be additionally accommodated by DERMS operating based on real-time grid conditions.

The second version of DERMS relies on predictive controls. Rather than responding to real-time grid conditions, predictive DERMS forecast grid constraints using a model that employs both current and historical grid data.

For example, predictive DERMS incorporates up-to-date information from the geographic information system, as well as DER forecasts, working in tandem with the distribution management system. As with corrective DERMS, the predictive software adjusts and limits DER output based on methodologies that determine which assets are curtailed when grid constraints arise. Predictive DERMS has its limitations, including a reliance on uncertain DER forecasts, potentially dated power system models, and a lack of situational awareness about grid conditions.

A how-to for assessing DERMS

Another recent research project provides a guidebook for utilities to understand and evaluate DERMS offered by different vendors. “A lot of utilities understand conceptually that DERMS is a solution to address issues raised by DER. But they don’t always know what functions DERMS must have to address the problems,” Ajit said. “In order to go to the marketplace and find a vendor and say this is how I want DERMS to be built, it’s important to have a deep understanding of the requirements and use cases.”

EPRI’s [report](#), *Distributed Energy Resource Management Systems Requirements for Managing Grid Constraints*, is meant to provide the guidance utilities need to craft precise DERMS requests for proposals. Included in the report are three prominent DERMS use cases:

- Managing equipment capacity and voltage constraints during normal grid states;
- Managing constraints during abnormal grid states; and
- Coordinating operation of DER across the transmission and distribution grid

FERC’s orders allowing DER participation in the wholesale market have focused special attention on improved coordination of DER across the transmission and distribution grid. This is a complex task. For example, FERC’s Order 2222 stipulates that an aggregator can offer up to 100 megawatts of PV plus storage to an ISO a day before the resource may be needed. “The problem is that the aggregator has no awareness about whether the output of the DER aggregation will violate the distribution grid constraints by offering their assets to the ISO,” Renjit said. “This requires coordination between the ISO, the aggregator and the distribution utility so that the distribution utility assesses the DER dispatch and may go back to the aggregator to adjust their dispatch because some of the planned DERs will exceed the limits of the distribution system. DERMS can be built to deal with those coordination issues.”



The research also outlines the system architecture needed to manage grid constraints with DERMS. It also provides an in-depth explanation of the DERMS requirements necessary to integrate with other utility enterprise systems, interface and monitor DER and DER aggregators, be secure against cyber attacks, and other needed capabilities. “The fundamental problem this research is meant to address is the lack of a reference that utilities can use to specify their DERMS,” Renjit said.

Leveraging existing utility assets for DERMS

Reliable and secure communication is essential for DERMS to function effectively. Many utilities rely on a robust network for communication between their supervisory control and data acquisition system, their DMS, and meter data management systems, and the various grid devices such as reclosers, voltage regulators, capacitor banks, and meters deployed in the field. Working with Central Hudson, EPRI investigated whether their existing communications network could also be effective at communicating with large numbers of DER.

“The growing concern here is the cost of enabling connectivity to DER using utility communication networks. The alternative is to use public networks that are less secure, untrusted and often unreliable,” Renjit said. “As the role of DER moves from passive participation to active participation in providing grid services, their communication networks will be mission critical in providing reliable and resilient power to the grid and to the customers. Low-cost options for DER telemetry do exist in the marketplace but they need to be tested for adequacy and security before being used for integrating DER with DERMS.”

Using real-world data from Central Hudson’s grid, EPRI analyzed whether the communications network already in place had enough bandwidth to accommodate a large increase in the quantity of DER. The main takeaway of the report, *Analyzing Telecommunication Systems for DER Integration*, is that Central Hudson’s planned and existing communications infrastructure can handle a significant amount of DER.

“We were looking at Central Hudson’s communications network and calculating what the current bandwidth is and how much headroom is available when existing DER in the interconnection queue and forecasted future DER are managed by DERMS and we were looking for a scenario where DER traffic will break their limits,” said Tim Godfrey, who leads EPRI research on telecommunication systems.

“The important thing the evaluation confirms is that utility communication networks can meet the stringent requirements for managing DER, because they have been planned and securely designed with robustness and scalability to support distribution system operations.”

Lessons from Central Hudson

The challenge and opportunities represented by DER are not abstract for Central Hudson. Already, the utility has more than 200 megawatts of solar DER connected on its transmission and distribution system and another 600 megawatts in the interconnection queue. In addition, Central Hudson has more than 850 megawatts of battery storage in its queue. Given New York’s regulatory environment and

the large amount of developable land in its service territory, Central Hudson expects the volume of solar and storage projects to increase in the future.

Currently, there are times when DER can overwhelm Central Hudson’s system because of the excess energy being produced – situations that require DER curtailment. “Only a portion of these resources on the transmission system are subject to dispatch, all others need to be fully deliverable at all times, resulting in interconnection investments or the project not being able to connect,” said John Borchert, senior director of energy policy and transmission development at Central Hudson. “In addition, there is no existing method of dispatching resources outside of the NYISO wholesale market.”

Central Hudson has been proactive about finding solutions to better manage and interconnect DER, including its DERMS work with EPRI. The utility is currently working on a grid modernization project, which includes advanced distribution management systems, grid automation devices, and networked communication. “A DERMS platform is currently in the plans following this deployment, and this research project is intended to help us define what is needed for implementation,” Borchert said.

Already, Central Hudson has learned a lot from its research with EPRI, including the DERMS logic needed around curtailment, the costs and benefits of DERMS, and the necessary requirements to communicate with DER and the utility’s system operators. Among the most important lessons is that DERMS can play an important role in managing the changes Central Hudson is navigating.

“The role of Central Hudson is to plan for and make investments needed to operate the transmission and distribution system safely, reliably, and cost effectively. A DERMS will be a tool in this process, allowing for the transmission and distribution grid to operate at higher levels of efficiency without compromising reliability,” Borchert said. “It will allow the system to interconnect resources beyond its normal capacity and operate these resources in a fair and logical manner under all system conditions, until such time when system upgrades are the better choice to allow renewables to operate without curtailment.”



In the News

Recent research from the U.S. Department of Energy (DOE) highlights current inequities within U.S. energy power systems – and also the potential for utilities, regulators, and equity advocates to solve them. But who foots the bill? [A new article in UtilityDive](#) explores the challenges and opportunities facing recognizing and resolving power system inequity.

Part of the Bipartisan Infrastructure Law will help fund a stronger supply chain pipeline for battery storage. [Read more in T&D World](#) about the \$3 billion investment designed to help bolster U.S. battery production and increase economic competitiveness, energy independence, and national security.

A new flat-fee EV charging subscription incentivizes North Carolina customers to charge during low-demand times. The new pilot program from Duke Energy offers “all you can charge,” with some restrictions and control tradeoffs, utilizing EPRI’s Open Vehicle Grid Integration Platform. Utility Dive shares [more here](#).

Upcoming Events

[DISTRIBUTECH International Conference](#), May 23-25, 2022 in Dallas, TX

[EPRI’s Electrification 20epri22 International Conference and Expo: Building a Net-Zero Future for All](#), June 28-30, 2022 in Charlotte, NC

[Roadmap](#) Conference, June 29 –30, 2022, Portland, OR

EPRI Resources

[Building Better: A roadmap of Building Decarbonization Strategies to Reduce Global Greenhouse Gas Emissions](#) - December 2021

[EPRI Insights: Current Events, Industry Forecasts, and R&D to Inform Energy Strategy, December 2021](#) - December 2021

[Quick Insights: Impacts of Extreme Temperatures on HVAC Load and Flexibility Capacity – Implications for Power System Operation](#) - November 2021

About EPRI’s Efficient Electrification Initiative

In developed economies, electrification refers to the expanded use of electricity. This may involve powering new uses (such as cellular phones, computers, and server farms) or switching everyday technologies (such as automobiles, forklifts, and furnaces) from direct combustion of fossil fuels to electricity. Electrification offers potential to transform utilities and other industries in which power is a key input. As the electric supply becomes cleaner, electrification can reduce society’s overall emissions. It can also lower costs and energy use for utility customers and improve economic efficiency, water use efficiency, grid utilization efficiency, productivity, indoor environments, and safety. Through collaborative research, development, and demonstration, EPRI’s [Efficient Electrification initiative](#) is examining the impacts and technical aspects of electrifying the end use of energy—where it is more efficient to do so—for the benefit of customers, the environment, and society.

