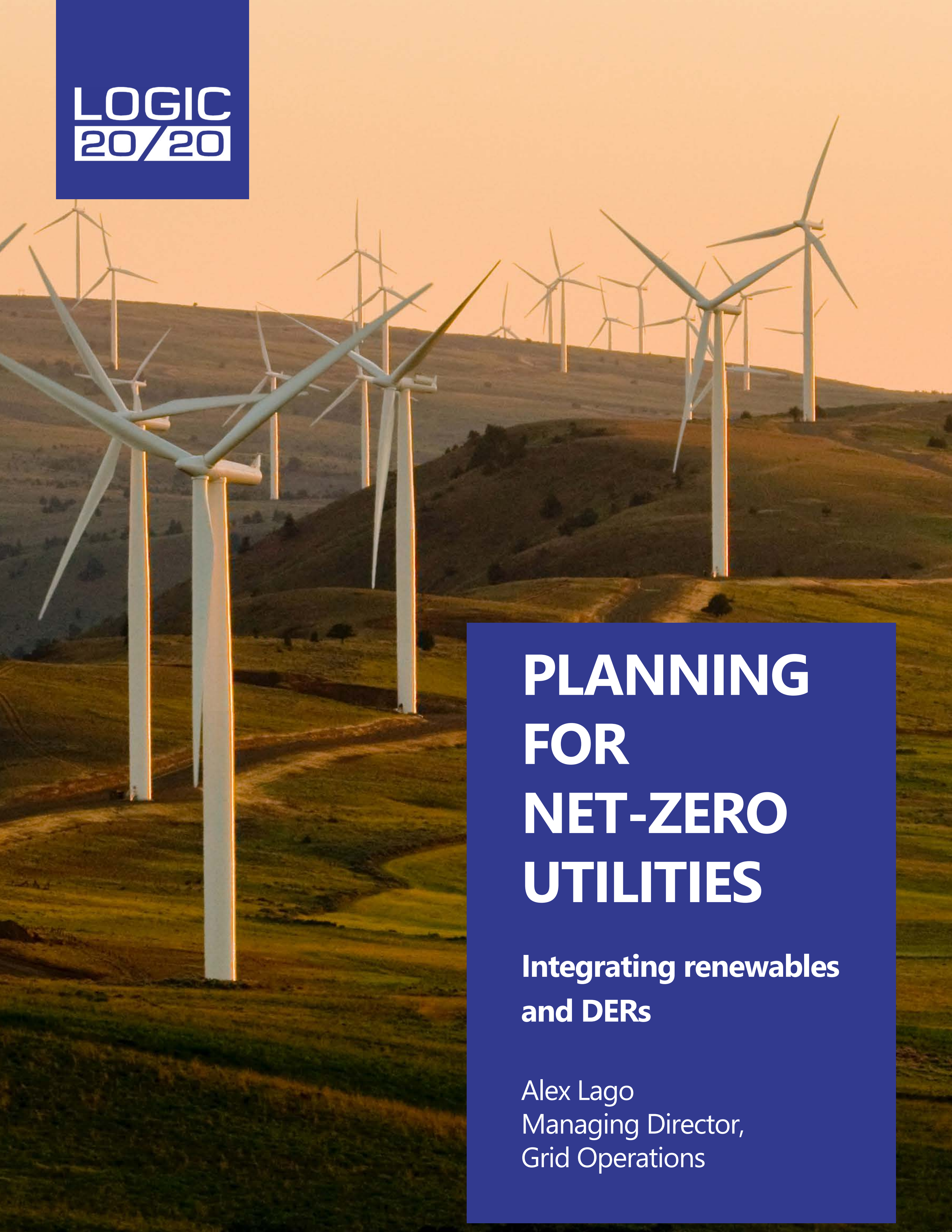

LOGIC 20/20

PLANNING FOR NET-ZERO UTILITIES

Integrating renewables and DERs

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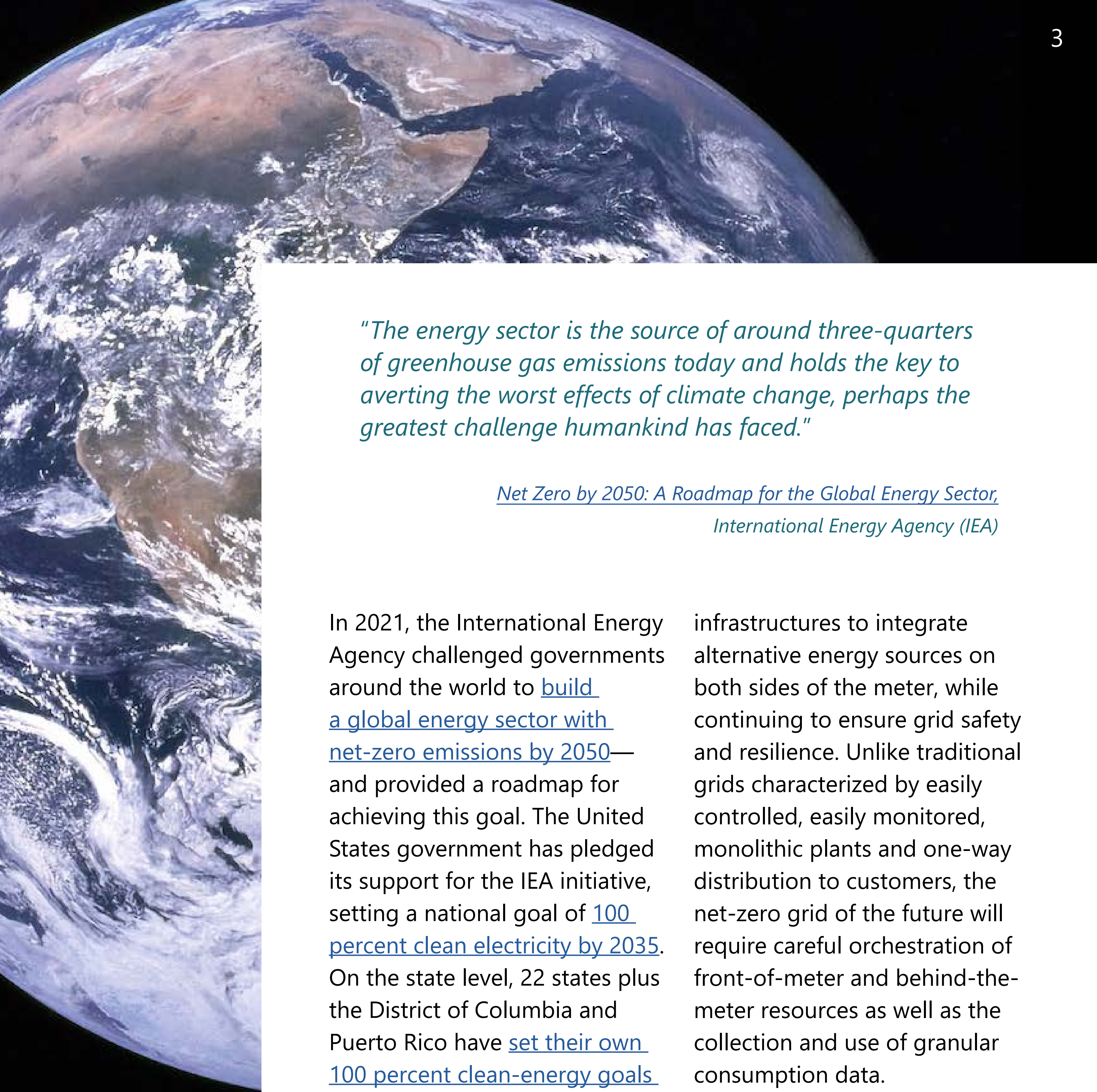


"The energy sector is the source of around three-quarters of greenhouse gas emissions today and holds the key to averting the worst effects of climate change, perhaps the greatest challenge humankind has faced."

Net Zero by 2050: A Roadmap for the Global Energy Sector,
International Energy Agency (IEA)

In 2021, the International Energy Agency challenged governments around the world to build a global energy sector with net-zero emissions by 2050—and provided a roadmap for achieving this goal. The United States government has pledged its support for the IEA initiative, setting a national goal of 100 percent clean electricity by 2035. On the state level, 22 states plus the District of Columbia and Puerto Rico have set their own 100 percent clean-energy goals for electricity, with target dates ranging from 2032 to 2050.

Amid mounting pressures to usher in a cleaner, greener energy landscape, utility operators face the challenge of updating decades-old infrastructures to integrate alternative energy sources on both sides of the meter, while continuing to ensure grid safety and resilience. Unlike traditional grids characterized by easily controlled, easily monitored, monolithic plants and one-way distribution to customers, the net-zero grid of the future will require careful orchestration of front-of-meter and behind-the-meter resources as well as the collection and use of granular consumption data.

In this paper, we'll explore how U.S. utilities are taking the first steps towards this vision: integrating utility-scale renewables as well as distributed energy resources (DERs) into a rigid, outdated legacy grid.

Motivating factors

In addition to the IEA's 2050 initiatives, many other external factors are driving utilities towards rapid but strategically planned integration of utility-scale renewables and DERs.

According to the Building Decarbonization Coalition,

over 100

U.S. jurisdictions have issued zero-emission building ordinances.

An evolving energy landscape

The clean-energy movement has already perpetrated monumental shifts in the American energy landscape. In 2001, coal accounted for more than half of total U.S. electricity generation; in 2021, it accounted for only 22 percent. The shift away from natural gas has already begun, with a growing number of U.S. cities banning natural gas connections in new construction projects.

Legislation concerning transportation fuel sources is also shaping the future of the grid, with California passing a ban on the sale of new gas-powered automobiles by 2035 and other states following suit.

Price considerations

The combination of rising electricity rates and declining costs of solar solutions is driving more consumers to install on-site, renewable electricity generation. In 2022, consumers paid an average of 14.3 percent more for grid electricity over the previous year, more than double the overall inflation rate of 6.5 percent. At the same time, the cost of residential rooftop photovoltaic (PV) panels has fallen by 64 percent since 2010, compounded by a federal tax credit of 30 percent for installations from 2022 to 2032.

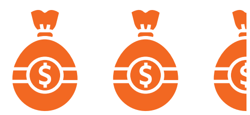
As a result of these and other factors, in 2022 the residential solar market saw its sixth consecutive record year, with 5.9 GW installed—a 40 percent increase over 2021.

Average price of residential rooftop solar panels

2010

$40,000

2022



$25,000

Source: Solar Energy Industries Association

FERC Order No. 2222

In September 2020, [the Federal Energy Regulatory Commission (FERC) announced Order No. 2222](), which enables DERs to participate in regional wholesale electric power markets through aggregations. (See below for an introduction to DER aggregation.) As most DERs produce energy from renewable sources such as solar and wind, this development marks a significant step forward in the journey to net-zero. Additional expected benefits include lower consumer prices driven by increased competition, a more flexible, resilient power grid, and increased innovation in the utilities industry.

The order requires regional grid operators to revise their tariffs in a way that "allow[s] [DER] aggregators to register their resources under one or more participation models that accommodate(s) the physical and operational characteristics of those resources." The status of compliance with Order No. 2222 currently varies across FERC-jurisdictional independent system operators (ISOs) and regional transmission operators (RTOs). CAISO (California) and NYISO (New York), for example, are well on their way to achieving full compliance, while other ISOs are working on getting there.

25%

of U.S. households use electricity as their only source of energy.

Source: Energy Information Administration

Increasing peak loads

Escalating penetration of electric vehicles (EVs), heat pumps, and other high-consumption electrical products, plus the electrification of a growing number of buildings, is dramatically increasing peak loads on the grid.

A cost-benefit analysis of EV development in New York recently revealed that "around USD 2.3 billion more would be required between 2017 and 2030 to cover grid upgrades and generation costs to implement state-wide EV charging."

How utility-scale renewables contribute to net-zero goals

Utility-scale renewable energy sources appear to be ideally positioned to drive progress towards net-zero goals.

The first clear advantage is economy of scale: the levelized cost of utility-scale solar panels, for example, is up to seven times lower per MWh than that of rooftop solar PVs. Utility-scale resources are also far easier for grid operators to monitor and control than distributed energy resources owned by consumers, businesses, or independent producers.

Challenges

The fundamental challenge in integrating utility-scale renewables is that renewable energy plants are typically not dispatchable—they cannot generate power 100 percent of the time when called upon.

Weather-dependent sources such as wind and sunlight are inherently variable due to day/night cycles and changes in meteorological conditions. Regarding solar power specifically, the viability of solar panel farms is limited in states where the climate is cloudy, rainy, or foggy.

On cloudy days, a solar panel produces about

10-25%

of its typical power capacity.

Source: Solar Alliance

Solutions

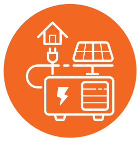
Utilities are developing an array of solutions for addressing the challenges surrounding renewable energy sources, including the following:

- Increasing investment in energy storage
- Installing new transmission lines from high-production to low-production areas, e.g. from desert to city
- Diversifying their renewable energy portfolios among various sources (wind, solar, geothermal, hydroelectric)
- Incentivizing generator flexibility, as California has done by offering a flexible ramping product that rewards generators for the ability to ramp up and ramp down quickly
- Leveraging AI and machine learning to improve forecasting of power generation from renewable sources (more on this below)

How DERs contribute to net-zero goals

FERC defines a distributed energy resource as "any resource located on the distribution system, any subsystem thereof or behind a consumer's meter. These resources may include, but are not limited to, electric storage resources, distributed generation, demand response, energy efficiency, thermal storage, and electric vehicles and their supply equipment."

As most DERs are based on renewable energy sources—wind turbines, solar panels, batteries, EVs, etc.—these resources are helping drive progress towards the United States' net-zero goals. Not only do they help consumers and businesses switch away from fossil fuel–based energy sources, but they also support decarbonization by helping utilities accommodate peak loads as an alternative to carbon-intense fuel sources.



The number of solar DERs alone is projected to

more than double

between 2021 and 2026.

Source: North American Electric Reliability Corporation (NERC)

Challenges

Perhaps the greatest challenge in integrating DERs is the fact that most grids are designed to work with large, centralized power generators and retailers, not a multitude of small resources dispersed over a wide geographic area.

Lack of visibility is also a factor as many DERs are located behind customer meters, which complicates monitoring and control of available resources.

Finally, traditional distribution grid management is characterized by a "fit and forget" approach rather than proactive management 24 hours a day, seven days a week.

"DERs can hide in plain sight in our homes, businesses, and communities across the nation. ***But their power is mighty.***"

FERC Chair Neil Chatterjee

Solutions

Several operational and technological solutions are available for utilities challenged by the task of integrating DERs, including:the following:

- Relying on aggregators to simplify monitoring and management by pooling small-scale resources and acting on behalf of individual DER owners

- Leveraging digital management systems

- Contracting with EV drivers to acquire using rights, enabling EVs to serve as grid storage solutions

- Making use of virtual power plants, which the IEA defines as "networks of decentralized power generating units, storage systems, and flexible demand, [which] can optimize the aggregation of distributed resources across large areas by using advanced analytics such as machine learning"

Integrating renewables into the grid

Utility-scale renewable integration

First, the good news: in 2022, the cumulative U.S. operating capacity of renewable sources was over 227 GW, enough to power 61 million homes.

Now for the rest of the story: This number would be much higher if not for the bottlenecks plaguing many interconnection queues—the queues of power generation and transmission projects requesting to be connected to the grid. Many states and regions are receiving a huge number of petitions to interconnect renewable energy sources, but lack the transmission capacity necessary to satisfy them.

Connecting renewables to the grid requires transmission to move energy from sources, e.g. wind and solar farms, to areas of consumption, and in many regions, this capacity is lacking. At the end of 2021, more than 1,400 GW of total generation and storage capacity were seeking connection to the grid, over 90 percent of which involved zero-carbon resources such as solar, wind, and battery storage.

Successful integration of renewable sources also promises to impact electricity prices. By increasing the energy supply from zero-cost sources like wind and sunlight, renewable integration has the potential to significantly decrease consumer prices. According to the IEA, if the world achieves net-zero emissions, average household energy bills in advanced economies will be lower in 2030 and 2050 than they are today.

In the following pages, I'll explore some of the tactics utilities are implementing to ensure faster and more efficient interconnection of renewable resources to the grid.

Renewable energy is the fastest-growing energy source in the United States, increasing

42%

from 2010 to 2020.

Source: Center for Climate and Energy Solutions

Using EVs as storage solutions

EV batteries can help address the renewable energy storage problem by serving as grid storage devices, both during and after their years of usage in vehicles. According to a recent study, EVs could meet grid demands for energy storage as soon as 2030, functioning in two capacities:

- **Vehicle-to-grid (V2G) capacity:** EV drivers can contract with utility companies to give them using rights—the right to control the vehicle's charging and discharging profiles—enabling EVs to serve as grid storage once their batteries are fully charged.
- **End-of-vehicle-life capacity:** When an EV battery drops to 70–80 percent of its original capacity, it becomes unsuitable for usage in vehicles; however, old batteries can have a second life as grid-storage devices, and repurposed batteries can be packed together into power banks for energy storage.

Implementing data-driven decision making

Utilities can leverage data to optimize decisions on where to place renewable resources for maximum effectiveness. Data for specific renewable sources at any given location that can support these efforts includes the following:

Wind data incorporates wind speed and direction at various elevations matching typical turbine hub heights (e.g. 30m, 60m, 80m, 100m, and possibly 120m).

Solar data encompasses

- **Direct normal irradiance:** Radiation coming directly from the sun
- **Diffuse horizontal irradiance:** Reflected or "scattered" radiation that hits the surface from multiple directions
- **Global horizontal irradiance:** Total radiation that hits a specific flat surface at any time during the day, made up of direct normal and diffused horizontal irradiance

Geothermal data looks at the overall favorability of geothermal development given certain factors, including the availability of

- **Hydrothermal resources:** Sources of steam or hot water beneath the surface
- **Enhanced geothermal resources:** Pockets of heat beneath the surface that are not tied to natural reservoirs

Driving further innovations

In an effort to address the core issues surrounding renewables interconnection, including data shortages, the U.S. Department of Energy launched the Interconnection Innovation e-Xchange (i2X) initiative, which provides technical assistance to help partners develop solutions to specific regional, state, and local interconnection issues.

The DOE developed the initiative to enhance overall grid reliability and improve market competition as well as transmission and distribution access for renewable sources.

As of December 31, 2022, the U.S. Department of Energy lists

650+

microgrids.

Source: U.S. Department of Energy

Integration of DERs

The number of solar DERs alone is projected to more than double between 2021 and 2026 and surpass 60 GW total capacity by 2031. The sooner utilities can integrate these valuable sources, the closer they come to resolving critical issues such as ensuring grid reliability amid growing electrification and reducing reliance on fossil fuel–based sources.

Like utility-scale renewables, DERs are poised to have a significant impact on electricity prices. As FERC Chair Neil Chatterjee asserted in his remarks on Order No. 2222,

> *Because DERs are nimble, more so even than many traditional resources, they can locate where price signals indicate they're most needed. This can, for instance, help reduce congestion costs, driving down prices for customers. That means smaller energy bills for hardworking families and businesses of all shapes and sizes.*

Following are some approaches that are helping utilities keep pace with the demand for interconnection of renewable DERs in their efforts to achieve net-zero goals.

Digitizing DER management

Many utilities currently manage DERs via manual processes. Even if these processes are viable today, they lack the scalability to remain effective as the number of distributed resources continues to escalate.

Distributed energy resource management systems (DERMS) are applications designed to monitor and manage DERs, which includes managing a group of DERs as a virtual power plant in a way that achieves an optimal balance between supply and demand.

As DERMS solutions continue to improve in usability and performance, more utilities are catching on: the global DERMS market was valued at $490 million in 2022 and is projected to grow from $570 million in 2023 to $1.86 billion by 2030.

"Using artificial intelligence, DERMS serve as one solution that can learn and respond to customer usage patterns, adjusting to manage various types of DER classes."

"DERMS Get the Most from the Existing Grid"
T&D World, June 24, 2022

Meeting telemetry requirements for DER data

One hurdle that DERs must jump through as a prerequisite for integration is meeting the ISO's telemetry standards. NYISO, for example, requires data updates every 6 seconds in the two-way operational communications that take place between the DER and the ISO.

Here again, technology offers a solution. Numerous customer-owned telemetry (COT) applications are available for DER owners at relatively low cost, enabling end-to-end communications between distributed resources and ISOs that meet or exceed established guidelines.

Enabling visibility of DER data

Behind-the-meter DERs can be a significant "blind spot" for utilities. Unless customers opt in to data sharing, DERMS can't even see capacity being generated behind meters, let alone manage it.

Geographic visualization platforms open the "black box" of behind-the-meter generation and enable utilities to better plan strategic load management programs. These applications deliver anonymized data to create a live view of DERs connected to the grid, both residential and commercial.

Utilities can then capture data from customer systems in a specific area—including the number, type, and capacity of units, installer names, and utility codes—and create new opportunities for integrating newly approved DERs in the region.

DER deployment is expected to grow from approximately 90 GW in 2022 to approximately

380 GW

by 2025.

Source: U.S. Department of Energy

Driving towards an interconnected future

As the IEA stated in its roadmap document for the 2050 initiative, "[the] gap between rhetoric and action needs to close if we are to have a fighting chance of reaching net zero by 2050 and limiting the rise in global temperatures to 1.5°C." The wheels of progress towards this goal are already in motion, but much remains to be done, particularly in the area of integrating utility-scale and DER renewables.

Even if the 2050 initiative did not exist, successful interconnection of renewable energy sources would still be vital if utilities are to ensure grid resilience and keep pace with shifting demand profiles in both the long and short term. To achieve this, utilities must revise the way they think about generation, transmission, and distribution and assign priority to the operational, technological, and data-driven solutions that can accelerate interconnection of solar, wind, geothermal, and other renewable sources.

The solutions are there, and the time for implementing them is now.

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