OUR DECENTRALIZED

Energy Future

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The structure of the power industry is undergoing a fundamental shift...

...from one based primarily on a hub-and-spoke central generation model with one-way energy flows, to a hybrid system comprised of both distributed and centralized resources with two-way flows.

This growing trend of decentralization in electricity networks extends beyond energy to everyday life. From the many ways we listen to music and watch movies, to the instant precision that comes with 3D printing, decentralization allows consumers to demand more flexibility and customization of goods and services. In the energy sector, decentralized, or distributed, energy will have profound effects on the way we produce and consume energy in homes, businesses, industries, and cities across the world. Distributed generation technologies will be a cornerstone of tomorrow's electricity grid in both mature and emerging economies, where decentralization enables wider access to electricity.

GE believes energy decentralization will empower consumers, increase access to power for the one billion people who lack electricity, increase resilience, reduce consumer costs in many areas, and can accelerate decarbonization of the electricity system.

What is distributed energy?

Distributed energy systems can be made up of a single technology—like aeroderivative gas turbines or reciprocating engines supplying a single end-user—or they can be hybridized by combining several technologies, such as solar power and energy storage technologies. These systems can be digitally controlled and tied together to operate collectively to help meet local and system-wide electricity demand requirements.

GE has been a long-time advocate of enabling smaller, distributed energy systems, beginning with the Pearl Street Station built by Thomas Edison in the late 19th century to serve a small part of New York City. This is due, in part, to our ongoing commitment to developing new and more efficient energy technologies, digital platforms, and business model solutions that can scale from large to small systems.

The need for distributed energy and the technology driven push toward it

This transition to more distributed energy resources can create substantial value for customers through lower electricity costs, reduced environmental emissions, and increased reliability. It's being driven by a combination of falling costs, increased performance, consumer choice, and regulation.

The rapid advancements of battery storage, electric vehicles, solar, digital technology, and connected devices have enabled the proliferation of distributed energy resources into homes, commercial buildings, industrial settings, hospitals, university campuses, and cities.

The cost and performance of all distributed energy resources have continued to decline over time, with solar photovoltaic (PV) technologies and batteries experiencing the greatest cost declines in recent years. For example, the average global price of lithium-ion battery packs has fallen by 80 percent since 2010, from a price of $1000/kWh in 2010 to $209/kWh in 2017, according to Bloomberg New Energy Finance.[1]

The rate gap between wholesale and retail electricity prices has also accelerated the adoption of distributed energy resources. On the whole, retail electricity rates have been slow to follow fuel prices down and the costs to maintain legacy T&D systems and install new ones also elevate retail electricity rates. Comparatively lower-cost distributed energy technologies are therefore increasingly more attractive.

Civic and business commitments are also accelerating renewable energy. Many local and national governments are pledging to run entirely on renewable energy and large companies like Apple and Facebook are joining in, with commitments to power increasing portions of their global operations with renewable and often distributed resources.

[1] New Energy Outlook 2018, Bloomberg New Energy Finance, Fig. 28

The demand for more reliable and resilient energy systems is also making distributed systems more attractive. As it becomes more common for extreme weather events to leave millions without power for weeks, months, or even years at a time, the need to transition from systems with a single point of failure to multiple, distributed points of support is urgently felt.

Additionally, in many parts of the developing world, transmission networks are either not available or are often less reliable. In these situations, microgrids linked up to main grids are used to provide reliable electricity where it is needed. Furthermore, remote microgrids enable electricity to be made available in areas beyond the reach of the grid, like remote mountain villages, islands, and archipelagos. In all these places economic development follows electricity access.

Case study: a microgrid solution in rural Ethiopia

Ethiopia has the third-highest installed available capacity for electricity generation in sub-Saharan Africa at 4.5 GW and nearly 80 percent of the population lives within proximity of medium-voltage transmission lines. Meanwhile, it has plentiful renewable energy resources, such as solar, wind and geothermal. Still, over 70 percent of the population live without electricity while only 24 percent of primary schools and 30 percent of health clinics have access, according to the World Bank.[2] The need for electrification is urgent. The country hopes to have universal access to electricity by 2025—with 65 percent of the population gaining access to electricity through the grid and the other 35 percent through off-grid technology.

The country is turning to advanced technologies to provide energy to deep rural areas. Through a scalable microgrid, GE and local entity Solar Tech installed and commissioned three systems—two for health clinics and one that's providing enough power for 1,500 residents of rural Digo Village in the Oromia region. Powered by a hybrid distributed power unit, these microgrid systems combine PV solar panels, batteries, and a diesel generator to provide cost-effective, reliable power to sites and communities that are off the grid. The entire system, which can fit inside a standard shipping container that can be efficiently and quickly installed, is doing its small part in helping 10 million households gain electricity access by 2025.

[2] World Bank Supports Ethiopia's Endeavors to Provide all Citizens with Access to Electricity, March 1, 2018, https://www.worldbank.org/en/news/press-release/2018/03/01/world-bank-supports-ethiopias-endeavors-to-provide-all-citizens-with-access-to-electricity

In developed economies with legacy transmission and distribution (T&D) systems, distributed energy resources are used to power communities and cities, industrial facilities, commercial complexes, and residential communities, as well as campuses such as colleges, universities and hospitals. In these applications, end-users typically have access to the local power network. Here, distributed energy resources are used to supplement the grid or provide solutions that reduce costs relative to utility-supplied power. Distributed energy systems also are an increasingly popular solution for military bases that want the option to draw power from the grid or operate in island mode.

An advantageous aspect of distributed power systems is their ability to meet the heating, cooling or steam needs of end-users. Many industrial processes require heat as well as electricity as an input into production. Distributed, on-site generators such as reciprocating engines, steam turbines, and gas turbines can supply multiple forms of energy to meet customers' power, heating, cooling and steam needs. When operating in combined heat and power (CHP) or trigeneration mode, distributed technologies can achieve total efficiencies approaching 90 percent.

There is a vast global market for so-called "combined heat and power" projects. According to IEA, CHP represents 9 percent of the global power generation today . In addition, CHP is a cleaner energy solution for campuses, islands, and cities that can be aggregated in microgrids with advanced digital tools.

Another important part of the decentralization movement is the role of increasingly affordable, modular energy storage solutions. These batteries enable distributed power systems to store energy from variable generation sources and discharge it at periods of peak demand. This means that renewables like solar PV can meet a broader spectrum of on- and off-grid customer needs.

The global distributed energy market is responding to these drivers with increased expansion. According to Navigant Consulting, the collective group of distributed energy technologies, including distributed solar PV, small and medium wind turbines, microturbines, fuel cells, natural gas gensets, diesel genset, distributed energy storage, and microgrids had an installed capacity of 94 GW in 2017. As a group, the installed capacity of these technologies is expected to double by 2026. The annual average growth rate of these technologies is estimated to be 7.7 percent between 2017 and 2026.

The latest in decentralized technology innovation

Distributed Energy Solutions

GE has established a business to work with customers to develop and implement customized distributed energy solutions, enabled by a digital platform that connects the distributed assets to the central power system with a goal of optimizing energy performance. This platform can enable onsite energy optimization, visibility to energy assets, and interface to the utility to deliver a two-way energy system that can enable new revenue streams for our customers. GE's Distributed Energy Solutions will consult with customers to design and implement an optimized system, as well as operate it on behalf of the customer with financing to reduce barriers to implementation. This new business utilizes a combination of GE and third-party equipment while tapping into the best of GE's capabilities, including GE Global Research, digital tools, and operations and management systems.

Case study: Philadelphia Navy Yard

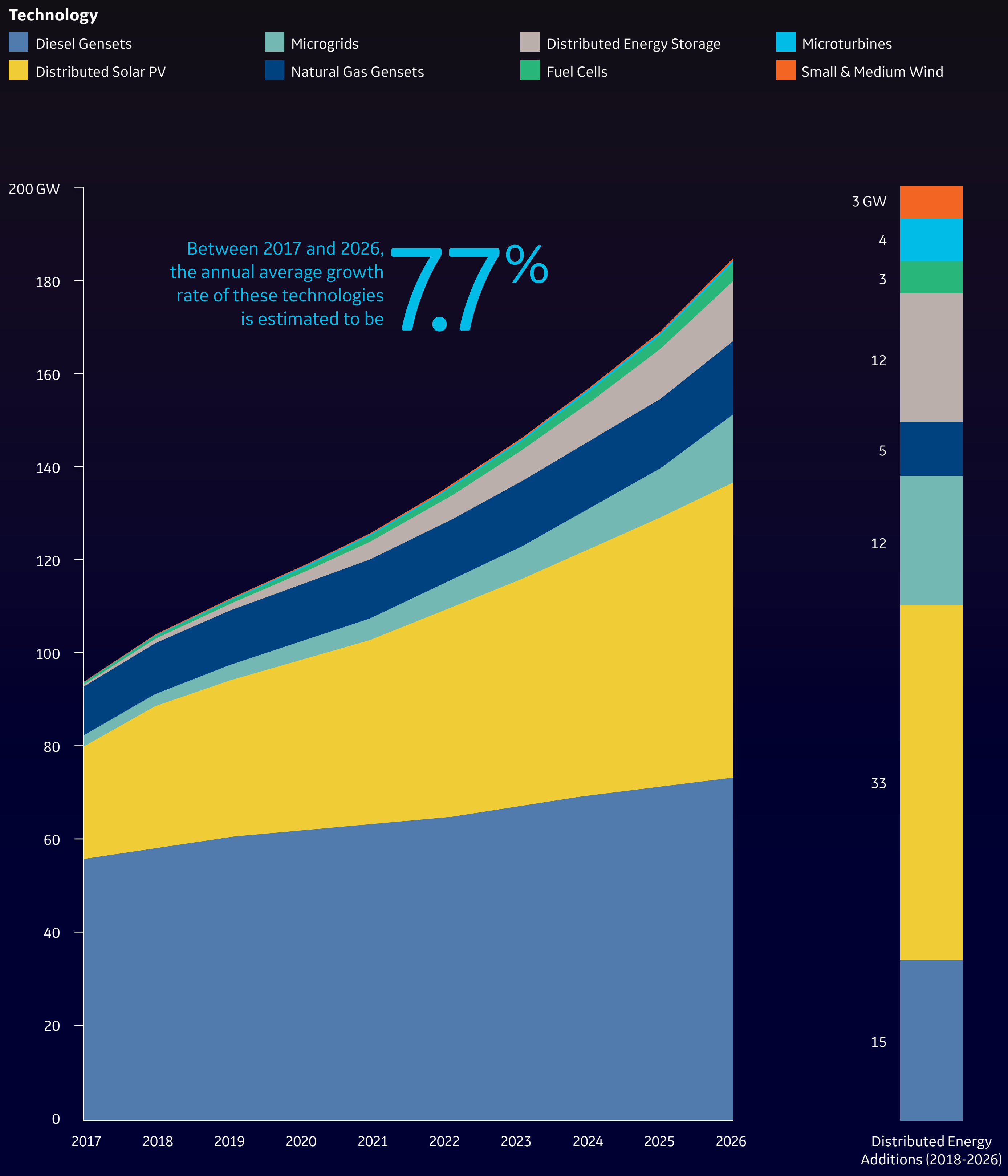
The Philadelphia Navy Yard is a 1,200-acre facility used by the U.S. Navy from the 1780s to the 1990s. It is now a fast-growing business and industrial hub, with over seven million square feet of occupied space housing 145 companies and 11,500 employees, with a net utility demand of 82-MW, all expected to double or even triple before the project is complete.

In partnership with GE, the $4 billion Yard project is building a 35-MW hybrid microgrid that will realize 61,000 MWh in energy savings over its lifetime, supplemented by an 8-MW natural gas-fired peaker plant. In concert with a 3-MW combined heat and power facility, a 1-MW solar photovoltaic storage facility, and a 600kw fuel cell, the whole project is estimated to reduce net utility demand by 10MW, as well as provide more reliability, efficiency, and independence to the Yard's rapidly expanding customer base, a key part of Philadelphia's economic future.

GE's Distributed Energy Solutions team runs the energy plaform and manages site energy performance—a system acts as the brains of the Yard energy system—from the onsite Network Operations Center to support the Yard's grid operator, tenants and the Independent System Operator (ISO).

Installed Distributed Energy Capacity (2017-2026)

The installed capacity of these technologies is expected to double by 2026. The annual average growth rate of these technologies is estimated to be 7.7 percent between 2017 and 2026. Distributed solar, diesel gensets, and microgrids are expected to add the most capacity during this period. Over 12 GW of new microgrid capacity will be added during this time.



Source: Navigant Consulting, Inc.

Distributed Energy Resource Management System

GE's Distributed Energy Resource Management System (DERMS) platform has helped California utility Pacific Gas & Electric use grid-responsive "smart" solar inverters in customers' homes. With the DERMS platform, utilities can monitor and control distributed energy resources in businesses, customers' homes and on the grid[3]. The result is decreased emissions, reduced expenditures, and improved grid reliability and operational efficiency. GE can do this for clients on the scale of PG&E because of our legacy of innovation in digital, combined with our deep expertise in physical infrastructure.

Case study: world's first megawatt scale smart solar grid in Nice, France[4]

Despite being just 7.5 miles from Nice, France, the commune of Carros, relies on a single electricity line. Outages were common, particularly in the summer tourist season when demand surges. Adding more solar panels caused more headaches, generating more electricity than the grid could carry.

Carros experienced an energy transformation when GE Grid Solutions and the French distribution grid operator ERDF installed a centralized 1-megawatt battery to store and release excess electricity. The existing grid was modernized with software and automatic switches and solar panels were placed on more than 500 buildings. GE's DERMS allows grid operators to communicate consumption information in real time from smart meters. The software can allow operators to even send text messages that offer subsidies to customers to use excess electricity from neighbors. The smart solar grid is just one way distributed energy enables people with reliable and optimized energy, a lower carbon footprint, and better quality of life.

Solar

GE has long provided solar power equipment, such as inverters, and solar power solutions to commercial, industrial, and utility customers. After over a decade of being an integral part of the solar PV market, GE also offers customers turnkey solar PV project development. Our energy development solution for The Home Depot is the largest rooftop solar array in Washington, D.C. The 1,400 LG photovoltaic panels are expected to supply more than 9.9 million kilowatt hours of electricity to The Home Depot over the 15-year power purchase agreement, providing about 35 to 40 percent of the store's annual energy use. The solar power system is expected to avoid more than 7,300 metric tons of carbon dioxide, about the same benefit as removing 1,578 cars off the road.[5]

Battery Storage

GE's Reservoir battery energy storage solutions help customers provide flexibility across the grid by combining expertise in plant controls, power electronics, and a variety of battery and enclosure technologies—all backed by performance guarantees. The Reservoir, a grid-scale energy storage system, can help operators stabilize the grid and pick up the slack from solar systems when the sun wanes or from wind farms when the wind dies down. It's a system that's powerful enough to restart an entire power plant rather than keeping it running in standby mode. Next to comparable technology, GE's Reservoir has a 15 percent longer life and 5 percent higher efficiency. Because it's assembled and tested in a factory, Reservoir shaves off installation time by as much as 70 percent.[6]

Gas Turbines

GE is the leading provider of gas turbines in the world. Our first applications of aeroderivative gas turbines for power generation used adaptations of jet engines, hence the term aeroderivative to describe them. After having specialized in jet engines for over a decade, GE introduced its first aeroderivative gas turbine, the CF6, for hydrofoil vessels in 1959. In 1985, GE's aeroderivative CF6 product line had a maximum power output of 35 MW. Today, the LM6000, a descendant of the CF6, offers simple cycle output in the 55 MW range with efficiencies higher than 40 percent and reliability approaching 97 percent.

Aeroderivative gas turbines are ideally suited for distributed applications because they have the ability to start frequently and rapidly ramp up or down to meet load and demand fluctuations–providing a solution for power grids that rely heavily on renewables. GE's aeroderivative gas turbines provide flexible power using a variety of fuels and can be installed in as little as three months on a greenfield site.

[3] GE and PG&E to Unlock Distributed Energy Resource Potential in California, August 12, 2016: https://www.ge-gridsolutions.com/press/gepress/2016%2008%2011%20GE%20and%20PGE%20to%20Unlock%20Distributed%20Energy%20Resource%20Potential.pdf

[4] GE microgrid: http://www.gegridsolutions.com/PowerD/catalog/microgrid_smart_cities.htm

[5] Press release: Constellation, GE Team with The Home Depot to Install Largest Solar Array in Washington, May 30, 2018 D.C.: https://www.businesswire.com/news/home/20180530005232/en/Constellation-GE-Team-Home-Depot-Install-Largest

[6] GE Reports: Leading the charge: as battery storage sweeps the world, GE finds its place in the sun. March 7, 2018. https://www.ge.com/reports/leading-charge-battery-storage-sweeps-world-ge-finding-place-sun/

After Hurricane Maria, three GE aeroderivative gas turbine engines were deployed to Puerto Rico and were producing power only one month after the devastating storm hit the island.[7]

Today, GE aeroderivatives are the world's leading technology for industrial power use. More than 3,600 aeroderivative turbines have been produced, logging more than 100 million operating hours around the globe – from north of the Arctic Circle to Indonesia.

As the trend toward decentralization unfolds over the next decade, we are committed to providing a full range of solutions to help meet customer needs. In an age of increasing demand and interconnected solutions, one single technology is not enough. Customers and their needs are too diverse, fuel and technology economics vary too much by location, and policy and regulatory frameworks differ markedly from country to country. To win in this world, customers need a partner that understands digital innovation, has hardware expertise, and a global understanding of policy and business environments.

At GE, our focus will remain on being a world leader in providing energy technology solutions and services across the entire electricity value chain from the point of generation to consumption. To serve this need, we are continuously exploring opportunities to investigate new technologies, develop new business models, and establish the right local and global partnerships.

Case study: Aeroderivative gas turbines in Indonesia[8]

The turquoise, nutrient-rich waters off the coast of the Indonesian island of Lombok are perfect for growing pearls. But when pearl farmer Fauzi Se wanted to take advantage of nature's bounty and expand production at his jewelry business, he was stymied by a problem only humans can solve—his workshop didn't have enough electricity to power his machines.

This is not an unusual problem in Indonesia. The world's fourth most populous country desperately needs to send more power to its 255 million residents spread across 18,000 islands. But the country's geography creates a special set of challenges. You can't just build big power plants and string wires across the sea. GE's solution for Lombok was to deploy two TM2500 "fast power" aeroderivative gas turbines. These truck-mounted mobile gas turbine generators can produce more than 25 megawatts of power, have 50 percent fewer emissions than comparable diesel equipment, and can be cranked up to full power in as little as 10 minutes.

Less than three months after arriving on site, the gas turbines were connected to the grid and producing electricity for Mr. Se and the other residents of Lombok.

[7] The Nassau Guardian, "GE wants to educate local market about gas turbines." June 27, 2018: https://thenassau-guardian.com/2018/06/27/ge-wants-to-educate-local-market-about-value-of-gas-turbines/

[8] GE Reports, Fast Power: Grounded Jet Engines are Powering Indonesia's Pearl Paradise, Oct 12, 2017, accessed at: https://www.ge.com/reports/grounded-jet-engines-powering-indonesias-pearl-paradise/

Conclusion

The global power system is rapidly moving from an electricity system built on central generation resources with one-way flow to an integrated and hybridized network that contains a mixture of centralized and distributed technologies. These developing networks will combine the most efficient central generation and new distributed technologies to provide reliable, affordable, and sustainable electric power for factories, businesses, and communities around the world.

Today, GE provides a wide range of distributed energy products and services to help customers meet this global megatrend head on. As a global company serving over 180 countries, we see ourselves as the world's electricity company. And we don't just sell machines, or software, or services: we deliver outcomes — like well-lit classrooms and the automated factories of the future.

Consistent with our 125-year history, GE is adopting a holistic approach by partnering with our customers to understand their challenges and help us explore potential solutions. This involves bringing the best that we have to offer, from technical expertise to technology-specific know-how. There's no better way to help our customers thrive and win in an uncertain world.

Join us, as we accelerate our distributed energy future. We welcome partners as we help shape the future of energy. The innovation has just begun, and the best is yet to come.