NAVIGANT
RESEARCH

WHITE PAPER

Disruptive Generation

A Cloud-Enabled, Platform Based Approach to Reliable Power Generation

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Section 1
EXECUTIVE SUMMARY

1.1 Disruptive Generation: Distributed Energy Transformation

The global energy system is shifting to cleaner, more affordable, and decentralized options that are providing customers with more flexibility in meeting their core energy and power needs. While the emphasis over the past 10 years has been on renewables, all forms of generation are shifting to a smart, platform-based business model. This will soon become the new norm, allowing customers to flexibly adapt their generation systems to meet their own specific need for reliable power. Within this mix of distributed energy resources (DER), generator sets (gensets) have an opportunity to become smart, cloud-enabled sources of reliable power. They are a highly mature technology with an enormous installed base, and with the right controls and business model, they are emerging as a key enabling technology for the next generation of integrated DER. This white paper explores the role of platform-based generation from smart gensets that are highly efficient, reliable, and will increasingly be deployed via as a service business models, accelerating adoption of other DER technologies.

What is the future role for platform-based power that is reliable and offered to end-use customers under a service guarantee? What business model makes sense in an evolving market shifting toward cleaner (and in most cases more variable) and platform-based distributed power generation? This white paper explores one approach that holds promise because it couples efficiency with lower operational costs. The approach also takes away customer risk as OEMs are now willing to share risks with end customers through monitoring and the ability to offer performance and reliability guarantees. Solutions that extract the greatest value from existing assets while paving the way for a future of platform-enabled hybrid DER solutions will be well positioned to address these questions.

This white paper explores how generator manufacturers are responding by:

- Providing dispatchable and flexible power
- Enabling fuel savings and renewable DER deployment
- Enhancing reliability
- Creating new business models where OEMs and their customers share risks and lower overall cost of energy for the lifespan of an onsite generation contract.

Platform-based generation solutions may represent an evolutionary step in an industry that is looking to move beyond traditional hardware and service contracts toward the Energy Cloud—Navigant Research's framework for describing the global energy system's transition to a market that is more dynamic, responsive, and transparent.

Section 2

PLATFORMS ENABLE DER DEPLOYMENT AND POWER RELIABILITY

2.1 The Increasing Value of Reliable Power: Developed Economies

Across the developed world, energy users are placing a higher premium on reliable power. The US, which has an aging electric grid, had the most expensive hurricane season ever in 2017, with billions in damage to the electric grid and millions of outages. Electricity users increasingly want to generate smart onsite power, but many do not want distraction or complications arising from straying from their core business functions. The market for onsite reliable power generation today in developed economies in North America, Europe, and the Asia Pacific is driven by large commercial and industrial (C&I) customers. Onsite power generation—including combined heat and power (CHP) for facilities with high heat loads—is critical to manufacturing, hospitals, campuses, and other large facilities. To these customers, loss of power can cost close to $1 million per minute.

2.2 The Increasing Value of Reliable Power: Emerging Economies

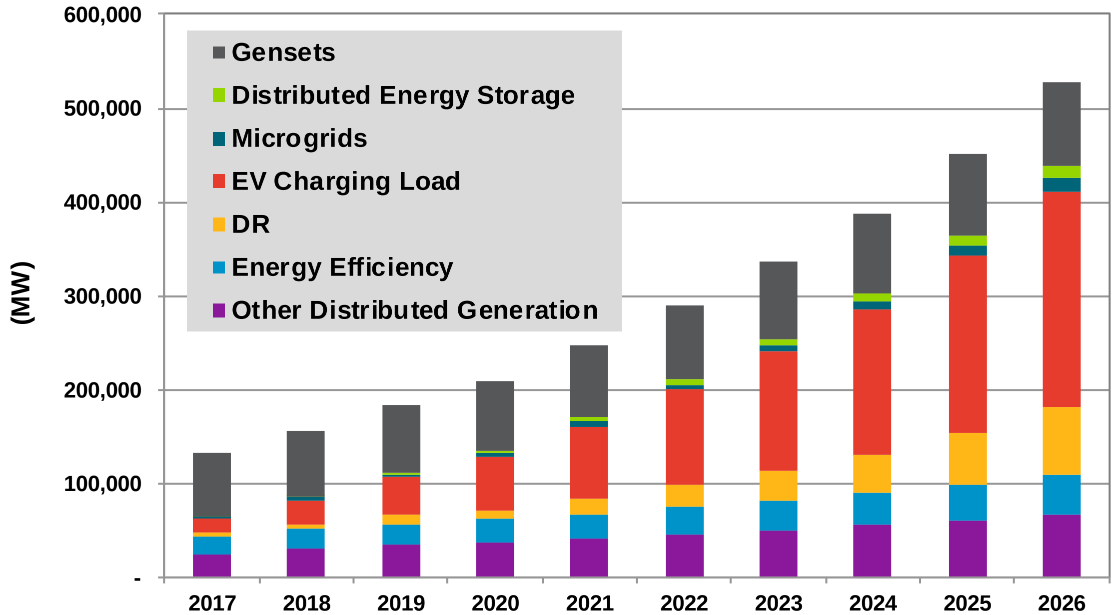
Another area of growth for smart, platform-based power generation is in emerging markets where developers are moving beyond basic rural electrification programs focused on providing minimal electricity services to a more robust system enabling major economic development. Sixteen percent of the global population lacks access to reliable power. The same reverse auction mechanism that has grown in use (in places such as Latin America, South Africa, and elsewhere) to contract hundreds of megawatts or even gigawatts at a time is also used to procure decentralized power systems in 500 kW-30 MW microgrids. It is in this emerging economy sector where onsite power generation has had the most success to date out of necessity; power reliability will become increasingly prized to deliver electricity for the first time in the most remote places of the world.

2.3 Dispatchable DER

The evolution of energy markets is rapidly shifting toward greater reliance upon distributed energy resources (DER). The lion's share of this DER portfolio is composed of distributed generation (DG) technologies, both fossil and renewable, and energy storage. But other resources, including demand response (DR) and other forms of load management and EVs, are all emerging as parts of an increasingly complex puzzle of DER that both create challenges and offer solutions to end-use customers.

Increasingly, these assets will be brought together into distributed power systems or microgrids that will be backed by smart generator sets (gensets) to aid in their ability to be dispatched quickly or enhance reliability.

Chart 2.1 Annual Installed Total DER Power Capacity by Technology, World Markets: 2017-2026



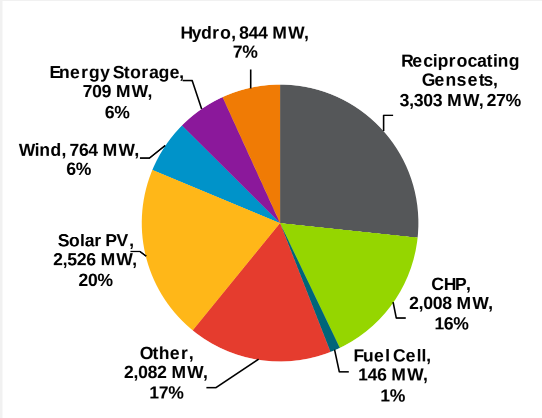
(Source: Navigant Research)

How can end users make sense of this evolving landscape and capture the benefits attached to DER rather than be saddled with shortcomings that could retard rather than enhance reliability? The answer lies in distributing intelligence into devices while also managing and monitoring them in real-time to ensure they deliver the premium cleaner power that end-use customers desire and demand in today's digital-enabled energy economy.

If one were to boil down the demands being placed on today's increasingly diverse DER portfolio—ranging from frequency to voltage deviations and a long list of ancillary services the power grid requires—the word would be "dispatchable." In a world ever more dependent upon variable generation and loads, and where centralized sources play a shrinking role in maintaining overall grid stability, the industry is moving toward a platform approach where multiple energy sources can be integrated and optimized for a variety of applications ranging from simple fuel savings to interacting to providing services to the grid.

Given the rapid capital cost decline of distributed renewables, and increasing energy storage, one could be forgiven for thinking this was the only pathway. In the near- and mid-term, gensets will continue to be one of the primary DER technologies deployed because of their unique value-add benefits. Gensets provide the backbone to many of the world's microgrids; for example, enabling the deployment of remote, distributed power systems and critical black-start functions for grid-connected systems.

Navigant Research anticipates strong demand for smart gensets in microgrids, where gensets are the cornerstone to the majority of microgrids online around the world today. Smart gensets in a microgrid will increasingly enable the addition of renewable energy assets over time, thereby further reducing diesel costs while providing scalability and reliability that onsite C&I customers require (such as mining or oil & gas operations). Reciprocating gensets make up the largest technology deployed in identified microgrids today, accounting for 27% of the global total, as seen in the chart below.



Note: Other capacity includes DR, geothermal, non-CHP turbines, and others
(Source: Navigant Research)

2.4 Platform of the Future: Smart, High Efficient Generators as System Backbone

In contrast to the traditional standby generator, smart gensets are becoming increasingly interactive with humans, other DER, and the larger electrical grid. Navigant Research defines a smart genset as:

> *A genset equipped with advanced controls that allow it to interact with remote parties and/or respond to signals beyond just the loss of utility power.*

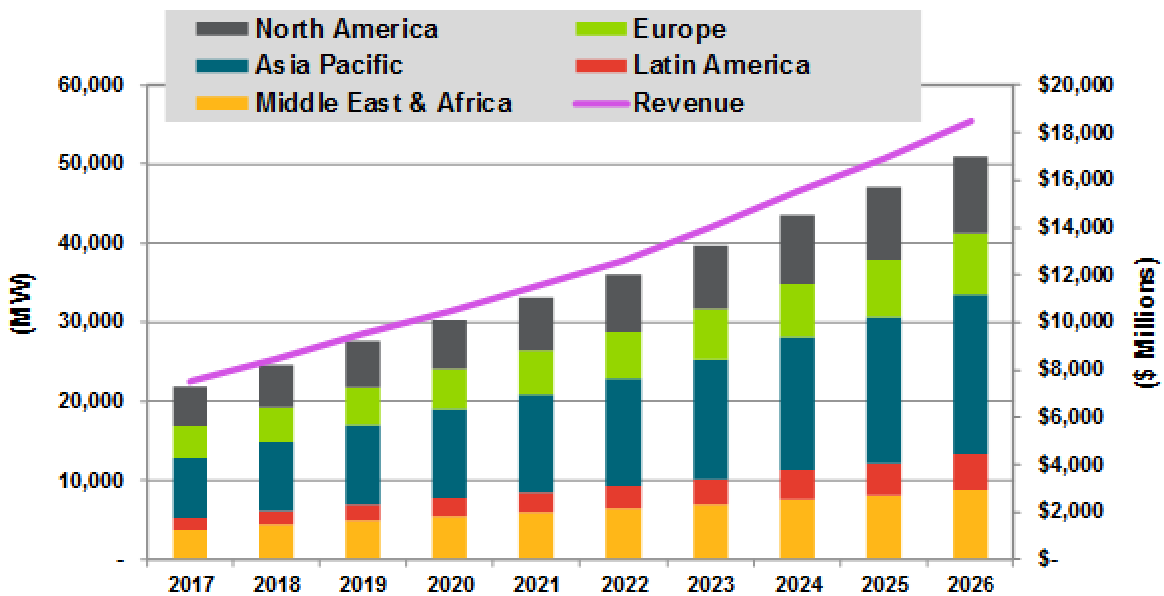
Although smart gensets are not new—they have existed for decades—Navigant Research expects rapid growth in both deployment and sophistication of smart gensets in the coming years. Key benefits of platform-based smart gensets include:

- **High efficiency:** The importance of fuel savings to an industrial customer cannot be overstated. C&I facilities operate on lean margins and are highly sensitive to fuel price fluctuations. High efficiency generators both reduce OPEX and make a plant operation mitigate fuel price shocks over the lifetime of a system.
- **High reliability:** Thanks to advanced remote monitoring technologies, operators can monitor system performance and make adjustments in real-time. With continued monitoring, maintenance teams can be dispatched with the right tools the first time, allowing enhanced system reliability.
- **New business models:** High efficiency and high reliability with cloud-enabled monitoring enables performance-based contracting and favorable service arrangements for customers.

The market for smart gensets is expected to surpass $18 billion in annual revenue by 2026 at a compound annual growth rate of 10.5%. Annual global capacity additions are expected to reach 51 GW by 2026. Asia Pacific has the highest demand over the forecast period, accounting for an estimated 38% the cumulative capacity additions through 2026, or 134 GW. Growth in the region is led by developing countries including China and India as gensets are deployed to support infrastructure expansion, accelerate rural electrification, and mitigate the power deficits that occur when too little generation is available to meet demand.

North America is expected to account for 20% of the global cumulative installed capacity (72 GW) through 2026, driven by the increasingly smart use of distributed natural gas generation for grid support and resilient power. The Middle East & Africa is expected to account for 18% (62 GW) through 2026, thanks to rapid electrification and infrastructure growth. Europe and Latin America round out the global regions, accounting for 58 GW and 28 GW of capacity, respectively.

Chart 2.2 Annual Smart Genset Installed Capacity and Revenue by Region, World Markets: 2017-2026



(Source: Navigant Research)

2.5 Emerging Smart Genset Platforms

In response to customer demands for higher efficiency, lower emissions, and real-time data access and analytics, Navigant Research sees three emerging smart genset platforms that can serve a range of customer types.

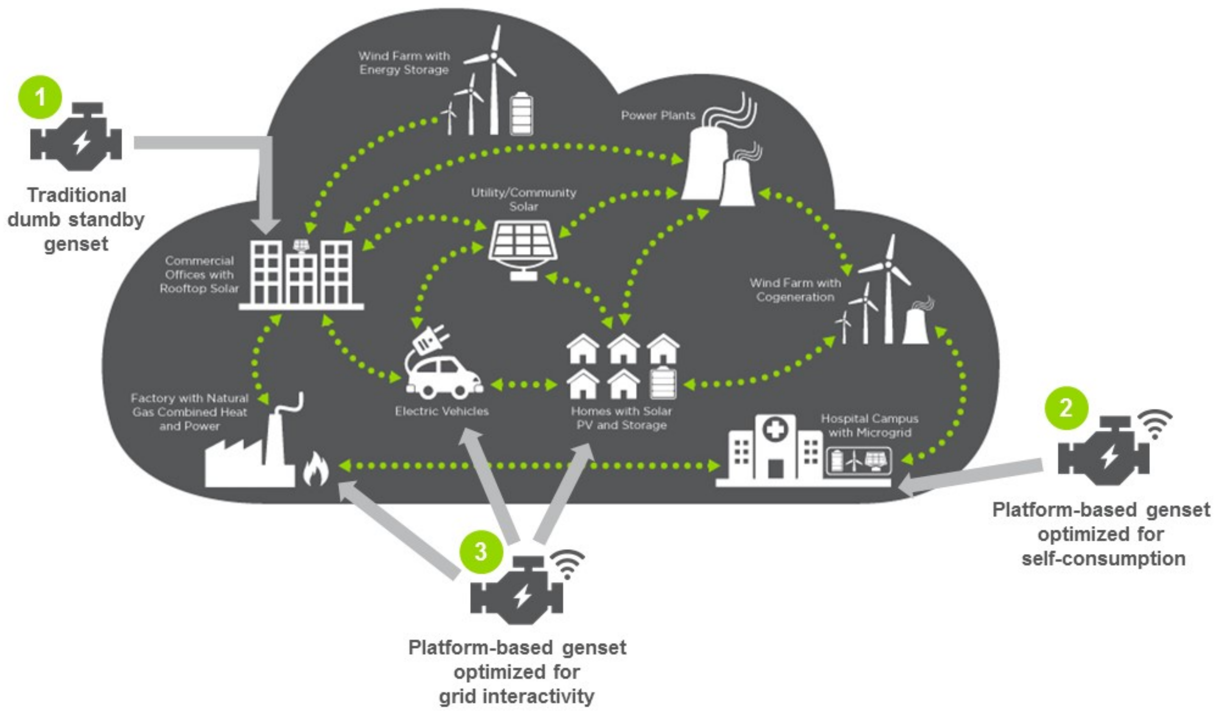
Table 2.1 Smart Genset Platforms

	Status Quo (OEM)	Platform: Optimized for Self-Consumption	Platform: Optimized for Grid Interactivity
Business Model/Value Proposition	Manufactures, distributes energy technology; offers standard or premium hardware warranty	Improved efficiency, cheaper and faster O&M (predictive analytics), improved asset management; demand charge abatement, enhanced renewables self-consumption; guaranteed reliability performance agreement.	Improved efficiency, cheaper and faster O&M (predictive analytics), improved asset management; demand charge abatement, enhanced renewables self-consumption; guaranteed reliability performance agreement. ***Platform provider manages ancillary services, DR, other new and lucrative value streams.***
Enabling Technology	Diesel, natural gas, or dual-fuel genset + Remote monitoring add-on	Diesel, natural gas, or dual-fuel genset Integrated remote monitoring. Genset control for seamless support of local loads and DER such as energy storage, solar.	Diesel, natural gas, or dual-fuel genset. ***Integrated remote monitoring.*** ***Genset control for seamless support of local loads and DER that are dispatched based on economic signal provided by software.*** ***Smart meters and economic dispatch signals from software*** ***Integrated weather forecasting.***
C&I Value	Prime, backup solution for weak grid	Prime, backup solution for weak grid, demand charge abatement. Customer can focus on core business.	Prime, backup solution for weak grid, demand charge abatement. ***Customer can focus on core business and take full advantage of additional revenue streams.***
Rural Electrification Value	Prime, backup solution for weak grid, energy access	Prime, backup for weak or non-existent grid, reliable power source for productive uses, critical loads. Customer can integrate additional DER technologies	Prime, backup solution for weak or non-existent grid, reliable power source for productive uses, critical loads. ***Customer can integrate additional DER technologies and expand service as a load-serving entity in the future, and during disasters.***

(Source: Navigant Research)

These platform types are exemplified in Figure 2.1. System 1 is a traditional standby genset without remote monitoring capability; it turns on only when the grid goes down. System 2 is platform-enabled for self-consumption; it is remotely monitored, and is integrated with other DER in a hospital campus microgrid. System 3 is platform-enabled for grid interactivity; it can be located behind-the-meter at any location, can provide all the services of system 2, and is able to react to signals from the grid to provide dispatchable services to the local energy grid on-demand.

Figure 2.1 Platform-Based Smart Gensets: Examples in the Energy Cloud



(Source: Navigant Research)

2.6 Platforms Will Enable a Focus on Service Delivery and New Business Models

Today, service for power plants is reactive. Tomorrow, the provision of such services will be local, platform-based, and predictive. Why? The answer is simple. Along with the shift toward DER providing a greater portion of energy supply, there will be a corresponding increase in the need for controls and optimization—the same digital enabling technologies that continue to improve. It is a transition to the Internet of Things, whereby data analytics and interconnectivity and monitoring in real-time all allow for squeezing the most value out of every asset, no matter how large or small. When linked to concepts such as artificial intelligence and machine learning, the possibilities for value creation multiply. The value can be captured in a remote power system operating in a jungle not interconnected to any traditional distribution grid or in a sophisticated C&I customer integrated into a modern smart grid. In the latter case, it is true that policymakers and regulators need to create market structures whereby such services can be properly accounted for and valued. Yet the trend is in that direction.

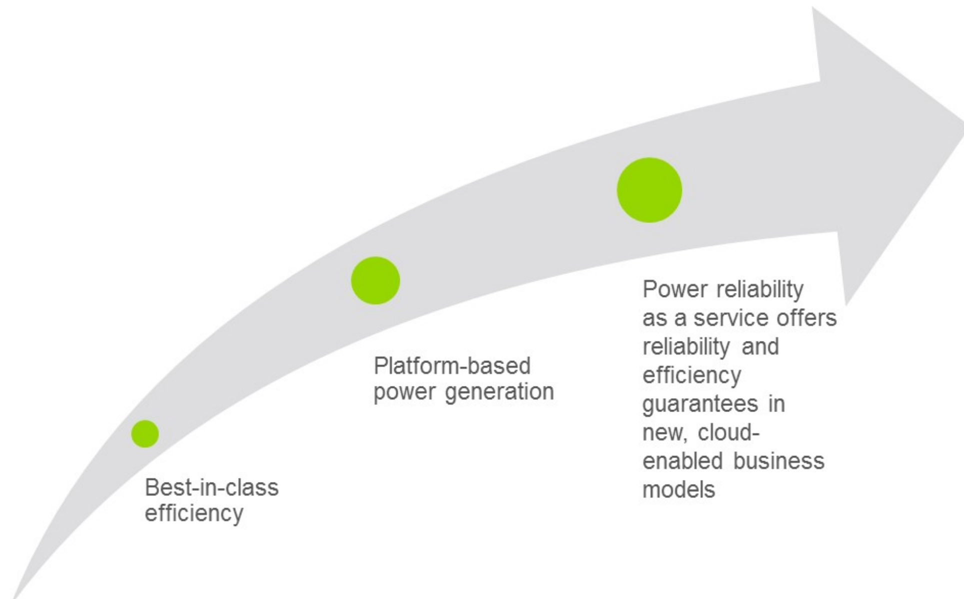
The future is heading toward aggregation, optimization, and monitoring via smart inverters and sophisticated software. Can the business models that helped mainstream solar PV, and now energy storage and microgrids, also be applied to generators being enablers of an even more diverse Energy Cloud paradigm? What lessons have been learned in the overall DER space? Is power more valuable than energy in a market where real-time response is highly valued?

In short, the answer to these questions is a resounding "yes." The customization of energy—and even more importantly power services—is where the industry is going. A platform-based approach to power reliability will enable formerly passive generator companies to cooperate with other DER. It will also leverage asset value through new business models that will deliver higher reliability, fuel savings, and energy cost reductions while also shrinking carbon footprints and operations and maintenance (O&M) exposures. The industry is also moving away from a direct ownership model to a service delivery model, thanks to the commoditization of key components and increased investor appetite for DER plays in key market segments.

As seen in the changes disrupting the telecom industry in the past 10 years, customers want choices; they want to be in control, but they also want transactions to be easy. In the energy space, this means customers want an onsite power solution that meets both their operational and financial profiles. Should a customer be able to decide upon their own level of reliability in a power purchase agreement?

Smart gensets provide increasing levels of value, as indicated in Figure 2.2.

Figure 2.2 Smart Genset Platform: Recipe for Success?



(Source: Navigant Research)

Section 3

GENSET MAKERS RESPOND: PLATFORMS AND THE FUTURE OF RELIABLE POWER

3.1 New Opportunities

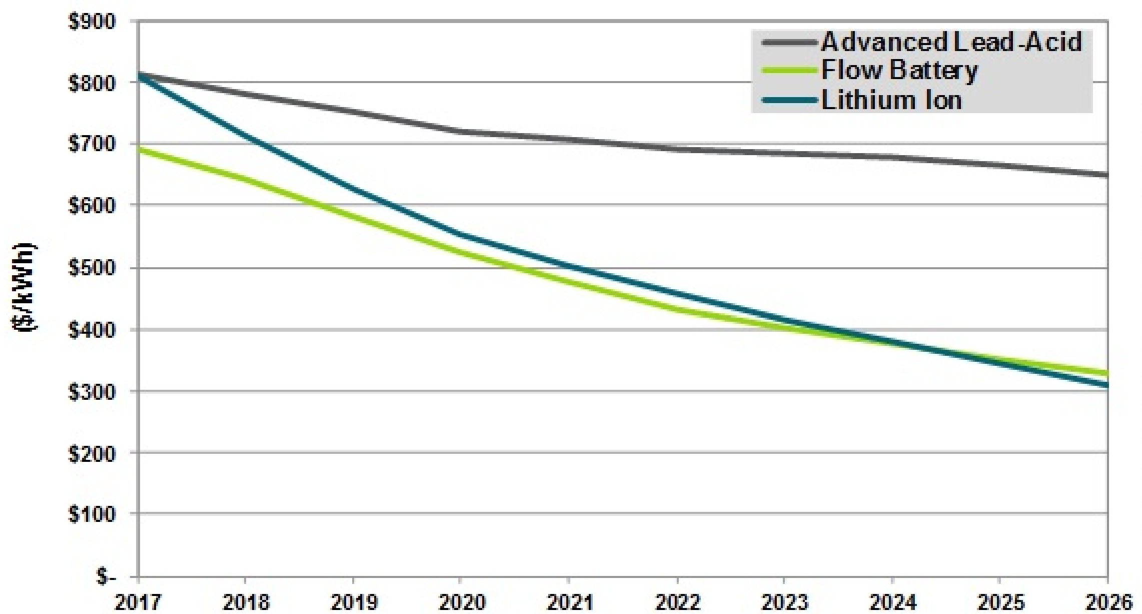
Generator manufacturers are in a similar position as utilities, and could view the evolution toward DER like energy storage, renewables, and digital grid as a threat. Today, however, both utilities and generator manufacturers are realizing the value of new partnerships, collaborations, and even acquisitions in the DER space. Both generator manufacturers and utilities are exploring new opportunities within the DER landscape, shifting focus from the assets themselves to creative strategies and new business models that can stack value.

This section takes a deeper look at how generator manufacturers are responding to DER and the effect DG can have on this segment of the market, honing in on two approaches: energy storage-based approaches and cloud-enabled, platform-based approaches. Both approaches take advantage of market disruptions that have been stimulated by increased competition, greater diversification in supply, and major advances in controls and financing business models.

3.2 Energy Storage-Based Approaches

Energy storage is often referred to as the “holy grail” for integration of larger amounts of variable renewable energy while also improving power quality and reliability. Given the billions of dollars in public and private investment, energy storage is largely delivering on aggressive cost reductions. But cost reductions alone are only part of the solution.

Chart 3.1 C&I Energy Storage CAPEX Assumptions by Technology, Average Installed Costs, World Markets: 2017-2026



(Source: Navigant Research)

Recent market activity indicates generator manufacturers, with existing global supply chain, distribution networks, and sales channels will play an important role in scaling up energy storage deployment in the near term.

In both developed and emerging economies, generator manufacturers are increasingly delivering integrated solutions that include energy storage, gensets, and renewables. A list of recent notable genset company acquisitions and partnerships are found in Figure 3.1.

Figure 3.1 Genset Company Recent Acquisitions and Partnerships

(Source: Navigant Research)

3.3 Cloud-Enabled, Open Platform-Based Approaches

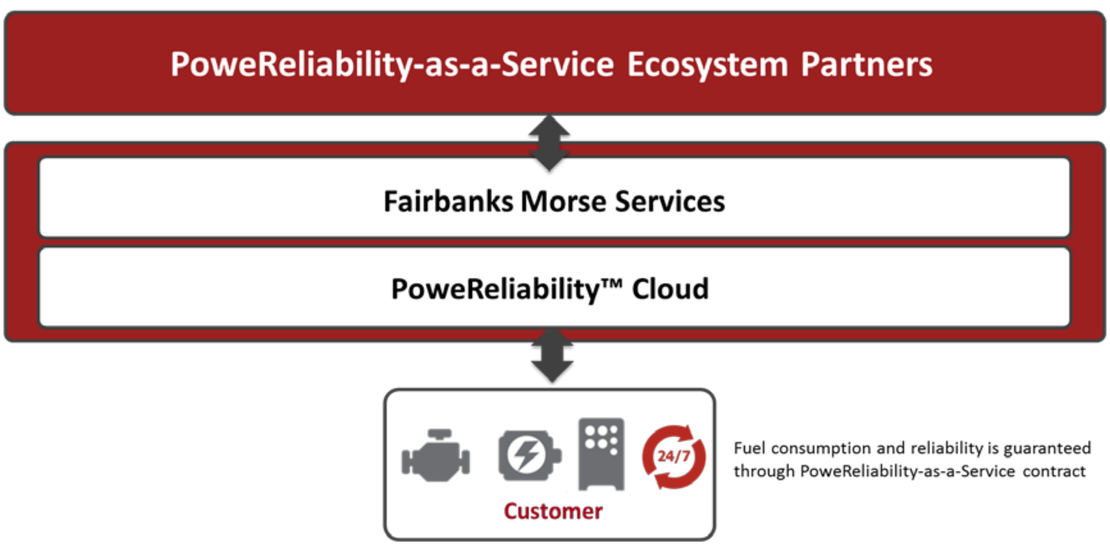
Some generator manufacturers are realizing the potential of taking a flexible, open platform-based approach as a way to future-proof themselves and their customers against energy industry disruption. In short, they have realized that one size will not fit all the needs of their customers. With an open, platform-based approach, these generator OEMs are betting on gaining a competitive advantage by offering customizable hybrid generator solutions that are open to all DER at the customer site, along with third-party software solutions that can form an enabling ecosystem through the Energy Cloud. Here, the platform advantage takes shape when a rich ecosystem of software partnerships can push value-added services (e.g., DR, ability to participate in wholesale markets, or creation of virtual power plants) to meet end customers' needs.

These can be customized specific to markets and regions (e.g., regulations, emissions standards, carbon footprints, reliability needs). The enabler of these types of hybrid platforms is now available as a result of the ability to tie into the Energy Cloud.

Fairbanks Morse is an example of a generator OEM player transitioning into a hybrid, open platform taking a cloud-based approach. The 125-year old manufacturer from the power generation industry has been seen as a quieter player in recent years. However, in 2017, the OEM launched a new, updated version of its opposed piston engine technology called Trident OP™, claiming best-in-class fuel efficiency and 30% fewer parts over conventional four-stroke engines for better reliability and lower overall lifecycle costs. The engine can be customized into a standalone genset or hybrid power plant dependent on a customer's needs. Power generation is monitored in real-time and enabled by the cloud, where data is shared with the Fairbanks Morse Services team and third-party software ecosystem partners. Integrating machine learning and predictive algorithms to determine preventive maintenance can help enable Fairbanks Morse to meet pre-determined reliability or performance service level obligations. Through the platform, Fairbanks Morse is proactively working to identify third-party software providers of DR solutions to allow end customers to tap into local markets and enhance revenue streams for the power they generate.

Fairbanks Morse plans to take this a step further with its turnkey PoweReliability-as-a-Service™ offering. Under this arrangement, customers pay for the reliability they need per-megawatt over a fixed price contract. If reliability guarantees are not met, the customer can cancel at any time.

Figure 3.2 Fairbanks Morse PoweReliability-as-a-Service™: An Open Platform-Based Approach



(Source: Fairbanks Morse)

The Fairbanks Morse PoweReliability-as-a-Service platform delivers distributed power generation for independent power producers or large C&I organizations. Backed by fuel efficiency and reliability performance level guarantees that are monitored in the cloud-based platform, PoweReliability-as-a-Service is designed to reduce the risk and OPEX for end users who want to generate their own power—whether grid-tied, or remote and off-grid. Through the new offering, Fairbanks Morse was able to offer a power producer more than $35 million in savings through guaranteed fuel consumption and increased reliability. In this example, PoweReliability-as-a-Service could allow the power producer to develop a 10 MW isolated distribution system that will deliver reliable electricity to remote regions of Latin America.

By offering guarantees over a long term, Fairbanks Morse envisions its PoweReliability-as-a-Service contract as enabling customers to determine their generation, emissions, and reliability requirements, based on the specific needs of each specific site. PoweReliability-as-a-Service platform is cloud-based with bidirectional data flow and control, so power generation can be monitored in real-time to deliver on specified fuel and reliability guarantees. As an open DER platform, it can be customized to integrate current or future solar, wind, CHP, energy storage, and other DER to facilitate a variety of use cases and maximize value stacking. This is intended to allow independent power producers and C&I end customers to integrate the DER of their choosing to be operated full-time as an independent microgrid or, where available, participate in ancillary market services such as DR.

Section 4
CONCLUSIONS

The global energy revolution is underway, and a seismic shift is underway from the centralized one-way model of the past to a distributed, efficient, and intelligent power system of the future. Navigant Research's Energy Cloud 2.0 analysis concludes that roughly $10 trillion can be attributed to the digital innovations necessary to integrate renewables, which will represent the majority of new power supplies supporting the grid by 2030. Revenue across the electricity value chain is shifting downstream toward the edge of the grid.

The platform-based approach is an opportunity for incumbent OEMs to assert themselves as catalysts for the global deployment of DER including renewables and energy storage.

New platform-based business models can help to de-risk investment in onsite power generation among a greater number of end users in both developed and emerging economies. At the same time, these models offer potential for new revenue streams for the C&I customer in particular—both now, and in the future as ancillary services markets evolve. Increasingly, the specific DER technologies become less important in this brave new world relative to the value they are able to extract from these expanding revenue streams.

For decades, generator OEMs have accounted for the majority of global DER deployment, yet are often overlooked in conversations about the distributed energy future. The platform-based approach is an opportunity for incumbent OEMs to assert themselves as catalysts for the global deployment of DER including renewables and energy storage. Offering new business models around platform-based approaches could allow innovative OEMs to share customer risk and deliver high end-value to customers who are looking to capture higher returns from power generation investments.

Section 5
ACRONYM AND ABBREVIATION LIST

C&I .... Commercial and Industrial

CHP .... Combined Heat and Power

DER .... Distributed Energy Resources

DG .... Distributed Generation

DR .... Demand Response

EV .... Electric Vehicle

Genset .... Generator Set

O&M .... Operations and Maintenance

OEM .... Original Equipment Manufacturer

US .... United States

Section 6

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Section 7

TABLE OF CHARTS AND FIGURES

Section 8
SOURCES AND METHODOLOGY

Navigant Research's industry analysts utilize a variety of research sources in preparing Research Reports. The key component of Navigant Research's analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Navigant Research's analysts and its staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Navigant Research's reports. Great care is taken in making sure that all analysis is well-supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

Navigant Research is a market research group whose goal is to present an objective, unbiased view of market opportunities within its coverage areas. Navigant Research is not beholden to any special interests and is thus able to offer clear, actionable advice to help clients succeed in the industry, unfettered by technology hype, political agendas, or emotional factors that are inherent in cleantech markets.

NOTES

CAGR refers to compound average annual growth rate, using the formula:

$$CAGR = (\text{End Year Value} \div \text{Start Year Value})^{(1/steps)} - 1.$$

CAGRs presented in the tables are for the entire timeframe in the title. Where data for fewer years are given, the CAGR is for the range presented. Where relevant, CAGRs for shorter timeframes may be given as well.

Figures are based on the best estimates available at the time of calculation. Annual revenues, shipments, and sales are based on end-of-year figures unless otherwise noted. All values are expressed in year 2017 US dollars unless otherwise noted. Percentages may not add up to 100 due to rounding.

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