Gas Turbines and Decentralized Energy Systems

ETN Global takes a deep dive into decentralized energy systems—advantages such as modularity, roadblocks for integration, and the future of power demand—and the role of gas turbines in a decarbonized future.

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ETN Global's recent global report, *Decentralized Energy Systems: Toward Carbon-Neutral Energy Solutions for Gas Turbines*, compares decentralized systems to centralized heat and power units and highlights its advantages—including modularity, the possibility to exploit waste heat avoiding energy transmission losses, and reducing energy distribution costs.

Giuseppe Tilocca, Scientific Officer at ETN Global, reviews these advantages in detail, as well as trends and emerging market opportunities. He also dives into gas turbines and how they fit into decentralized energy systems.

Q Can you provide a background on ETN Global and its report on decentralized energy systems?

Tilocca: ETN Global is a non-profit association. We have OEMs, users, the R&D community, suppliers—the entire spectrum of stakeholders. We mainly work on technology, but we also delve into market and policy. We gather users' challenges every year through high-level meetings and transform them into pathways for technical requirements.

Considering this specific report, we all know that the energy sector is transforming very quickly, and it's mainly driven by the increasingly high share of renewable energy sources. In this scenario, which is dominated by variable sources, the demand for daily, weekly, and seasonal flexibility is set to grow dramatically. To meet the system requirements while accomplishing the ambitious decarbonization goals, we need to support traditional centralized generation with a mix of centralized components, such as demand response and stability generation.

It is about going into the critical role of decentralized energy systems to achieve carbon-neutral energy solutions, particularly focusing on the integration and application of gas turbine technology.

Q How do you define a decentralized energy system, and what is its advantage over centralized heat and power units?

Tilocca: Historically, we established centralized energy systems, meaning large plants located far from consumers. The reason behind it is merely economy of scale and efficiency, so it is cheaper to have one big plant than many small ones; however, with the increasing integration of variable renewable energy sources, which are inherently decentralized, we now need to adapt our infrastructure and incorporate technologies that are traditionally used for centralized energy. By definition, a decentralized energy system is located close to the consumption nodes—so on the end user side of the network—and therefore it's connected to the distribution grid rather than the transmission grid.

The advantages of a decentralized energy system are mainly modularity, the possibility of exploiting waste heat, and a positive contribution to stability. One of the main benefits of being close to consumption nodes is avoiding transmission and distribution losses and costs compared to centralized generation. Decentralized energy systems are pivotal in meeting the pillars of the energy trilemma, which stress the principles of affordability, security, and climate neutrality and hence align with the requirements for the transition toward 2030 but also 2040 and 2050.

Q What are the biggest hurdles that decentralized energy systems face?

Tilocca: There are three main hurdles. Technologically, it is scale. Smaller equipment is proportionally more expensive than larger equipment, as are installation costs. As a result, capital expenditure per kW installed is less competitive than for larger equipment. Similarly, operating expenses may proportionally increase as size decreases; this includes maintenance, onsite operations, and fuel costs. (Smaller units usually have lower fuel-conversion efficiency.) These two hurdles may somewhat balance the benefits of reducing transmission and distribution losses.

On the user side, one of the many hurdles is commitment. This applies to residential, commercial, and industrial sectors. Investing in energy isn't necessarily seen as a priority—in many cases, it's far easier to plug into the grid and forget about it. This is not the case when energy is a primary cost, or you need heat or mechanical power.

One of the most challenging aspects of decentralized energy systems is the integration of different energy sources, energy technology, and energy products—they all need to coexist. You could have variable renewables providing power; you could have storage during a surplus or need storage as a battery or fuel; or you may have flexible technology to ensure available power. Having many sources, technologies, and products presents a huge quantity of data to manage and, in such complex systems, integration and controls are among the biggest challenges.

Q What are some trends and emerging opportunities identified by ETN Global in this space?

Tilocca: With the increasing penetration of renewables and decentralization, we often hear the word "flexibility", which we define as power balance. To maintain electricity and meet demand in Europe, we'll need more than double the current flexibility by 2030 and five times more by 2050. There are not many available, affordable, and scalable alternatives for gas turbines' long-term flexibility, so this is a focus of ours.

Energy balance is only part of the problem, as many auxiliary services are of critical importance to maintain a reliable power supply. We see the market moving toward integrating smaller units or virtual power plants in auxiliary market services. These two factors are even more relevant if we consider congestion and bottlenecks in the power grid that will limit interconnection capacity and flexibility—this will require substantial investment.

A matter we often forget is energy includes not only electricity but also mechanical power and heat, which are inherently decentralized. Electrifying high-temperature heat presents several challenges, which is why gas turbines in decentralized energy systems will have a role in providing flexibility, auxiliary services, mechanical power, and heat.

Q How do gas turbines fit into decentralized and carbon-neutral energy systems?

Tilocca: In terms of decentralization, gas turbines are recognized for their low maintenance, fuel flexibility, and compactness. Their successful applications include primary generation, continuous power, and standby power. In these applications, they leverage low maintenance, especially for remote locations offshore. They're fuel flexibility means they are often used with waste fuels that other technologies may struggle to run, such as flare gas from oil and gas, biofuels, etc. Gas turbines also have the potential to provide waste heat for residential, commercial, and industrial cogeneration applications.

Small turbines can help in remote locations with no access to the grid or access to an unstable grid. They're expected to play a significant role in emerging economies like Africa, where natural gas will drive industrial growth. Standalone generation will provide cost-effective electricity access for nearly one-third of Africa by 2030. Here, smart grids and microgrids present significant opportunities. An EU-funded project studied the impact of integrating decentralized energy systems, including solar, wind, gas turbines, hydrogen, and biogas, onto an island near Norway.

Gas turbines' carbon neutrality is not a matter of technology but fuel. Gas turbines can already use fuels like hydrogen, but the infrastructure for these fuels is missing.

Q What are the advantages and struggles of gas turbines in these systems? What solutions and applications are addressing these issues?

Tilocca: Gas turbines enable flexibility. In decentralized energy systems, clean and dispatchable solutions such as gas turbines enable the energy transition—in fact, there is no energy transition without dispatchable solutions. We're now seeing the role of gas turbines change rapidly in decentralized energy systems—moving from 8,000 operating hours per year to about 1,000 and from two to three cycles per year to two to three per day. This operational change will impact energy systems both economically and technically.

On the technical side, new market requirements will affect maintenance and operations. The R&D community is working on fuel flexibility to minimize emissions like NOx, which will position dispatchable, affordable gas turbines as sustainable and clean technologies for the energy trilemma. ■

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