Green biofuels: A proven fuel for gas turbines

As we move away from fossil fuels, green fuel alternatives are needed to balance the volatile nature of solar and wind. A key option is to replace conventional natural gas and diesel fuels with green biofuels in gas turbines. By **Heidi Vella**, energy and technology journalist

World energy consumption is expected to grow by nearly 50% over the next thirty years. While rapid expansion in renewable electricity generation, such as solar and wind, is expected to absorb much of this new demand, this alone won't be enough. New green fuels and technologies will be needed to maintain the supply and balance the volatile nature of solar and wind while ensuring a sufficiently rapid power generation transition away from fossil fuels.

Replacing natural gas with green biofuels in gas turbines is one key solution that's often overlooked. Made from renewable sources, biofuels, such as Hydrotreated Vegetable Oil (HVO), can be deployed in existing infrastructures to provide backup and peaking power, thereby complementing renewables at a low carbon footprint.

SIMILAR OR LOWER NOX EMISSIONS

Recently, Göteborg Energi and Siemens Energy have demonstrated how to use biofuels effectively together with combined cycle gas turbine technology at the Rya CHP district heat and electricity plant in Sweden. As part of a program supported by the Swedish Energy Agency, the plant was operated for two days in November 2021 on HVO, proving both start-up and stable operations.

"The tests successfully demonstrated both start-up and stable operations. The operations also showed that the emissions of nitrogen oxides (NOx) were similar or lower than when operating on conventional diesel," says Dr. Daniel Moëll, Project Manager for Green Fuel Combustion at Siemens Energy.

Additionally, a new backup plant planned by Stockholm Exergi will be operating solely on liquid biofuel, securing electricity for the entire city of Stockholm at all times. These projects demonstrate that green biofuels are a viable replacement for natural gas or diesel in backup and peaking plants and can support energy transition.

UNDERSTANDING THE POTENTIAL OF BIOFUELS

But first, let's look at the bioenergy market in general before approaching these applications. Bioenergy is electricity and heat generated from organic matter, such as plants and timber, agricultural and food waste, and even sewage. The energy stored in biomass can be utilized in different ways; combustible feedstocks can be burned to produce heat and steam (e.g., to generate electricity through a steam turbine), turned into a gaseous fuel via anaerobic digestion or gasification, or converted into liquid biofuels (such as HVO, other biodiesels, biomethanol, etc.). The latter two have the potential of being used in gas turbines.

Biofuels are showing that they have real potential in addressing the energy challenges that Europe and the world are facing today. The European energy market has proven sensitive to geopolitical events and unexpected cold snaps. Both can result in skyrocketing electricity prices and increased coal-fired power used to plug the supply gap, thereby causing more pollution and adverse environmental impact.

FLEXIBLE BACKUP AND PEAKING POWER WILL BE VITAL

Currently, Europe has ambitious renewable energy targets for addressing these challenges, but most are set for the end of the decade and require rapidly scaling up projects and grid upgrades, which have long lead-in times. Therefore, as these projects come online, flexible backup and peaking power will be vital for grid balancing to avoid blackouts and ensure electricity supply. Green biofuels can provide this while transitioning away from natural gas, diesel, and coal-powered generation.

Biofuels, such as HVO, can cut greenhouse gas emissions by up to 93% compared to fossil fuels. They can be produced utilizing a closed-loop circular process and are thus considered renewable. Moreover, as the International Energy Agency (IEA) states in its 2021 World Energy Outlook, a further advantage of biofuels is that they can be adopted with minimal retrofit costs by end-users. As recently proven in Gothenburg, biofuels can utilize already existing gas turbines and infrastructures.

GROWING MOMENTUM FOR GREEN BIOFUELS

So, it´s no surprise that opportunities offered by green biofuels for both simple cycle and combined cycle power plants are piquing operators' interest. Swedish operators, such as Göteborg Energi and Stockholm Exergi, are at the frontline and supported by Siemens Energy.

Göteborg Energi produces both district heating and electricity at the Rya KVV power plant and plays an important role in the city's electricity supply. The validation of biodiesel (HVO-100) at the plant has proven its suitability with Siemens Energy medium-sized gas turbines using third generation DLE (Dry Low Emission) burners. While the utility facility plans to switch to green fuels in its SGT-800 gas turbines, it continues to collaborate with Siemens Energy to achieve this.

BECOMING A FOSSIL-FREE CITY

The successful tests in Gothenburg were of course good news for Stockholm Exergi, who provide heating, cooling, and electricity to the Stockholm area, and recently invested in an SGT-800 gas turbine as a backup application that will run on liquid biodiesel starting in 2025. This move will help the company reach its target of becoming climate-positive in its operations as well as be able to contribute to Stockholm's goal of becoming a

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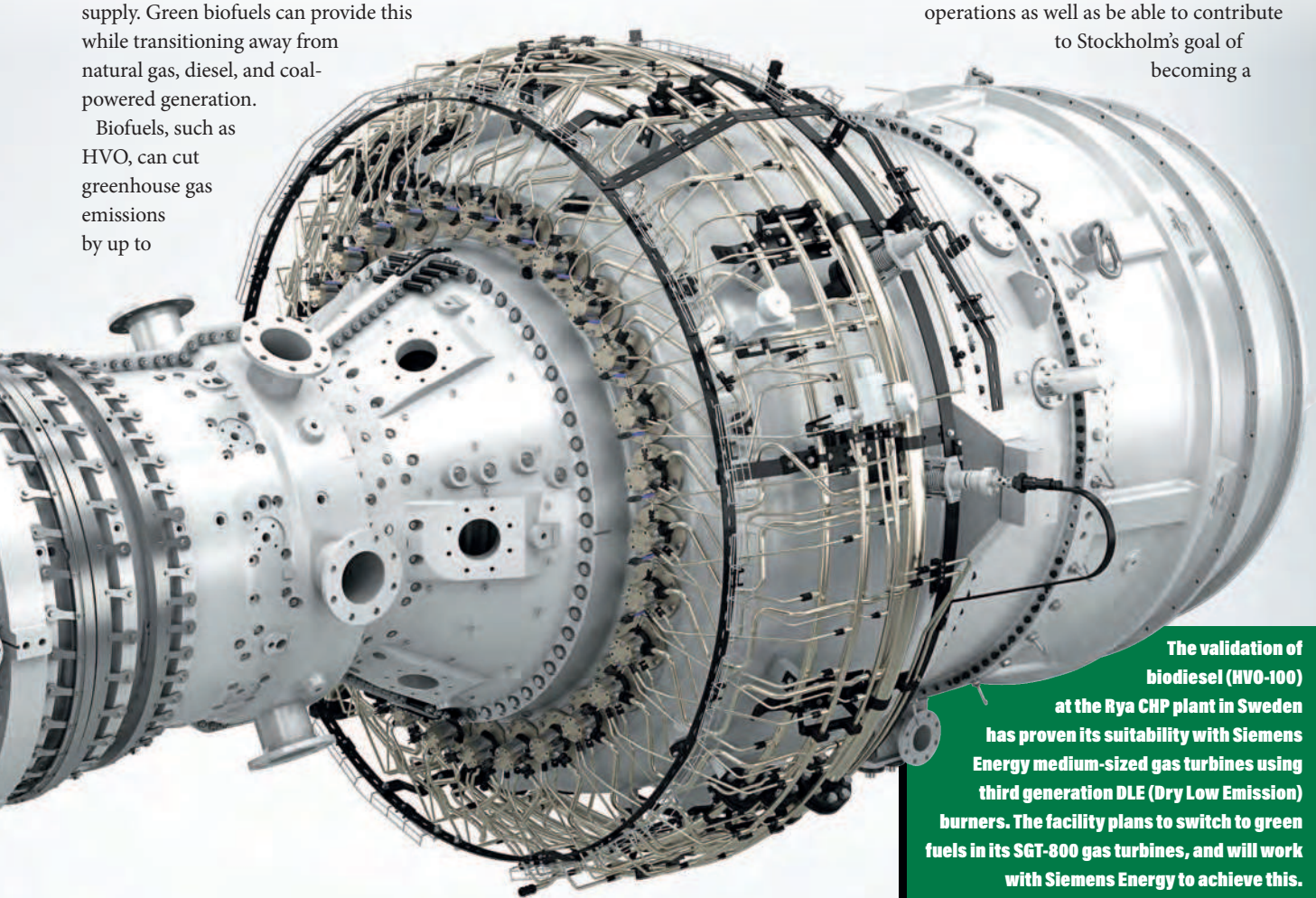

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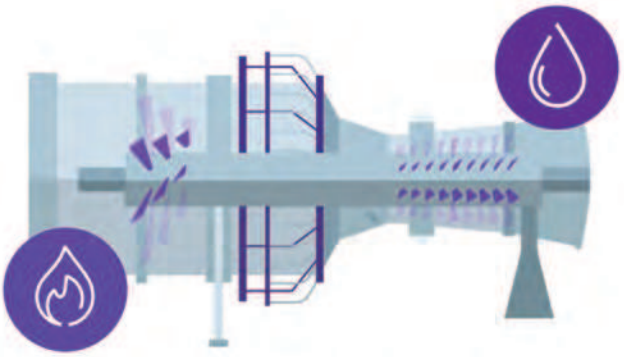
fossil-free city.

To ensure electricity for the entire city, the plant requires fast-starting dispatchable power with black-start capability. The new SGT-800 simple cycle gas turbine plant on biodiesel can provide this with a low carbon footprint. Stockholm Exergi's investment gives credence to biofuels having real potential for supporting the ongoing energy transition for power generation.



Our dual-fuel capable gas turbines can switch between liquid and gaseous biofuels at any moment – for maximum fuel flexibility.

THIRD GENERATION DLE BURNER DEVELOPMENT

"Green Biofuels are an important part of our gas turbine R&D roadmap. We are continuously developing our third generation DLE burners for wider fuel flexibility, and our gas turbines can already operate today on renewable fuels, such as biogas and up to 75% hydrogen. We have now shown the possibilities of also using liquid biofuels, providing increasing flexibility for our customers", says Hans Holmström, Vice President of the Industrial Gas Turbine business at Siemens Energy.

Siemens Energy is deploying innovative technologies, such as Additive Manufacturing (3D printing), to develop this next generation of flexible burners with greater speed and optimization. Additive manufacturing enables advanced burner designs with optimized functionality to handle different green fuels.

BIOFUELS CAN BRIDGE THE GAP

Siemens Energy is planning further fuel flexibility testing of both existing and newly developed burners going forward. The aim is to offer several alternatives soon for operating their turbines on 100% renewable fuels, including hydrogen and green biofuels.

At the same time, given Europe's ambitious targets for the scale-up of hydrogen, one might ask why not focus only on hydrogen as an alternative to natural gas? Why do we also need green biofuels? Without a doubt, building the necessary infrastructure as well as expanding renewables significantly needed for hydrogen production will take time. Biofuels, on the other hand, can add to the diversity of fuel supply much sooner and require less storage capacity than hydrogen due to their lower volumes. While hydrogen is undoubtedly set to be a dominant fuel of the future, biofuels can bridge the gap in the medium to short term as well as be a complementary fuel to hydrogen in the longer term.

SOLUTIONS TO BIOFUEL CHALLENGES

Biofuels are already available today and the IEA forecasts demand to grow by nearly 1.5 million barrels of oil equivalent per day. Fortunately, with emerging technologies, the fuel has robust scale-up potential.

For example, biomass gasification can be used to produce both gaseous and liquid biofuels from forest and agriculture waste. Though much of this waste isn't suitable for conventional biomass-fired power plants, it still can be efficiently used to produce advanced biofuels at scale and is ultimately more sustainable and significantly cost-efficient.

SUSTAINABLE FORESTRY SUPPORTS CO_2 REDUCTION

While biofuels still produce emissions when generating electricity and heat, they can come from a closed-loop renewable feedstock cycle. This requires growing as much biomass as is being harvested. But how they're derived is also important. EU taxonomy states that fuels produced from sustainable production, which are not obtained from land having high biodiversity or carbon stock and can provide more than 80% GHG saving, are considered sustainable.

The most optimal solution is using waste from agriculture and forestry for fuel production. Sustainable forestry, such as using timber as construction wood and forestry waste as an energy feedstock, can create negative CO_2 release as well as displace other CO_2-emitting materials, such as steel and concrete. This sustainability edge under current and upcoming EU taxonomy can help secure

BIOFUEL GROWTH

According to the International Energy Agency (IEA) predictions, annual global demand for biofuels is set to grow by 28% by 2026, reaching 186 billion liters. The United States leads in volume increases, but much of this growth is a rebound from the drop caused by the pandemic. Asia accounts for almost 30% of new production over the forecast period, overtaking European biofuel production by 2026. This is thanks to strong domestic policies, growing liquid fuel demand and export-driven production. Recent Indian ethanol policies and blending targets for biodiesel in Indonesia and Malaysia are responsible for most of the growth in Asia. India is set to become the third largest market for ethanol demand worldwide by 2026.

Between 2010 and 2019, global biofuel consumption expanded 5% on average per year, according to the IEA Although achieving the Net Zero Scenario's 14% average annual growth between 2021 and 2030 will require considerably stronger policies, similar expansion has been achieved in some countries and regions in the past. In fact, Europe, North America and several countries in Asia are considering or implementing policies that could accelerate biofuel demand.

financing for projects utilizing it.

As with hydrogen, biofuels face competition for supply, largely from the transport sector, and to a lesser extent, for product manufacturing. Therefore, it's important to develop gas turbine capabilities, so that many different fuels can be used. The operational profile of a gas turbine is already evolving along with increasing amounts of solar and wind entering the energy system. Gas turbine power plants are typically located closer to larger cities and can provide these cities with backup power using biofuels when renewable electricity supply is low or during times of peak demand. Electric power generation can even be varied in tandem with fluctuating power prices due to variable solar and wind power production patterns.

BIOFUELS ARE DEMONSTRATING THEIR VALUE

The future lies with the flexible. CHPs, which have efficiencies above 90%, can utilize biogas or liquid biofuel to provide important flexibility in the electricity market while also producing heat. This might mean operating for slightly fewer hours a year than today, at which time, current biofuel availability is likely to be sufficient.

Furthermore, by adding a thermal energy storage solution to the CHP plant, electricity production and heat supply can be uncoupled, enabling a more agile operational profile. This means that the generation of electricity can be varied to follow fluctuating power prices resulting from variable solar and wind power production patterns.

For district heating and cooling applications, thermal storage may consist of relatively simple water tanks, which can provide storage system benefits to the energy system at a fraction of battery system costs. As it allows the CHP plant to participate in supplying ancillary grid services, it can deliver additional value to the plant operator as well as contribute to a reliable and well-functioning energy system.

SETTING AN EXAMPLE FOR GREEN AND FLEXIBLE POWER GENERATION

Gas turbines can also complement batteries. They can start up quickly, though not as fast as batteries. However, whenever the need arises, they have the advantage of continuing operations for far longer. In wind-dominated energy systems, gas turbines are very competitive in balancing renewables, since fluctuations are relatively few, irregular, and longer in duration.

There is a myriad of opportunities presented by biofuels for existing and new power plant operators. Given the expected growth in energy demand, and gas supply challenges made acute by recent geopolitical events, the low carbon energy system of the future needs access to a wide range of solutions – biofuels can be one of them. Siemens Energy, along with Göteborg Energi and Stockholm Exergi, will certainly continue to be at the forefront of driving energy transition efforts forward and setting an example for green and flexible power generation. ■