Hydrogen CHP: The future has begun

Projects demonstrate the technology's potential in decarbonizing the energy supply.

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Courtesy APEX.

The hydrogen power center at APEX Energy Teterow GmbH, Germany.

One of the greatest gifts of technology is the ability to solve the challenges of humanity and to do so in new ways that are environmentally responsible and sustainable. Thanks to technology, it is possible to meet the demand for energy production while also achieving aggressive carbon reduction goals. For example, the development of hydrogen as a fuel source provides one of the most viable pathways to a low-carbon future.

After being discussed for decades, hydrogen is now in the early stages of large-scale adoption in the energy supply. As low-carbon fuel options evolve over the coming decades, it is clear that hydrogen will play a large role in decarbonizing our world both thermally and electrically.

There are several drivers of the growing demand for hydrogen as a fuel source. It has unique and highly compelling characteristics: Hydrogen emits no carbon in combustion and can be considered a zero- or lower-carbon fuel, depending on the energy source used in its production. It offers great flexibility and enhanced energy security, as it can be generated from a variety of resources either locally/on-site or centrally for distribution. In addition, hydrogen is an attractive alternative or complement to another major trend in decarbonization: electrification. This strategy cannot stand alone due to aging grid infrastructure, the intermittent nature of most renewables and the energy density constraints of battery storage. Hydrogen can also be used to supplement and/or replace fossil-based gaseous fuels in today's existing energy infrastructure.

The potential for hydrogen as a climate-neutral fuel for combined heat and power systems is currently being demonstrated in numerous commercially operating projects, including multiple installations in which 2G Energy Inc. is a partner.

POWER TO GAS TO POWER

One of the most common methods of producing hydrogen is electrolysis, in which electricity is used to split water into hydrogen and oxygen. This power-to-gas (P2G) process, which takes place in an electrolyzer, has the potential to produce "green hydrogen" – i.e., carbon emissions-free, when clean, renewable energy sources such as wind and solar power are used in the generation. ("Gray hydrogen" is produced primarily by reforming natural gas, which emits carbon; "blue hydrogen" captures and stores the emissions from that process). The hydrogen resulting from electrolysis is compressed and stored for use in such applications as hydrogen fuel cell electric vehicles and power generation. In this way, the hydrogen serves as an energy carrier, uncoupling electricity generation and energy consumption. Green hydrogen CHP systems can convert the gas back into electricity and heat or cold in an efficient and economically attractive way.

NATURAL GAS TODAY, HYDROGEN TOMORROW

Given its benefits and flexibility, hydrogen is getting increased attention as an important fossil fuel alternative.

The pathway to a hydrogen economy will require hydrogen to be phased in while natural gas is phased out. In the early 2020s, preparation for the transition to hydrogen through pilot programs will take place, while the late 2020s will see the activation of the hydrogen production market to support further growth. The 2030s will bring an expansion of the supply of hydrogen and of pilot programs to universities, commercial entities, municipalities and industrial clusters with hydrogen blends. By the 2050s, most of the gas being used is expected to be a combination of methane and hydrogen.

THE PATHWAY TO A HYDROGEN ECONOMY WILL REQUIRE HYDROGEN TO BE PHASED IN WHILE NATURAL GAS IS PHASED OUT.

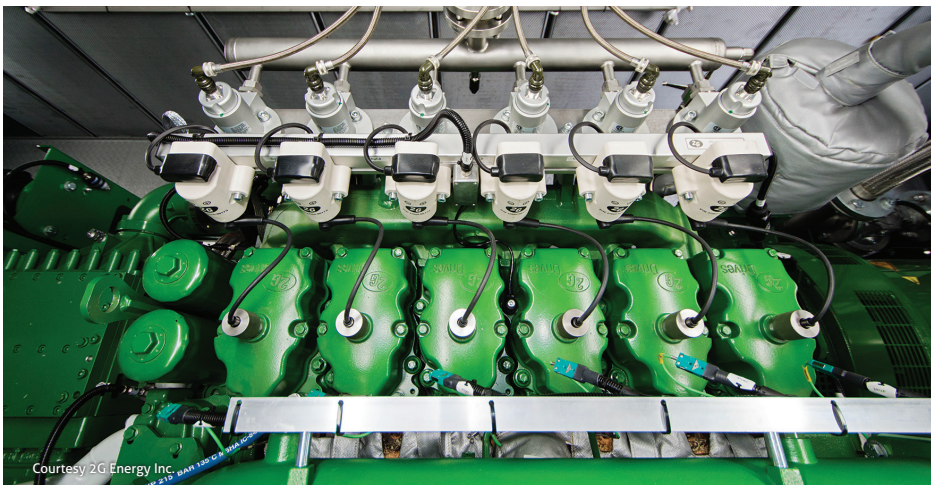
Natural gas is the bridge to a hydrogen-based future, facilitating the transition to greater reliance on renewables. With modest modifications, the current natural gas infrastructure can be used to transport blends of up to about 15 percent hydrogen. To accommodate higher-hydrogen blends in the range of 15 percent-50 percent, changes will need to be made to existing natural gas pipelines, such as an increase in compression capacity along distribution mains serving industrial users. For blends above 50 percent hydrogen, issues needing to be addressed include pipeline materials, safety and modifications required for end use.

With these types of modifications, hydrogen can be delivered using much of the current 300,000 miles of natural gas pipeline already in place in the United States. Local hydrogen production is already feeding pilot projects and other applications making use of this fuel.

Some natural gas engines are being manufactured today "hydrogen-ready" – able to operate on blends of hydrogen in natural gas or in some cases pure hydrogen. The hydrogen CHP units from 2G can operate on blends of up to 40 percent hydrogen with no modifications to standard gas products or up to 100 percent hydrogen with the addition of hydrogen injection systems. The availability of hydrogen-ready technology means that a natural gas CHP unit can be installed today and incorporate hydrogen in the fuel mix when and as it makes sense for the system. That may be when the supply of hydrogen is more readily available or the natural gas supply is reduced. For the first time, CHP can be considered a future-proof, carbon-free infrastructure investment.

DEMONSTRATED POTENTIAL

Currently, green hydrogen technology is being deployed in several innovative combined heat and power systems supplied by 2G. These CHP units with a reciprocating engine as the prime mover have been commissioned or sold to run on up to 100 percent hydrogen. Among these projects are four in Germany and one in the U.K. (The company currently also has another installation in Dubai and a distribution agreement in Japan.)



This hydrogen engine can be operated with 100 percent hydrogen as well as natural gas or biogas.

Berlin Brandenburg Airport

The world's first 100 percent hydrogen-burning CHP plant was installed in 2012 by 2G at the Berlin Brandenburg Airport (BER), at a "green hydrogen hub" known as H2BER. At this location, hydrogen is produced via electrolysis using wind power generated at a nearby wind farm. The hydrogen is stored and used at the hub at a multienergy fueling station and the CHP plant, which converts the green hydrogen into electricity and heat. Alternatively, the plant can be operated with natural gas (10 percent biomethane). The 160 kW CHP system supplies all of the fueling station buildings, including the H2BER control room, shop and vehicle washing area.

At the multienergy station, the hydrogen is offered for refueling fuel cell electric vehicles (dispensed from two pumps, one each for cars and buses) along with natural gas and liquefied petroleum fueling and charging points for battery electric vehicles. The company is also integrating a rooftop solar installation.

The carbon-neutral hydrogen is produced in a McPhy 650-psi, 500 kW alkaline electrolyzer that can create more than 200 kg (441 lb) per day of hydrogen, enough to refuel around 50 fuel cell electric vehicles. Hydrogen production at high wind speeds will also be tested and observed by scientists in a dedicated research campus as part of this project.

City of Hassfurt, Germany

After the installation of green hydrogen CHP at the Berlin airport, demand for the technology increased. In the city of Hassfurt, Germany, the local utility, Städtische Betriebe Hassfurt GmbH, expanded its existing power-to-gas plant by installing a hydrogen CHP system, commissioned in 2019. The system can run on 100 percent pure hydrogen without any integration of fossil fuels. It has a production capacity of 140 kW when fueled with hydrogen and 200 kW with natural gas. The plant supplies heat and electricity to utility

The Hassfurt green hydrogen CHP system – the first municipal application of the technology.

customers in the region. The project represents the first time carbon-free, renewable hydrogen has been used to generate electricity from CHP in a municipal installation.

THE HASSFURT PROJECT REPRESENTS THE FIRST TIME CARBON-FREE HYDROGEN HAS BEEN USED TO GENERATE ELECTRICITY FROM CHP IN A MUNICIPAL INSTALLATION.

The energy storage chain starts with local wind and solar power generation and continues with conversion into hydrogen on-site at the utility by electrolysis. The hydrogen is then stored in pressure vessels as fuel for the CHP plant. The hydrogen storage system allows for continuous operation at the facility, significantly increasing the flexibility of the overall energy system.

This groundbreaking project was funded by the Bavarian State Ministry of Economics, Regional Development and Energy. In addition to 2G, project partners included Stadtwerk Hassfurt GmbH and the Institute for Energy Technology at the East Bavarian Technical University Amberg-Weiden.

APEX Energy Teterow

Another hydrogen CHP case study is in northern Germany, where APEX Energy Teterow GmbH, a leading developer of green hydrogen production and storage systems, operates a hydrogen power center at its headquarters in Rostock-Laage. Inaugurated in June 2020, the hydrogen plant incorporates a 115 kW hydrogen CHP system with 1 MW of battery storage. The system generates electricity and heat for use at the manufacturing plant and office buildings.

It can be operated with up to 100 percent green hydrogen produced on-site from renewable energy using a McPhy electrolyzer that can generate up to 300,000 kg (more than 661,000 lb) per year. The hydrogen is stored in an APEX storage system, a fuel cell with 100 kW electrical power. In addition to its use in CHP, the hydrogen produced at the power center is also made available at a public hydrogen filling station on the factory premises that can supply up to 40 buses and 200 cars.

APEX Energy CEO Mathias Hehmann sees hydrogen CHP as a key source of environmentally friendly power for the future: "For industry and commerce, housing associations, for the intermediate storage of balancing energy, mobility solutions or for the connection of remote locations – hydrogen is the driving power behind a zero-emission future. The combined generation of power and heat in the H_2 CHP is an important component in this equation."

Neue Weststadt Urban Quarter

In Esslingen, in the Stuttgart region of southern Germany, another pure hydrogen CHP project serves a new urban quarter under development. The Neue Weststadt ("New West City") district will be home to 500 apartments, office and commercial space, and a building for the local university. The project offers a glimpse of the future standard for producing and using hydrogen in 10 to 20 years. The goal is to build an urban district with less than 1 ton of carbon dioxide emissions per resident per year for housing and transportation.

THE GOAL IS AN URBAN DISTRICT WITH LESS THAN 1 TON OF CO_2 EMISSIONS PER RESIDENT PER YEAR FOR HOUSING AND TRANSPORTATION.

This project uses an underground electrolyzer to produce green hydrogen with electricity generated from local rooftop solar installations, which is stored and then converted back into electricity via CHP. Fueled with up to 100 percent hydrogen, the CHP system supplies heat to the local heating network. An absorption chiller also effectively converts some of the CHP waste heat generated at a high-temperature level into cold, rounding off the reconversion of hydrogen to create combined heat, power and cooling. The CHP unit can work with a hydrogen-green gas mixture or pure green gas, so CHP operation is possible even if the electrolyzer fails.

The hydrogen produced in Neue Weststadt will also be supplied for use outside the district at a hydrogen filling station as well as fed into the local natural gas grid. A visitor and information center on-site will showcase the sustainable energy concepts applied in the district.

About the choice of CHP technology for this project, Manuel Thielmann, managing director of Green Hydrogen Esslingen GmbH noted: "A fuel cell would have converted a higher proportion of the energy contained in the gas into electricity, but the costs per installed kilowatt are many times higher than with a motorized CHP. And we couldn't have obtained a fuel cell in this performance class."

Scotland's Kirkwall Airport

In Orkney, Scotland, Kirkwall Airport has selected a 100 percent hydrogen CHP unit that will be coupled with its existing heating system. The installation will meet the heating and power requirements of the main airport buildings. The airport will deploy and demonstrate the 160 kW CHP unit for an extended trial period in 2021. The first such 2G system operating in the U.K., it will run on green hydrogen supplied by the Orkney Islands-based European Marine Energy Centre (EMEC).

The demonstration project is funded by the Scottish government via Highlands and Islands Enterprise. It is part of a package of initiatives to decarbonize the airport after a study by EMEC found that space and water heating in the airport terminal generated the most greenhouse gas emissions after aircraft operations.

According to Scottish Energy Minister Paul Wheelhouse, the project, the first of

Hydrogen-ready CHP technology at Kirkwall Airport, Scotland.

its kind in the U.K., has the potential to be replicated by airports across Scotland as the country aims to decarbonize the aviation sector. The Scottish government has set a goal for the Highlands and Islands to become the world's first net-zero aviation region by 2040.

THE PATH FORWARD

The world needs environmentally friendly and economic solutions in order to achieve growth without fossil fuels. Companies and governments will be rewarded for their commitment to the environment, sustainability and growth – all of which can be achieved with the introduction of hydrogen into the energy supply. Eliminating fossil fuels will not happen overnight. It will take great consideration, time and investment to implement. But hydrogen is key in this path to a zero-carbon and low-emissions future; and, as projects already show, hydrogen CHP can serve as the bridge from our fossil-fuel based technology to the economy of tomorrow.

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