A Voyage Fueled by Green Hydrogen

The technologies are ready: Supported by scientific imperative and driven by public pressure, green hydrogen is making the energy transition to a decarbonized future possible – especially in combination with highly efficient gas turbines.

*An outlook by **Karim Amin**, Siemens Energy's Executive Vice President Generation.*

When it comes to reducing carbon emissions, the world is quickly making its choice: Every week, almost every day, another country or another business announces its often very ambitious commitments for reducing CO2 emissions. Financing institutions have started to make investment decisions based on a company's sustainability and its environmental, social, and governance (ESG) declarations. So, it's no surprise that in the energy sector, the transition to zero CO2 emissions is on many people's minds.

But while the destination is clear, it's not quite as clear how to get there: how fast and on what route. As far as speed is concerned, a lot depends on regulations, which at present are lagging behind what's technologically possible. The route, in contrast, is already sketched out, because the technologies are available or in the process of being developed. It's important to bear in mind that there's no single technology that will take us to our destination. The technologies we need – and in which we're investing a lot of our R&D resources – include energy storage, heat pumps for district heating, carbon capture, and highly efficient gas turbines. Gas turbines specifically are of utmost importance for a decarbonized future, because they'll be co-firing more and more green fuels. There's no doubt that green hydrogen will play a significant role on our path toward a net-zero emissions future – as a long-term storage system for renewable energy or a medium that will be used in various sectors of the economy, be it mobility, industry, or buildings. But it's the combination of gas turbines and green hydrogen that will be the main focus of my argument here.

Improving the existing fleet

Let me begin with the existing fleet of gas turbines. One thing is clear: Coal-fired power plants will no longer be part of the energy picture. At Siemens Energy, we've stopped building new coal power plants; all we do is service the existing ones so that they run as efficiently as possible and emit as little CO2 as possible. The story is different, however, when it comes to gas-fired power plants. Here our focus is on how to run gas turbines with less CO2 emissions while at the same time securing our energy supply and its affordability. For instance, we can improve their efficiency with upgrades so that they'll consume less gas and thereby emit less CO2.

Increasing the hydrogen in gas turbines

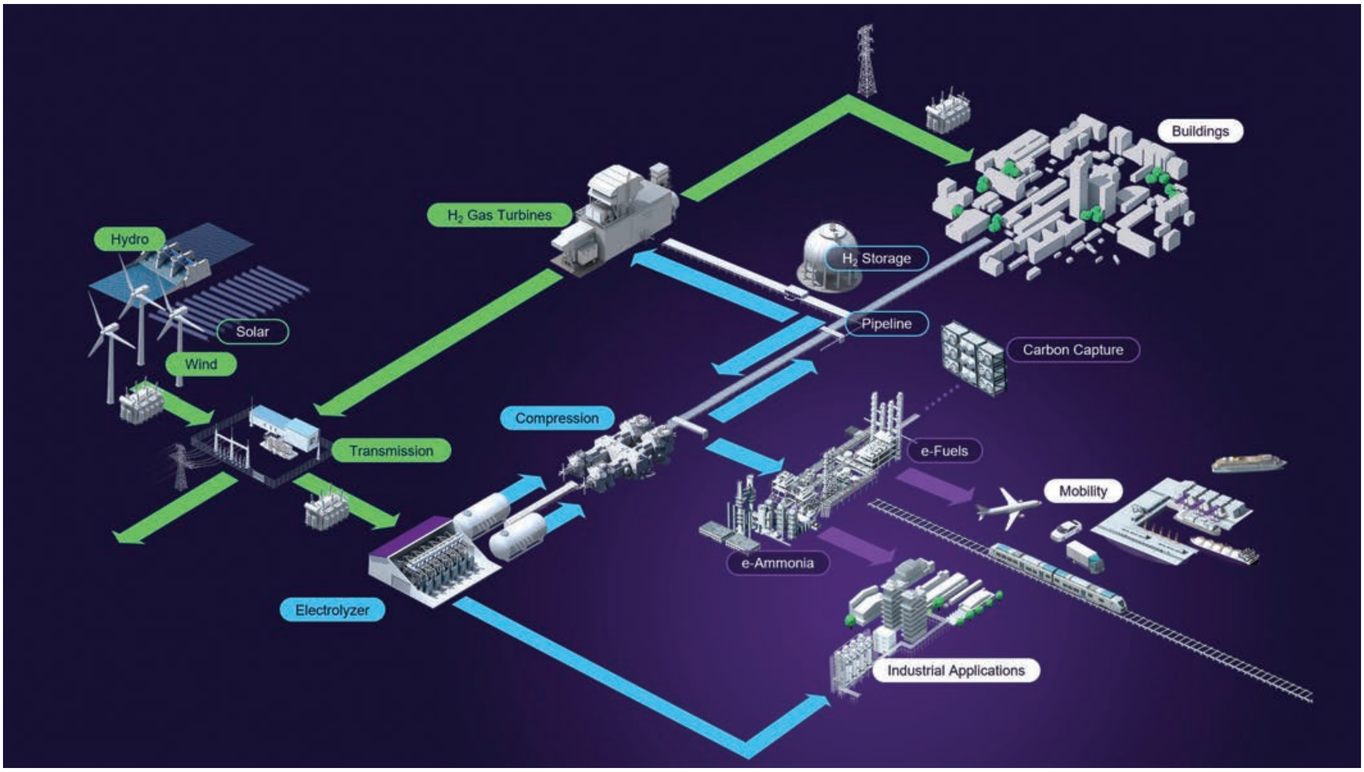
Even better, we can facilitate hydrogen co-firing using hydrogen produced from renewable energy, which results in even higher potential to reduce CO2 emissions. With today's technology, some of our gas turbines can burn up to 75 percent hydrogen. The average for our gas turbine portfolio is between 30 and 50 percent hydrogen. This figure is improving year by year, and we have a clear technology roadmap to reach 100 percent hydrogen by 2030.

At the Zero Emission Hydrogen Turbine Center in Sweden Siemens Energy is developing with partners a demonstration plant for a decarbonized energy future. Source: Siemens Energy

For example, if you replace an existing 1,500 MW coal power plant with a combined cycle gas turbine that runs on 30 or 40 percent hydrogen, that will save more than three million tons of CO2 every year. And because there are many countries that rely on gas power generation for the security of their energy supply, upgrading those units with hydrogen co-firing is an important part of our commitment. This includes the work we do at our Zero Emission Hydrogen Turbine Center in Sweden. The Center hosts an EU-funded study in which we're working with partners to develop a gas turbine test facility as a zero-emission demonstration plant.

Producing hydrogen the right way

It's of crucial importance that we produce hydrogen the right way. Traditionally, hydrogen is generated during the steam reforming process: CO is converted to CO2, and further down the process this is removed from the stream and emitted into the atmosphere. This blights the environmental credentials of this type of hydrogen: It's not green hydrogen but referred to as grey hydrogen, and it's highly inefficient. There are two ways to improve hydrogen's environmental footprint. First, we can capture the carbon emissions generated during production, resulting in what's commonly called blue hydrogen. Or we can use renewable energy for hydrogen production which, with the expansion of solar and wind, should be amply available. In this process, renewable energy is used for electrolysis with water, resulting in green hydrogen that's free of CO2 emissions. This is the route we're taking with the development of our proton exchange membrane (PEM) electrolyzers. This technology has distinct benefits over alternative methods: It's very safe, and it produces gas



Green hydrogen can be used as a long-term storage system or for various sectors of the economy, be it mobility, industry, or buildings. Source: Siemens Energy

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with an outstanding degree of purity.

Developing cost-effective electrolyzers

At present, we're working on several research projects to scale up the size of electrolyzers by scaling up automation in the manufacturing process and thereby reducing costs. However, it's important to note that we don't use electrolyzers as standalone products: They're always part of a solution. For instance, there could be an electrolyzer on the site of a wind or solar farm that uses green energy to produce hydrogen. Alternatively, it could also be located next to a gas generation plant that burns hydrogen in its turbines. As a guiding principle, we always look at solutions that combine different portfolio elements to optimize sustainability, security of supply, and affordability.

Advanced materials for turbines

I'd like to mention one other issue that we're dealing with, which is developing the materials needed for hydrogen combustion. We have a very clear roadmap here as well. The main challenge is that hydrogen burns differently than natural gas, so you need to have different designs for the burner nozzles to ensure that the flow of hydrogen delivers a stable flame. One technology that can help address this problem is additive manufacturing, or 3D printing. Although using additive manufacturing for gas turbines was originally conceived as a technology for the repair and refurbishment of burners in older turbines, over the years it's become mainstream in the development and manufacture of a number of parts for hydrogen-enabled gas turbines.

The right time for hydrogen

With all these technologies available, there is no doubt that we're ready to make hydrogen a successful part of our path toward greener energy. Except for one question, perhaps: Many of us, including me, have lived through several hydrogen "hype-cycles" over the past few decades. What's different this time? I have a simple response: What's different now, aside from advances in the technology itself, is that the environment where we operate is vastly different. The current energy transition is driven by both scientific imperative and public pressure. And so, we can see it clearly before us: our voyage toward a net-zero future fueled by green hydrogen. ■

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