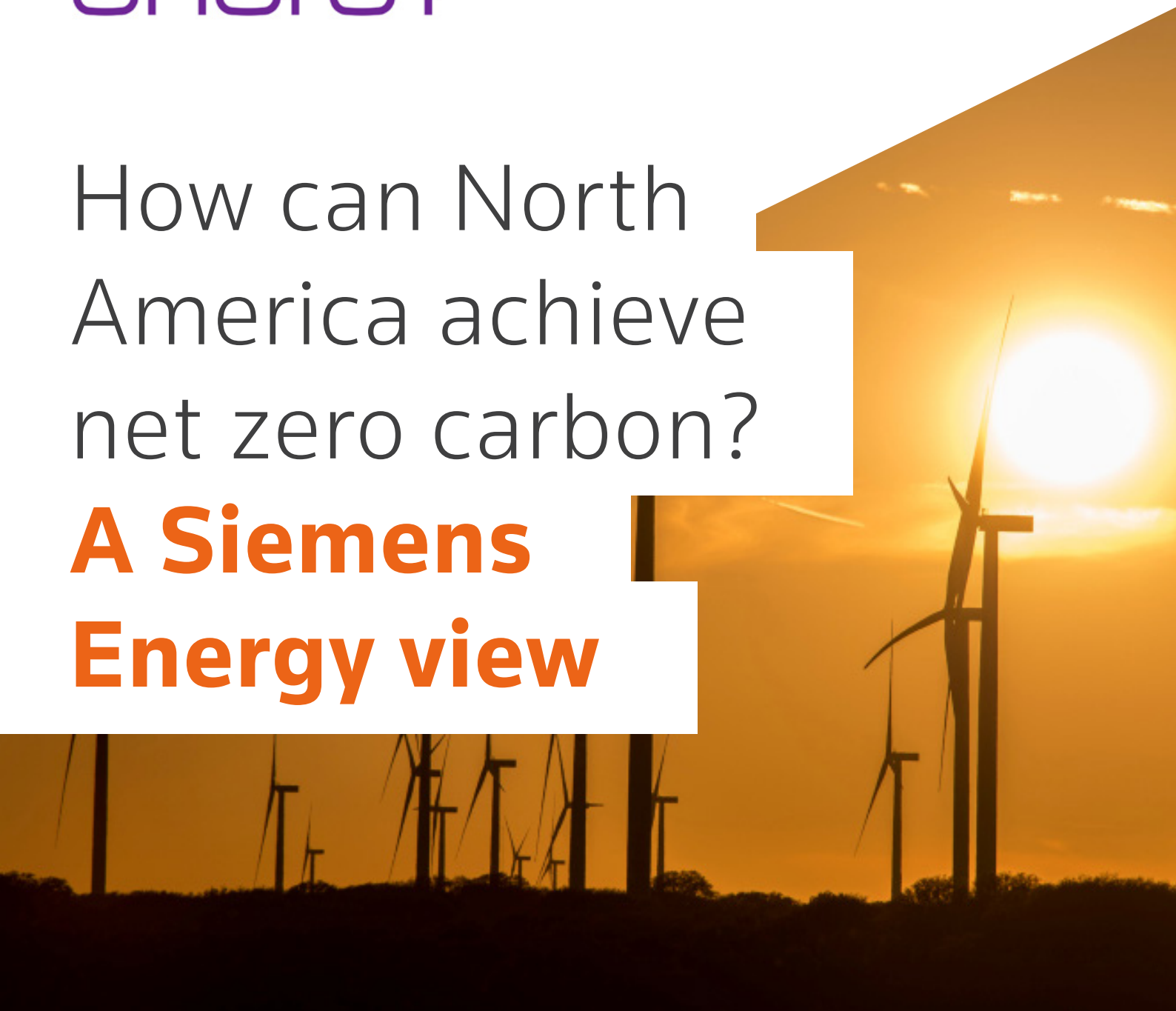
REUTERS EVENTS™

In partnership with

SIEMENS energy

How can North America achieve net zero carbon?

A Siemens Energy view



Contents

Executive summary

Humanity faces what is likely the biggest challenge in history. Without rapid action to curb carbon emissions, there will be environmental impacts of huge concern. The most important will include reduced snow and polar ice, leading to rising sea levels and increased coastal flooding and erosion. There will also be extreme weather events, with more precipitation leading to flooding in some places—while there is severe drought in others.

Meanwhile, more extreme heat waves will also bring a greater risk of forest fires. Secondary impacts from these changes include loss of species because of their inability to adapt to changing habitats, as well as more exposure to disease and invasive species. Human health will also be affected. There will be greater risks of death from dehydration, heat stroke, and respiratory, cardio-vascular and waterborne diseases. Various industries will be impacted as well, from agriculture to transportation infrastructure.

The only way to avert these outcomes is to eliminate carbon as far as possible from global energy systems. And North America must play a key role in this process, not only because the region is the world's second largest emitter, behind Asia, but also because the United States has long championed the carbon-based economy now wreaking havoc with the climate.

Luckily, North America is well placed to lead global decarbonization efforts, thanks to its industrial strength and history of innovation. The question for business leaders is what concrete actions need to be taken to embrace the low-carbon economy and plot an effective energy transition path.

Siemens Energy, which provides technologies and services right across the low-carbon value chain, is uniquely positioned to help answer this question. This paper, developed with input from several senior Siemens Energy executives, looks at the current state of energy transition policy in the United States and Canada, and what key approaches need to be considered on the road to low-carbon operations.

It also considers the main challenges facing decarbonization efforts, including the need to decarbonize the whole value chain and break down generation, transmission and distribution silos. One shift of particular importance will be the replacement of fossil fuels with low-carbon hydrogen in hard-to-abate sectors, such as heavy transportation and industry.

This paper looks at the role of transmission and the decarbonization of the high voltage electric grid, the impacts in the oil and gas sector and the potential applications of green hydrogen. Finally, the paper notes how Siemens Energy is well placed to act as a partner of choice in the decarbonization journey.

Net zero in North America

The United Nations (UN) recent IPCC report has made it clear that global warming is close to spiraling out of control and has sounded "code red" for humanity. Noting how the decade up to 2019 was the warmest ever recorded, and with a clear trend of global temperatures continuing an accelerated rise, the UN has made taking "urgent action to combat climate change and its impacts" one of its essential sustainability goals.

To overcome the crisis, the world must address the root cause of global warming, which is the release of greenhouse gas emissions into the atmosphere. These emissions must be dramatically reduced, which means there must be a massive effort to decarbonize on a global basis. Decarbonization literally means the reduction of carbon, in which fossil fuels are removed from the world so there can ultimately be net zero carbon emissions.

There is a global consensus that net zero must be achieved by 2050 if the world is to limit the rise in global temperatures to 1.5°C, the point at which the negative environmental impacts can be considered manageable. The new federal administration in the United States, under President Joe Biden, has communicated that combating climate change is a top priority.

In the campaign leading up to his election, Biden announced that in the early part of his first term he would focus on nine actions that move the country toward decarbonization. These are:

- **Executive actions for emission limits.** In his first day in office, Biden reversed key policies of the previous administration, including putting in limits on methane emissions for new and existing oil and gas operations.
- **Halving greenhouse gas emissions by 2030.** The Biden administration has pledged to reduce greenhouse gas emissions by up to 52%, compared to 2005 levels, by 2030. This more than doubles the commitment the United States had given in 2015 as part of the Paris climate agreement.
- **Rallying the world.** Biden convened a climate world summit within his first 100 days in office, to try to persuade other countries to follow the lead of the United States. The clear intent is to put the nation in a global leadership position on decarbonization.
- **Investing in clean energy.** Within the Biden administration's infrastructure bill, there are large commitments to build out clean energy infrastructure. That includes $174 billion to boost the electric vehicle market and $100 billion to update the grid.

- **Accelerating the deployment of clean technology.** The administration is promising to reduce the carbon footprint of the U.S. building stock by 50% by 2035. This is to be achieved by incentives for retrofits spanning appliance electrification, efficiency, and on-site clean power.
- **Environmental justice.** The administration is mandating all federal agencies engage in community-driven approaches to deliver solutions that reverse environmental injustices disproportionately affecting communities of color, indigenous populations, and low-income areas.
- **Polluter accountability.** Public companies must disclose climate-related financial risks and operational and supply chain greenhouse gas emissions. Legislation has been promised that will require polluters to be responsible for the full cost of their climate pollution.
- **Creating green jobs.** The administration has an objective to create 10 million high-quality jobs to help prevent, reduce, and withstand climate-related impacts. This includes line workers for the electrical grid, technicians capping abandoned wells and electric vehicle builders.
- **Assisting communities and workers in the transition away from fossil fuels.** The administration has pledged to offer greater support for coal miners in getting health-related benefits and is establishing a task force to help communities affected by the shift to renewables.

After months of negotiations and despite deficit concern, the Senate recently passed Biden's bipartisan $1 trillion infrastructure bill. Whilst it remains to be seen how the largest long-term U.S infrastructure investment in almost a century will unfold, the political mandate for U.S. decarbonisation is now clear.

Over the border, Canadian policy has tended to be a little more aggressive in combating climate change when compared with the United States, mainly because of a willingness to introduce carbon taxation. This difference is generally mirrored by the beliefs and attitudes of the countries' respective populations.

Public opinion surveys show that both countries have substantial backing for taking decarbonization actions and combating climate change, with Canadians modestly more supportive. However, "when you look at Canada, it's significantly different province to province," Rich Voorberg, President, Siemens Energy North America, says. "For example, if you look at Quebec, which is heavily involved in hydroelectric, they've got a lot of green power. And then you look at Western Canada, where they still have a greater dependence on fossil fuels."

Want to hear more from Siemens Energy?
Join us at Reuters Events: Energy Transition North America (December 6 -7, 2021) to hear more!

Understanding approaches to net zero

Given the magnitude of what decarbonization entails, it must be embraced with a sense of urgency. Furthermore, experts at Siemens Energy have identified three other key factors for success:

- **Everyone must do their part.** All segments of society, and every individual, has a role to play. As Voorberg puts it: "It's really an amalgamation of what the energy producers can do, what we can do, and then what universities, different agencies and governments can do. And we must partner together to make this happen."
- **A wide variety of technologies and solutions is needed.** There is no singular technological magic bullet that will deliver total decarbonization. Instead, a wide variety of technologies and technical solutions are required. That includes everything from nuclear energy, natural gas, carbon capture, and renewables as well as new transmission technologies that offer net zero equivalent greenhouse gas emissions and optimize operation of the grid.
- **Government incentives are essential.** Governments have a central role in galvanizing players, especially through taxation and related financial incentives. Voorberg emphasizes these must be over a short-to-medium timeframe, because long-term incentives could create a false economy.

However, once the government provides what is needed to get the marketplace moving, experts say R&D and other investments will take off and the solutions will become more economical, more widespread and ultimately self-sustaining. In the United States, the Department of Energy, working with universities, can be an essential player in this process.

That was the case with wind and solar, which took a long time to become established, and where market growth was ultimately only made possible through tax incentives and support from government agencies. It is likely, therefore, that innovations such as low-carbon hydrogen will follow that same model.

How can companies be sure of taking the right path towards decarbonization? Based on discussions with customers in the power and industrial applications sectors, Siemens Energy offers the following fundamental guidelines:

- **Create a plan and start executing it immediately.** The plan will change over time, especially as it gets closer to 2050, but it is critical to begin taking actions that get things moving in the right direction. Smaller changes such as technological upgrades, can make incremental reductions in emissions in the short term while working towards a larger solution, such as a major asset replacement in the long term.
- **Introduce prototypes as an early part of the plan.** There needs to be boldness right from the earliest stages of the plan, with a willingness to try to prototype solutions and see what happens.
- **Adjust the plan over time.** As the process of trial-and-error learning unfolds, plans will evolve and road maps will change. That should be expected and embraced. What is not successful will be dropped. What is successful will be refined and grown; and new alternatives and technologies will be developed.
- **Ensure progress is tangible.** Initially, the focus should be on goal setting and expressing ambition toward reaching carbon neutrality. But there must soon be a subsequent step in companies' plans that is focused on progress measurement and reporting actual numbers.
- **Align everyone in the organization.** "That means all employees, not just the C-level," says Arne Wohlschlegel, managing director at Siemens Energy Canada. "The whole organization has to be on board and work towards this new plan."

The challenges of decarbonization

There is no one switch that can be turned on one night to ensure that everything is decarbonized the next day. There is going to be a long transition period. Existing assets and methods will need to gradually get phased out or upgraded. Hence, "I always caution about the timelines," Voorberg says. "Yes, we need to act now. But how long will that really take? Realistically, we are not going to see the results in the next couple of years. This willstart now with prototypes and pilots and develop over the next few decades."

The scope of change is enormous and includes the following challenges.

The whole value chain must be decarbonized
The process of decarbonization is "going to be huge," says Voorberg. "A lot of things are going to become much more electrified."

There can no longer be the decades-long separate silos of generation, transmission and distribution
To ensure grid stability, "lots of activities will have to happen in parallel," says Wade Lauer, senior vice president for transmission at Siemens Energy in North America. "We're going to have to be working hand-in-hand on the grid priorities to manage these additional unstable, fluctuating energy sources."

Some tough technical hurdles must be overcome
The intermittency of renewables limits their potential impact. "Managing the intermittency of renewable energy requires energy storage, so you would have to add another energy system to your generator and that increases the capital expenditure," says Wohlschlegel. "Firming up and backing up renewable energy will be a priority for grid operators."

The economics are uncertain
For new energy sources like green hydrogen, the cost of production must come down, while production capabilities scale up. "The simple part is utilizing hydrogen in one

of our turbines," says Voorberg. "The tough part is to make the economics work by producing inexpensive green hydrogen."

There must be a viable market for new renewable sources like green hydrogen
"We are starting to see projects developed in the market that are larger than pilot demonstrators," notes Wohlschlegel. "The biggest hurdle for these projects is financial viability."

New levels of financial risk must be managed
"To finance a project, a business case looks at off-take agreements, fuel prices, capital and operational expenditures," he adds. "With uncertainty during the energy transition, long term off-take agreements are more difficult to secure, and financing now needs to be based on short term off-take or merchant power pricing. You cannot get off-take agreements for 20 and 30 years anymore. It's more like five or seven years. So, there are greater market risks."

Emerging project execution risks must be managed
Wohlschlegel also believes there should be new approaches to project management with a focus on new ways of managing risks. In the energy transition "there is a higher development risk as we work with new partners and new technology," he states. "As an example, there are increasing supply chain challenges in a global economy, not only due to the pandemic, but also with international trade agreements and transportation infrastructure shortages that are causing delays. How you manage these risks?"

There is risk from lack of regulation clarity
Regulatory uncertainty must be fixed for decarbonization to proceed, Wohlschlegel says. "People are hesitant to pull the trigger on investments if they are not clear what the regulation will look like in the short or in the long-term," he points out. "That's the big question for hydrogen projects."

Want to hear more from Siemens Energy?
Join us at Reuters Events: Energy Transition North America (December 6 -7, 2021) to hear more!

The role of transmission

Power transmission's vital role in decarbonization includes being the vehicle for efficiently integrating clean energy into the power grid while simultaneously keeping it stable. Distributed clean power installations need a method of transport to the users of that energy. "They can make the best wind turbines in the world and it doesn't mean anything if we can't get it efficiently transmitted to the load centers. Transmission is the enabler to make clean energy happen," says Lauer.

"As energy generation becomes increasingly diversified, the big challenges our customers are facing evolve around reliability and grid stability," notes Lauer. Understanding how to cleanly transport power to consumers and integrate mixed renewables whilst maintaining high levels of operational integrity is essential.

The grid needs to be modernized, expanded, and made more efficient in order to more effectively manage the growing influx of renewable energy. "Imagine injecting 30 gigawatts of wind power into a system that is not prepared to take it! We are introducing all these new fluctuations in voltages onto a grid that is decades old. It was never developed for these mixes of sources, it was always thought to be one-way flow from the large power generation plants to the load centers. That needs to be addressed. The grid has to increasingly accommodate bi-directional flow, where traditionally, it has been considered one-directional."

Additionally, upgrading equipment can eliminate harmful SF6 (sulfur hexafluoride) gases. "Our Blue portfolio of transmission products uses compressed clean air as the insulation medium instead of SF6 or any other F-gases (gas mixtures that contain Fluorine), which are powerful greenhouse and hazardous toxic gases that we want to remove from the transmission grid." Says Lauer.

The impacts on the Oil and Gas sector

Contrary to some preconceptions, the oil and gas sector in North America has been at the forefront of global decarbonization and greenhouse emission restrictions. In the US, there has already been some important measures implemented to reduce CO2, NOx, and methane emissions. "A concrete example is the permitting of pipelines," says Patrice Laporte, vice president of industrial applications for Americas sales at Siemens Energy. The single digital NOx emissions in some states is "probably one of the strictest regulatory environments in the world."

The industry is not starting from scratch, but the oil and gas sector must further reduce their level of emissions in order to maintain a long-term position in the energy mix. This is the challenge. Whilst Laporte suggest that this has already started, with some oil and gas companies taking the lead by committing to carbon neutrality long before government regulations force them. However, all oil and gas companies must focus on improving efficiency, reducing emissions through technology, and carbon capture to continue to decarbonise their emission scopes.

Long-held assets need to be upgraded in order to improve efficiency so emissions can be reduced while achieving the same level of output. Additionally, a new mix of energy sources should be used by integrating hydrogen and other renewables sources.

"To produce hydrogen, to transport hydrogen, and even to consume hydrogen, is not new," says Laporte. "Some companies have been doing this for decades. But they have been doing this based on [carbon-intensive] grey or [relatively cleaner] blue hydrogen. What is new now is that green hydrogen from the electrolyzer technology with a power source coming from renewable is aiming to compete in the middle term with the traditional fossil fuel energy."

"On top of that," Laporte adds. "new carbon capture technologies will not only help capture the carbon but monetize it too."

Want to hear more from Siemens Energy?
Join us at Reuters Events: Energy Transition North America (December 6 -7, 2021) to hear more!

A deeper dive on hydrogen

The prospects for hydrogen as a decarbonization solution have exploded in the past two years as new developers and existing utilities recognize its potential.

Utilities are actively looking at ways of incorporating hydrogen into their operations as a viable, long-term alternative source of energy. "As the utilities companies try to figure out how to decarbonize their current plants, they see that they can put hydrogen into gas blending for their gas turbines," says Katy Perry, proposal manager within the new energy business at Siemens Energy.

"The use of coal is still a big issue and hydrogen can help there," says Perry. "Hydrogen can be one of the major catalysts to help us fight climate change because it can help reduce or eliminate different emission contributors."

Elsewhere, hydrogen can play a key role in reducing the emissions of various industrial processes. For instance, says Perry: "Concrete is a sector that emits something like 6% of the world's emissions. Electrolyzers can be used to produce hydrogen to address that. We're also seeing how it can be used for industrial applications like ammonia or fertilizer."

She adds: "Right now, that specific industry is using gray hydrogen which is not friendly to the planet. These companies want to clean that up and produce hydrogen in more of a green form, while still getting the same product."

Finally, hydrogen can be essential for reducing emissions. But for widespread adoption, there must be a focus on making the economics work. It has to become much less expensive to produce green hydrogen. Today, says Voorberg, you can produce green hydrogen for about $4.50 a kilogram. "We expect that by 2025 it will be down to about $1.50," he says. "But even at $1.50 per kilogram, the economics are still tough. When you evaluate the business cases, the lower cost of natural gas makes it very hard to switch to hydrogen."

Early players know the price must come down a long way, but "they are rolling the dice and taking the risk, hoping that they see a return on investment in five or 10 years," Perry says. "Until we see more demand in the market, it's not going to go any lower. But I also think that the government, specifically the Department of Energy, has a role to play here by offering tax incentives."

In the short and middle term, says Laporte, "gas will remain the more predominant clean source of energy. However, we are likely to see an increased quantity of hydrogen to be transported as part of the mix through the existing pipelines. Current technologies enable this without any significant investment."

The partner of choice

Siemens Energy is poised to become the partner of choice for the decarbonization journey, working with customers to jointly devise and implement innovations and solutions. "As a technology and a service provider to the industry, we are already well-positioned to help our customers decarbonize their operations," says Wohlschlegel. "Our mission is to support them in transitioning to a more sustainable world based on our technologies and our abilities to turn ideas into reality."

The company is focused on five fields of transformative actions that are going to be increasingly relevant to customers focusing on decarbonization, he says. These are:

- Power to X, or sector coupling using hydrogen as a building block.
- Decarbonized heat and industrial processes.
- Condition-based service interventions.
- Resilient grids and reliability.
- Energy storage.

The breadth of the decarbonization solutions, technologies and expertise Siemens Energy can offer customers is unique in the industry. "If you look at our portfolio, we have more than 50 technology solutions, covering everything from the near-term to the medium-term to the long-term for shifting from where we are today to getting to a fully decarbonized world," Voorberg says.

"Everyone has a different plan and path forward, and no one can do it all with just one technology, so we have the whole spectrum covered."

Importantly, Siemens Energy is also in a superior competitive position when it comes to hydrogen.

"We are the only OEM [original equipment manufacturer] that can produce, transport and burn hydrogen inside the turbine," Voorberg notes.

A big part of Siemens Energy's hydrogen proposition is in turbines. "That means we can go to a customer and say: 'If you want to burn 50% hydrogen today, we know how to do that,'" says Voorberg. "We can supply you with the equipment. We can even install it, commission it and run it through for you."

That's "a huge benefit," he says. "Remember that these are all new technologies. Customers don't have the experience they used to have. A lot of them have outsourced that because they have had a lot of their subject matter experts retire and not be replaced."

Relying on an all-round industry leader such as Siemens Energy has other advantages for hydrogen customers, Voorberg says. "They don't want many different contracts where there could be gaps or overlaps within contracts," he says. "Instead, we can offer a full solution when it comes to hydrogen."

Beyond hydrogen, Siemens Energy offers compelling and innovative technology solutions for decarbonization, spanning generation, transmission and industrial applications. "Reliability of the grid system is critical, and it's a priority for Siemens Energy with our technology on the high-voltage side," says Wohlschlegel.

Hence, "when building a power generation plant or a high voltage transmission project, customers rely on our experience," Wohlschlegel says. "They say: 'You've done it many times. You are the experts. We trust you.'"

Want to hear more from Siemens Energy?
Join us at Reuters Events: Energy Transition North America (December 6 -7, 2021) to hear more!