Hydrogen Overview for Aeroderivative Gas Turbines

TAKEAWAY: 01

GE supports customers in their decarbonization* journey, including hydrogen, carbon capture, coal-to-gas switching or other approaches.

TAKEAWAY: 02

GE has more than 100 gas turbines operating on hydrogen fuel blends that have accumulated more than 8 million hours of operation.

TAKEAWAY: 03

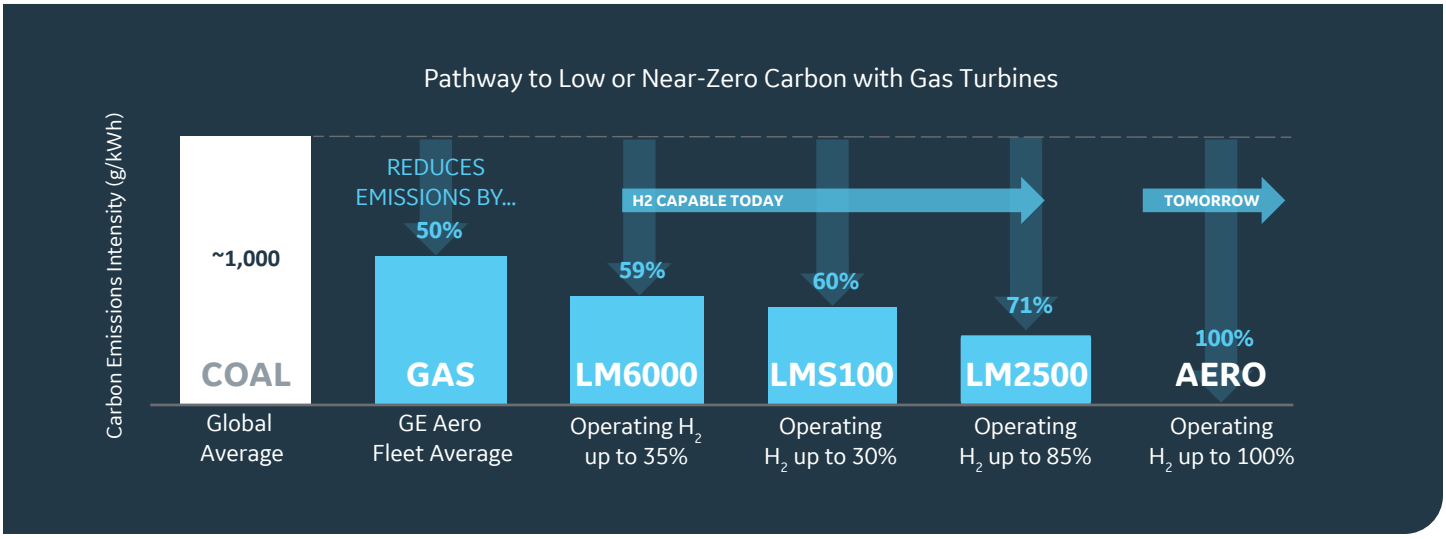
GE is partnering with customers on both hydrogen demonstration and commercial projects across the globe.

ENERGY TRANSITION: A DECADE OF ACTION

- The energy transition remains the greatest uncertainty for the power sector today. While the sense of urgency to address climate-change has never been higher, the pace and scale of investments must increase significantly in order to meet decarbonization goals.
- More work needs to be done to reduce the cost of hydrogen and carbon capture and sequestration technologies to accelerate their deployment. These technologies have the potential to significantly enable near-zero-carbon power generation and some governments are offering incentives to foster adoption.

HYDROGEN AS A FUEL FOR GAS TURBINES

- Burning hydrogen is a potential pathway to decarbonize gas turbines by replacing natural gas fuel with hydrogen, which has no carbon, and therefore, no CO_2 in the exhaust. One area to consider when burning hydrogen is that more NO_x may be produced compared to natural gas.
- Most (~95%) of the hydrogen produced today is produced using natural gas via the Steam Methane Reforming process, with the resultant CO_2 released to the atmosphere. This is called **"grey" hydrogen.**
- Adding a carbon capture system to this process results in **"blue" hydrogen.**
- **"Green" hydrogen** is produced by electrolyzing water into hydrogen and oxygen using renewable energy as the power source.
- **A gas turbine does not care which "color" hydrogen is used as fuel.**



OVER

CHALLENGING HYDROGEN ECONOMY

- Low carbon hydrogen fuel costs are trending lower, but are expected to remain 2–10X more expensive than natural gas at least through the end of the decade.
- Carbon taxes or other incentives may improve the economics of hydrogen compared to fossil fuels, but we anticipate that hydrogen will be used in long-haul transportation, maritime shipping, and industry before it is broadly adopted in the power sector.
- With large scale RE addition in some countries and price point of $1.0 to $1.5/Kg for green hydrogen by the end of this decade, power generation based on green hydrogen can be expected.

DELIVERING VALUE FOR ITS CUSTOMERS

- Power plant operators are increasingly exploring the option to use hydrogen as a fuel and requesting OEMs to identify their specific capability.
- GE has more experience burning hydrogen than any other OEM. This experience goes back to the mid-1990s and includes more than 100 gas turbines that have accumulated more than 8 million** hours of operation. This experience enables us to understand the unique challenges using hydrogen as a gas turbine fuel.
- GE's aero derivative gas turbines operating on hydrogen can be a great substitute to oil fired peakers thus providing net zero CO_2 to the grid or as a viable complement to renewables

NEW HYDROGEN PROJECTS WITH AERO GAS TURBINES

New York Power Authority (NYPA) – Brentwood Power Station (NY, USA)

- NYPA-led, first-of-its-kind demonstration project
- LM6000 combustion turbine currently fueled by natural gas
- Investigate the potential of substituting REN H_2 for a portion of the natural gas used to generate power
  - Evaluate different concentrations of H_2 blended with natural gas at regular intervals
  - Assess the blend's effect on reducing GHG emissions and its overall system and environmental impacts, including NO_x emissions
  - The project will begin in Q1 2022 and is expected to last six to eight weeks

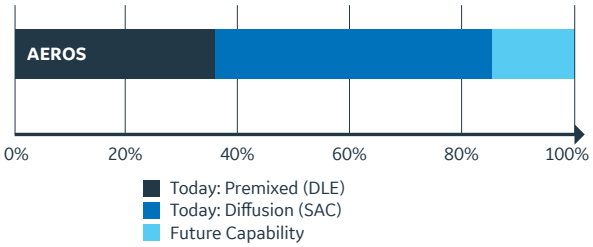
Black Hills Energy – Cheyenne Prairie Generating Station (WY, USA)

The Wyoming Energy Authority announced that it will provide an award to Black Hills Energy under a recent RFP for the development of hydrogen pilot projects.

- GE's scope will be to support a conceptual engineering assessment of equipment modifications of GE LM6000 combustion turbines to accommodate blended fuel mix of hydrogen and methane.

GE GAS TURBINE HYDROGEN CAPABILITY

- Each gas turbine model has specific capability for burning hydrogen, dictated primarily by the combustion system. Some are capable of burning 100% today.
- Our most versatile aeroderivative gas turbine, the LM2500, is capable of burning as much as a 85/15 hydrogen/natural gas blend.
- Work is underway to increase hydrogen burning capability across the entire aeroderivative portfolio, with a specific goal of achieving 100% capability within the decade.
- Existing gas power plants can be retrofitted to burn higher volumes of hydrogen than originally contemplated. These upgrades can be scheduled with planned outages to minimize the time the plant is not generating power, and for new units these capabilities can be part of the initial plant configuration or phased in over time as hydrogen becomes available.



CONCLUSION

- There is tremendous industry "buzz" around hydrogen, and it holds promise for decarbonizing the energy sector.
- However, because of the huge quantities of fuel needed for a gas power plant, questions remain about the timing of sufficient quantities of cost-competitive hydrogen for the power sector.
- Regardless of what challenges there are for building a hydrogen economy, our purpose is to support our customers on their hydrogen journey.
- Pilot projects are already demonstrating GE's technical leadership and innovation in decarbonization technology and we continue to build partnerships to deliver decarbonization solutions today, and at the same time build a more differentiated offering for our customers.
- GE's hydrogen fueled aeroderivative gas turbines can provide excellent peaking capability to the grid or as a viable complement to renewables.

For more information, visit our website: **gepower.com/hydrogen**

*Decarbonization in this paper is intended to mean the reduction of carbon emissions on a kilogram per megawatt hour basis.
**GE H_2 statistics as of September 2021: inclusive of both heavy-duty and aeroderivative gas turbines.