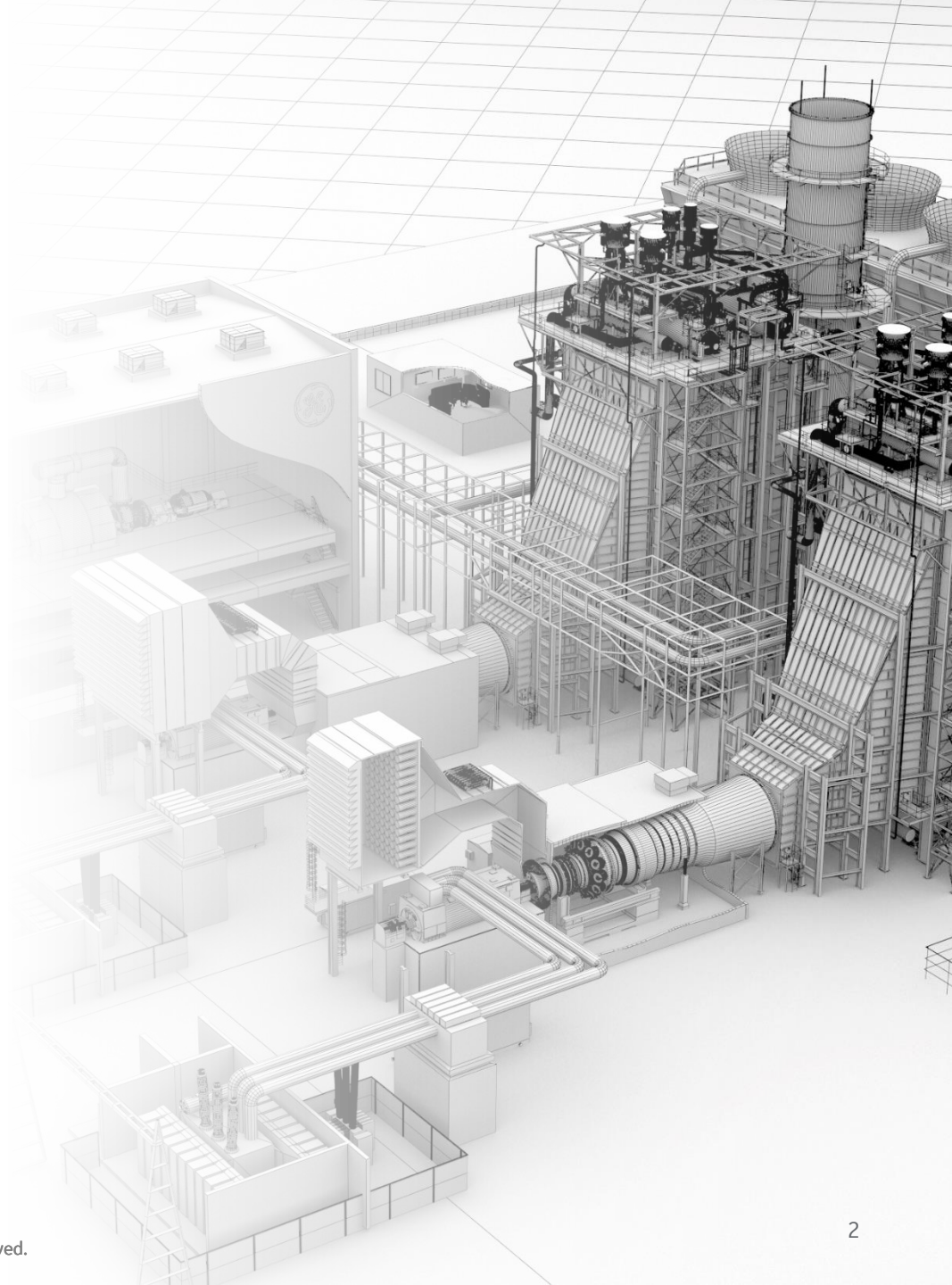
Gas Turbines: Hydrogen Capability and Experience

A presentation to the DOE Hydrogen and Fuel Cell Technology Advisory Committee

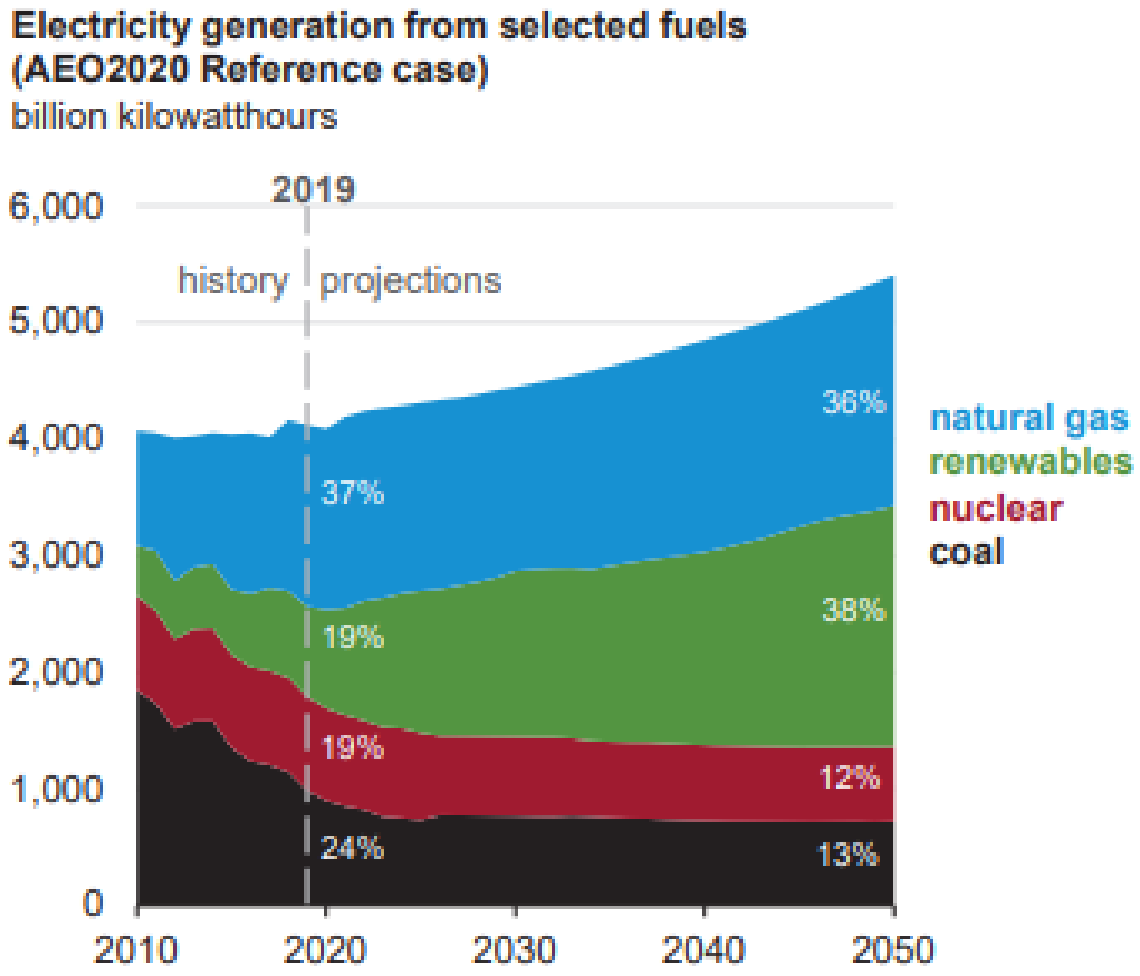
Dr. Jeffrey Goldmeer
Emergent Technology Director, GE Gas Power
9 March 2020

Overview

- Gas turbines are capable of operating on a wide variety of fuels, including hydrogen and other low heating value fuels
- Hydrogen and other low heating value fuels have been used to power gas turbines for decades
- Gas turbine based power plants can be configured to operate on these fuels as a new unit, or upgraded at a later date



The role of gas turbines



Source: EIA AEO 2020

- Today, natural gas provides 37% of electricity generated in the US
- The EIA's forecast shows this percentage staying effectively the same for the next three decades
- Therefore as we look at a transition to decarbonized energy ecosystem, we need to include the current gas turbine fleet

KEY THEMES

1

Gas turbine intro & combustion technology

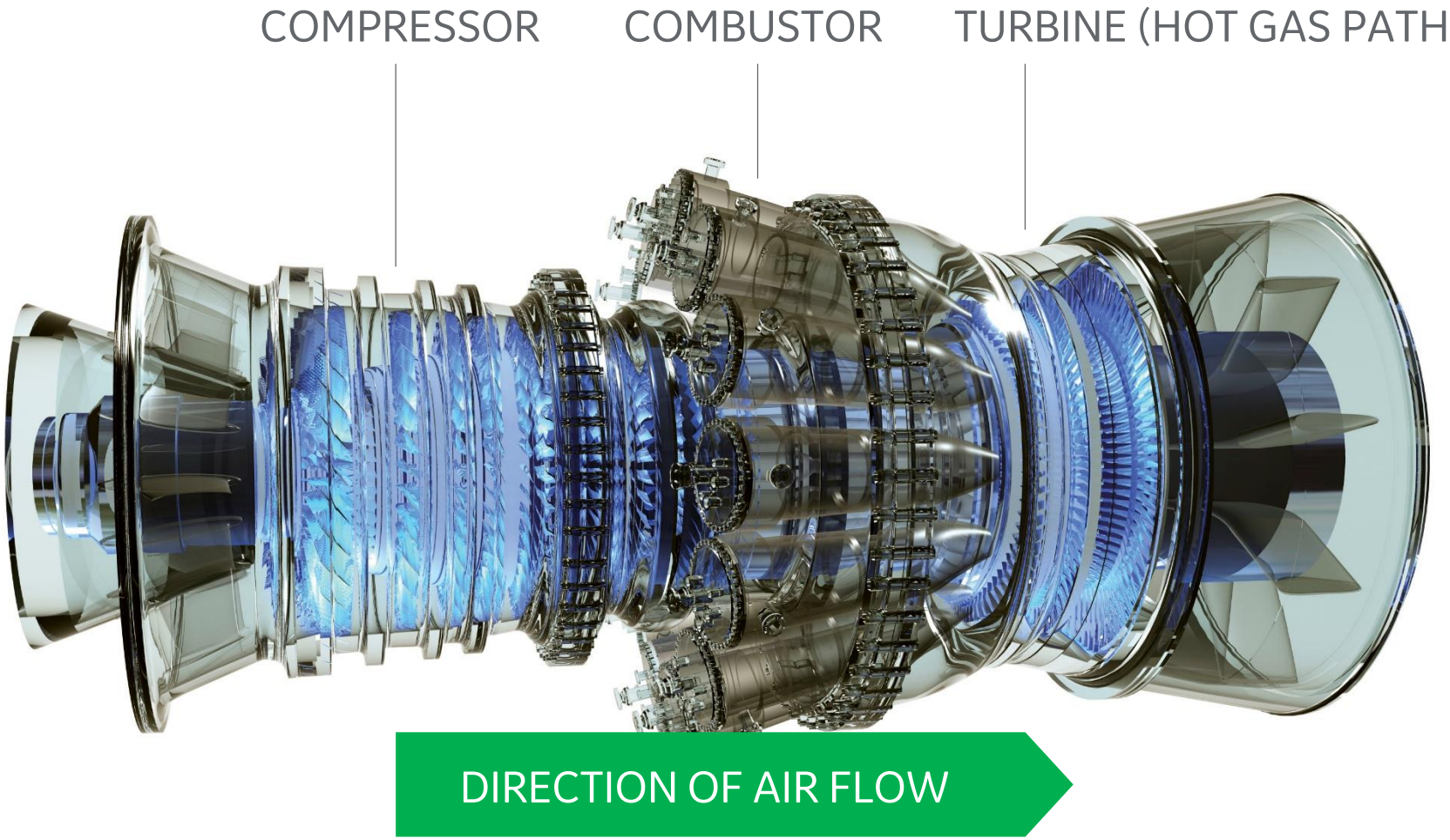
2

Gas turbine experience & capabilities

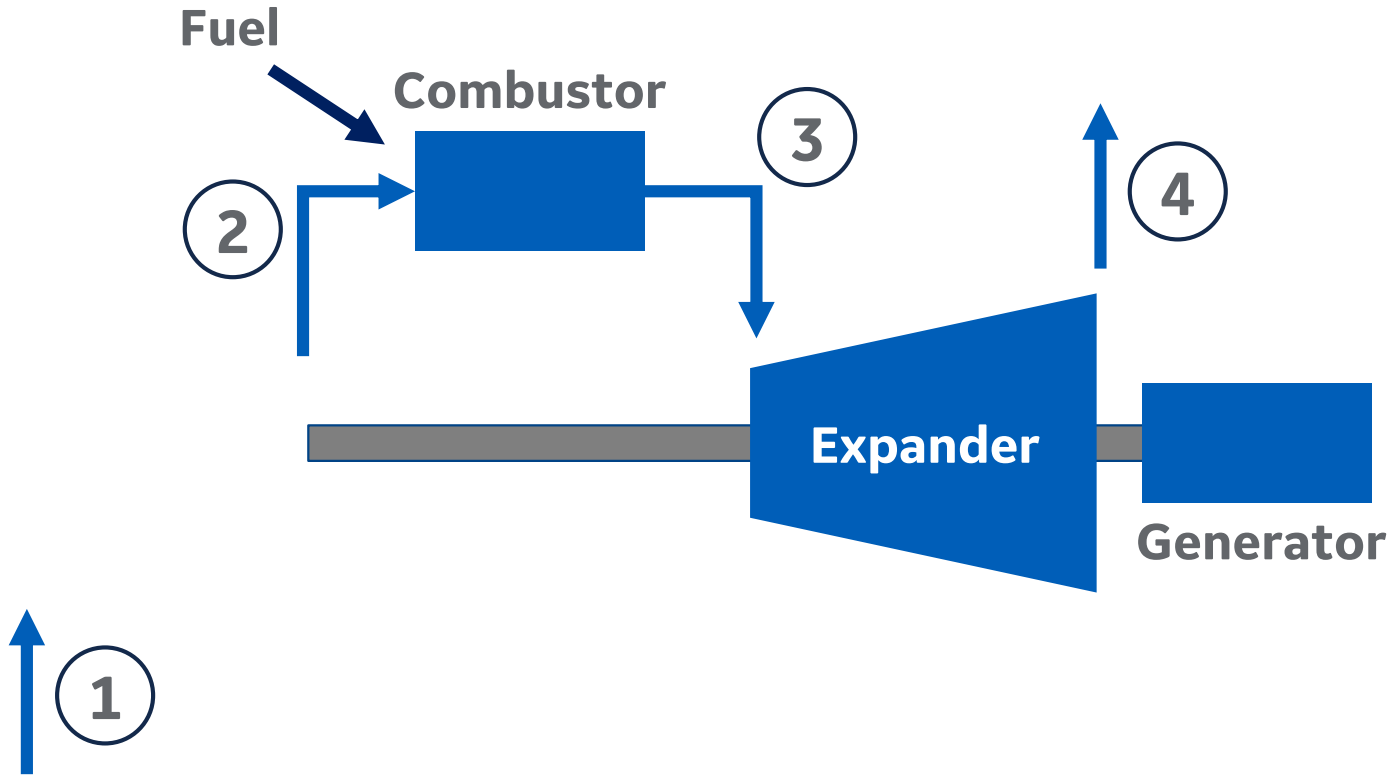
3

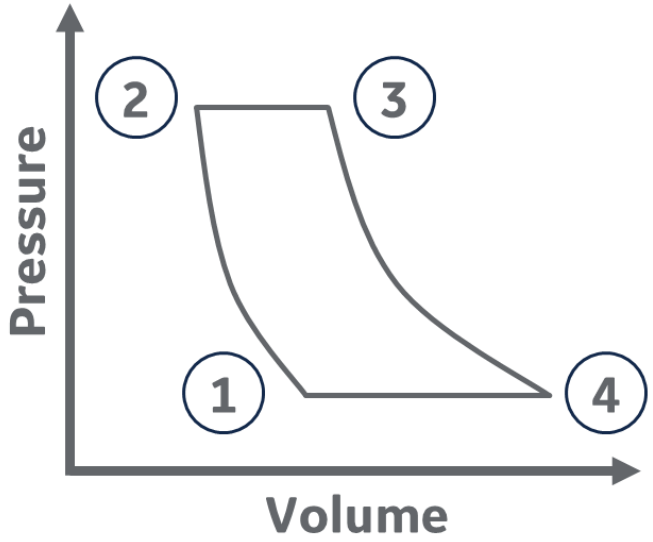
Implications of hydrogen for power gen

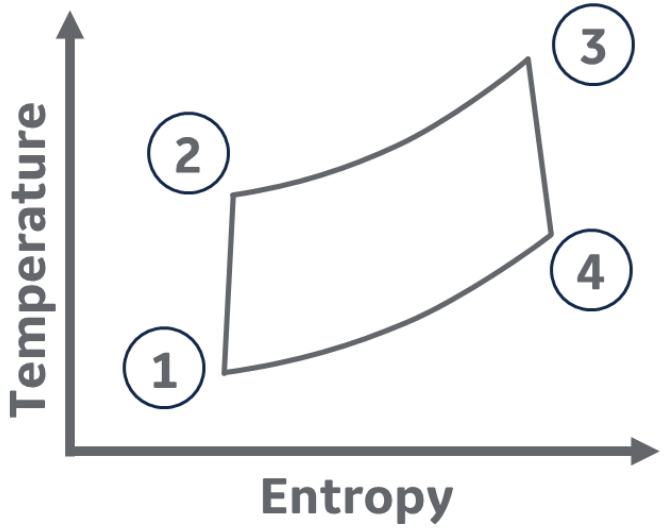
Gas turbine introduction – major systems



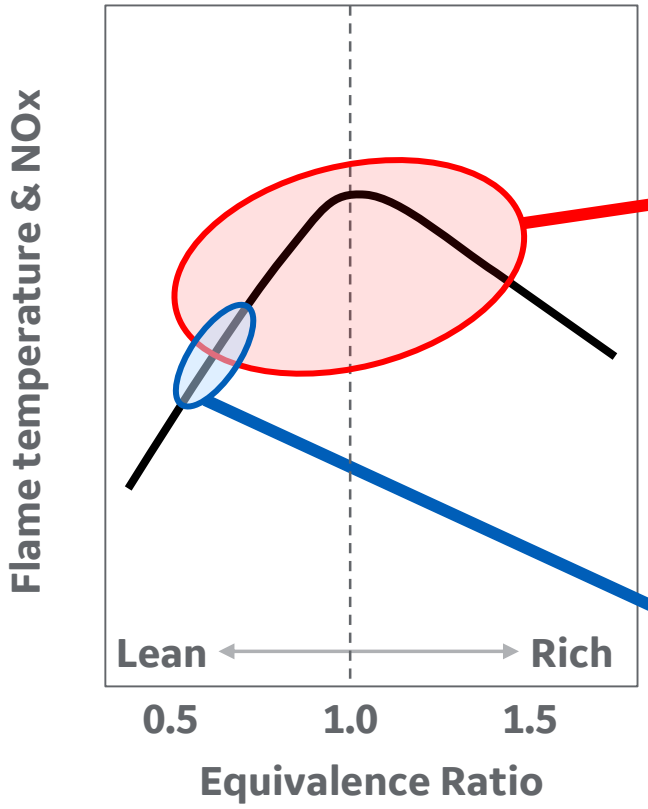
Gas turbine thermodynamics – Brayton Cycle







Combustion science: premixed versus diffusion flames



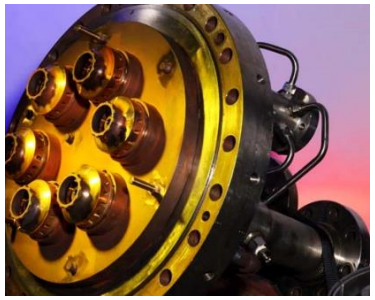
Example of stoichiometric reaction

$CH_4 + 2(O_2 + 3.76\ N_2) \rightarrow CO_2 + 2H_2O + 7.56\ N_2$

Diffusion flame

Characteristics

- At or near stoichiometric proportion
- Increased flame stability
- High peak flame temperature
- NOx: 200–600 ppm



GE Multi-nozzle quiet combustor

Premixed flame

Characteristics

- Air rich (fuel lean) conditions
- Low NOx without diluent
- More susceptible to combustion dynamics
- NOx: single digit ppm

GE DLN2.6+

Advanced premixer technology development

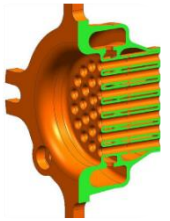
2005 | **2016** | **2018**

Swozzle based architectures
Target premixing and flashback tolerance for NG

Hydrogen limits
- DLN 2.6 ~5% (vol)
- DLN 2.6+ ~15-18% (vol)

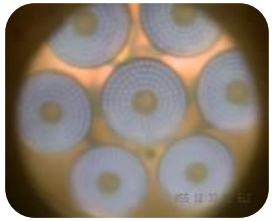
DOE High-H_2 program*
Target premixing and flashback tolerance for H_2

Small prototype



Prototype fuel nozzle

Full head end combustion test



Demonstrated single digit NO_x emissions at F-class temperatures and pressures

Demo
7HA.01 TS7

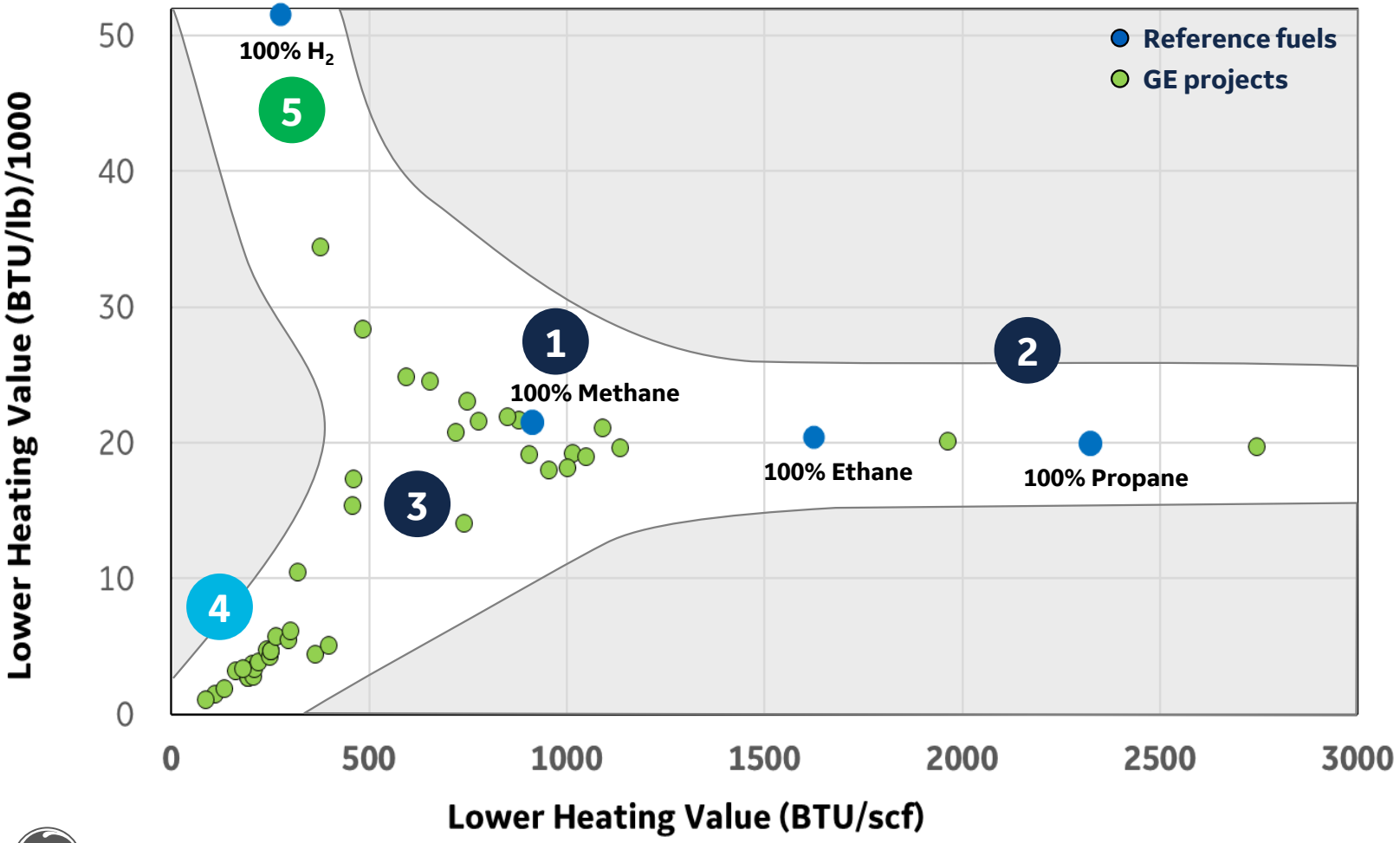
DLN 2.6e
1st commercial shipment in 2018

- This technology can be applied to natural gas or H_2 fuels… decouples flashback, premixing and dynamics
- Demonstrated capability to **50**% (by vol) H_2

*US Department of Energy under Cooperative Agreement DE-FC26-05NT42564

GE gas turbine experience and capabilities

Gas turbine fuel flex capabilities:
GASEOUS FUELS MAP



1. Natural gas, LNG, and shale gas
2. Non-methane hydrocarbons: ethane, propane, LPG, etc.
3. Lean methane fuels
4. Low heating value fuels: syngas, steel mill gases
5. High hydrogen (H_2) fuels

Timeline of GE experience with H2 and associated fuels

1x7F IGCC (USA)

1x7F IGCC (USA)

1x6B IGCC (Europe)

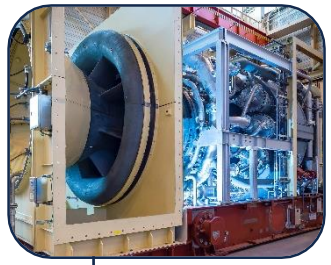
2x6F Refinery (USA)

2x6F Syngas Refinery (Asia)

1xGE10 High H_2 (Europe)

2x7F Syngas coal IGCC (USA)

2x9E Refinery (India)



1990 2000 2010

1x7E IGCC (USA)

1x6B Refinery (Europe)

1x6B Refinery (Korea)

1xGT13E2 Refinery (Europe)

3x9E Refinery (Europe)

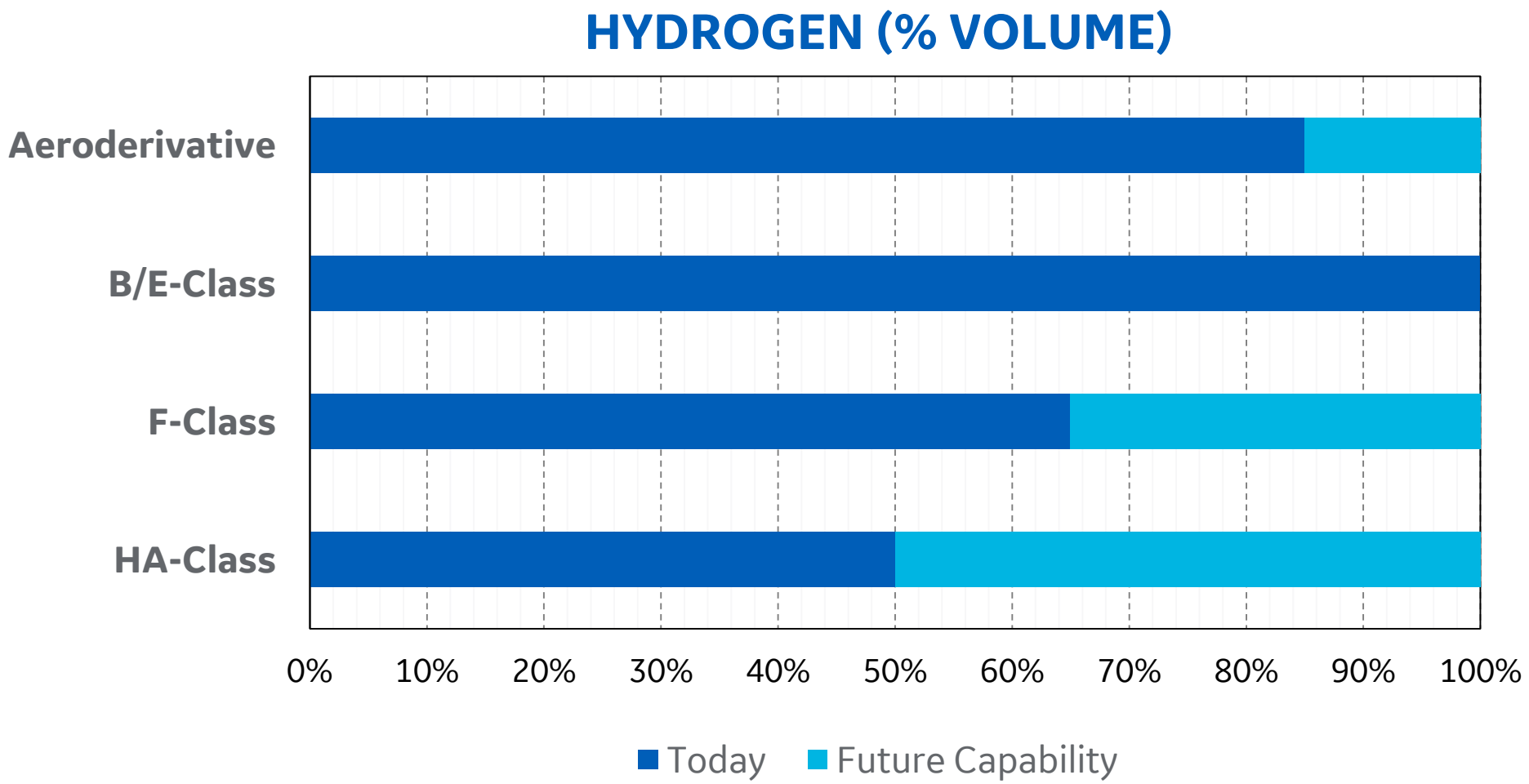
2xGT11N2 Steel mill (Brazil)

2xLM2500 Steel Mill (China)

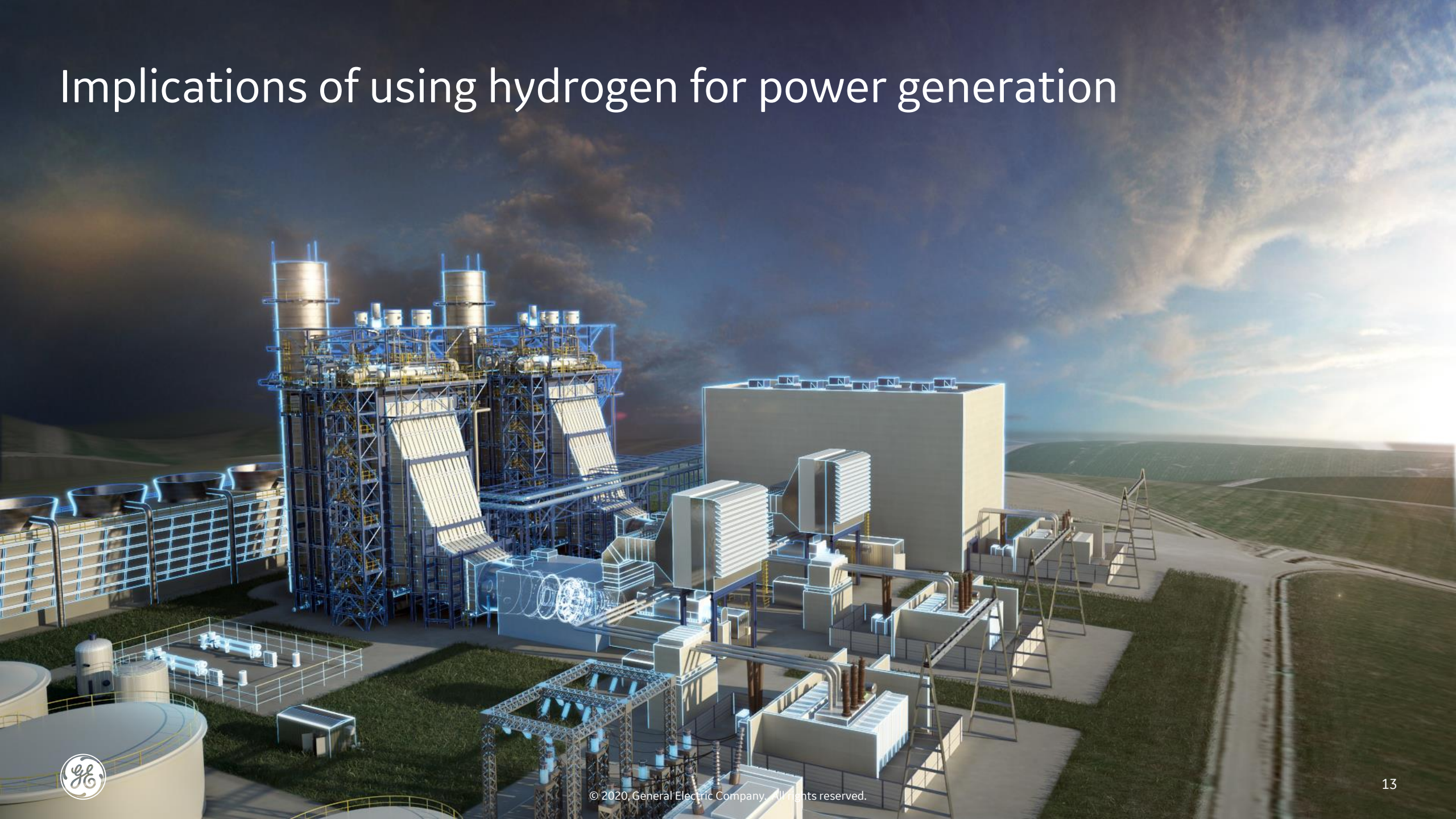
1x7F Syngas IGCC (Korea)

Over **75** gas turbines with more than **5 million hours** on hydrogen and associated low BTU fuels

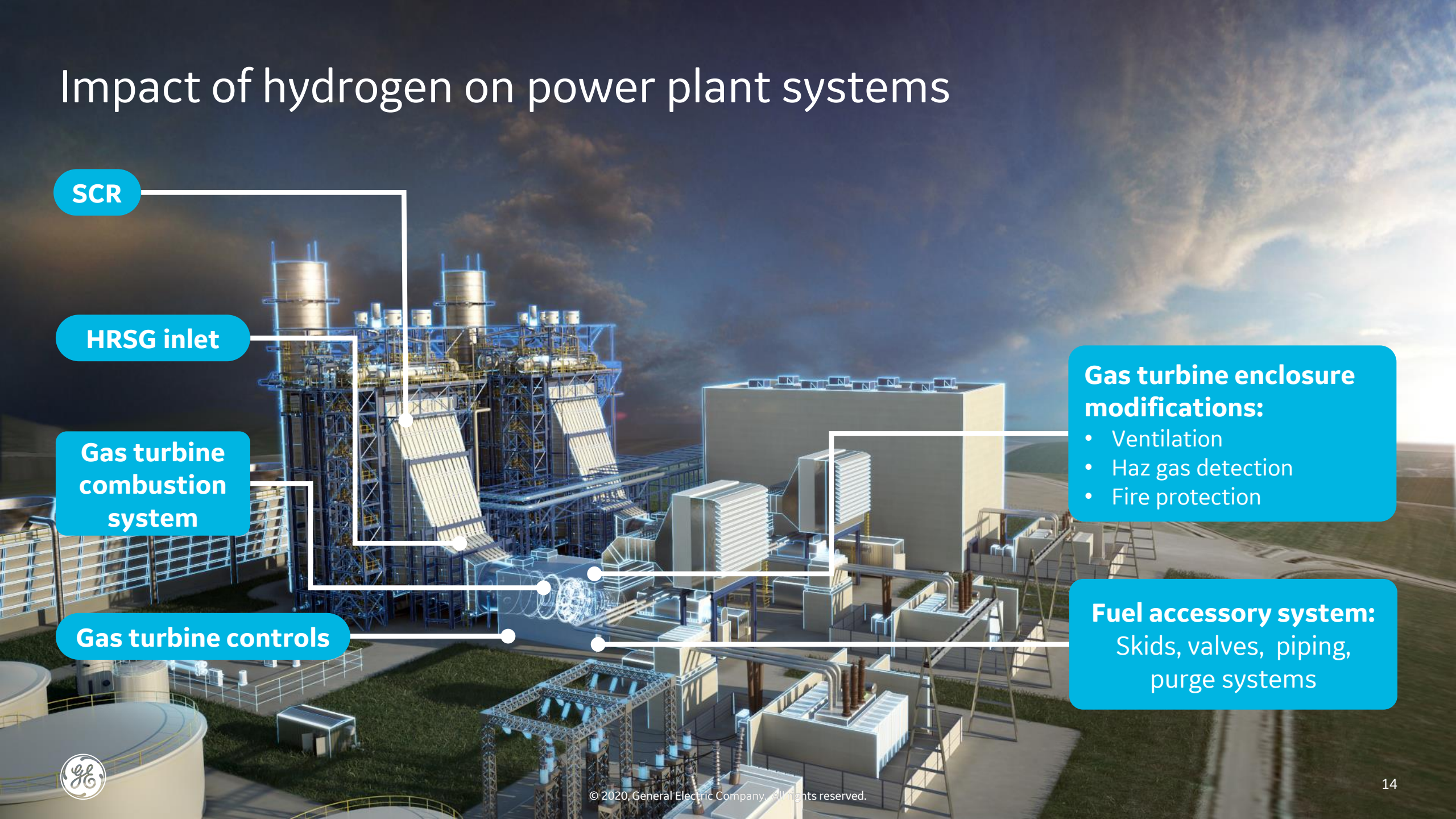
GE gas turbine hydrogen capability



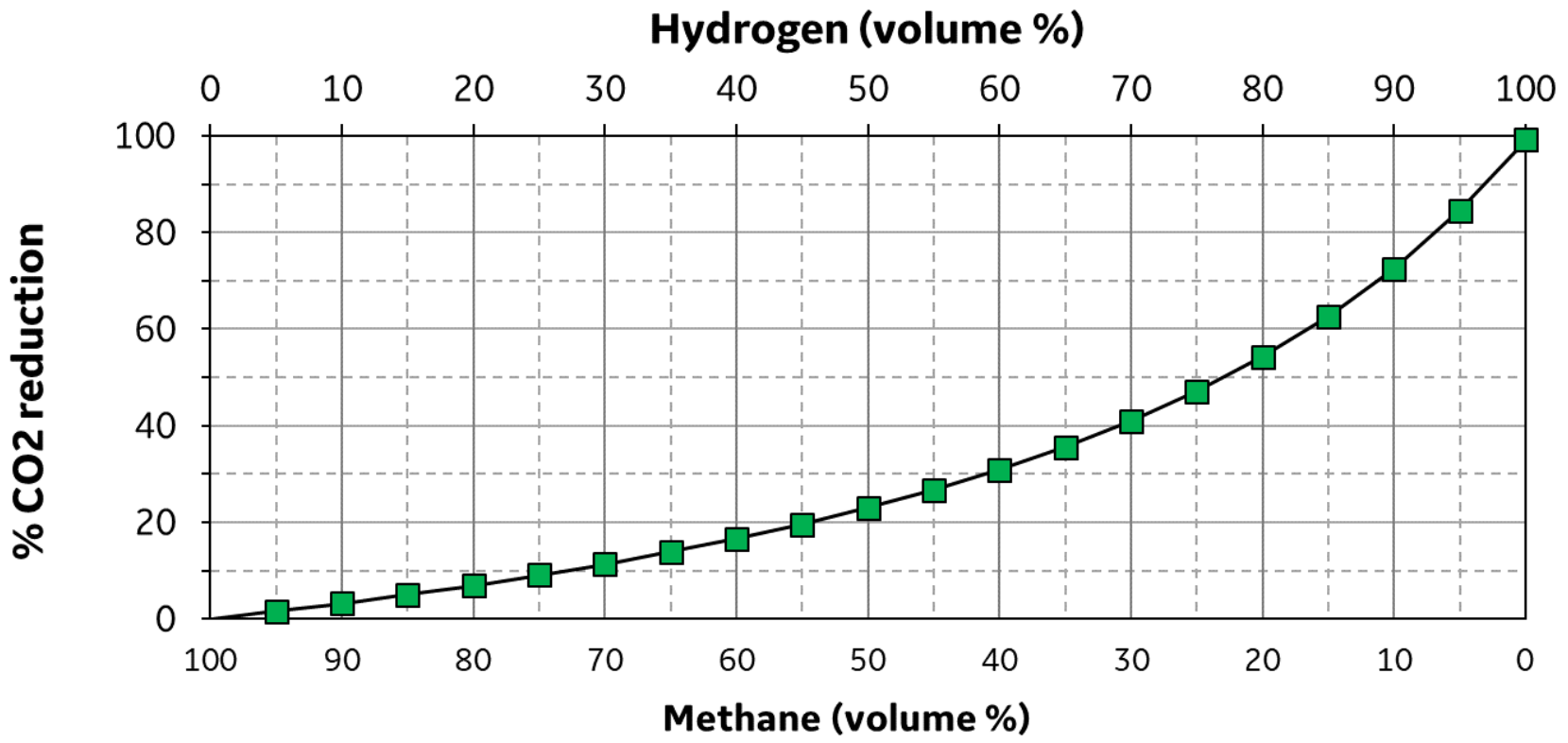
Implications of using hydrogen for power generation



Impact of hydrogen on power plant systems



CO_2 emissions reduction when operating on H_2

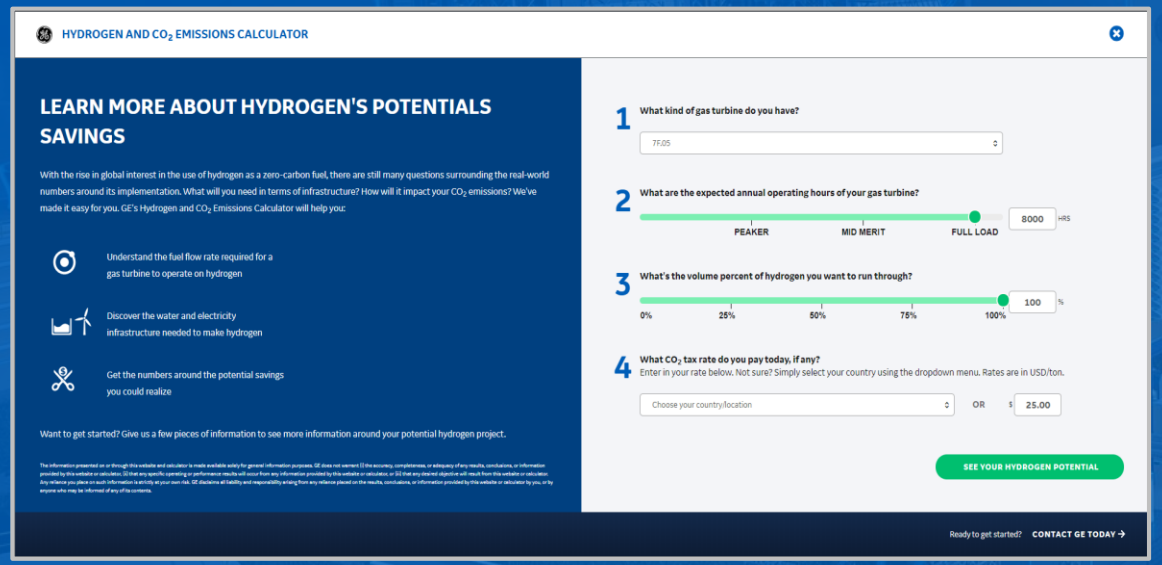


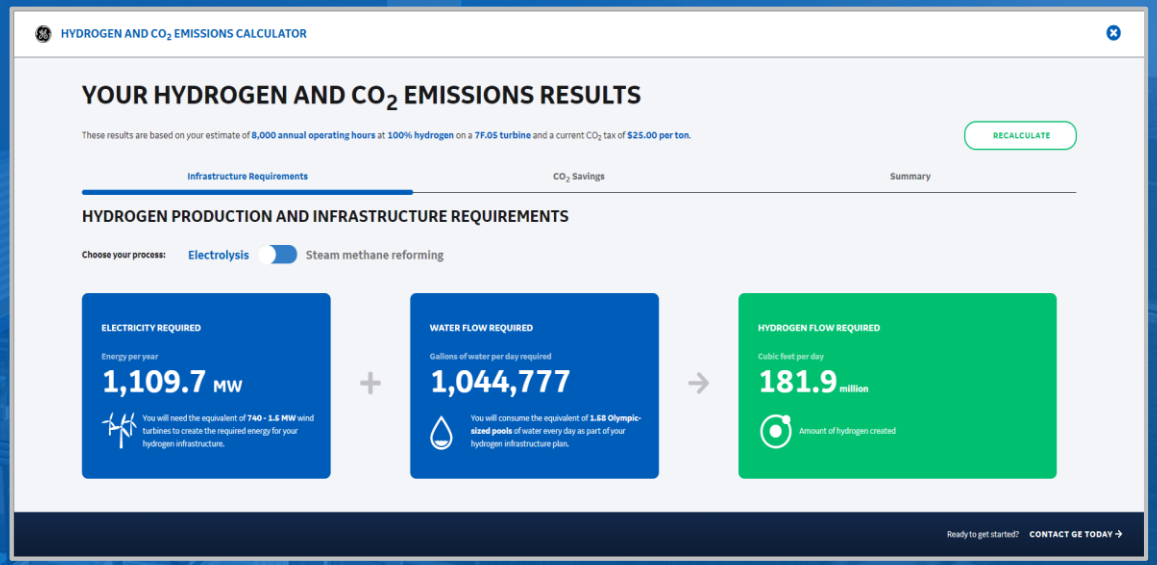
The use of H_2 as a gas turbine fuel, even if blended with natural gas, can reduce CO_2 emissions

CO2 emission impact – hydrogen

- To help customers determine the impact of using hydrogen on carbon emissions and the economics of carbon emissions, GE has created a new online tool.

- With a few simple selections (gas turbine model, plant configuration, carbon tax rate, etc.) the tool will calculate infrastructure requirements, carbon emissions reduction, and the avoided cost of carbon emissions.





gepower.com/h2turbines

Closing thoughts

LOOKING TOWARDS THE FUTURE

The gas turbine industry has **proven experience** operating with H_2 and similar low BTU fuels

Combustion technology exists for operating with H_2 blends and high H_2 fuels

Gas turbines are ready for a world with **low-carbon fuels**