



# Gas Turbines

**Fuel & operational flexibility that  
complements & enables renewables growth**

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# Gas ( $\text{CH}_4 \rightarrow \text{H}_2$ ) plays a vital role in accelerating the pathway to a lower carbon future



**US Power sector  
 $\text{CO}_2$  ↓33%**

GAS  
ENABLED ~40%

of net reduction  
since '07

**Flexible to  
complement  
renewables**

FAST START TIMES  
AND RAMP RATES,

low minimum  
turndown

**Reliable,  
dependable  
capacity**

WHENEVER  
NEEDED,

day or night,  
regardless of  
weather

**Abundant  
and affordable  
natural gas**

TRADED LNG  
TO 80% INCREASE

by 2040, leading to  
increased availability  
everywhere

**Less space  
required in  
urban areas**

HUNDREDS MORE  
MW/ACRE

than renewables  
+ storage

**Multiple  
pathways to  
decarbonize\* GTs**

H2 FUEL, CARBON  
CAPTURE, BIOFUEL

avoid  $\text{CO}_2$  lock-in  
or stranded assets

*Society is demanding aggressive  
action to address climate change ...*

**GASEOUS FUELS ( $\text{CH}_4 \rightarrow \text{H}_2$ ) WILL  
PLAY A CRITICAL ROLE**

# Industry leading flexibility

## Complementing intermittent renewables



### ELEMENTS OF SUSTAINABLE GRID

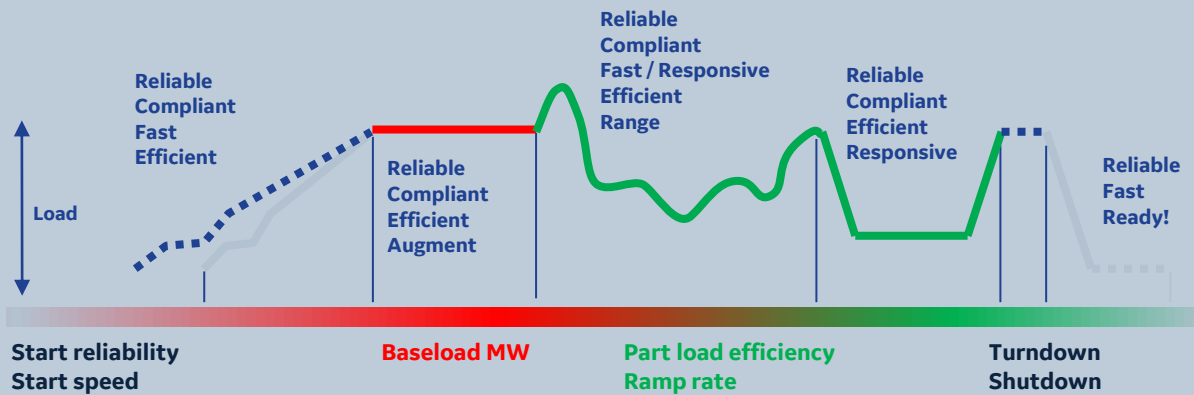
- Carbon footprint
- Consumer cost
- Reliability



### Needs for renewables integration

- Respond to transients in renewables “fuel” availability
- Shift inflexible tech (coal, nuclear, hydro) to flexible sources
- Capability to support unseen/uncontrolled distributed gen

### HOW GAS (CH<sub>4</sub> → H<sub>2</sub>) CAN HELP ...



Sources: GE Energy Consulting, National Bureau of Economic Research



#### Fast & Reliable Start

Fast MWs when renewables ramp down



#### Baseload MW & Efficiency

Lowers consumer cost and carbon footprint



#### Fast Ramping & Partload Operation

Real-time, efficient response to minute changes



#### Low Turndown

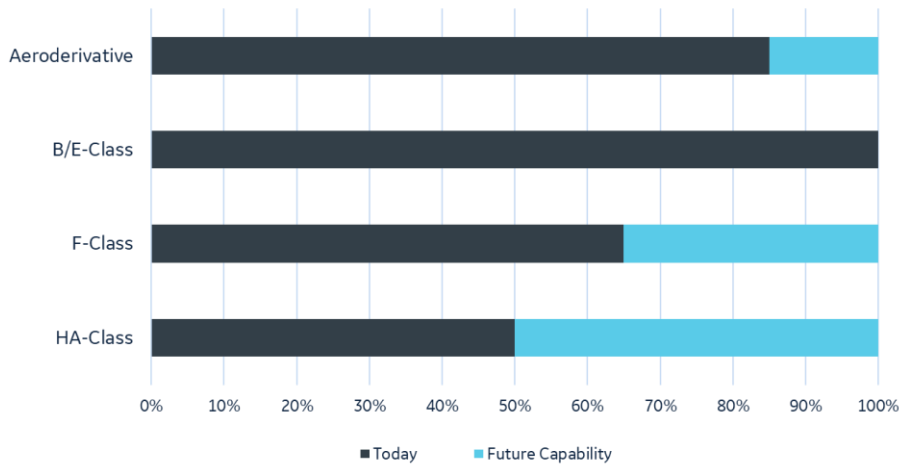
Accommodate renewables, maintain reliability

**Gas turbines provide the same fast and flexible generation whether using natural gas or hydrogen**

# Hydrogen capability of GE gas turbines



HYDROGEN (% VOLUME)



Over **75 gas turbines** with more than **6 million hours** on hydrogen and associated low BTU fuels



1x7F  
IGCC (USA)



1x6B  
IGCC (Europe)



1xGE10 High H<sub>2</sub>  
(Europe)



2x7F Syngas  
coal IGCC (USA)



2x9E  
Refinery (India)

1990

2000

2010

1x7E  
IGCC (USA)



1x6B Refinery  
(Europe)



1xGT13E2  
Refinery (Europe)



2xGT11N2  
Steel mill (Brazil)



2xLM2500  
Steel Mill (China)



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## Updating GTs for H<sub>2</sub>

*Applies to both New and Existing Assets*

- ✓ GT & Plant Controls
- ✓ Fuel Accessories (Valves & Piping)
- ✓ GT Modifications (Ventilation, Haz Detection, Fire Protection)
- ✓ GT Combustion System
- ✓ Emissions Treatment (NO<sub>x</sub>)
- ✓ Heat Recovery Steam Generator



Driving to  
**100% H<sub>2</sub>**  
capability  
in advanced  
gas turbines

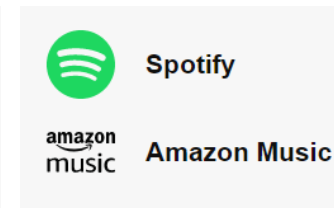
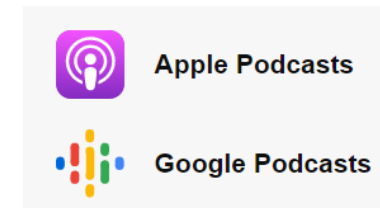
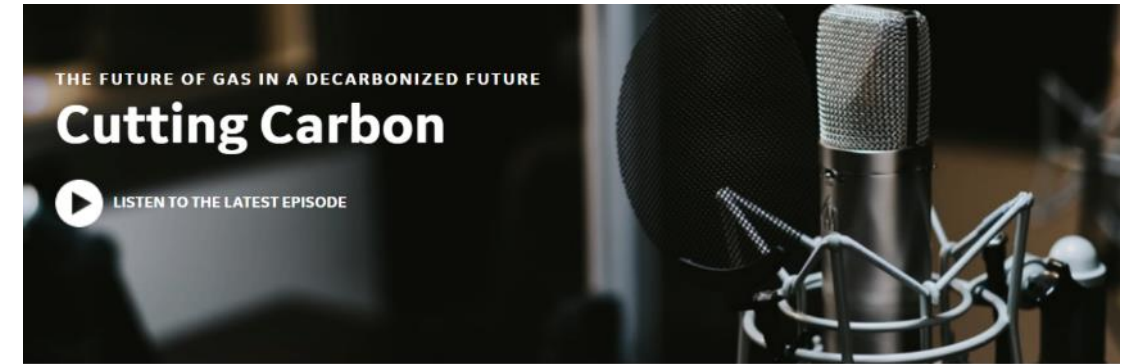
# GE is excited about the future and the role that gas turbines will play in decarbonizing\* our society



## The Future of Energy ... building a world that works



## Cutting Carbon: a conversation about our energy future



[www.gepower.com/hydrogen](http://www.gepower.com/hydrogen)

\*Decarbonization as used herein is intended to mean the reduction of carbon emissions on a kilogram per megawatt hour basis.