



GE Gas Power – Hydrogen Update

BofA Securities 2022 Hydrogen Conference

December 13, 2022

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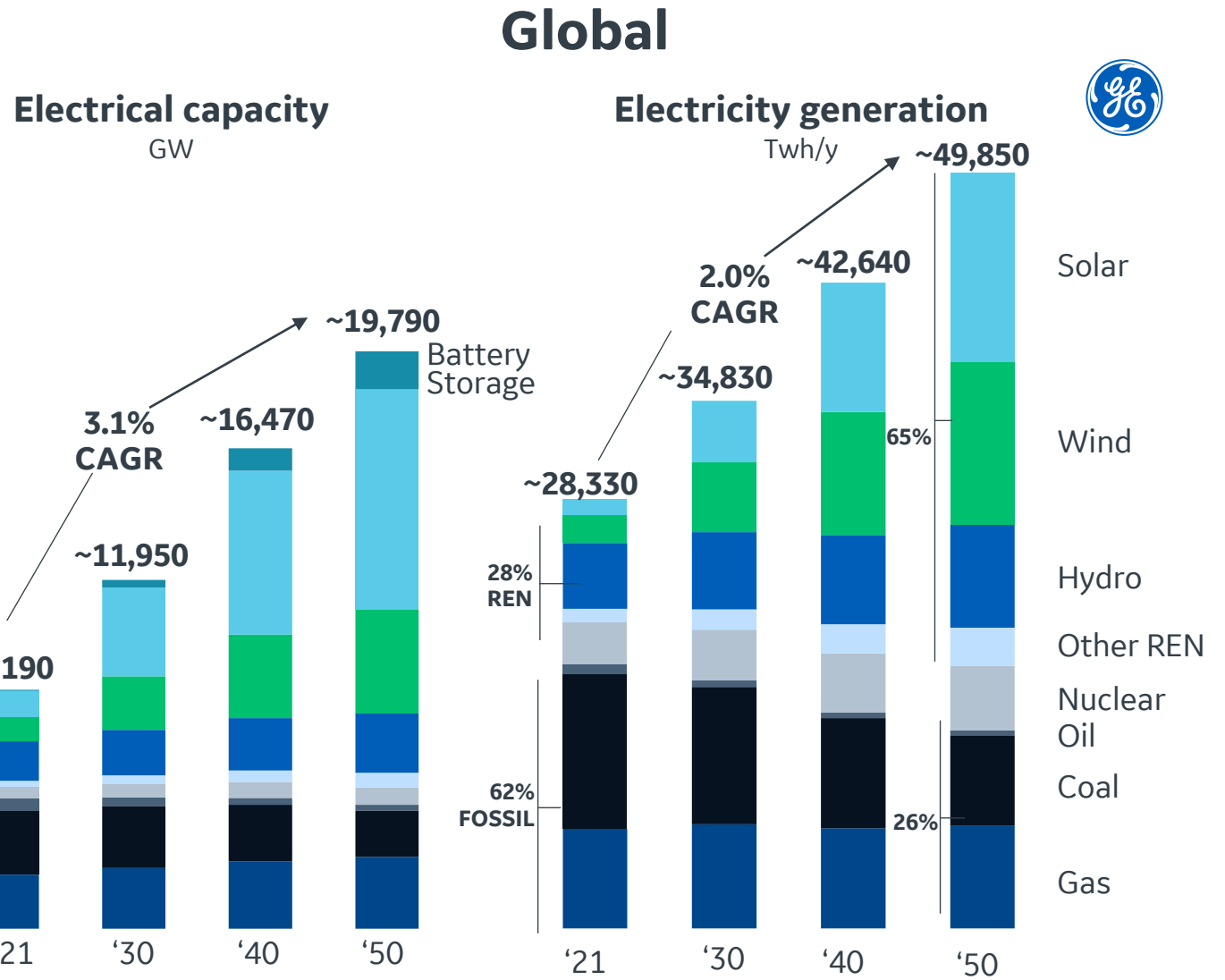
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30 YEAR VIEW Capacity vs. Generation

Wind and solar growth ...~80% of global net capacity additions

Coal generation down ~42%

Gas generation increases ~3% and will play a critical but changing role, as **flexible, affordable, reliable and lower CO₂ power**



Neither **RENEWABLES** nor **GAS POWER** are as effective alone at decarbonization* at the pace and scale needed to meet the goals of the Paris Agreement

*Decarbonization as used herein is intended to mean the reduction of carbon emissions on a kilogram per megawatt hour basis | Source: IEA WEO 2022 – Stated Policies Scenario

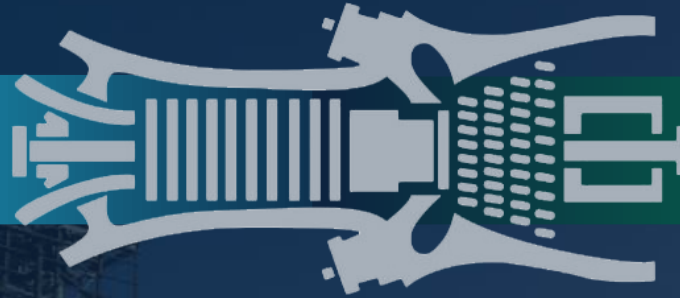
Multiple ways to decarbonize* existing and future gas power plants



PRE-COMBUSTION

Use a near zero or carbon neutral fuel

- Hydrogen (blue, green, pink)
- Synthetic (renewable) methane
- Ammonia (NH_3)
- Biofuels



POST-COMBUSTION

Remove carbon from the plant exhaust

- Carbon capture (liquid solvents)

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

Projects using hydrogen



Long Ridge Energy (USA)



Long Ridge Energy demonstrated hydrogen blending in their **new 7HA.02** gas turbine.

5%

**Demo completed
April 2022**

NYPA Brentwood (USA)



New York Power Authority has demonstrated blending hydrogen and natural gas in an existing **LM6000** gas turbine.

43%

**Demo completed
1H 2022**

Sharm El Sheikh (Egypt)



At COP27, demonstration of an Egyptian Electricity Holding Company (EEHC) **LM6000** gas turbine operating on a blend of hydrogen and natural gas.

**Demo completed
Nov 2022**

Guangdong Huizhou (China)



Guangdong Energy Group intends to operate their new **9HA.01** gas turbines on a 10% blend of hydrogen and natural gas starting in 2023.

10%

**Target COD
2023**

Tallawarra B (Australia)



EnergyAustralia intends to begin blending hydrogen in their **new 9F.05** gas turbine starting in 2025.

Expected to be the first 9F gas turbine to operate on blends of hydrogen and natural gas.

5%

**Targeted COD
Q42023**



7HA HYDROGEN BLENDING AND OPERATION DEMONSTRATION

Long Ridge Energy Terminal, Hannibal, OH



Project highlight video available [online](#)

Long Ridge Energy – hydrogen fuel system

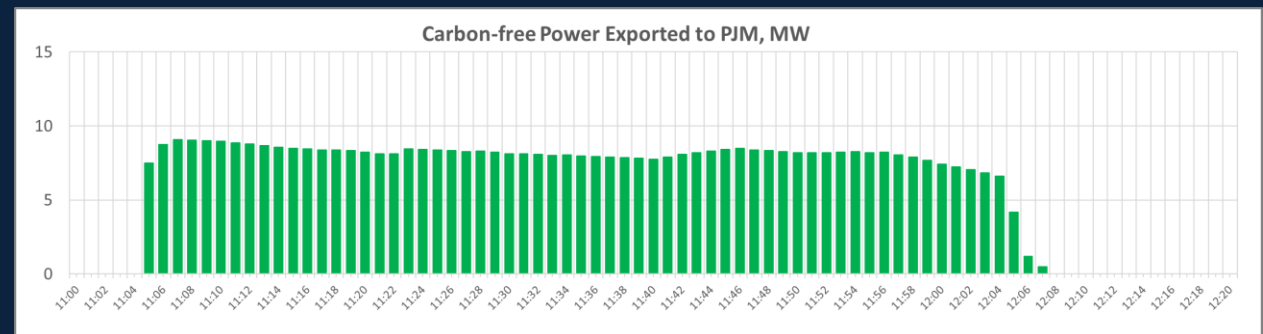
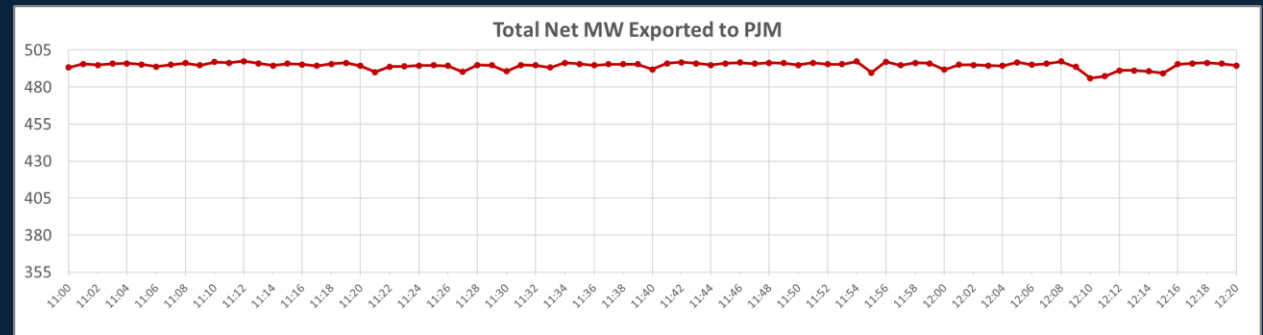
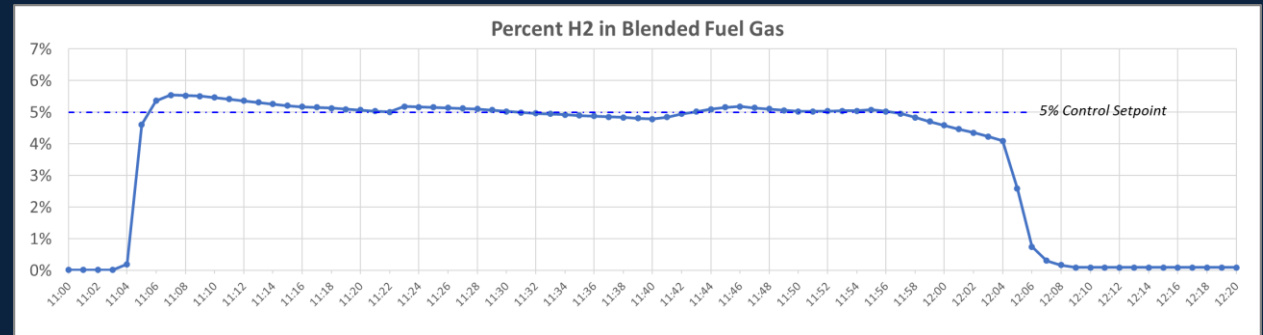


GE brings decades of experience developing plant level systems when using hydrogen fuels

Long Ridge Energy – hydrogen operation



- Data from 4/22/22 demonstration run
- Nominal 5% (by volume) hydrogen blend
- Stable operation on hydrogen for approximately 1 hour
- No change in power plant performance with addition of hydrogen
- This resulted in approximately 8MW of carbon free power being provided to the grid



Data is being used with permission of Long Ridge Energy.



LM6000 NYPA BRENTWOOD HYDROGEN DEMONSTRATION PROJECT

Brentwood Power Station, NY



Project highlight video available [online](#)
EPRI project executive summary available [online](#)

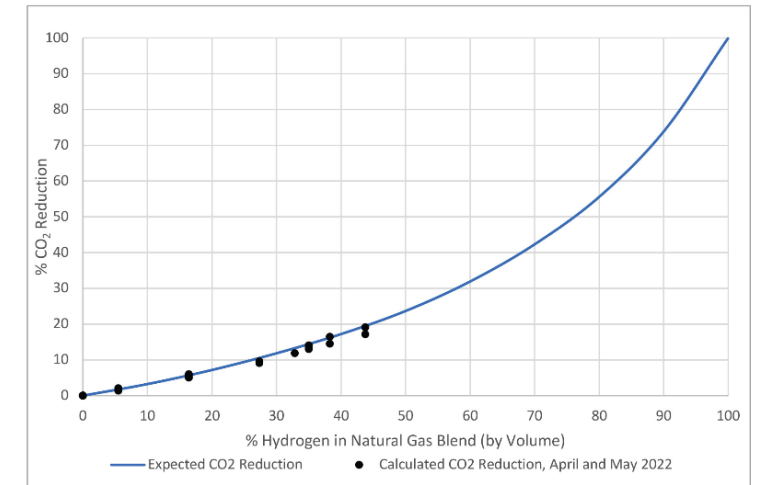
Project takeaways – operation & emissions



Gas turbine operation on blends ranging 5% to **43%** hydrogen (by volume)

Summary:

- CO₂ emissions decreased as hydrogen fuel percentage increased
- At steady-state conditions, NO_x and CO levels were controlled below the regulatory permit limits (based on the current NG fuel permit) with hydrogen cofiring
- CO levels decreased as much as 88% as the hydrogen fuel fraction increased during testing



EPRI project executive summary is available [online](#)

No significant changes to gas turbine operation were observed while maintaining current NO_x emission levels



COP27 HYDROGEN DEMONSTRATION PROJECT

Sharm El Sheikh Power Plant, Egypt



The project was executed safely and successfully in <5 months by the Egyptian Electricity Holding Company, GE, Hassan Allam Construction, and PGESCO. Learnings from the Sharm El Sheikh experience will be studied and shared by EPRI, through the Low-Carbon Resources Initiative.

Project partners:
GE / Hassan Allam Construction / PGESCO / EPRI - LCRI

LinkedIn post & video highlighting the project available [online](#)

A significant milestone by many measures ...



HYDROGEN FUEL VOLUME



~1 ton of H₂ blended;
600 m³/hour

GAS TURBINE



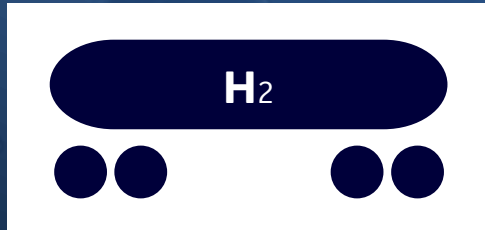
First LM6000
aeroderivative gas turbine
to burn H₂ blend in Africa

EXECUTION SCHEDULE



<5 months from
signature to first fire

HYDROGEN STORAGE



40 cylinders @ 2,900
pounds per sq inch

MANPOWER



Average localized
manpower of 33 per day



HYDROGEN COMBUSTION TECHNOLOGY



Addressing technology challenge – advanced combustion systems



Today's options for hydrogen:

- Diffusion combustion systems which require diluent injection to meet NO_x requirements (lowering efficiency)
- Premixed combustion systems which are H_2 limited due to operability issues (flash back, flame holding)

Challenges for 100% H_2 :

- Flashback and flame holding
- Combustor operability
- Combustion system durability
- NO_x emissions
- Plant safety

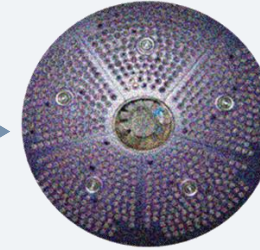
Heavy-duty gas turbine combustion systems



Diffusion combustors
Max H_2 ~70–100%



Premixed combustors
Max H_2 ~20–30%



Advanced premixer
Max H_2 ~50%



Advanced premixer
100% H_2

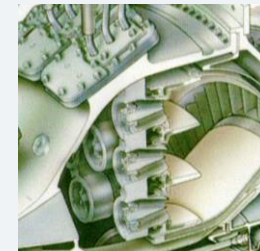
Aeroderivative gas turbine combustion systems



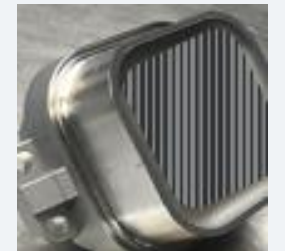
Diffusion combustors
Max H_2 ~30–85%



Premixed combustors
Max H_2 ~10%



Advanced premixer
Max H_2 ~60%



Advanced premixer
~100% H_2

Next generation combustion systems are being developed to operate on high H_2 fuels while meeting stringent emission standards

External awards & collaborations



- **US Department of Energy** award for development of a retrofittable **F-Class** combustor module with capability from 100% natural gas up to **100% hydrogen**
- GE received letters of support for this proposal from **10 US utility companies** with an aggregate 240 gigawatts of total installed generation capacity serving approximately 81 million people across 39 states



- **Shell Global** collaboration to develop potential lower-carbon solutions aims to reduce the carbon intensity of Shell's LNG supply projects around the world
- GE plans to accelerate development for the use of **100% hydrogen** as a low carbon fuel for **B&E class** gas turbines used in LNG and power generation applications



CUTTING CARBON

A Conversation About Our Energy Future



Season 6 is now available for download!



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