1ST NOVEMBER 2022

The Future of Energy
Decarbonizing Power Generation

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Director, Advanced Combined Cycles

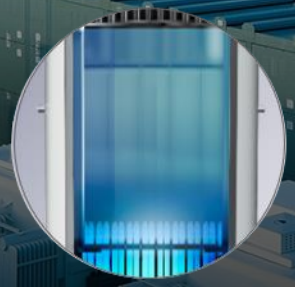
GE's complimentary portfolio of technology is continuously adapting to global customer needs

GE believes that decarbonization actions will be determined locally, based on resource availability, policy, current infrastructure, and demand for power

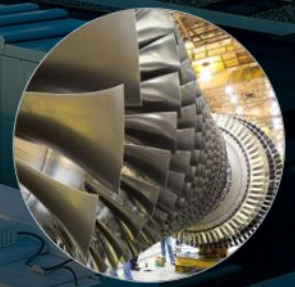
ONSHORE WIND

OFFSHORE WIND

HYDRO



SMALL MODULAR REACTOR



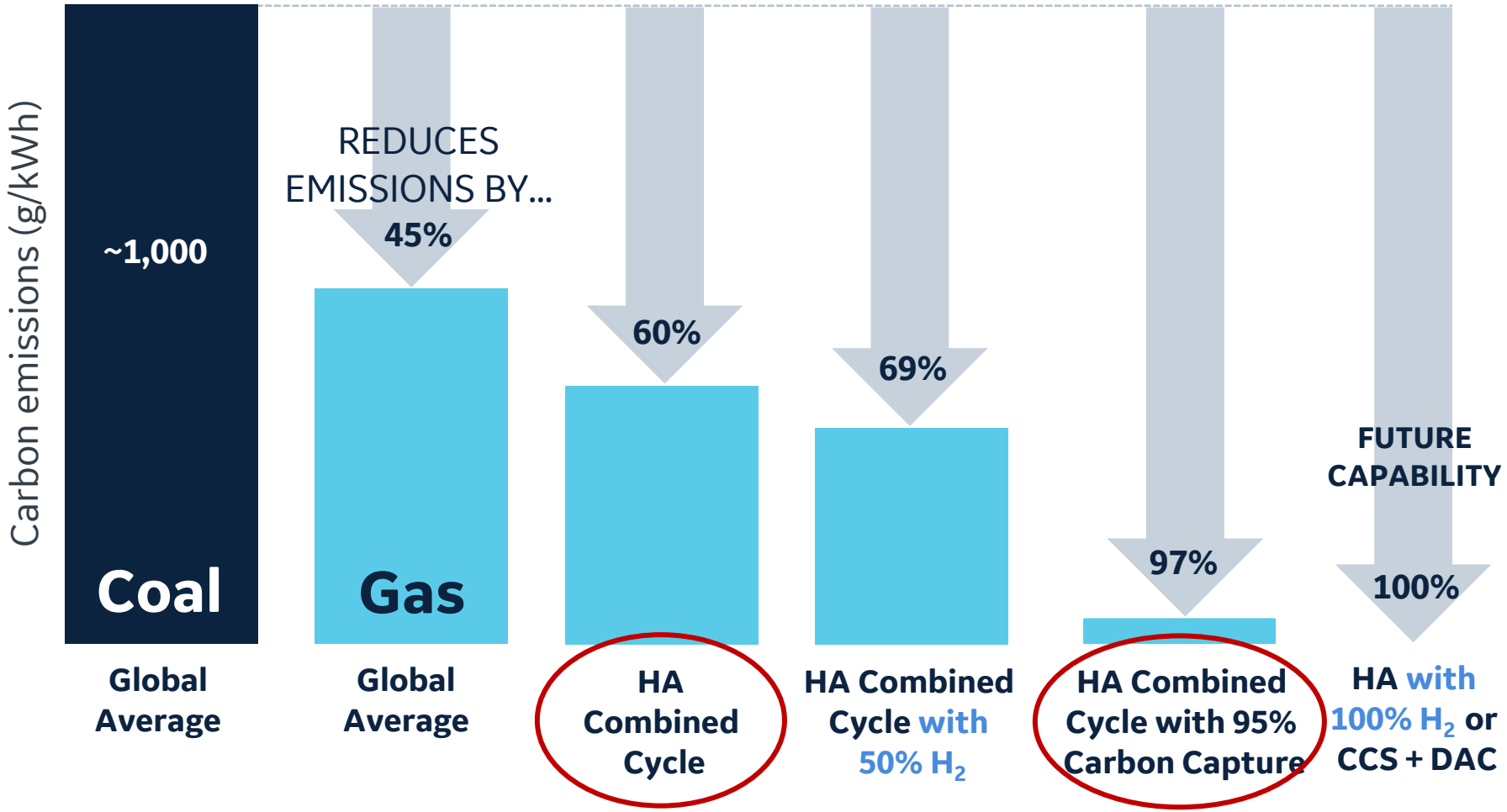
GAS FIRED POWER

DIGITAL SERVICES

STORAGE & HYBRIDS

GRID SOLUTIONS

Pathway to low or near-zero carbon power



Coal-to-Gas switching, Hydrogen, Carbon Capture and Sequestration

are viable pathways to low or zero carbon power

Source: GE Future of Energy White Paper Dec 2020

Gas Turbine Combined Cycle operational flexibility

Complementing Intermittent Renewables

ELEMENTS OF SUSTAINABLE GRID

- Carbon footprint
- Consumer cost
- Reliability

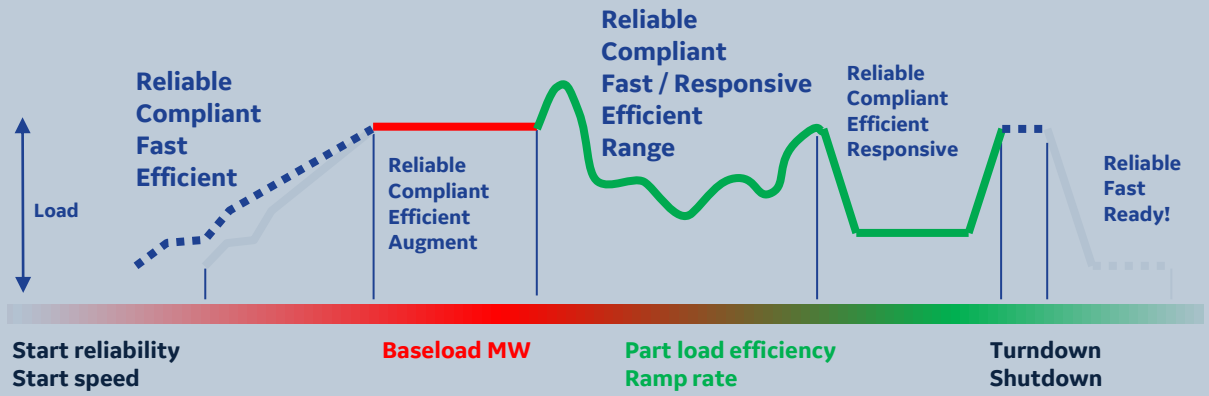
Needs for renewables integration

Respond to transients in renewables “fuel” availability

Shift inflexible tech (coal, nuclear, hydro) to flexible sources

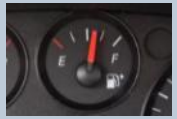
Capability to support unseen/uncontrolled distributed gen

HOW GAS CAN HELP …



Sources: GE Energy Consulting, National Bureau of Economic Research

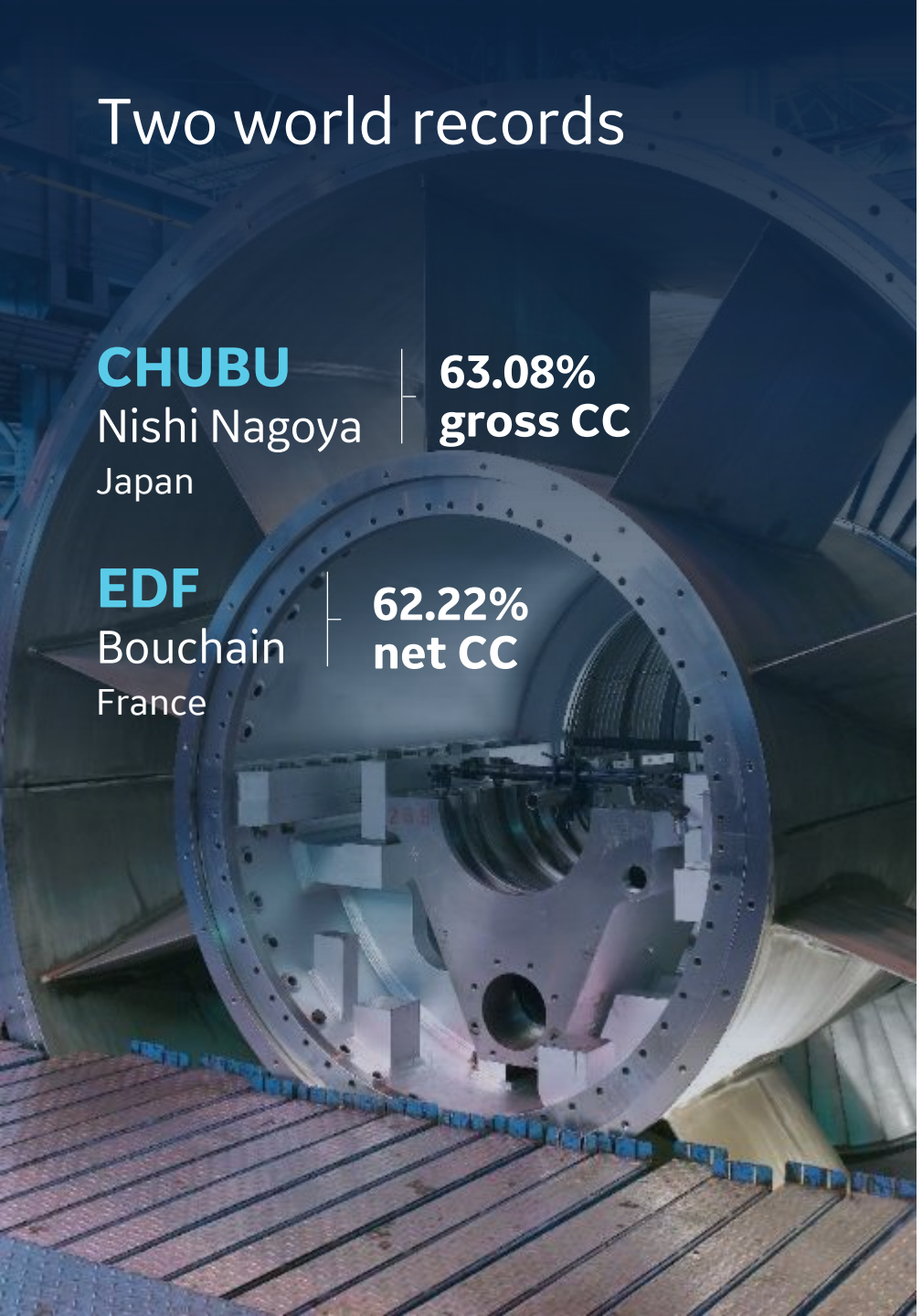
Fast & Reliable Start
Fast MWs when renewables ramp down



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



HA TECHNOLOGY:

Unlocking a new era of efficiency

137
units ordered

>64%
CC efficiency

50+
customers

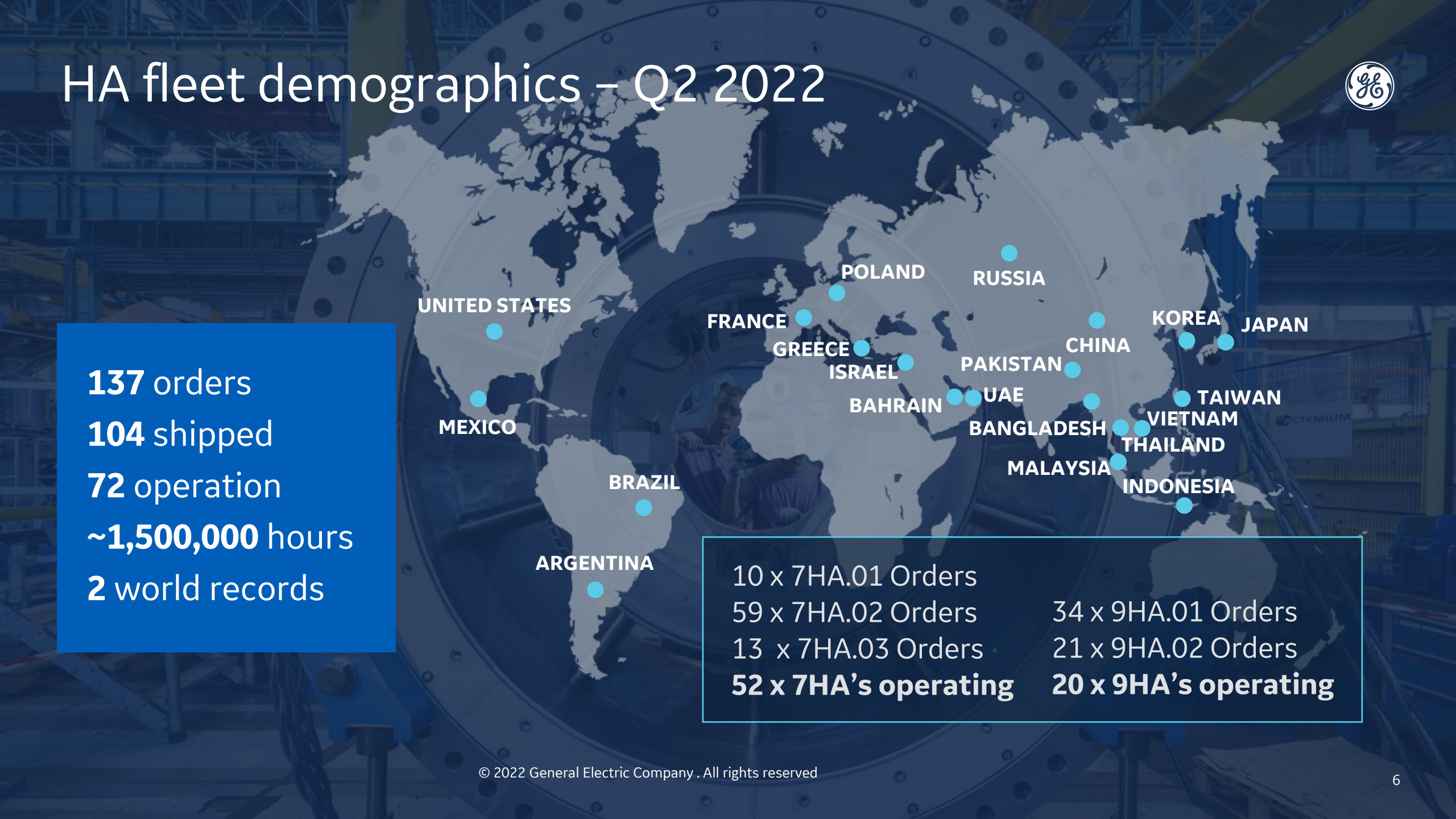
GE's HA Technology

21
countries

>US $2B
in R&D

1.5M
operating hours

HA fleet demographics – Q2 2022

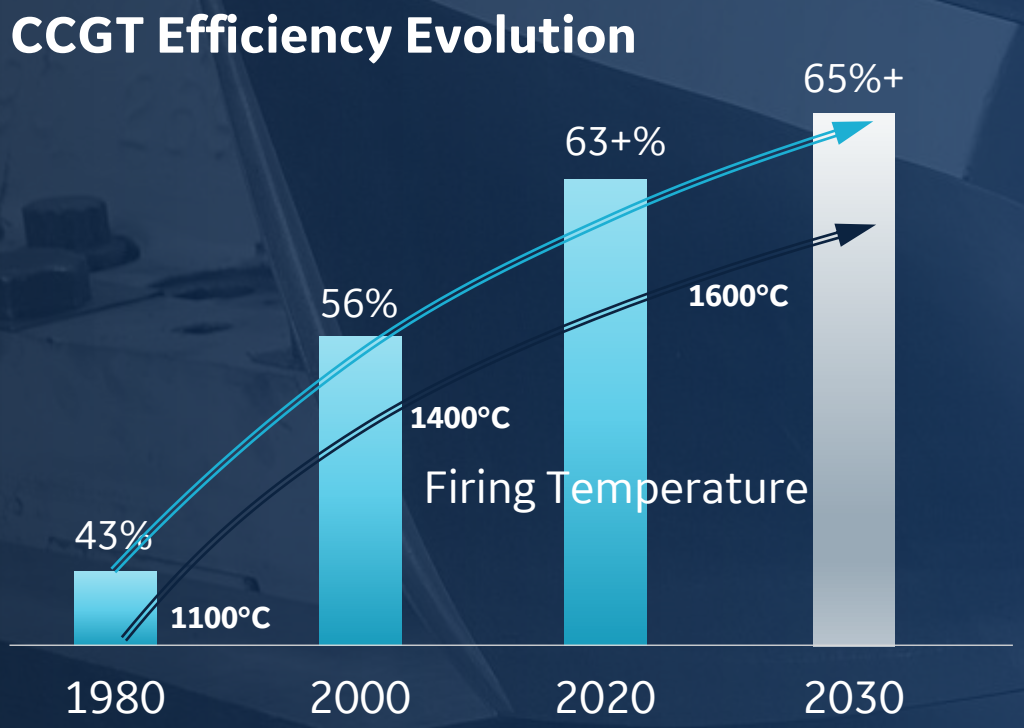


137 orders
104 shipped
72 operation
~1,500,000 hours
2 world records

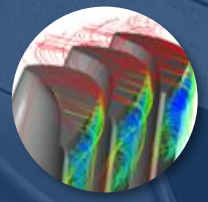
10 x 7HA.01 Orders
59 x 7HA.02 Orders
13 x 7HA.03 Orders
52 x 7HA's operating

34 x 9HA.01 Orders
21 x 9HA.02 Orders
20 x 9HA's operating

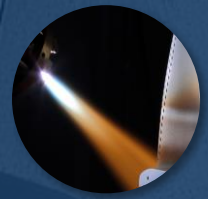
Continued Advances for Gas Combined Cycle Efficiency



Enabled by advances in engineering and manufacturing sciences


Aerodynamics & Heat transfer


Combustion


Materials & Additive mfct


Design

Advancing Aerothermal Technology

- Refractory Alloy Innovations for Superior Efficiency + compatible coating
- Creep resistant super alloys for rotor components

Technology investment in gas turbomachines is key to lower carbon future

Technology Roadmap – applied to the HAs

Model & efficiency

7/9HA.01

62 → 63%

IN OPERATION

9HA.02 / 7HA.03

63 → 64%

Installed & Commissioned

Product Growth

65%+

Under development

Technologies

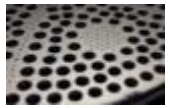
- 14 stage 3D compressor
- Fuel-staged combustion
- Titanium S1 comp blade

4-stage turbine

Flowpath sealing

Turbine aero

Micromixer



Micro-channel cooling

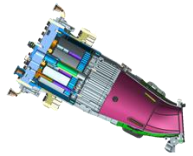
Advanced sealing

Cooled LSB

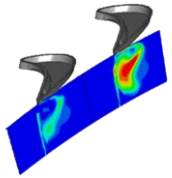
Ultra-Low k TBC

>600C Steam

Advanced Combustion



Unsteady aero



Advanced Core/Castings

High-temp additive

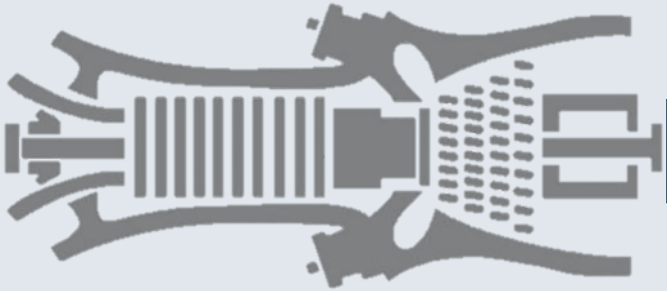
High Temp Rotor

Ceramic Matrix Composites

Continued improvements to aero efficiency through modelling, design and material science

Multiple ways to decarbonize* existing and future gas power plants

Pre-combustion



Post-combustion

Use a near zero or carbon neutral fuel

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

Remove carbon from the plant exhaust

- Carbon capture (liquid sorbents)

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

Decades of experience with hydrogen fuel

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)

1x7HA
H2 blend (US)*

1990 2000 2010 2020

1x7E
IGCC (USA)

1x6B Refinery
(Europe)

1x6B Refinery
(S. Korea)

1xGT13E2
Refinery (Europe)

3x9E Refinery
(Europe)

2xGT11N2
Steel mill (Brazil)

2xLM2500
Steel Mill (China)

1x7F Syngas
IGCC (Korea)

2x9HA
H2 blend (China)**

More than 100 gas turbines with more than 8 million operating hours

*first HA class on H_2 operation in 2022.

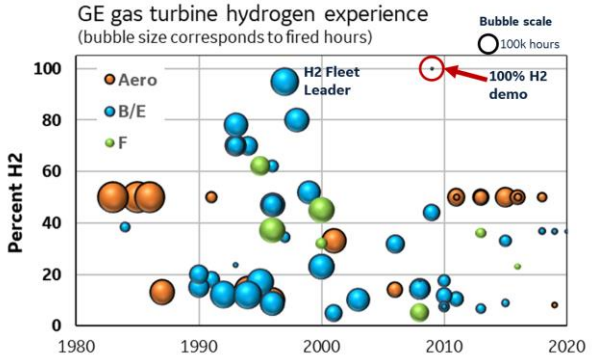
**Expected H_2 operation in 2023.

Hydrogen: GE Leading the way in future-proofing gas plants

Experience

100+ gas turbines, >8M hours

2021 Catalog data



H2 fleet leader
6B operating for 20+ years on high H_2 (**70-95% H_2**); more than 180k hours

F-class
4x7F.03 operated on **5%** H_2/natural gas blend

Aeroderivative
2xLM2500 operating on steel mill gases with **58%** H_2

Current Capability and Projects*

Aero: 85%

Diffusion: 30%–85%
Premixed (DLE): 35%

LM6000 35% H_2 (1Q22)

E-class: 100%

Diffusion: ~100%
Premixed (DLN): ~40%

6B 33% H_2 (2015–Present)

F-class: 100%

Diffusion: ~100%
Premixed (DLN): 10–40%

7F IGCC plants, 30–40% H_2 (1996–Present)

H Class: 50%

Premixed (DLN): 15–50%

Long Ridge 7HA.02
5% H_2 DLN (1Q22)

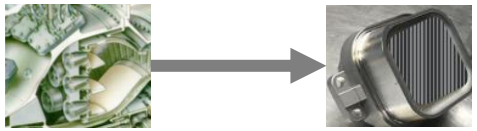
*H_2 maximum capability depends on specific unit, configuration, etc.

Path To 100% H_2

Combustion systems

Aero premixed combustion (DLE)

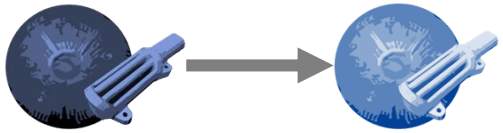
Phase 1: ~60%+ Phase 2: ~100%



Advanced premixer Lean direct injection

F & HA Premixed combustion (DLN)

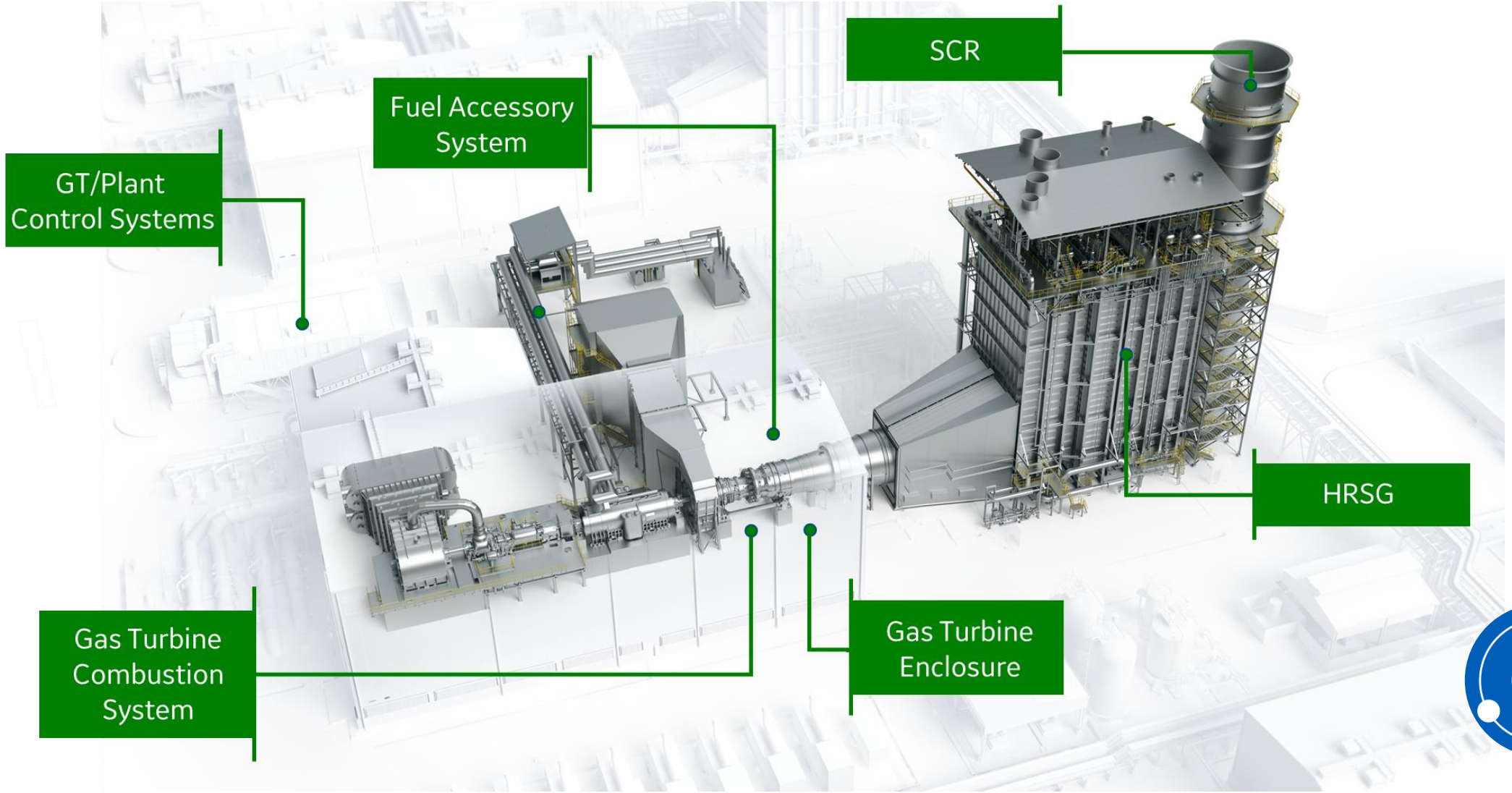
Phase 1: ~80%+ Phase 2: ~100%+



Advanced Micromixer + Axial Fuel Staging

Plant impact

Potential hydrogen impact on new and existing power plants



Hydrogen project lessons

- **H2 fuel system**
  - Need to have injection and measurement close coupled to the power block
- **Site BOP/safety**
  - Installation of hydrogen fuel introduces new hazardous zones
  - Potential venting of hydrogen
- **Hydrogen supply chain**
  - Securing large volumes of hydrogen, especially low carbon intensity hydrogen, is challenging today (650MW CCGT requires 28t/h H_2

Pathway to decarbonization: Carbon Capture through Solvents

26 CCS projects in operation (2020)

* Global data from Global CCS Institute

- Oxy-Combustion Projects
- Advanced Amine Projects
- Chilled Ammonia Projects

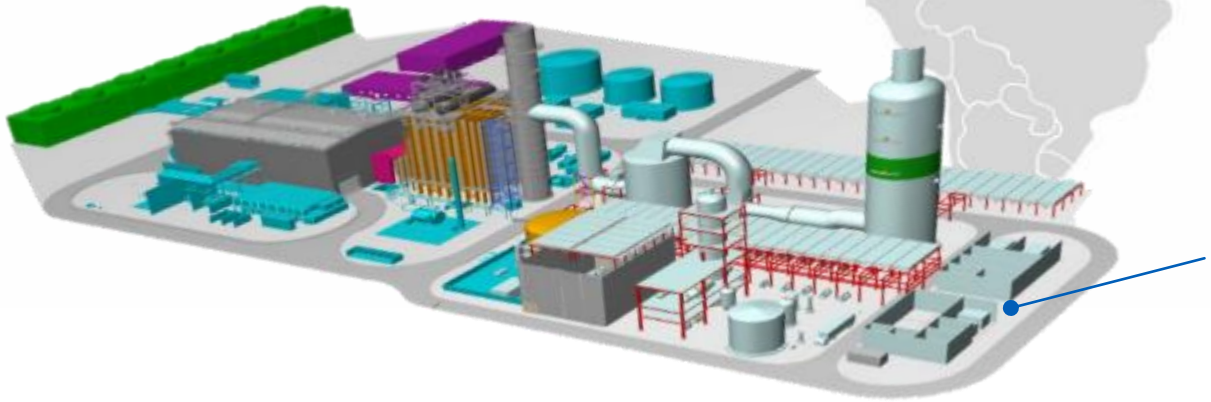
Amine
(Canada)

Chilled Ammonia
(USA)

Amine + Chilled Ammonia
(Norway)

Amine
(France)

Chilled Ammonia
(Romania)

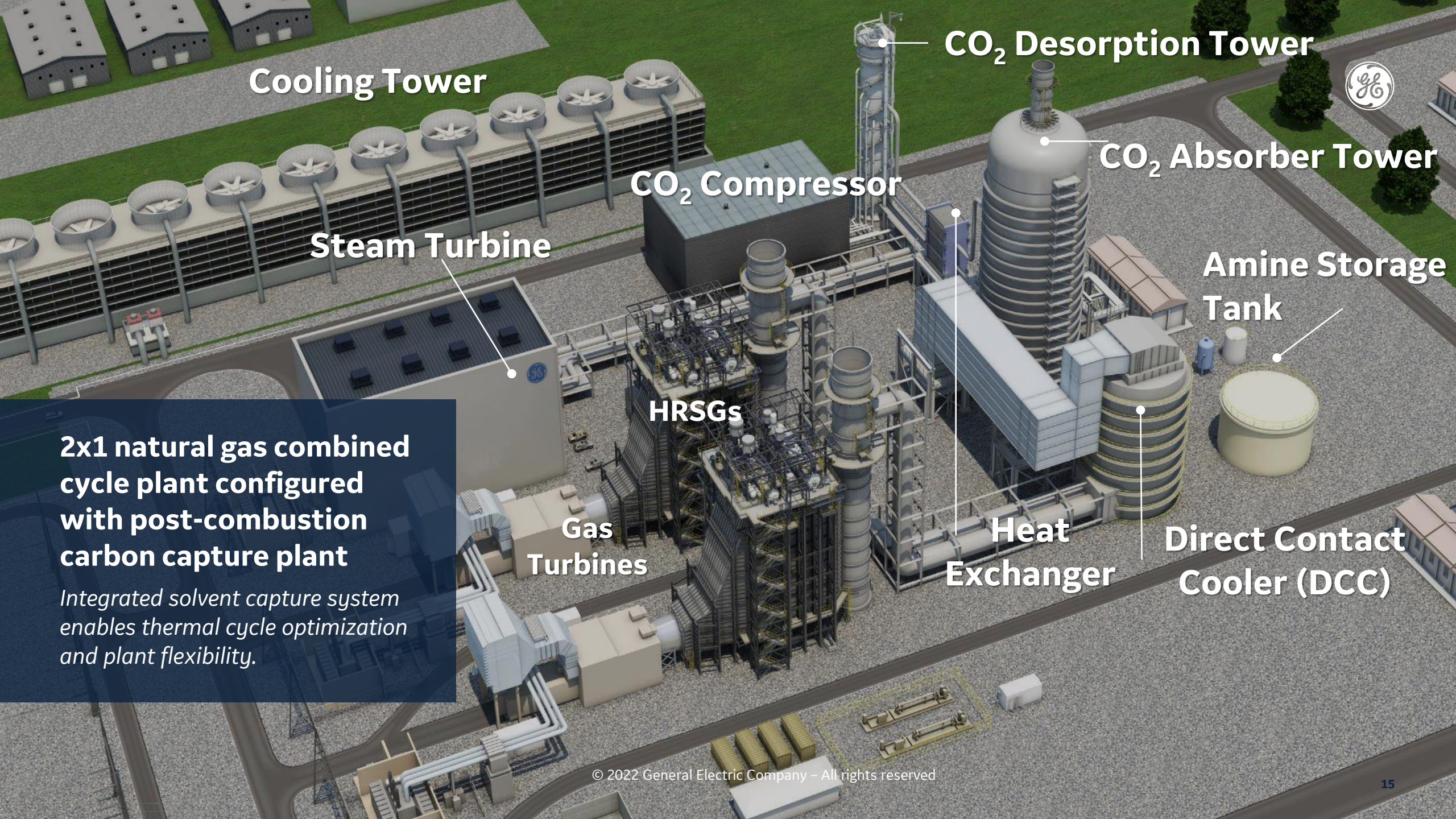


Combined cycle power plant with post-combustion carbon capture system (Amines)

4th generation of Solvents improve % capture rate >95%, lower degradation, lower environmental impact.

GE provides site specific NGCC / CCS Solutions: Pre-FEED and FEED studies

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



2x1 natural gas combined cycle plant configured with post-combustion carbon capture plant

Integrated solvent capture system enables thermal cycle optimization and plant flexibility.

GE Carbon Capture ongoing FEED studies

Southern Company Barry (USA)
7F.04 Retrofit

- DOE awards $5.7M focused on carbon capture, utilization, and storage (CCUS) with a goal of **commercial deployment by 2030**
- GE Gas Power, Southern Company, Linde, BASF, and Kiewit develop a detailed plan for integrating carbon capture technologies with a natural gas combined cycle plant to **capture 95 percent of carbon dioxide emissions** generated.

bp Net-Zero Teesside Power (UK)
9HA.02 New Unit

- Technip Energies and GE Gas Power develop a Front-End Engineering Design (FEED) study for a **large amine-based post combustion carbon capture project**
- Technip Energies and GE Gas Power will use Shell Cansolv CO2 capture technology with a **planned capture capacity of 2 mtpa**

Technologies to help customers reduce the carbon footprint are available today

Carbon Capture adapted to Combined Cycles requires Operations Considerations through smart Integration

SUPPORTIVE policies needed, to enable energy investments

Establish **market structures** that value energy, flexibility and dependable capacity separately

Support first CCS projects and the fast tracking of required infrastructure

Ensure transparency and predictability, and allow lifecycle economics to determine outcomes

Directive 2009/31/EC was a first step ✓

REpowerEU plan is a good approach

Setting national / EU wide targets for CCS applications.

⇨ To follow

2020 – 26 CCS projects

2022 – 65 CCS projects

(80% require CCS infrastructure that is not permitted today)

→ Fast track LNG terminals can work bi-directional, NG in, CO_2 out

Short term measures are needed to abate long term Climate Change

The decarbonization journey

1 **COAL TO GAS** … replacing coal with complementary mix of gas + renewables fastest path to reduce CO_2

2 **HYDROGEN** … **GE is** leading in experience and technology deployment : >75 GT's, +8MM fired hours

3 **CARBON CAPTURE** … **GE can integrate** CC technology today with downstream expert partners

4 **POLICY**… accelerate legislation to permit and finance new CO_2 infrastructure

5 **AMPLIFY THE CCS NARRATIVE** … accepting CCS as a cornerstone in reducing emissions for key generation assets in support of grid/network stability

ACCELERATED GROWTH OF RENEWABLES AND GAS POWER CAN RAPIDLY CHANGE THE TRAJECTORY ON CLIMATE CHANGE

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

The
Future of Energy

Accelerated and strategic deployment of

RENEWABLES AND GAS POWER

can change the near-term trajectory for climate change and deliver a path to substantive reductions in CO_2 emissions quickly.

Visit GE's future of energy website

GE Future of Energy White Paper Dec 2020

Building a world that works