

Technology development pathways for a carbon-neutral society

Gas turbines in the context of energy transition

ETN's 11th International Gas Turbine Conference (IGTC)

Dispatchable Technology & Innovations for a Carbon-Neutral Society

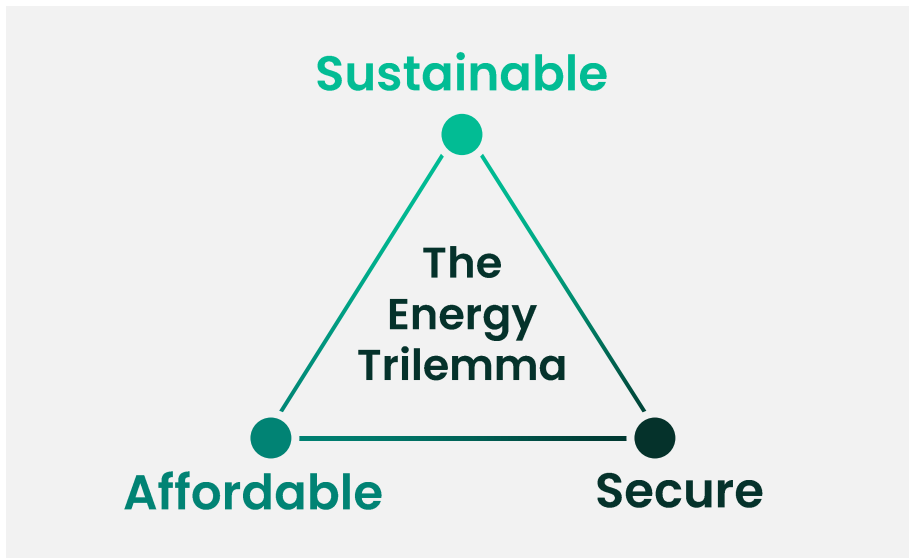
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October, 11th 2023

Addressing an evolving energy landscape

ENERGY NEEDS TO BE:



KEY MACRO THEMES

- Recent geopolitical events have **re-drawn the global energy map**, significantly changing the macro-outlook
- Governments are re-balancing their priorities between **sustainability, security, and affordability**.
- “Net Zero” ambitions remain urgent ... energy crisis changing perceptions and influencing a **more pragmatic approach**
- The need for **increased investment** in all forms of energy becoming more apparent to all parties

Positioning to help industry solve the energy trilemma with leading technology & solutions

We see three hard truths:

#1

Without major acceleration, the industry will not meet net-zero targets

While technologies in use today can deliver significant emission reductions, they are insufficient on their own to meet the Paris Agreement goals. We need a dual approach to implement efficiency measures today and invest in new energy solutions for the future.

#2

There's no scenario where hydrocarbons disappear, so efficiency matters

For at least the next 30 years, oil and gas will continue to play an important part of meeting global energy demand – even in the most aggressive of energy transition scenarios. Efficiency solutions are critical to reducing emissions, representing 37% of total emissions reductions needed to meet Paris Agreement goals.

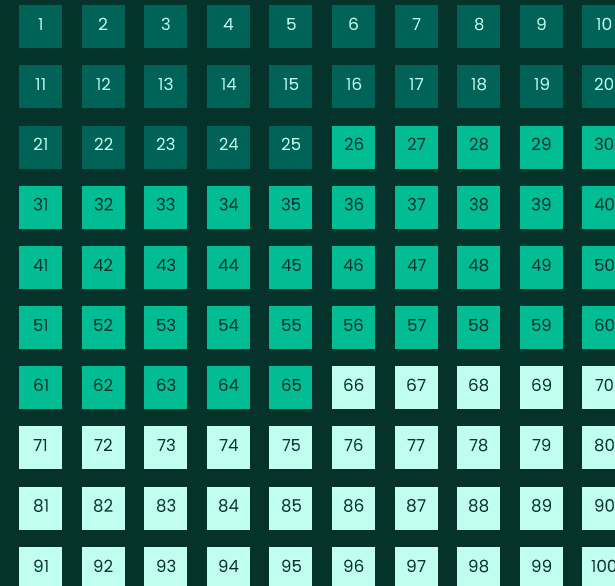
#3

There's no path to net-zero without partnership and collaboration

Our business was built on partnership and service. Today, we know this matters more than ever. We believe it will take energy producers, technology and service providers, energy buyers, policymakers, and the community at large working closely together to achieve our collective ambitions.

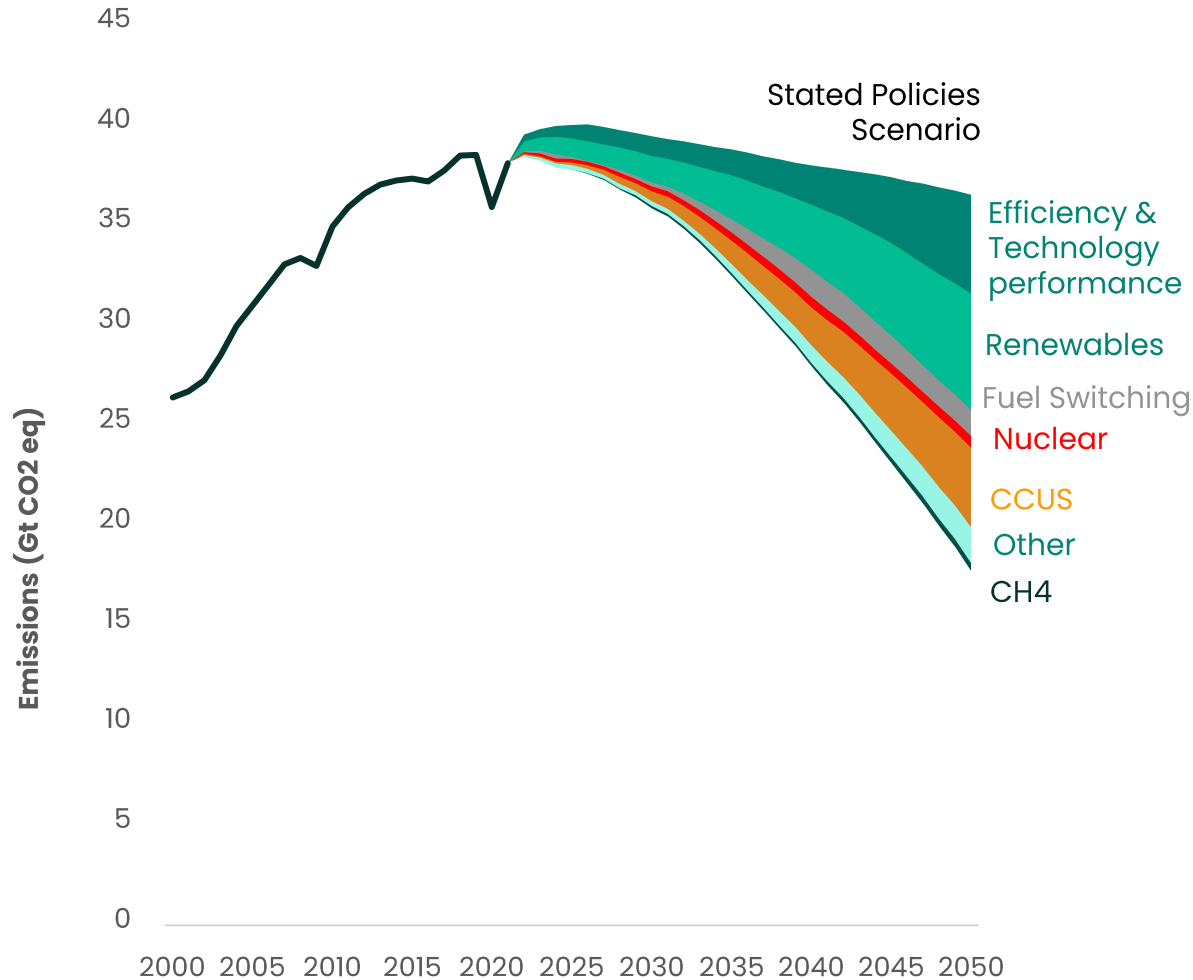
Why future technology is critical to meeting net-zero ambitions

% OF CUMULATIVE CO₂ REDUCTIONS BY TECHNOLOGY READINESS TO MEET NET-ZERO BY 2070



mature technologies
 early-stage technologies
 technologies currently in prototype and demonstration

A wide range of solutions is needed to drive substantial CO2 reduction



Solution categories

Efficiency gains	improved processes newer technology electrification
Renewables	low carbon electricity from renewables vs fossil fuels
Fuel switch	Coal to Gas (CH4 & H2) switching
CCUS	Carbon capture & storage including Blue H2
CH4	Methane detection and abatement

Source: Baker Hughes Energy Model. Derived partially from IEA carbon reduction analysis in WEO 2021

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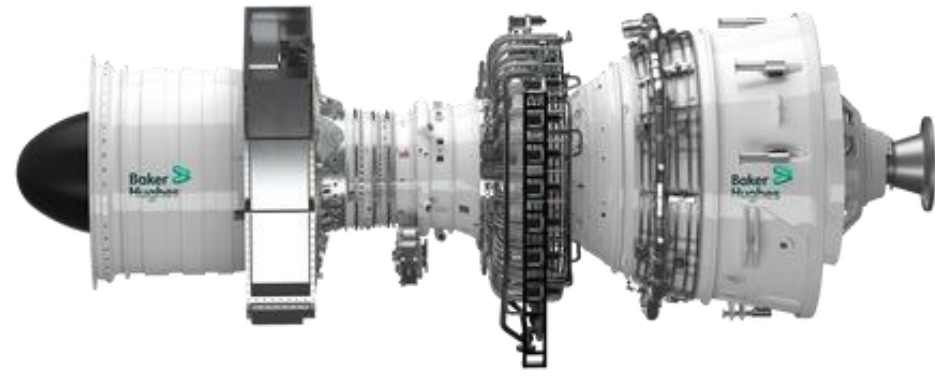
LM9000™ Carbon reduction by design



Carbon footprint reduction for LNG

The LM9000 is a 73 MW+ driver that has been developed with LNG customers in mind and with a **strong focus on reducing the carbon footprint** of the liquefaction plant.

**73+ MW
nominal
power**



Higher efficiency

Aeroderivative technologies achieve very high simple-cycle efficiency to reduce direct CO₂ emissions because the same power can be achieved using less fuel.

**44%
efficiency in
simple cycle**

The LM9000 gas turbine was tested at full speed and full load at the Baker Hughes Gas Technology turbomachinery testing facility in Massa, Italy.

Designed to reduce environmental impact

The turbine design also ensures successful start-ups with no need to vent process gases in the centrifugal compressors, thus further reducing the environmental impact of this driver. The LM9000 is among the best available technologies with values below 15 ppm for NO_x and 25 ppm for CO₂ at ISO condition.

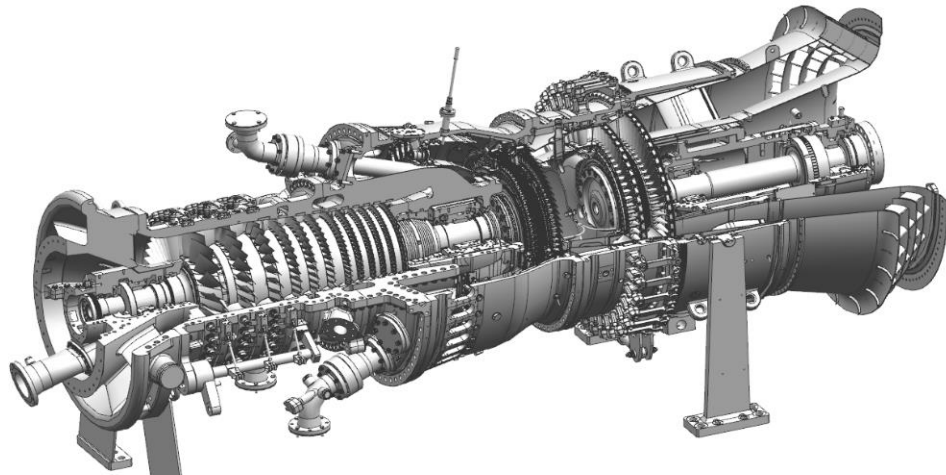
**NO_x < 15 ppm
CO < 25 ppm**



NovaLT™ Hydrogen Technologies



100% H₂ fueled GT
Zero CO₂ emissions



Partial premix combustion

Burner with multiple fuel lines enabler for wide range of fuels



100% Hydrogen 9 ppm

100% Hydrogen Fuel Flex

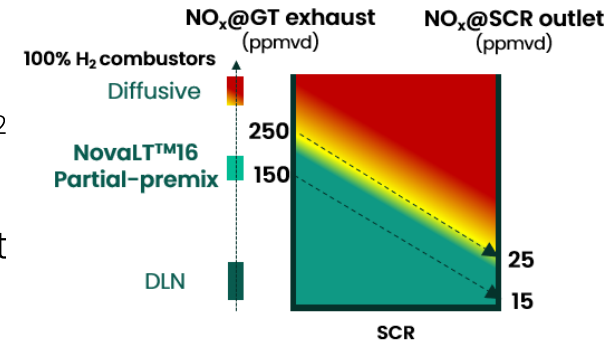
Natural Gas 9 ppm

TODAY

TECHNOLOGY DEVELOPMENT

NO_x Emissions Management

- NovaLT™16 NO_x emissions with 100% H₂ fuel can be abated with SCR without diluent.
- NO_x <15ppm directly at exhaust, w/out SCR



Fuel flexibility and switch on the fly

- Fuel blend composition variation
- Operation on natural gas in transient phase
- Switch to natural gas in case of H₂ supply shortage

100% H₂ start-up capability

- Start-up design up to 100% H₂
- No need to connect it to natural gas pipelines

100% H₂ full scale validation

Hydrogen testing capabilities at Baker Hughes Florence, Italy facility:

- 100% H₂ full speed full load
- Engine, package and auxiliaries
- Factory test for H₂ production engines

Advancing the Hydrogen Revolution



STRATEGIC
COLLABORATIONS

70+

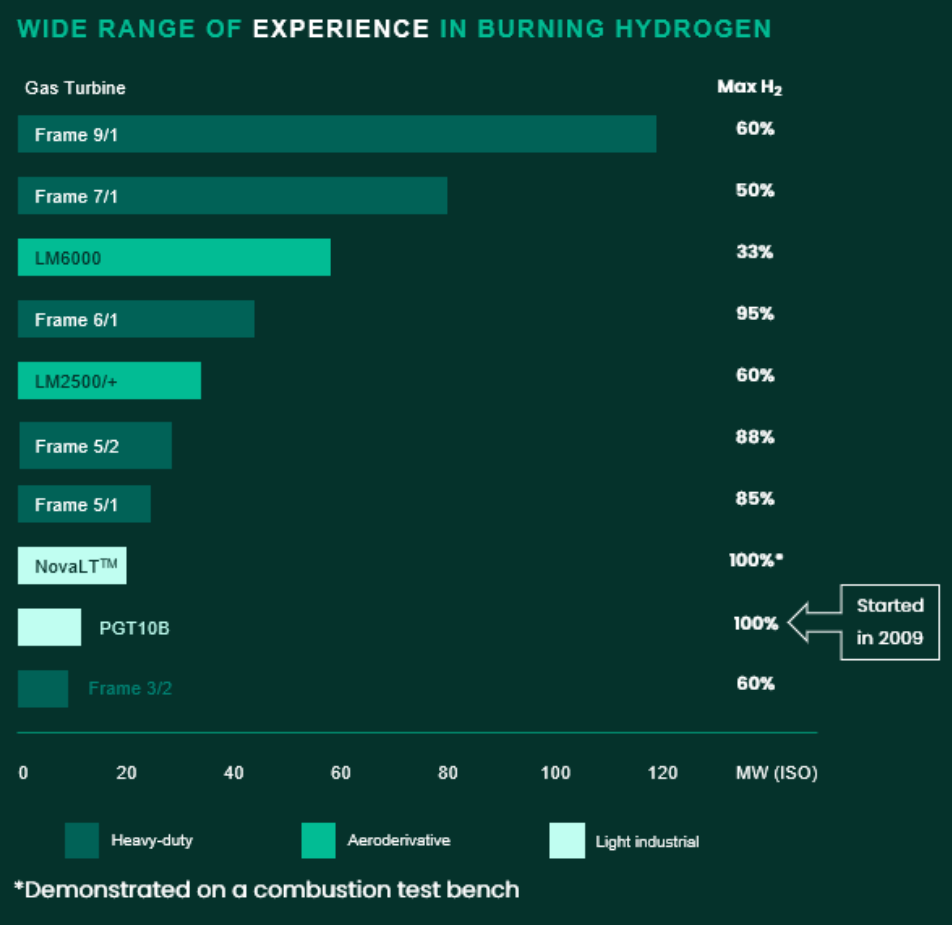
Units installed burning H₂ up to 100%

100+

Years of experience with H₂

2009

First 100% H₂ fueled gas turbine in commercial project



NovaLT™ turbine technology

The H₂ Flagship, dedicated LT combustion test with 100% H₂, able to start and run with 100% H₂.

Fr5/1 PA 100% H₂ fueled

Technology roadmap to achieve burnability of blends up to 100% H₂ with DLN combustion system (NO_x emissions below 25 ppm).

Bridge technology through wet configuration based on PEK kit hardware, able to burn 100% H₂ within 25 ppm NO_x with water injection.

H₂/NG Pipeline – Istrana, Italy



Nova LT™12

Snam and Baker Hughes successfully **Completed First Trial** for the use of H₂ as fuel in a Gas Compression Station

Blue H₂ – Edmonton, Canada



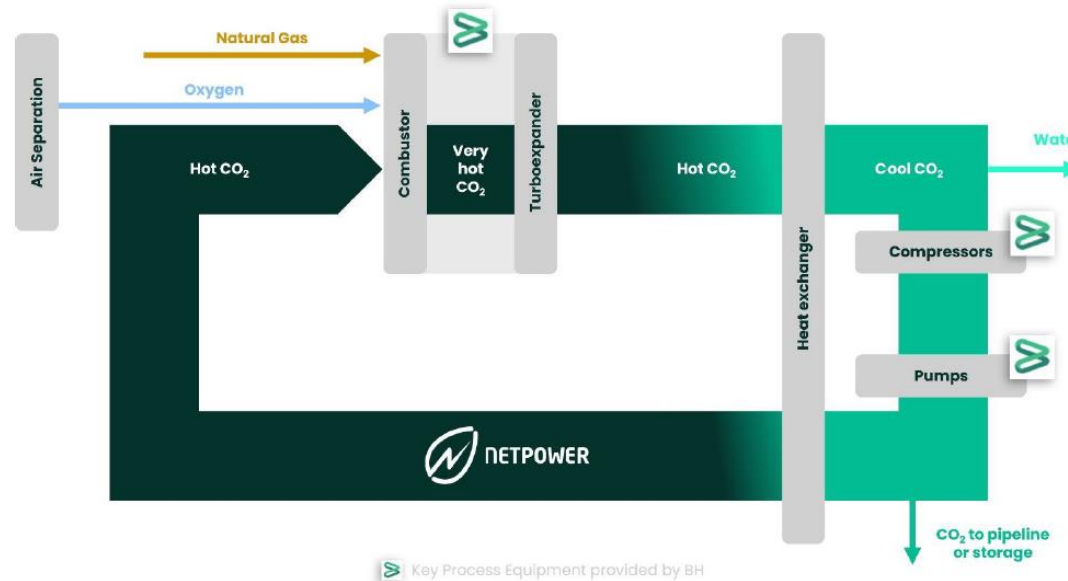
Providing **100% H₂ fueled** NovaLT16 gas turbine technology to Air Products

Oxyfuel Combustion Turbo Expander

 **Emission-free,**
dispatchable and low-cost
electric power

Direct Fired CO₂

- Game changer technology for the decarbonization pathway
- Competitive LCOE vs best in class GTCC in utility space
- Fully reliable and dispatchable power



Baker Hughes Scope

- **420MW Oxyfuel Combustion Turbo Expander (OCT)**
- Generator
- CO₂ Recycle compressor
- CO₂ Hot gas compressor
- CO₂ Recycle pump
- Oxidant pump
- Fuel gas compressor

Technology Challenges

- TEX Conditions beyond proven GT or ST design space
- High pressure-temperature combination
- Material selection...sCO₂ process environment
- Manufacturability...at the edge of technology
- Operability
- Combustion

Validation Roadmap

- Combustion tests of full scale burner
- Material characterization and environmental compatibility test
- Demonstrator test... 50MWth OCT operating in scaled plant
- Prototype test...550MWth OCT operating in full scale plant



50MWth Demo unit

Joint go to market with NET Power → 1st Plant West Texas, USA... ~300 MWe of capacity

Investing for growth today and tomorrow

\$2.1B of strategic acquisitions and investments



Carbon capture, utilization, and storage



Modular Carbon Capture technology
Nov 2020



Exclusive license for mixed-salt capture
Mar 2021



Bio-methanation & synthetic natural gas technology investment
Jun 2021



Next-gen Direct Air Capture technology
Apr 2022



Polaris carbon storage project in Norway
Mar 2021



Industrial process equipment and technologies to eliminate GHG emissions
Feb 2022



CCS hub for Norwegian Industrial Cluster
Jun 2021



Project developer that utilizes CO₂ & H₂ to produce eFuels
March 2023

Hydrogen



Methane pyrolysis technology to produce turquoise H₂
Nov 2021



Hydrogen compression and turbines for multiple projects
Jun 2021



Early-stage hydrogen technologies
Dec 2021



Hydrogen infrastructure investment platform
Anchor Investor
Apr 2021

Clean power solutions



Clean integrated power and hydrogen solutions
May 2021



Technology development & global deployment of zero-emission power plants
Feb 2022

Digital



Reliability and industrial asset management solutions
Feb 2021

Oilfield services & equipment



Well intervention services & downhole technology
Mar 2022



Advanced artificial lift and electrical submersible pumps technology
Jul 2022

Gas & industrial



Inspection solutions for critical infrastructure
Mar 2022



Power Generation

Electrification equipment, generators, and motors
Aug 2022

Geothermal



Closed loop geothermal technology
Mar 2022

We are Baker Hughes, an energy technology company. Together, we're making energy safer, cleaner, and more efficient for people and the planet.

Energy for today and tomorrow.

The energy sector is changing, faster than ever before. The energy trilemma – solving for energy security, sustainability, and affordability – is rebalancing our priorities and creating a new path forward for the industry.

We believe we can meet those objectives together. As demand for energy increases, we're demanding more from energy, making it more sustainable, more reliable, more abundant, and more accessible.

We take
energy
forward

An aerial photograph of a wind farm situated on a mountain ridge. The landscape is lush green with a dirt road winding through it. Several white wind turbines are visible, some partially obscured by a layer of mist or low clouds. In the background, more mountain peaks are visible under a soft, hazy sky. A teal arrow with three chevrons at its tip points horizontally across the middle of the image, passing behind the text.