



**ETN**  
Global

## GAS TURBINES: AN ENABLING TECHNOLOGY FOR A CARBON-NEUTRAL SOCIETY

### The energy trilemma in a future global energy scenario

Global pledges of carbon-neutrality by mid-century are rapidly changing the energy landscape. There are three core dimensions to consider in preparation of energy strategies: affordability and access; security of energy supply; and environmental sustainability. The World Energy Council defines balancing these aspects as the energy “trilemma”. Several factors challenge this balancing act. Firstly, wind and solar, the main contributors to an increasing share of renewables in the energy system are not ‘dispatchable’, hence unable to provide electricity on demand. Moreover, 70% of today’s European energy system relies on non-electric sources; 2050 projections indicate that this share will remain substantial. Even in high electrification rate scenarios, 40-60% of energy consumed will be met with molecule-based fuels.

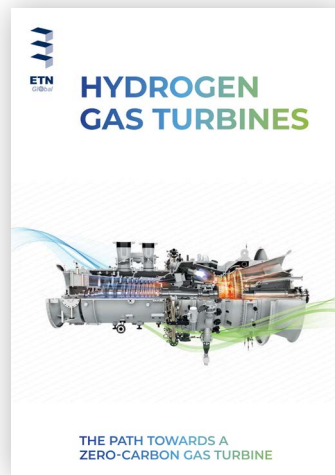
Solving the energy trilemma requires readily available, efficient and dispatchable technology, providing energy in a secure and sustainable way to back-up electricity from weather-dependent energy sources and heat solutions. Gas turbine technology is unique and versatile, capable of fulfilling all these needs using carbon-free molecule-based fuels such as hydrogen, synthetic-methane or other renewable fuels.

### Dispatchable decarbonised energy solutions to address the energy trilemma

Gas turbines offer high efficiency, reliability, operational flexibility, well-established low-emission credentials as well as ability to use hydrogen fuel blends. These attributes offer important decarbonisation opportunities in the energy transition, a clear path towards a dispatchable zero-carbon technology suited for a wide variety of applications along with the opportunity of additional efficiency increases through sector coupling.

The responsiveness and dispatchability of gas turbines, combined with the existing gas infrastructure and seasonal energy storage solutions, provide security of supply and grid stabilisation for large-scale integration of intermittent renewable energy. Hydrogen, in particular, is increasingly seen as an attractive option to decarbonise power for air, land and sea applications. Also, hydrogen

has greater potential for lower NOx emissions than hydrocarbon fuels. ETN’s Hydrogen Gas Turbines report [“The path towards a zero-carbon gas turbine”](#) showcases a more comprehensive overview of the benefits and roadmap, while wider gas turbine technology development opportunities and sustainable energy systems demonstrations’ needs are presented in ETN’s [2021 R&D Recommendation Report](#).



ETN Global  
Hydrogen Gas Turbine - The path towards a zero-carbon gas turbine



ETN Global  
2021 R&D Recommendation Report

### Holistic approach for deeper and wider decarbonisation

The all-encompassing challenge of the energy trilemma requires a holistic solution. This can be achieved through sector coupling, interconnecting all sectors that consume energy, e.g. buildings, transport and industry, with power producers. Conforming to different needs, various energy vectors such as electricity, heat, gas, and enabling technologies require integration into a single delivery system and to eliminate shortcomings through complementary solutions. In such a system, gas turbines play a vital role thanks to dispatchability and fuel flexibility. Solutions such as power-to-X allow surplus electricity to be stored in the form of carbon-free gases, to be re-used as and when needed. Consequently, gas turbines are suitable as a conversion technology in a wide number of applications across multiple sectors, as portrayed in the infographic on the next pages.

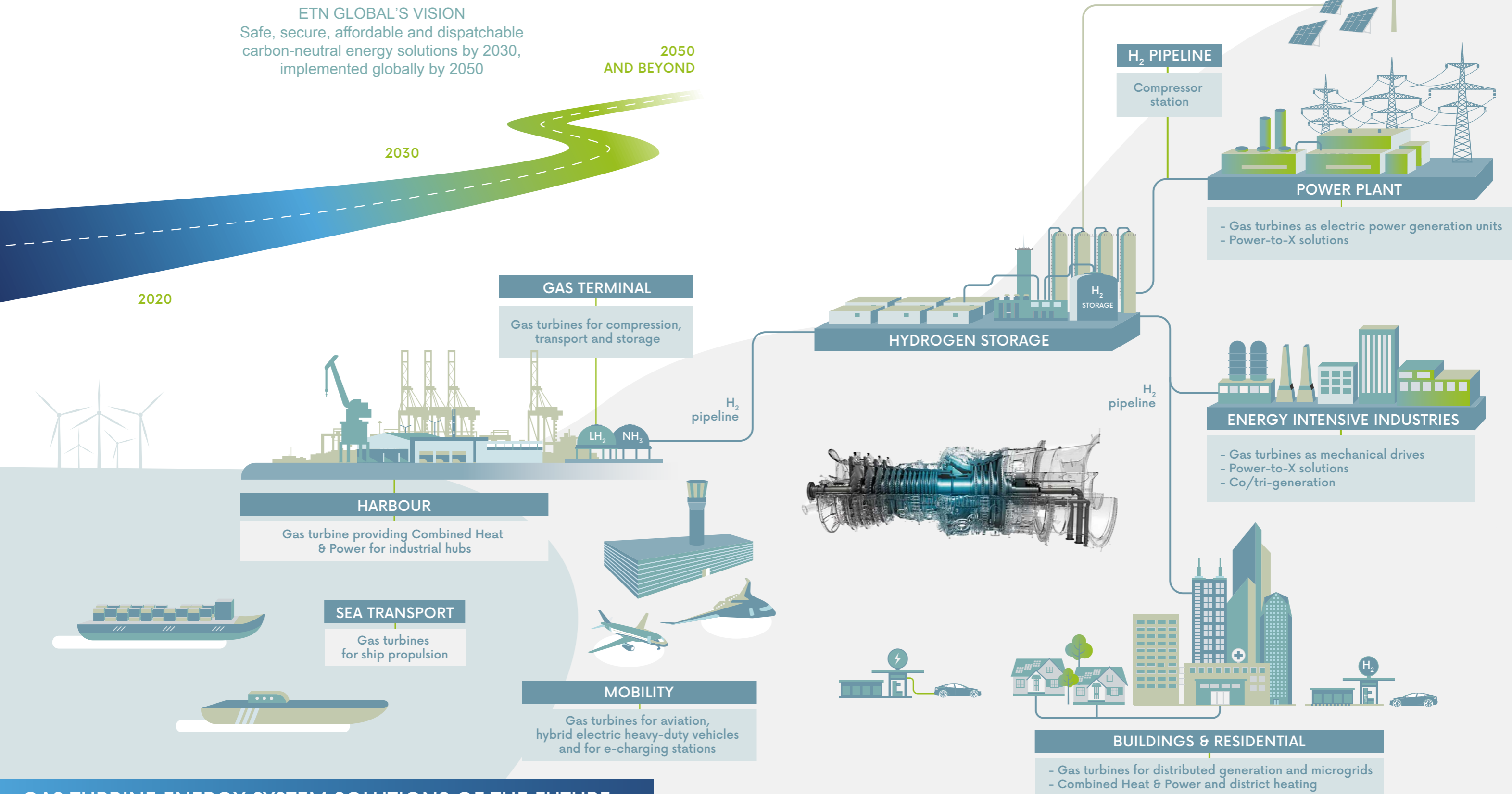
# GAS TURBINE APPLICATIONS IN A CARBON-NEUTRAL SOCIETY

ETN GLOBAL'S VISION  
Safe, secure, affordable and dispatchable carbon-neutral energy solutions by 2030, implemented globally by 2050

2050  
AND BEYOND

2030

2020



## GAS TURBINE ENERGY SYSTEM SOLUTIONS OF THE FUTURE:

COMPACT  
POWER DENSITY

DISPATCHABLE

FLEXIBLE

RENEWABLE FUELS

ENERGY STORAGE

COST COMPETITIVE

NET-ZERO SOLUTIONS

## Sectorial implementation

Gas turbines are uniquely positioned to provide a cost effective, clean, flexible and scalable power and heat solution to a broad array of societal sectors:

**In power generation** gas turbine flexibility enables use of an increasing share of renewable fuel as it becomes available. Dispatchable gas turbine-based power generation operating on carbon-neutral or decarbonised fuels will ensure security of electricity supply in a sustainable way and support the expansion of Renewable Energy Sources (RES) in the grid by providing frequency stability backup.

**In industry**, fine tuning power to heat ratio of gas turbine plants will lead to widespread use in industrial processes requiring multi (10+) MW inputs. With co/tri-generation of electrical and/or mechanical energy and of heat/cold, wide variability can be achieved. Finally, gas turbines running on renewable or decarbonised fuels will offer an opportunity to decarbonise energy-intensive industries.

**In commercial and residential buildings** future gas turbine Combined Heat and Power (CHP) solutions could be applied to a broad range of buildings, from single-family houses to large residential clusters and commercial buildings (office buildings, shopping malls, factories, leisure parks etc.). Highly efficient gas turbine-based CHP solutions could be deployed in electrical or thermal mini-grids, either for base load generation, or as backup options for renewable energy sources covering short-, medium- and long-term peak demand.

**In land, sea and air transport** gas turbines provide an opportunity to decarbonise propulsion units for large land-based vehicles, ships and aircraft. Through further gas turbine technology developments, such propulsion units will be able to operate on a variety of carbon-neutral or decarbonised fuels (hydrogen, methanol, ammonia, synthetic hydrocarbons) according to specific requirements.

## ETN's support and commitment to a carbon-neutral energy system

ETN Global brings together the entire gas turbine value chain community. In line with Paris Agreement goals, ETN Members are committed to the development of safe, secure, affordable and dispatchable carbon-neutral energy solutions by 2030, to be implemented globally by 2050. Gas turbine dispatchability, decarbonisation options and power density, combined with a wide range of applications across many sectors offer great potential to enable and support the present and future power and heat needs of a carbon-neutral society and beyond. It also demonstrates the need and relevance of continuous support for R&D efforts in the quest for a carbon-neutral society through:

- Hybridisation of gas turbine technology with renewables and energy storage;
- Retrofit solutions from 0 to 100 vol.% of hydrogen blends, and other renewable fuels;
- Increased energy efficiency and performance (CHP), and increased operational flexibility;
- Reduced carbon footprint of existing assets;
- Support of improvement and deployment of CCUS solutions.

To fully unlock the potential of zero-carbon gas turbine technology, governmental funding schemes encouraging cooperation between manufacturers, end-users and academia is essential to raise the technology readiness level to demonstration level. The deployment of technology solutions in a real-world environment is a challenge to overcome in the demonstration phase and to facilitate this appropriate cooperation among demonstration projects globally should be incentivised. From a policy and market perspective, technology neutrality should be ensured and all low-carbon solutions with the capability of becoming carbon-neutral should be met by favourable market conditions and a supportive regulatory framework. These actions will enable a wide-spread introduction of zero-carbon gas turbines, unlocking a cost-efficient solution to the energy trilemma and contribute to environmental performance, social benefits and economic growth worldwide.