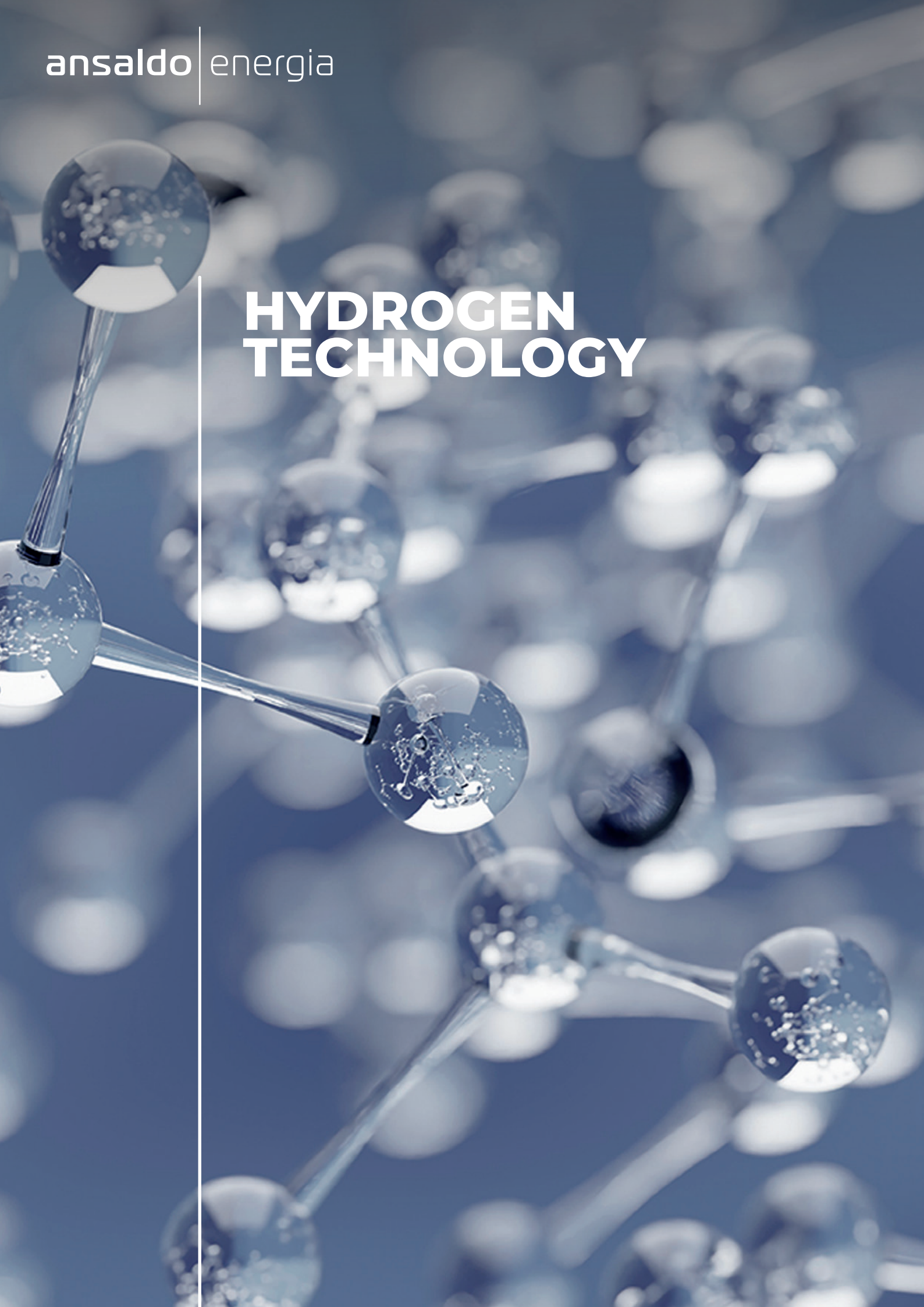


# HYDROGEN TECHNOLOGY



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## *Ansaldo Energia solutions for Hydrogen combustion: fast-forward to a Hydrogen Fueled Future*

Thanks to fast-paced technological advancements, the world is embracing new energy visions which feature hydrogen as a key driver in the energy transition, and so are plant owners, who are called to play a vital role in enabling the creation of an integrated, secure, environmentally sustainable energy system.

New renewables-driven scenarios envisage great opportunities to reduce cost and overcome barriers preventing green hydrogen from being a true game-changer in solving the security, storability and carbon neutrality challenges affecting the current energy landscape.

Despite the several steps that are still to be taken at different levels to break down the barriers to a hydrogen economy, the global energy landscape is turning in this direction. With hydrogen projected to meet increasing shares of the energy demand and the cost of green hydrogen production expected to drop sharply over the coming decades, a hydrogen-fueled future might be closer than we think.

Ansaldo Energia is fully committed to reach 100% of hydrogen capability on all its fleet.

Based on two different technological platforms, Ansaldo Energia offers solutions to best suit each Customer' generation profile: its versatile gas turbines are capable to burn any hydrogen-natural gas blend (see table below) and can easily handle intermittent or fluctuating H<sub>2</sub> supply maintaining full adherence to NO<sub>x</sub> emission requirements.

Ansaldo Energia is part of FLEX4H2 project with the main objective to Design, Develop and Validate a safe efficiency combustion system, capable of operating with 100% H<sub>2</sub>. This project, financed by EU and Swiss Federal Department of Economic Affairs, has an overall budget of approximately 8.7 MEUR and it is lead by Ansaldo Energia.

# Ansaldo Energia solutions for burning Hydrogen

Technology	Application in Gas Turbine (No hardware modification on gas turbine)	H <sub>2</sub> Capability: any blend between 0 up to max [vol %]
Sequential Combustion	GT36 New and Service	70
Sequential Combustion	GT26 New and Service	45
Single Stage Combustion	AE94.3A New and Service*	40
Single Stage Combustion	AE94.2 New and Service*	40
Single Stage Combustion	AE64.3A New and Service	40

\*including V94.3A/V94.2 technology

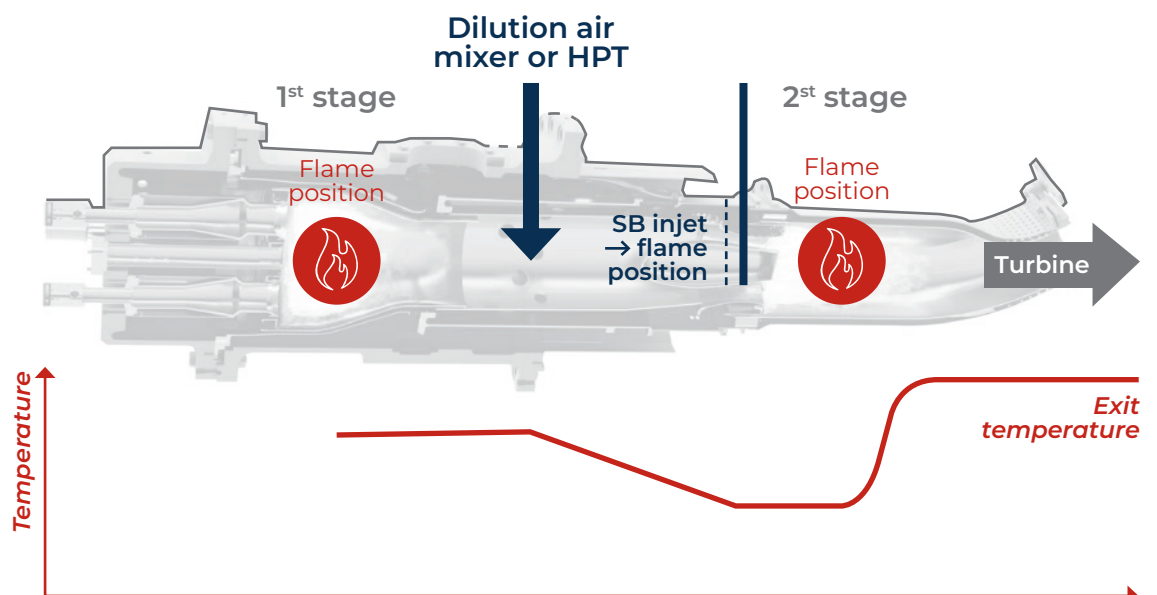
## Sequential combustion *Hydrogen, Outstanding flexibility*

The main challenge of hydrogen combustion lies in its properties, first and foremost its increased reactivity. Compared to natural gas, during H<sub>2</sub> combustion the flame position moves upstream, thus increasing the risk of flashback.

All conventional combustion systems fail to handle the special features of hydrogen without compromising performance: by injecting less fuel, flashback risks are mitigated and the flame is moved back to the design position, but exit temperature gets lower and performance is severely reduced.

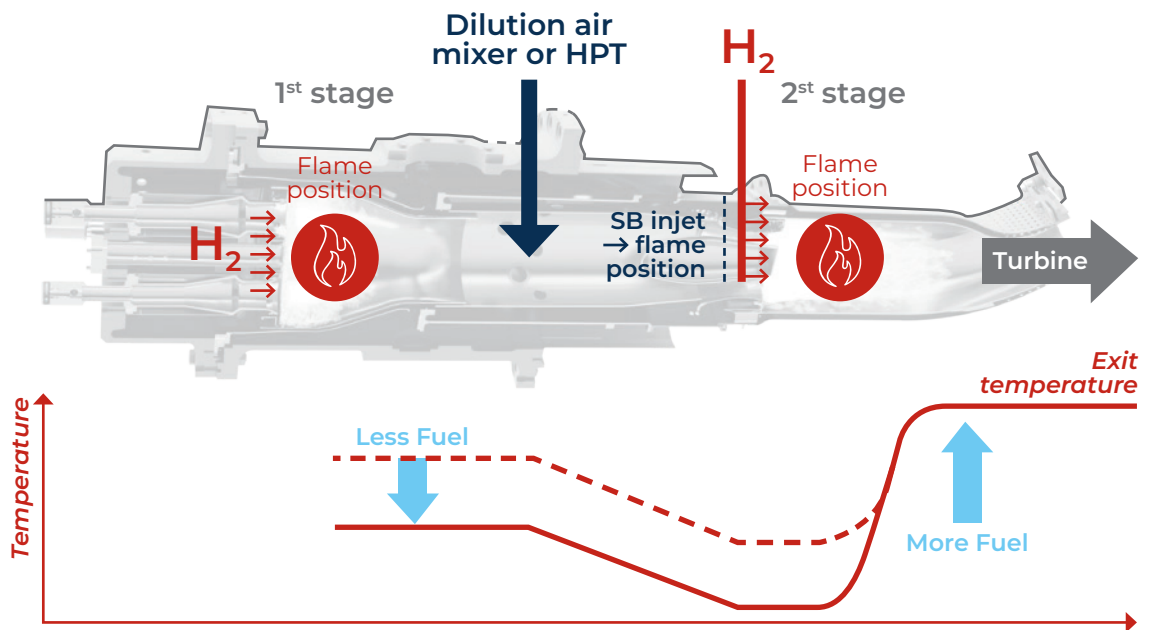
Ansaldo Energia developed a unique, unrivalled, state-of-the-art technology for safely burning very high H<sub>2</sub> contents while preserving top-level performance.

Ansaldo Energia's sequential combustion employs two combustor stages in series: one conventional stage followed by an auto-ignited second stage overcoming the limits of traditional combustion systems.



A shift of fuel from the first to the second stage compensates the higher hydrogen reactivity on both stages: the first stage flame location is maintained thanks to its lower temperature, while the resulting lower inlet temperature of the second stage keeps its flame at the desired location notwithstanding an increased fuel flow.

This is possible because the second stage flame is stabilized by auto-ignition, strongly driven by the inlet temperature and less sensitive to the flame temperature which can be maintained at full F and H class levels. This is critical to fully exploit the potential of H<sub>2</sub> combustion.



Ansaldo Energia has been at the forefront of hydrogen combustion development for many years, joining prominent European and international development projects.

## Single stage combustion

### *Hydrogen, Our experience*

The single stage combustion is the typical configuration of the AE94.3A and AE94.2 gas turbines which, with millions of service hours, are among the most representative fleets in the power generation field. Two AE94.3A, capable of burning a blend of natural gas and 25% H<sub>2</sub> by volume, started commercial operation in early 2006 in a combined cycle plant served by a refinery, reaching 300,000 EOH, using standard hardware with no bespoke fuel systems.

Smooth, trouble-free operation and highly stable combustion behavior allowed for a gradual increase of the mixture's hydrogen content of the mixture, reaching now 25% with a potential saving of 40,000 tons/year of CO<sub>2</sub> assuming a base load operating profile.

Indeed, the AE94.3A and AE94.2 are currently capable of burning 40% in premix mode.

## **Installed fleet**

### ***Hydrogen, Future proof your assets***

Ansaldo Energia can offer a wide range of specific solutions for installed and operating gas turbines to increase the amount of hydrogen that can be burnt in an installed plant, thus lowering emissions and reducing the overall carbon footprint.

Ansaldo Energia gas turbines and combustor upgrades can cope with extremely broad H<sub>2</sub>-methane blend up to still unmatched maximum H<sub>2</sub> content of 40% vol and more.

The versatility of Ansaldo Energia gas turbines allows for easy adaptation of the fuel system, requiring limited changes to the hardware setups in use. The capability to easily retrofit solutions for burning varying H<sub>2</sub> content becomes particularly important when H<sub>2</sub> availability fluctuates due to intermittent production from renewables. This expands plant operation horizons with no compromises on efficiency or performance. In addition, strikingly low NO<sub>x</sub> emissions levels ensure full environmental compliance.

### ***Retrofit solutions for GT26***

Thanks to its sequential combustion architecture, GT26 enables an enhanced management of continuously increasing hydrogen content. Its well-known combustion stability and combustor configuration allows it to burn hydrogen up to approximately 45%, by implementing the latest SEV burner generation.

### ***Retrofit solution for AE/V94.2 / AE/V94.3A / STG5-2000E / SGT5-4000F***

Ansaldo Energia's portfolio of single-stage hydrogen combustion solutions employs an extremely versatile technology allowing an easy retrofitting on the entire installed fleet of AE/V94.3A, AE/V94.2, STG5-2000E & SGT5-4000F gas turbines.

Current and future Customers are therefore offered a unique opportunity to convert their plant assets to run on hydrogen up to 40%. Ansaldo Energia can thus help Customers embracing the world's new energy trends.



For more information,  
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