

# TIME TO FACE OUR WORLD'S BIGGEST CH<sub>2</sub>ALLENGE

Our world's power generation landscape is changing fast: contemporary societies and globalized economies require a massive, uninterrupted flow of energy to live, function, and thrive. Such **huge energy demand** has posed and continues to pose systemic challenges, first and foremost the need to meet increasingly ambitious CO<sub>2</sub> reduction targets.

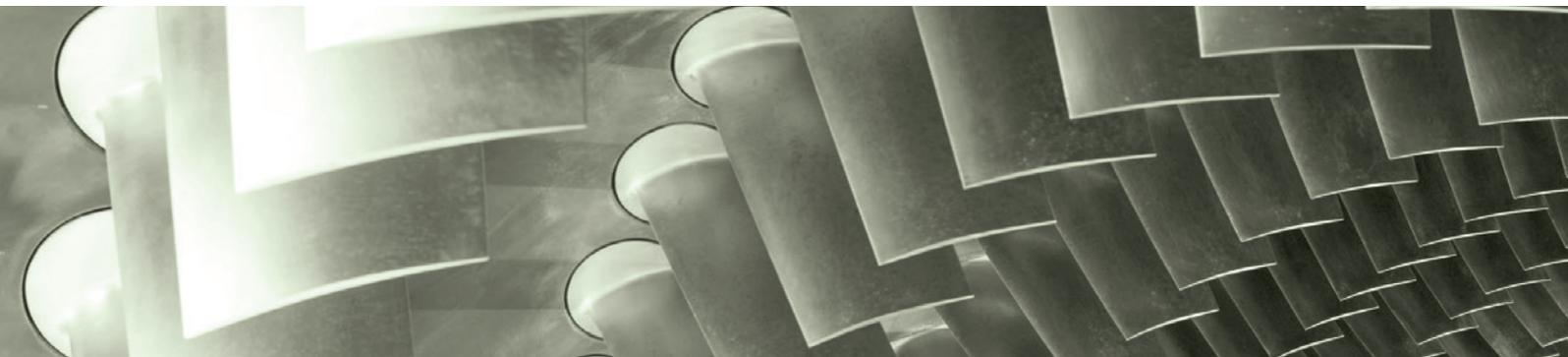
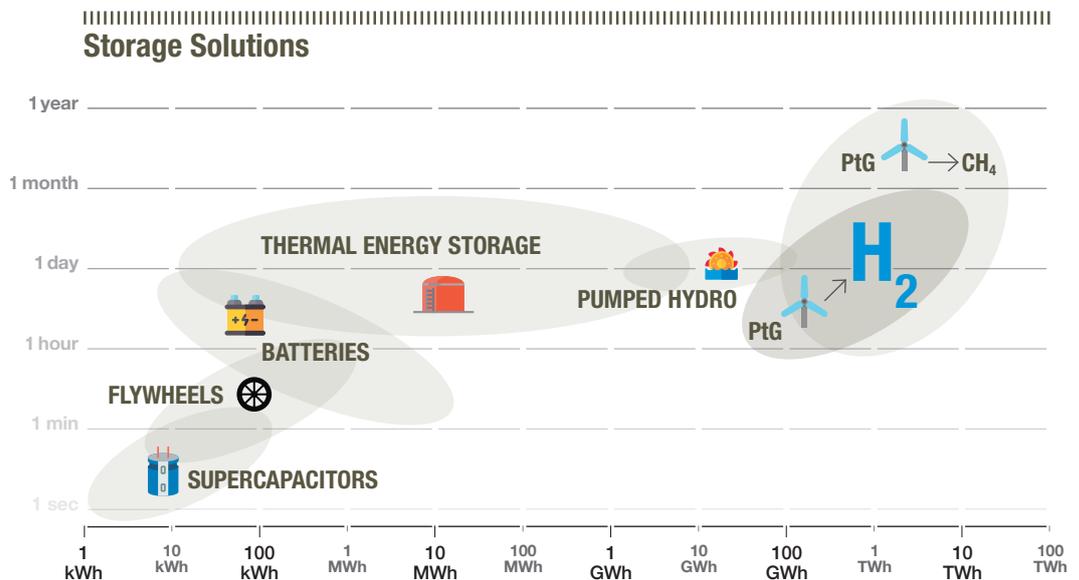
Reducing our dependence from highly polluting fossil fuels and finding reliable technologies that can provide us with a **clean, flexible, dependable and affordable** flow of energy is probably the biggest challenge our world will have to face in the near future.

Despite providing clean power, most new technologies failed to meet **two crucial criteria** that would make them ideal candidates to replace or supplement conventional power generation: dispatchability and storability. Indeed, much of the current renewable power production – sun & wind – is rather **unpredictable and intermittent**: times of overproduction alternate with times of shortage. In order to meet increasingly challenging CO<sub>2</sub> targets, a huge increase of renewable power generation will occur. As a consequence, more frequent and massive overproduction periods are expected.

To guarantee reliable power supply and take advantage of renewable power surplus production, storage solutions of increasingly bigger size – in the order of 10 GWh to 10 TWh, even bigger than pumped hydro plants, the largest energy reserves today – are needed.

**THERE IS NO SILVER BULLET TO FACE OUR WORLD'S BIGGEST CHALLENGE; HOWEVER, THERE IS AN OPTION THAT CAN PROVIDE CLEAN, STORABLE, FLEXIBLE ENERGY: H<sub>2</sub>**

## Storage Solutions



# CH<sub>2</sub>ANGING THE FACE OF RENEWABLE ENERGY SUPPLY

Gas turbines already play an important role in power generation, and in the light of an ever-increasing energy demand their importance is likely to grow in the years to come.

Indeed, according to the *World Energy Outlook*, **renewables and natural gas are the big winners** in the race to meet energy demand growth until 2040, but the variable nature of renewables in power generation entails a new focus on **electricity security**.

Consequently, gas turbines are bound to reinforce their role as guarantors of grid reliability in modern power systems; however, no attempt to improve or complement the existing systems must be done at the expense of the environment.

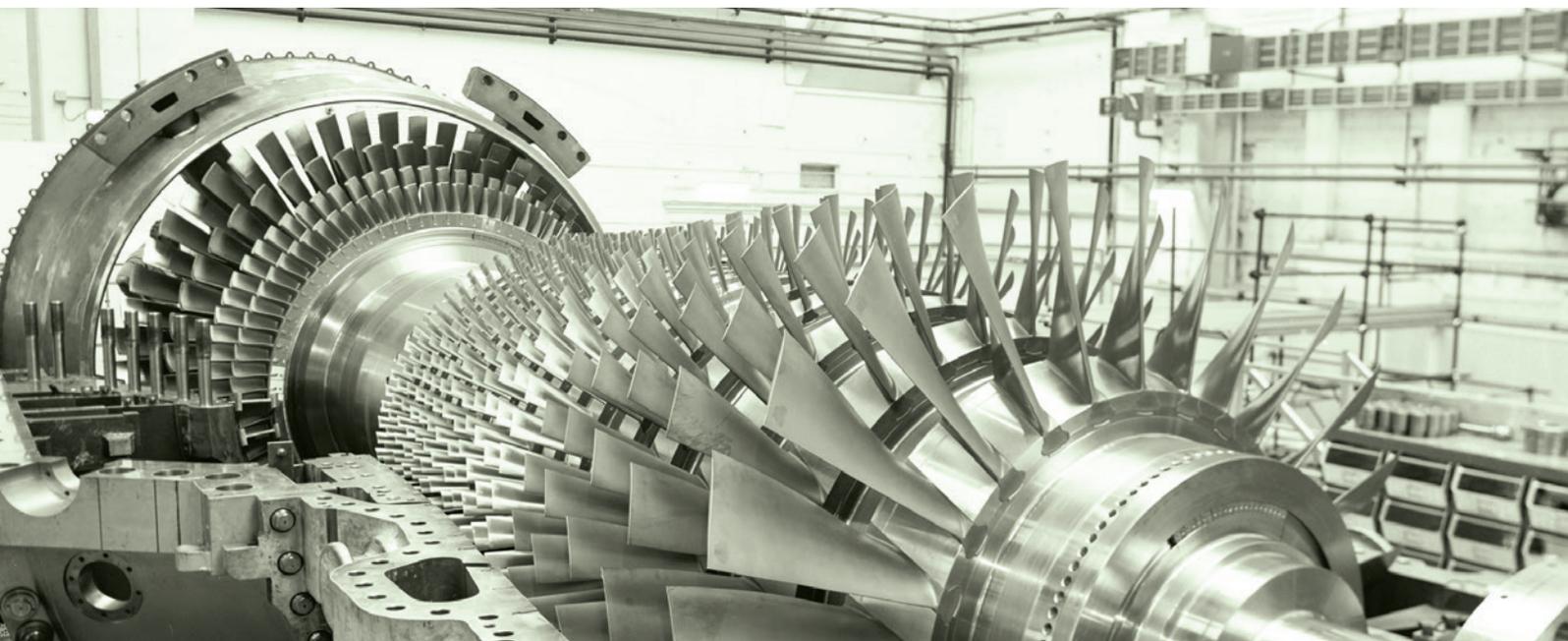
This is where hydrogen (H<sub>2</sub>) from renewables comes into play, allowing **totally CO<sub>2</sub> free combustion**, which makes it the cleanest possible fuel alternative. H<sub>2</sub> also features a **unique capability to store energy** for medium to long storage cycles – from hours to several months; it can be either stored pure in large underground facilities or blended through injection into existing natural gas pipeline infrastructures.

Furthermore, H<sub>2</sub> finds its best application in **Combined Cycle Power Plants** already producing high power outputs at high efficiencies, and with low emissions: by running on H<sub>2</sub>, they just go a step forward and pave the way to dispatchable, totally CO<sub>2</sub>-free power generation.

No generation technology alone can solve all energy issues, but H<sub>2</sub> combustion can be **a means to bring out the best of renewable energy** by overcoming its current limitations.

Dependability, ensured by the possibility of easily switching between natural gas and H<sub>2</sub>, mixing any blend up to the maximum H<sub>2</sub> content in order to reduce fossil fuel burning, will also play a fundamental role in the near future.

**HYDROGEN OFFERS  
AN EFFECTIVE,  
VIRTUALLY UNLIMITED  
STORAGE OPTION**



# COMBUSTION TECH<sub>2</sub>NOLOGY AT ITS BEST: CLEANER, MORE FLEXIBLE, MORE EFFICIENT

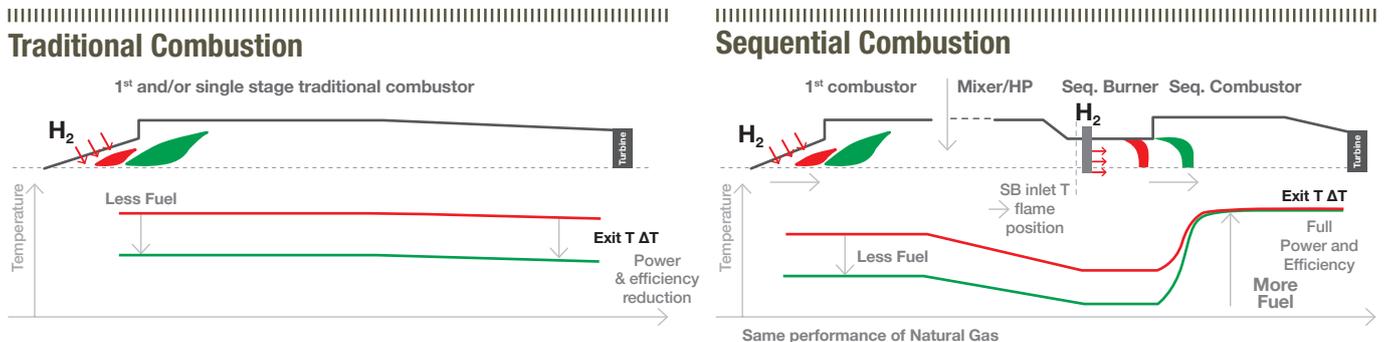
H<sub>2</sub>-rich gas mixtures not to mention pure hydrogen, require **very advanced combustion technology** to burn H<sub>2</sub> safely while preserving output and efficiency.

The main challenge of H<sub>2</sub> combustion lies in its properties, first and foremost its increased reactivity. As 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 hydrogen's special features 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 solution** that keeps hydrogen combustion under *control* while preserving top-level performance.

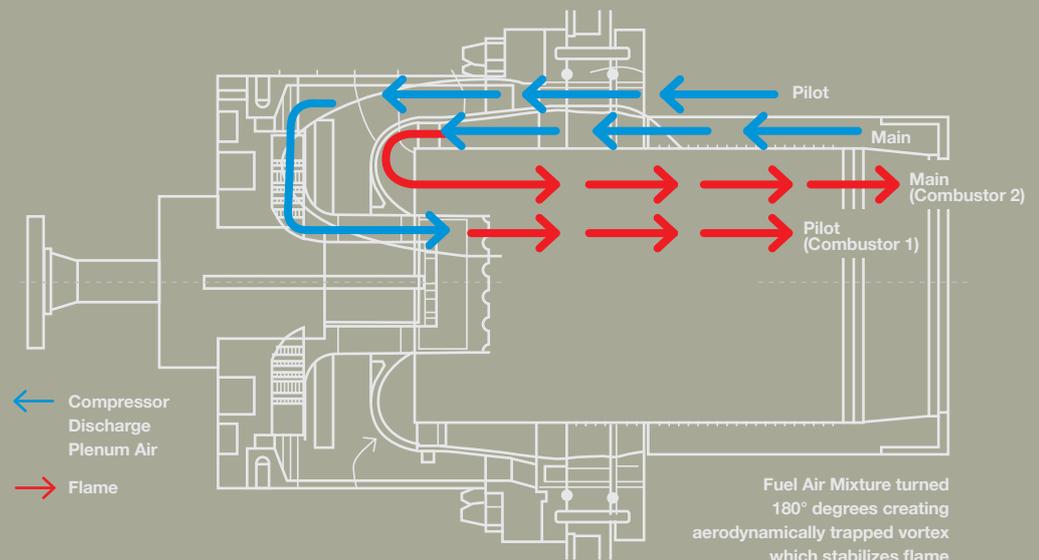
Ansaldo Energia's *sequential combustion* employs two combustor stages in series: one conventional stage followed by an auto-ignited second stage overcoming the limits of traditional combustion systems. A shift of fuel from the first to the second stage compensates the higher hydrogen reactivity on both 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 despite 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 **key in unleashing H<sub>2</sub> combustion's full potential**.

Fitted on Ansaldo Energia top range gas turbines – GT26 and GT36 – sequential combustion, therefore, offers a set of unique advantages without compromising performance, in compliance with emission requirements and over the full load range.



## RETROFIT SOLUTION

Via PSM, its own independent service provider, Ansaldo Energia can retrofit gas turbines with a cross platform compatible combustion solution, FlameSheet™, which burns up to 10 times more hydrogen than traditional Dry Low NOx combustors. The FlameSheet™ is a Trapped Vortex burner. FlameSheet™'s robust mixing techniques and high pre-mixer exit velocities provide substantially increased tolerance to highly reactive fuels like H<sub>2</sub>.



# H<sub>2</sub> HYDROGEN-IUS SOLUTIONS NO CHANGES, NO COMPROMISES

**UNLOCKING THE FULL H<sub>2</sub> POTENTIAL FOR LARGE-SCALE HYDROGEN APPLICATIONS, ANSALDO ENERGIA IS THE IDEAL PARTNER TO LEAD THE WAY TOWARDS CO<sub>2</sub>-FREE, DISPATCHABLE POWER GENERATION**

Ansaldo Energia has been at the forefront of H<sub>2</sub> combustion development for many years, joining prominent European and international projects including:

- EncapCO<sub>2</sub>** [Developing premix combustors for H<sub>2</sub> rich combustion]
- DECARBIT** [Developing reheat combustors for 100% H<sub>2</sub> by power - 70% (vol.) H<sub>2</sub> / 30% (vol.) N<sub>2</sub>]
- BigH<sub>2</sub>** [Fuel injector fundamentals co-/cross-flow]

During their development both the GT26 and the new GT36 gas turbine combustors underwent detailed validation under full engine pressure at the DLR (German Aerospace Institute) in Cologne.

Ansaldo Energia gas turbines and retrofit combustors can cope with any H<sub>2</sub>-methane blend up to still unmatched maximum H<sub>2</sub> volume content of 30, 40 and 50%, **with no need to change or adapt the existing hardware.**

This becomes particularly important when H<sub>2</sub> availability fluctuates due to intermittent production from renewables. Ansaldo Energia H<sub>2</sub> solutions allow customers to enjoy *twofold flexibility* in terms of fuel composition as well as in plant operation, thanks to a very wide load range. This expands plant operation horizons with **no compromises on efficiency or performance**. In addition, strikingly low NOx emissions levels ensure environmental compliance.

All these characteristics make Ansaldo Energia the technology leader in H<sub>2</sub> combustion both for new equipment and service with GT26, GT36 and FlameSheet™.

One of the **main ingredients of life** on Earth, H<sub>2</sub> is also the best option today to pave the way to tomorrow's energy – clean, storable, flexible. With their unique flexibility and performance, Ansaldo Energia solutions provide the best-suited technology to go 100% hydrogen by power in the future.

## ANSALDO ENERGIA SOLUTIONS FOR BURNING H<sub>2</sub> AT HIGH EFFICIENCY

Ansaldo Energia H<sub>2</sub> solutions for new equipment and service feature leading edge, unmatched technological characteristics in terms of:

- amount of H<sub>2</sub> volume mixed with natural gas;
- no or only slight derating compared to 100% natural gas;
- NOx emissions at 15 ppm or less;
- very broad load range (wider than 100% natural gas).

 Technology	 Application	 Max H <sub>2</sub> vol. %	 Derating	 Emissions NOx [ppm]	 Load range
Sequential combustion	GT26 New and service	30	<1%	NOx @ 15ppm	20-100%
Sequential combustion	GT36 New	50	<1%		
FlameSheet™	Service Retrofits Solutions for: GE Frame 6F, 7F, 9F MHPS 501F/G, 701F/G Siemens-Westinghouse 501F/G	40	<1%	NOx @ 9ppm	30-100%



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