

ITALIAN ENERGY

BRIGHTER FUTURE





**Enabling gas turbines to operate on hydrogen fuel in a future market.
An overview on how to match today's customer demands.**

Summary

- The EU Taxonomy regulates **private investment** and foresees plant readiness to use green fuels. It is a **guideline** with stringent **demands on CO2 reduction**.
- Hydrogen is considered as a replacement fuel for NG.
- Conversion of power plants to H2 combustion has to be planned as of today and onwards. H2 combustion capability must be made available to qualify for **“H2 ready”**.
- The actual implementation of H2 combustion will take place at some point in the future.
- The exact timing will depend on H2 availability and the market conditions for electricity production at that point in time.
- Power plants have **to be prepared for a number of possible conversion scenarios** which are mainly driven by the amount of co-fired H2. This ultimately drives a decision and investment strategy over the lifetime of a power plant.

EU Taxonomy classifies private investment activities with CO2 emission limits

1 Technology classified as **Significant Contribute to Climate Change Mitigation**

- for gas emissions **<100 grCO₂/kWh**

very high % H2 co-firing required

2 Technology classified as **Do Not Significant harm**

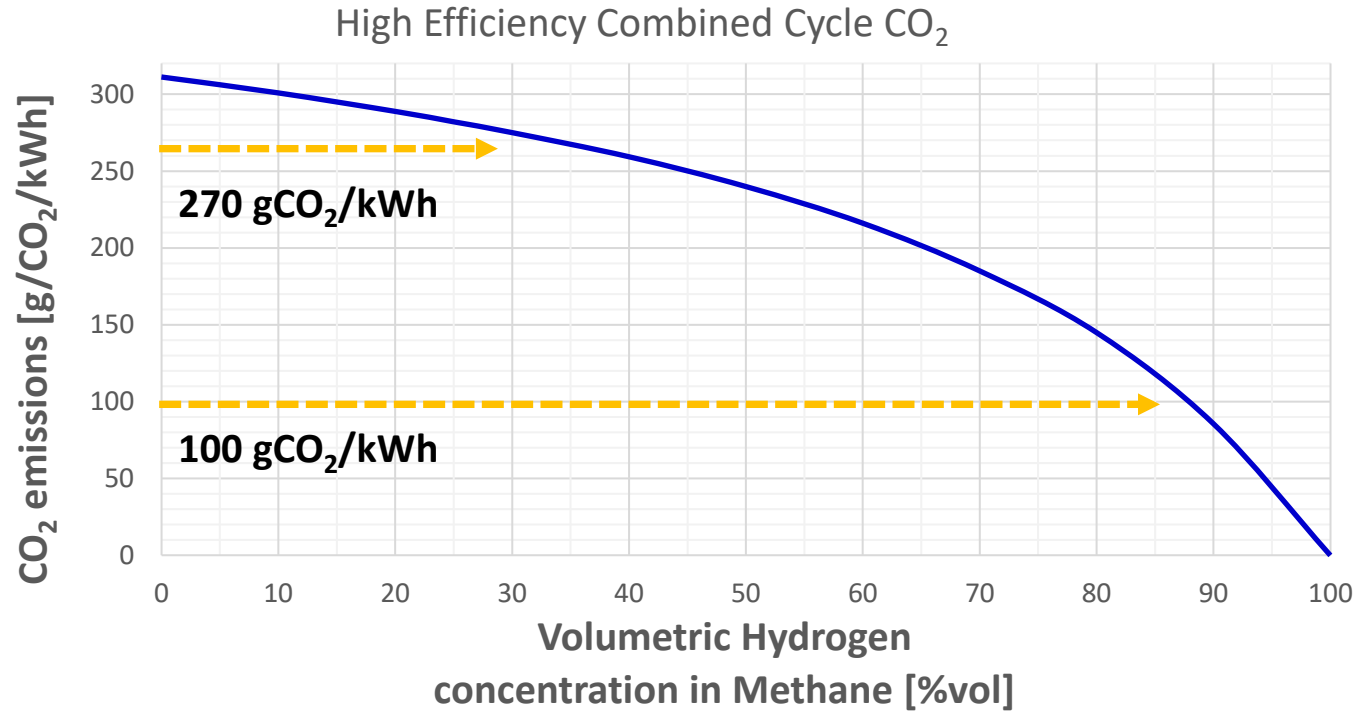
- construction permit is granted by **31 December 2030**
- accepted as **transitional** for gas emissions **<270 grCO₂/kWh ...**
- or **annual GHG emissions** of the activity do **not exceed** an **average of 550kgCO₂e/kW** of the facility's capacity **over 20 years**
- the facility is **designed and constructed** to use renewable and/or low-carbon gaseous fuels and **the switch to full use of renewable** and/or low-carbon gaseous fuels takes place by **31 December 2035**

partial % H2 co-firing

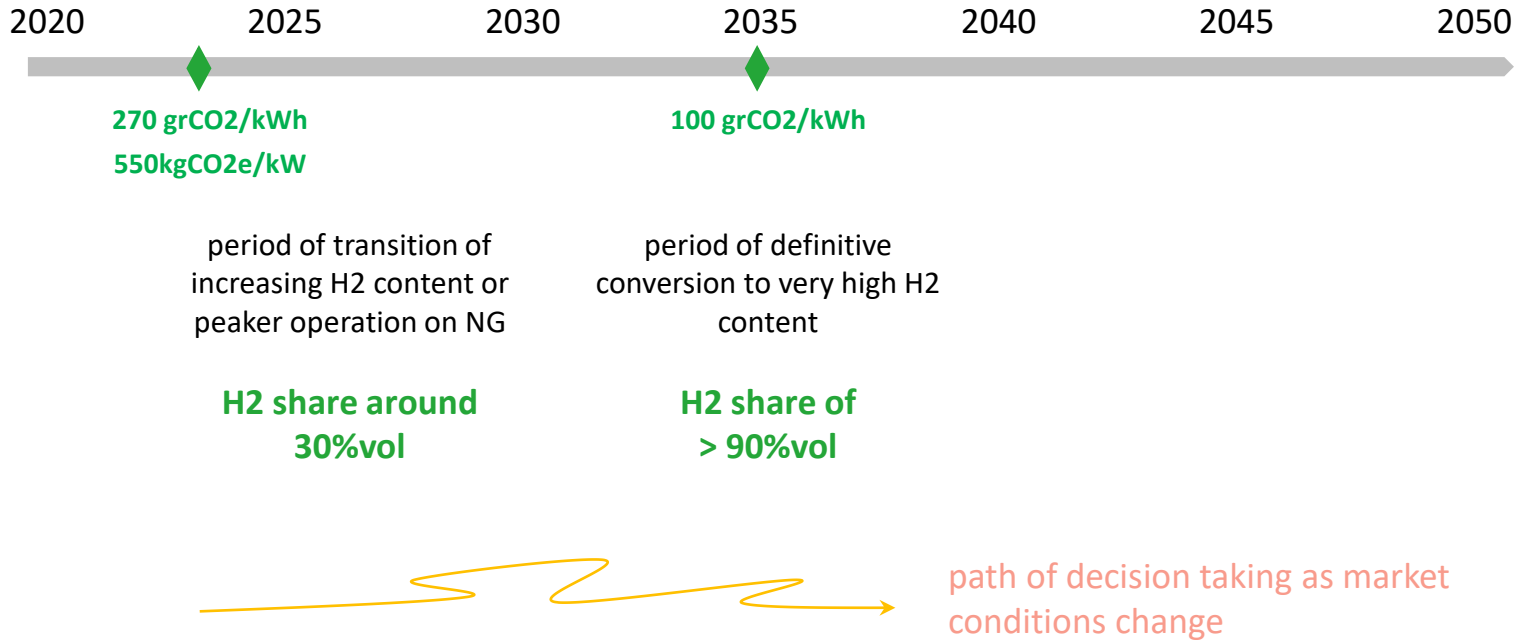
1800h/y on NG

demand for "H2 ready"

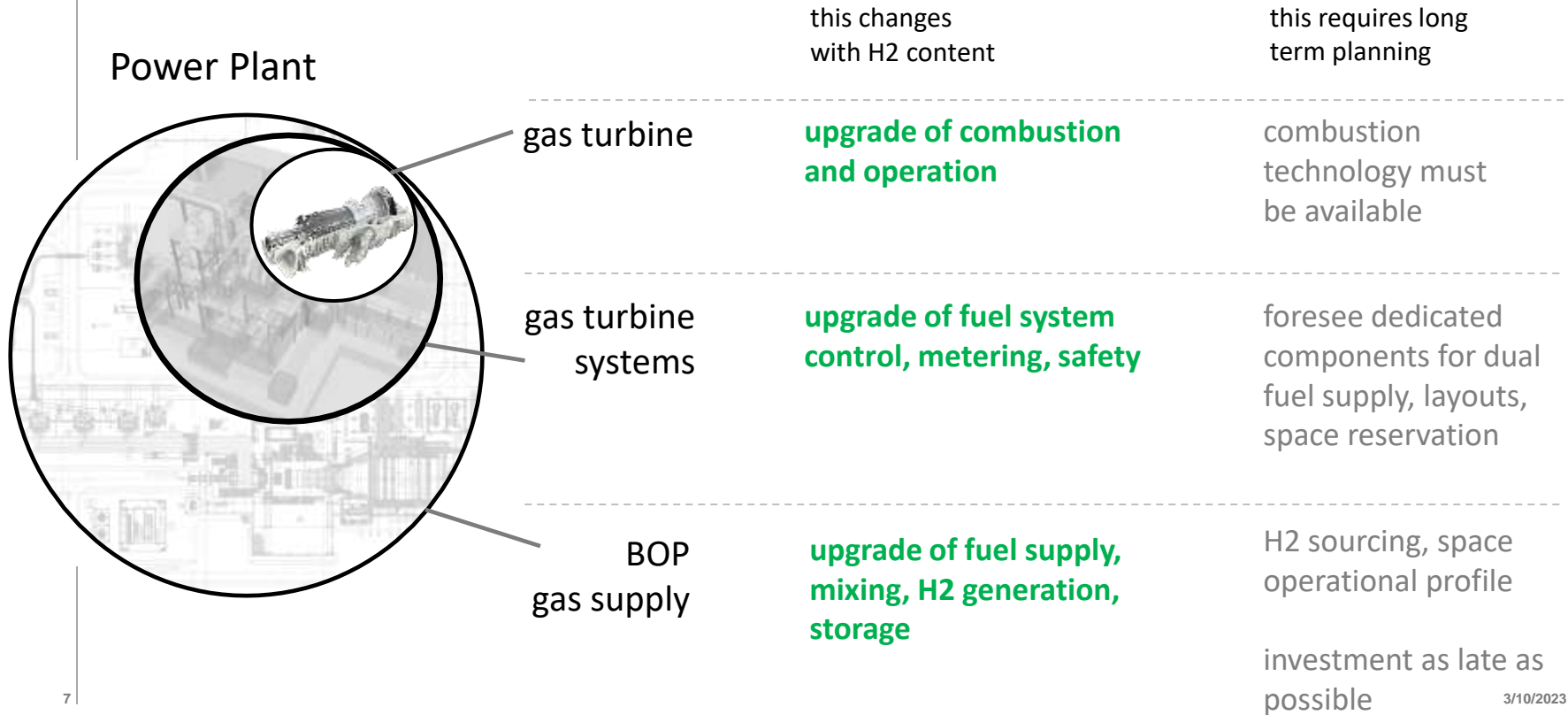
CO₂ emissions are markedly reduced at very high H₂ concentration



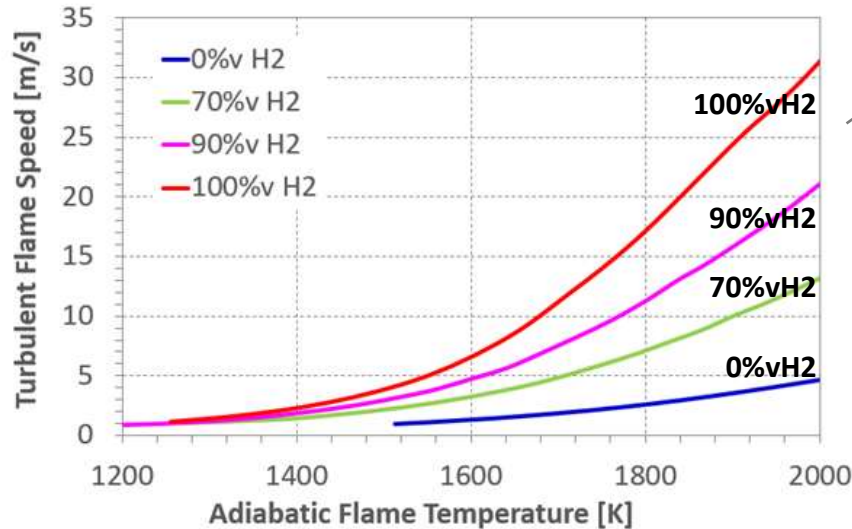
we are entering a period of continuous upgrade to high content of H2 combustion



Upgradability is enabled in three areas – making it "H2 Ready"



for very high H2 contents a dedicated combustion system is required



70 – 100%vH2 H2 dedicated combustion system required that enables flexibility between NG and H2

dedicated HW testing with atmospheric & high pressure, variant testing, whole engine testing

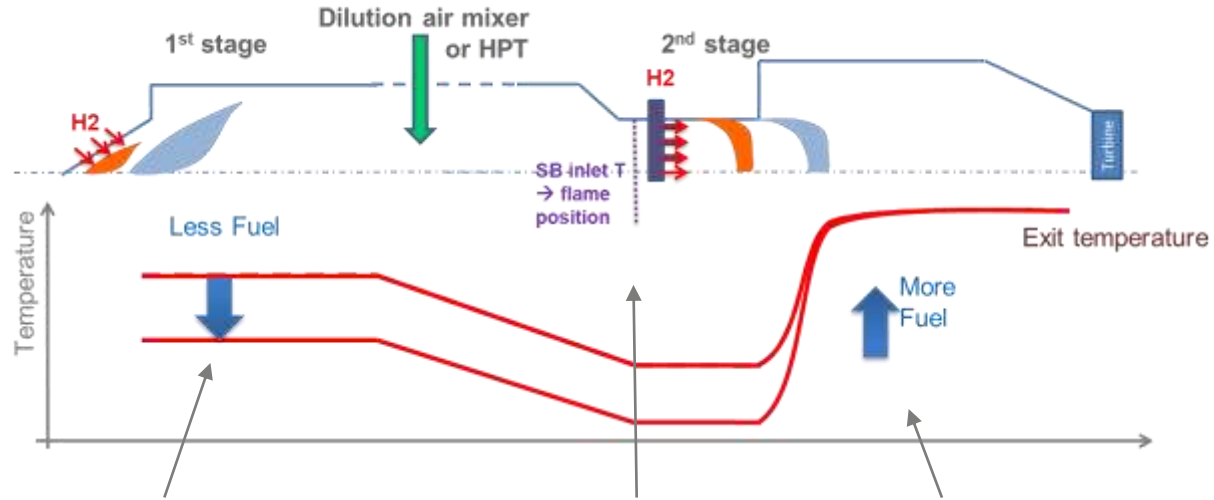
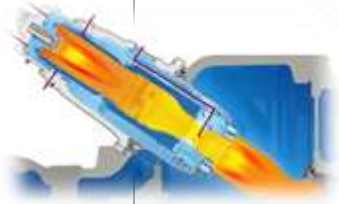
30 – 70%vH2 existing NG combustion system with modifications: tuning, staging, air management, de-rating, water injection

single burner testing, field testing of variants, atmospheric tests

0 – 30%vH2 existing NG combustion system might be used, depending on detailed design solutions

single burner testing, gradual increase of H2 in an operating engine

Reheat combustion for highly reactive fuels

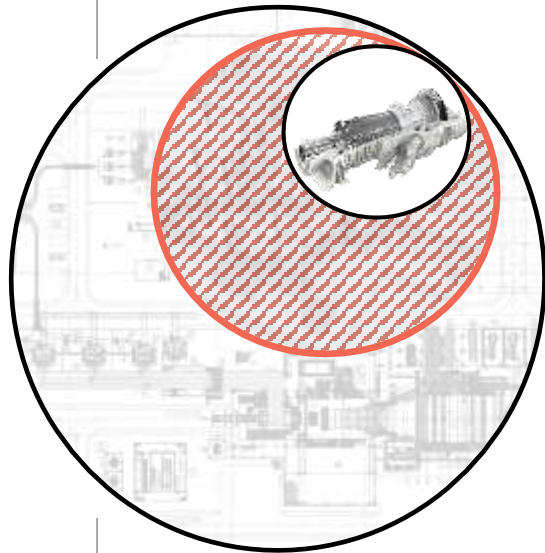


control 1st stage temperature

monitor autoignition

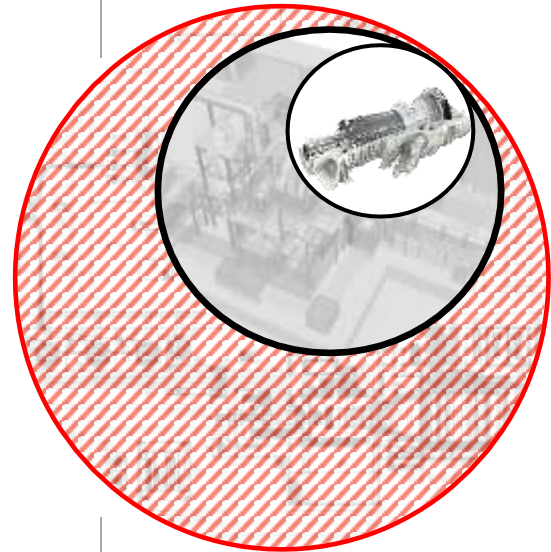
adjust 2nd stage to keep power

a dedicated fuel supply will be required at high %vol H2



| | at low %vol H2 | at high %vol H2 |
|-------------------------------|--|--------------------------------------|
| fuel supply | H2 is mixed in, gradually increasing | dedicated supply to combustor |
| metering & control | same as with NG comply with ATEX IIA through to ATEX IIC | dedicated H2 equipment |
| pipng, space | same as with NG comply ASME B31.1 & ASME B31.12 – H2 Piping | dedicated space & piping |
| safety | same as with NG comply with NFPA & NFPA 2 (H2) comply with ATEX IIA through to ATEX IIC ventilation | |

BOP: the type of H2 supply and usage defines the cost to H2 conversion



operational profile

H2 is mixed in for continuous operation

H2 peaker

H2 emergency operation

H2 supply solutions

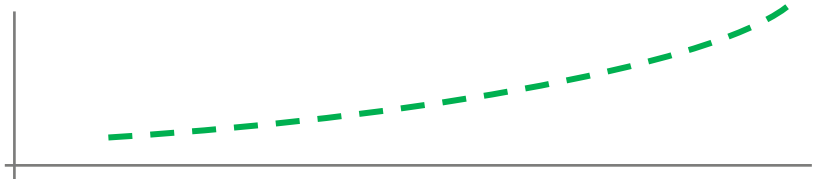
pipe line

local NG reformer & CCS plant

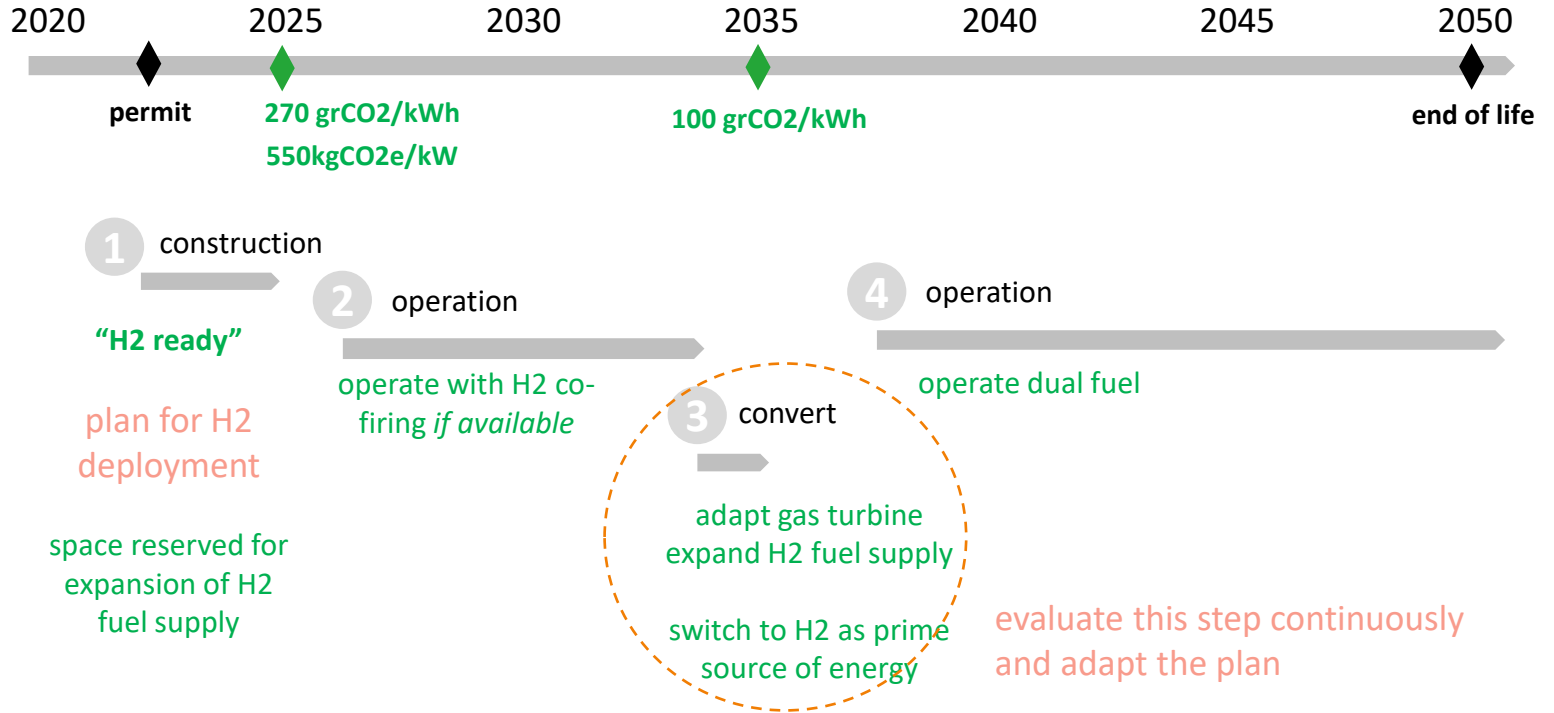
local electrolysis

H2 storage

cost and space for conversion



a new plant will see continuous adaptation to the available fuel mix



- Q & A

Ansaldo Energia Disclaimer

All information contained in this document is the property of Ansaldo Energia S.p.A. and/or all its controlled companies, whether directly or indirectly (hereafter “Ansaldo Energia Group”).

No part of this document may be reproduced, distributed, or transmitted in any form or by any means, without the prior written permission of Ansaldo Energia Group.