Hydrogen-ready solutions for compression stations

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Why Baker Hughes

Advancing the Hydrogen Revolution

2000+

Compressors working with H2 rich gases

70+

Gas Turbines burning H2 up to 100%

1915

First Reciprocating Compressor for H2

2009

First 100% H2 GT in commercial project

Hydrogen Transport: The EHB initiative

- Hydrogen is expected where electrification is not an option:
- energy-intensive industry
- heavy-duty transport sectors

Developing a dedicated hydrogen infrastructure is necessary to release the full potential of hydrogen as energy carrier.

Hydrogen blending existing pipelines

100% Hydrogen transport

Image Source: Council of European union (2023)

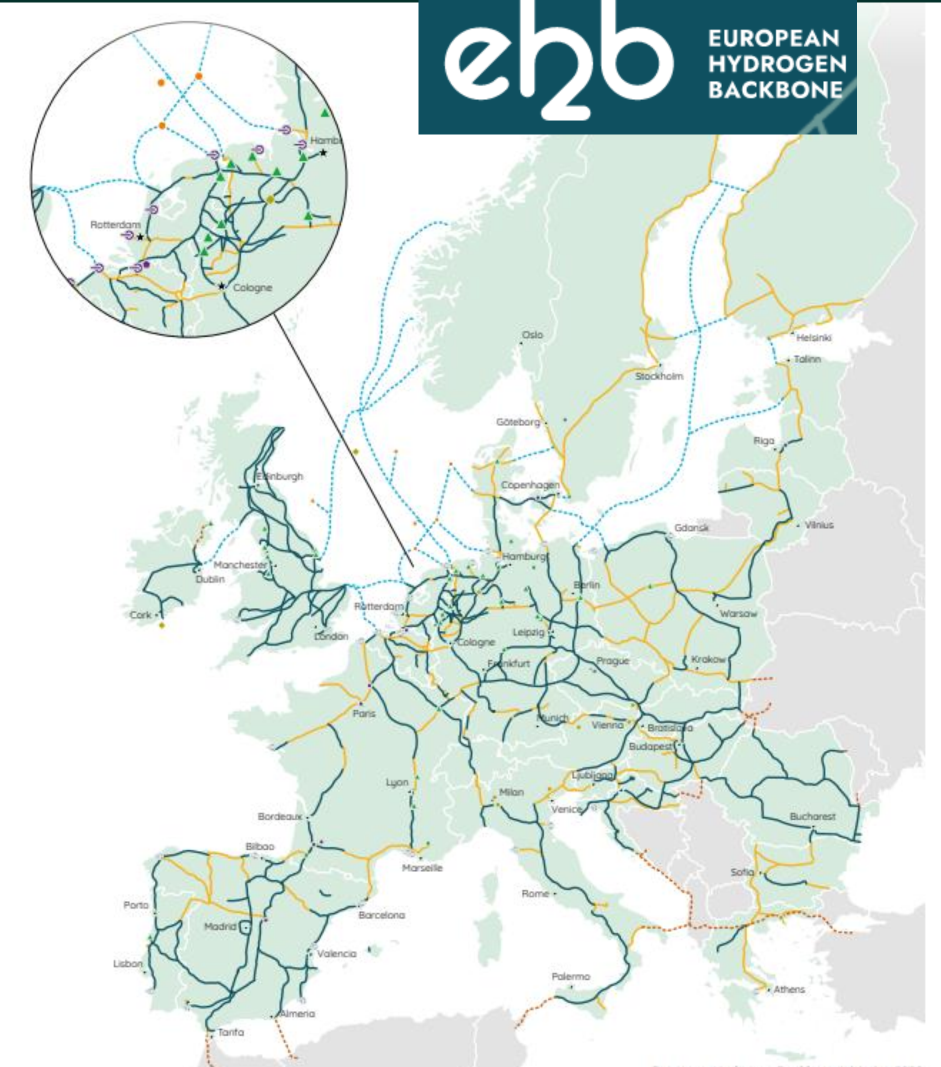

Image Source: European Hydrogen backbone (2022)

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H_2 Ready Pipeline Station Gas Turbine

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Managing Hydrogen in Gas Turbine: Blending H2 with Natural Gas

⇑H_2 = ⇓ CO_2 emissions

Different thermophysical properties

⇑H_2 = ⇓Energy density & Flame instability

⇑H_2 = ⇑ Flame temperature= ⇑ NO_X

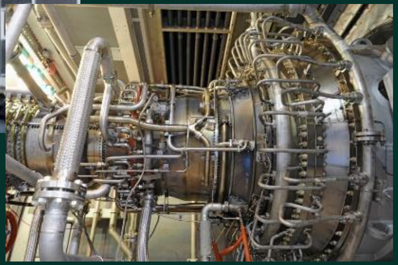
< 10% Safely tested at site for pipeline – no NOx increase

10% - 20% Minor modifications on package

>30% NOx significant increase and package modification

- **H_2/NG Pipeline—Istrana, Italy**

PGT25



Nova LT[TM]12

Snam and Baker Hughes successfully **completed First Trial** for the use of H_2 as Fuel in a Gas Compression Station

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Challenges of Hydrogen Utilization in Gas Turbines

Engine and package modifications are needed for hydrogen fuel

Combustion

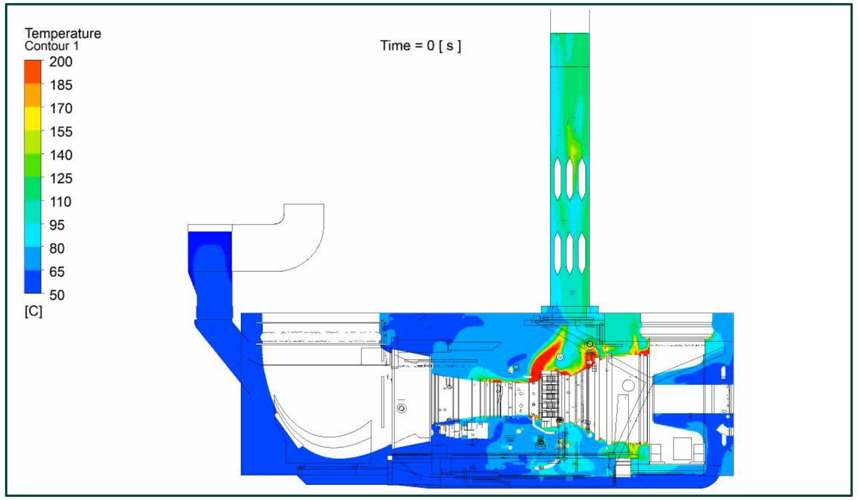
- High flame speeds
- Wide flammability limits
- High flame temperatures
- Flashback
- Combustion dynamics

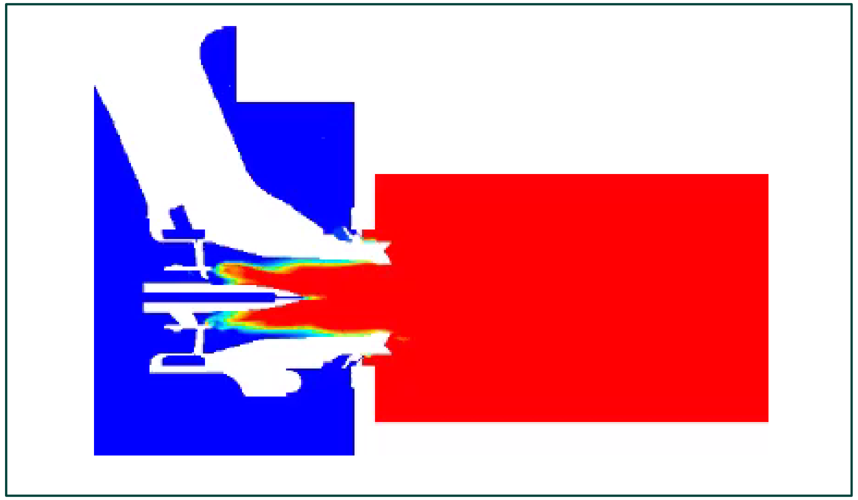
Delivery & Package

- Storage
- Sealing
- Material compatibility
- Equipment validation & ATEX/NEC certifications

Operation

- Start-up and shut-down procedures
- Fuel system/engine/package purge requirements
- Flame detection
- Gas detection
- Performance/durability (high % H_2)





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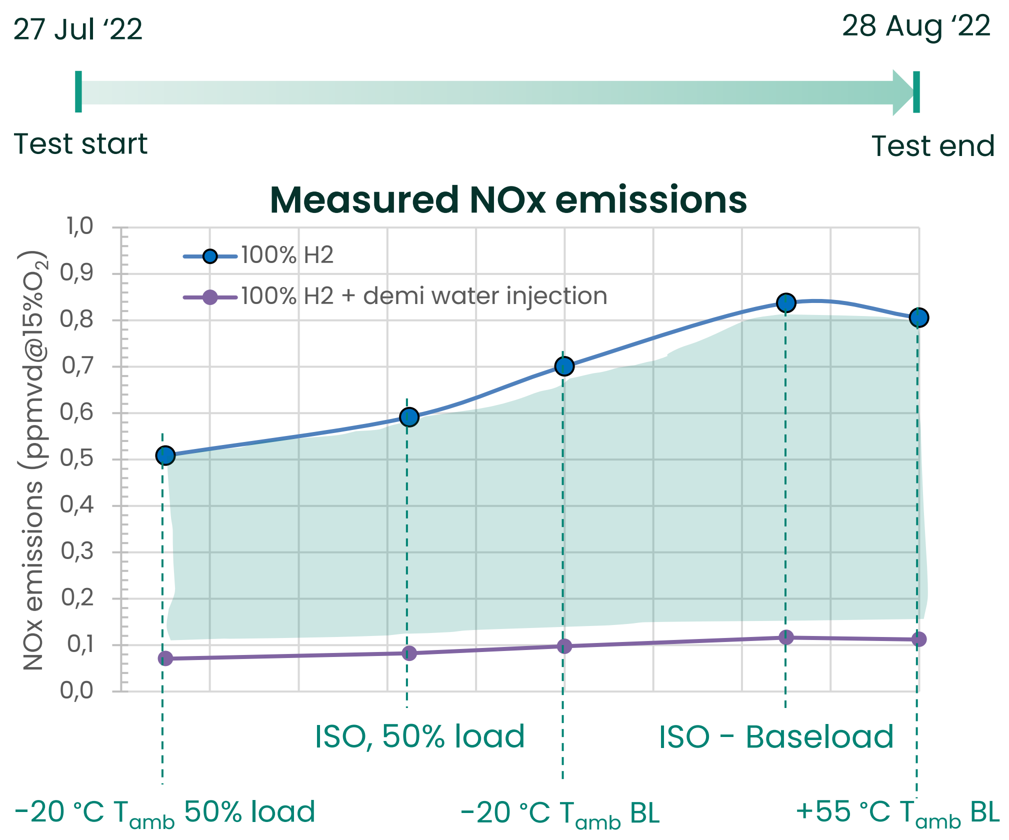
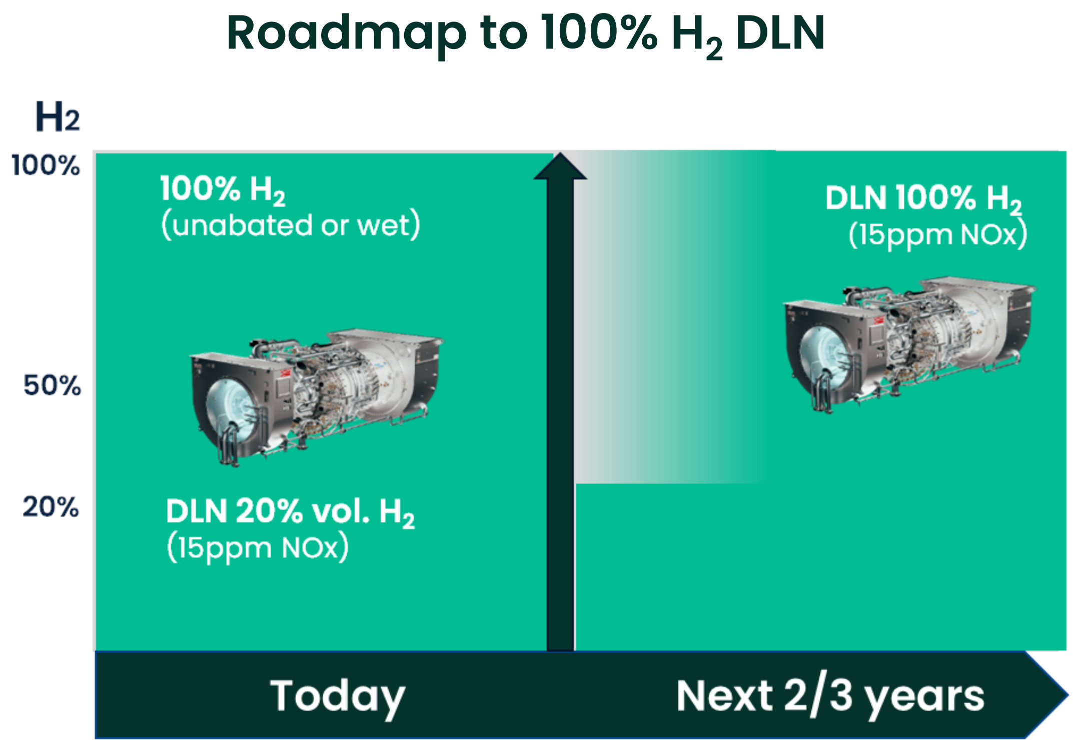
Managing Hydrogen in Gas Turbine: 100% Hydrogen





- Unabated NOx emission 160 ppmvd @15%O_2
- Enhanced burners design: Parts' life analysis in line with NG maintenance plan
- Specific solutions to reach 15 ppmvd @15%O_2 or less

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H_2 Ready Pipeline Station Compression

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Impact of hydrogen on centrifugal compressors

Material

- ***Hydrogen Attack***

  Affect Carbon and low alloy steels, T > 200°C
  usually not applicable for pipeline CC

- **Hydrogen Embrittlement (HE)**

  Affect high-strength steels and titanium alloys, T < 150°C
  applicable for pipeline CC

↓

Hydrogen dissociates in atoms and penetrates the material → local plasticization and brittle failure

↓

LIMITS ON MAXIMUM YIELD STRENGHT AND HARDNESS

Thermodynamic performances

When Hydrogen content increases..

↓

- Head increases
- Power increases
- Discharge temperature increases

↓

MAIN CHALLENGE → COMPACT SOLUTION

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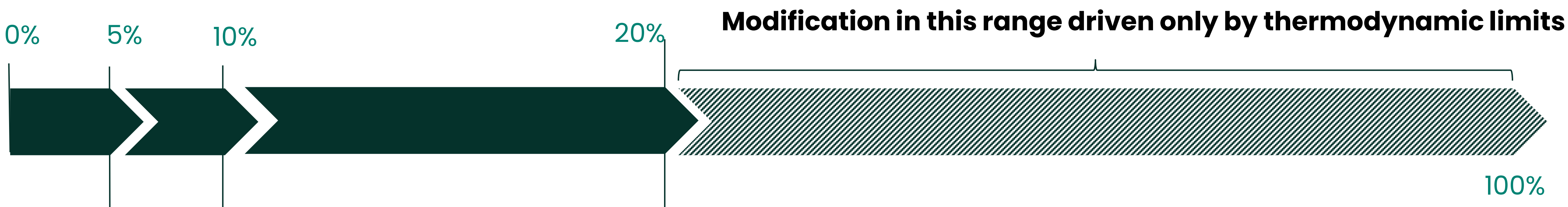
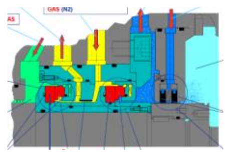
Summary – material impacts

considering ≈ 70 bar reference pressure (assuming also for auxiliaries)

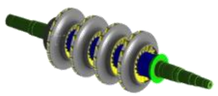


Detailed checks on DGS cartridge



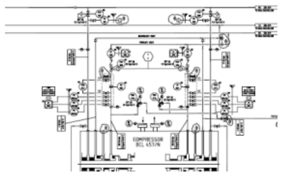
Worst case: to replace the cartridge

Detailed checks on Flange to flange is required

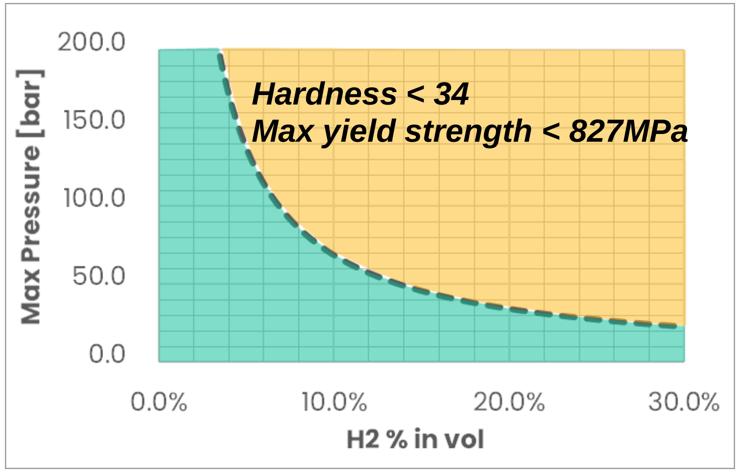


Worst case: to replace the rotor

Detailed checks on auxiliaries are required



Worst case: to replace seal system and antisurge loop



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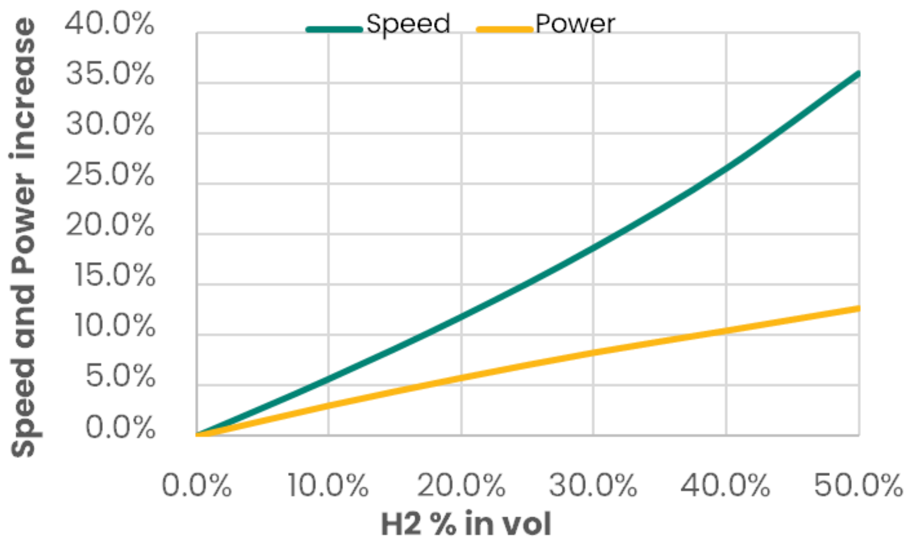
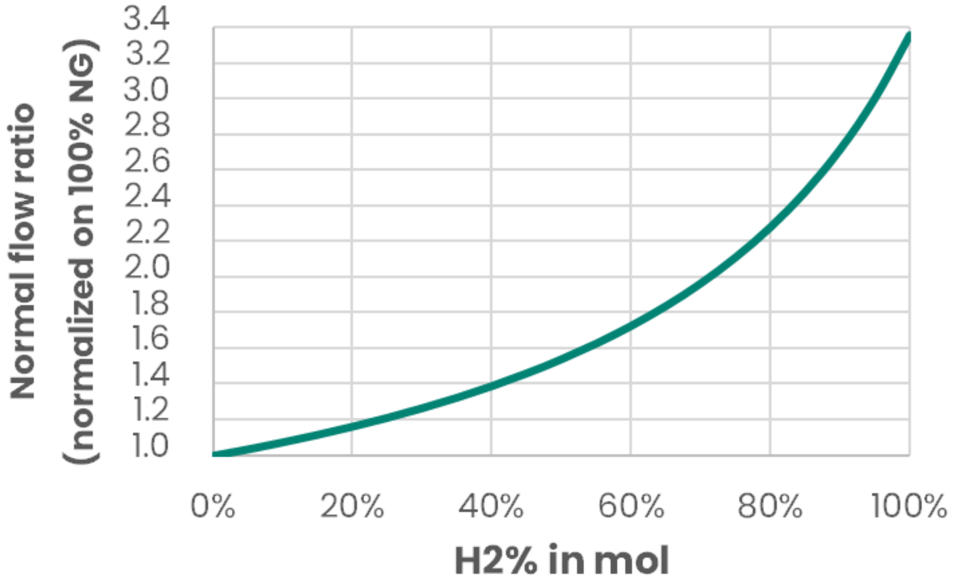
Performances impact – General

Impact on speed and power (at constant Nm3/h)



When the H_2 content raises, both operating speed and absorbed power increase as indicated in the graph above

Impact on Nm3/h (at constant gas energy)



At constant gas energy, higher is the H_2 content, larger will be the flow, demanding more speed and power

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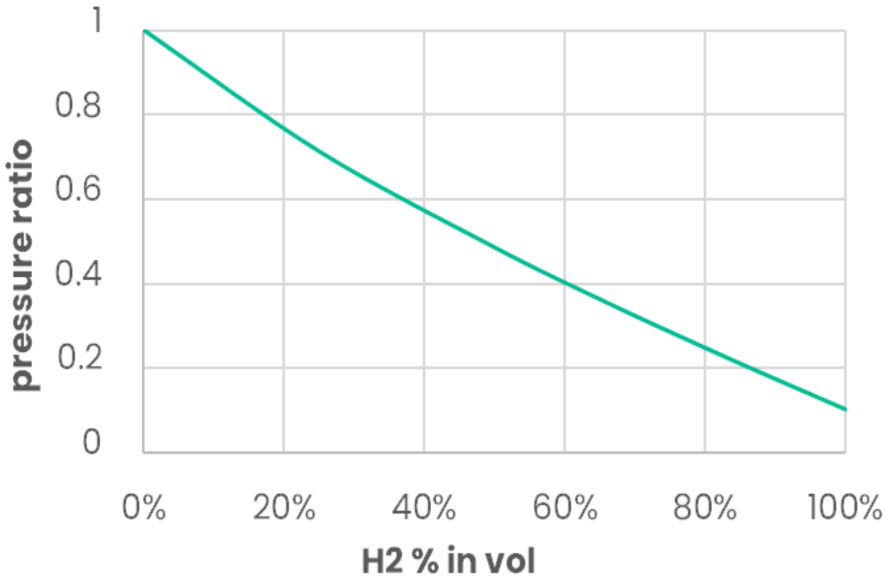
Performances impact – General

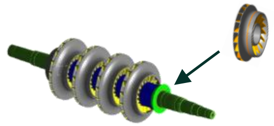
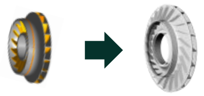
Impact on Pressure Ratio



Pressure ratio decreased by 9 times with 100% H_2 compared to 100% CH_4

Keeping same pressure duty, polytropic head requirement increases consequently

How to increase head capability?

	*Increasing the number of stages (up to the max allowed by one casing or adding casings)*
	*Using high head impellers*
	*Increasing rotating speed (increase impeller tip speed)*

High Pressure Ratio Compressor technology

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Case study – Pipeline Compression Station

Case study

Flow constant: 2000 MMSCFD,

Inlet Pressure: 60 bar

Outlet Pressure: 110 bar

Hydrogen Blend [% mol]	0%	10%	20%	30%	40%	50%	100%
	Number of impeller required						
Standard PCL impellers U2 = 250 m/s	3	4	4	5	5	6	28
High head impellers U2 = 300 m/s	2	3	3	3	4	4	18
HPRC impellers U2=450 m/s	1	2	2	2	2	2	9

100%
28
18
9

HPRC solution is a great option when H2 content is predominant

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Conclusion

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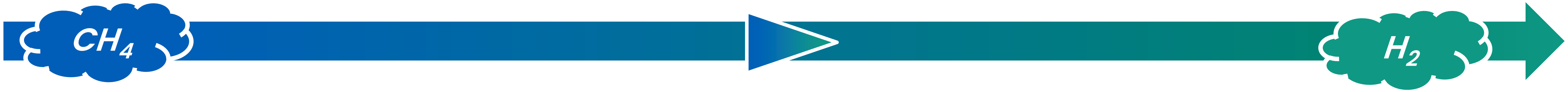
Conclusion - Roadmap to decarbonization

Initial H_2 availability



Natural Gas | **H_2 blend with natural gas** | **Full H2 availability**

Today → **Tomorrow**

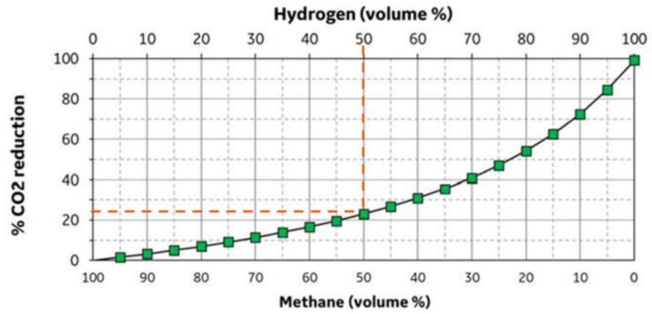
First step to decarbonization

Goal: starting H_2 demand, test of infrastructure

Blend up to 10%:
possible with little modifications
- No need for compressor rebundle
- No major impact on safety

Blend up to 20%:
Possible with minor modifications
Engineering work to be foreseen
Check of compressor performances (possible rebundle)

Further CO_2 reduction leveraging H_2



Combustion system ready for H_2 blend up to 100%

Compression technology ready for 100% H_2 pipeline station

Full decarbonization

Goal: Decarbonization of the hard to abate sectors

Specific equipment 100% H_2 ready
- Low Nox Gas turbines
- Compression equipment fit for H_2
- Package components tested for H_2
- Safety handling

Decarbonization journey can start today

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