Revolutionizing Gas Turbine Combustion
The H2R® Fuel-Flexible Low Emissions Burner
Applied to the Frame 5 and Avon

- **H2R® Burner Development: The Clean Air Solution**
- **Frame-5 & AVON Product Status**

ETN Global/Crosstown H2R
Webinar: 25th June 2025

Agenda

- Overview of the H2R®
- Crosstown Team Extensive Experience
- The Development of the H2R®
- Application of the H2R® to the Frame 5
- Application of the H2R® to the Avon

H2R® Burner: The Clean Air Solution
Gas Turbine Asset Life Extension

H2R® delivers Gas Turbine Asset Life Extension & ”Future-Proofs” the GT

H2R® delivers sub 15ppm NOx with Natural Gas and sub 25ppm with 100% Hydrogen (Dry)

H2R® Operates with any blend of Natural Gas & Hydrogen and other low Carbon Fuels

H2R® is a Multi-Platform system and easily adaptable

- Frame 5: Convert to a Dry Low NOx System on your single or two shaft engines
- Avon: A Specific In-Line solution for maintaining existing Enclosure & Craneage


Minimal change


Fits most gas turbines

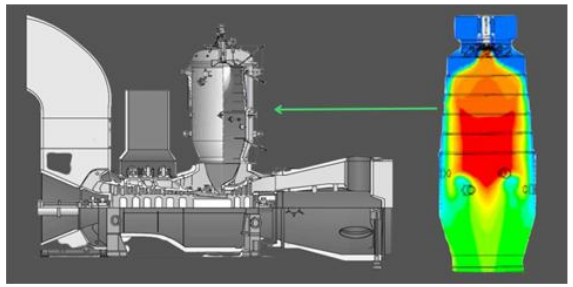

Dry low emissions solution


Up to 100% hydrogen capability

Crosstown Team Extensive GT Experience

CROSSTOWN H2R

BBC

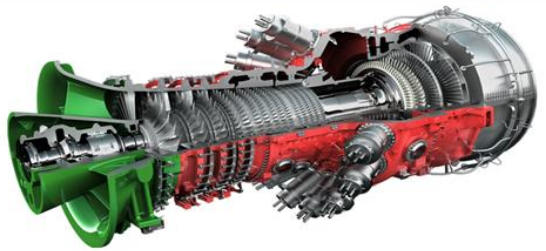


GT8/11/13 (SB, EV)

ABB

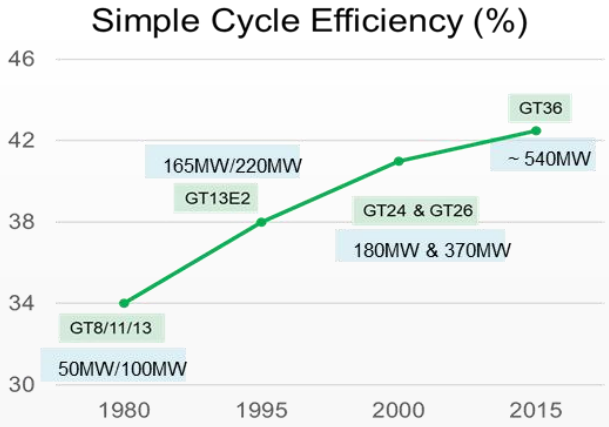
GT13E2, GT13E2MBTU (40% H2)
GT10B (SGT600), GTX100 (SGT800)

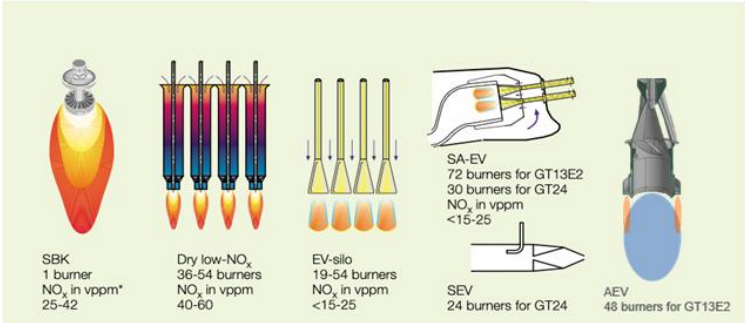
ALSTOM/GE/ANSALDO



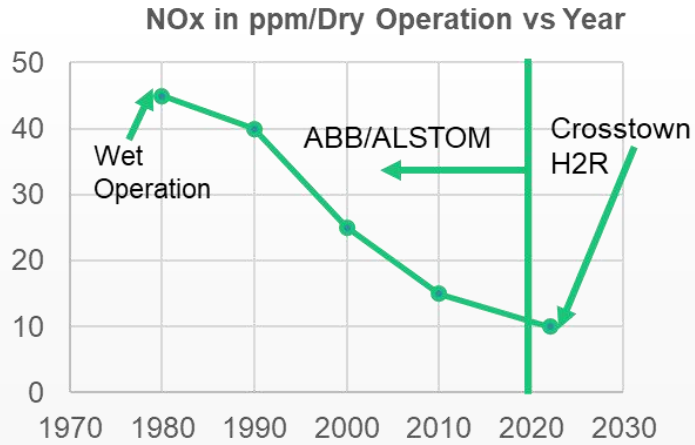
ALSTOM/ANSALDO: GT36
Other: WI501F, SGT800, SGT4000F

1980's 1990's 2000's 2010's 2020's





The H2R® team has over 120 patents on Dry Low NOx & Hydrogen Combustion Systems



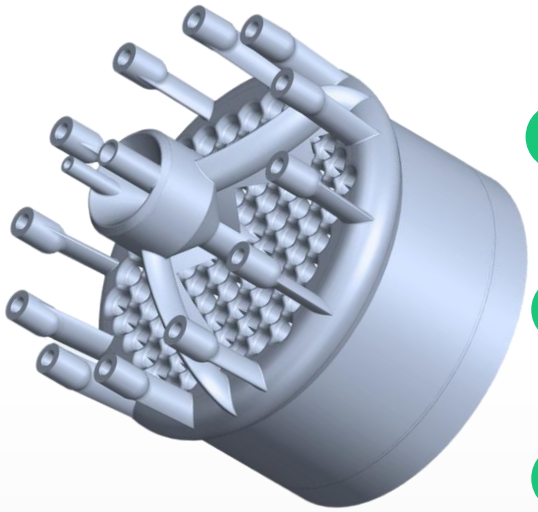
Development of the H2R® Burner

The Clean Air Solution

The Need and the H2R® Solution

The Need

- Cost effective solution for GT life extension
- Compliant NOx emissions and CO2 abatement
- Wide fuel flexibility requirement
- Combustion stability under all operating conditions

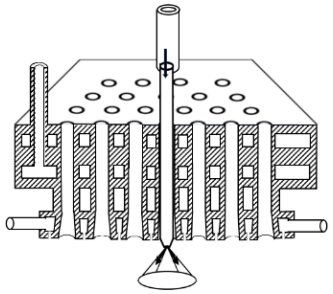


The Solution

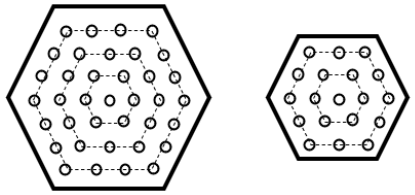
- Scalable Multi-Platform product. Applicable to several Gas Turbines & Energy Systems
- Multi-Fuel capability
- Revolutionary technology ➔ Zero CO2 capability
- Fulfils your Net Zero commitments
- Proprietary Technology with Patent Granted in March 2025

Low emissions, multi-platform, fuel flexible, product able to address future emissions goals

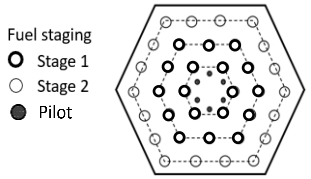
H2R® Burner Adaptability



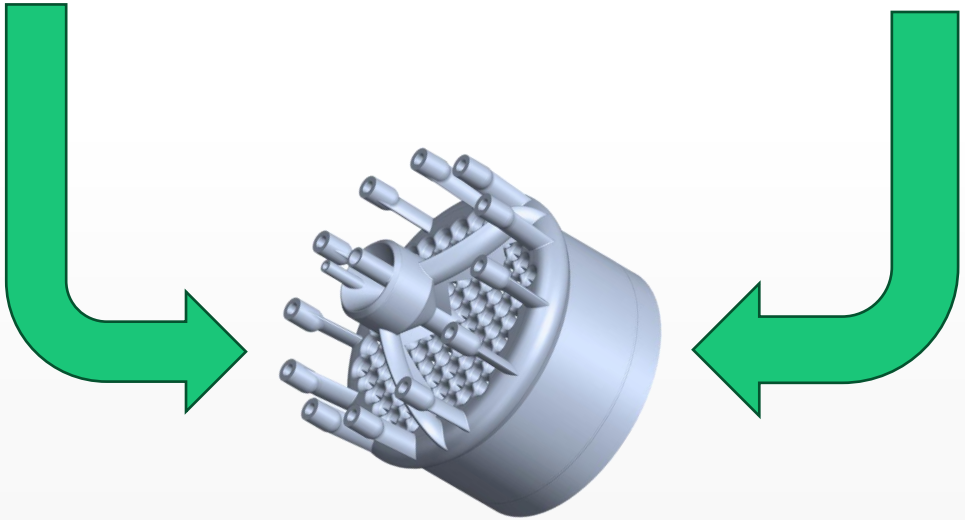
Modular design



Scalable & Adaptable



Flexible



Engine Ready Burner

- **Multi-Cluster Tubular Burner**
- **Separate feeds for Main and Pilot Fuels**
- **Main Fuel line feeds Multiple Chambers within burner body for feeding of Staged systems**
- **Central Hole for inclusion of Spark Plug, Oil Lance or Water Injection**
- **Customised Fuel inlet configurations**

Development utilising Atmospheric Pressure tests

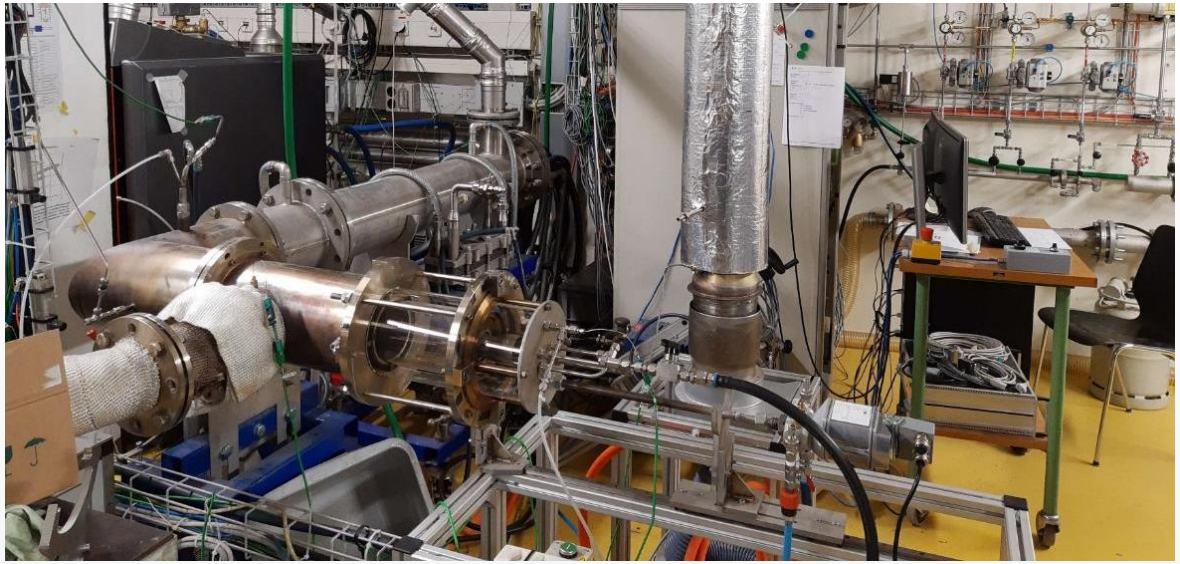
- Hot gas temperature: up to >2000 K
- Testing from 100% Natural Gas right through to 100% Hydrogen

- Verification of conceptual characteristics
- Validation of design features
  - Scalable, fuel & operationally flexible, durable
- Burner down selection

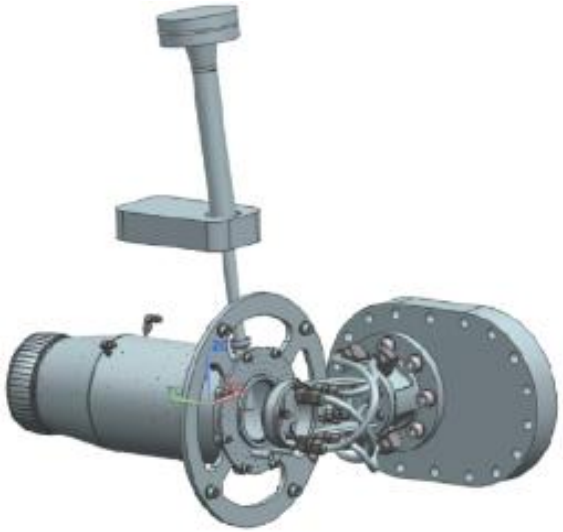
Proof of concept | 1st Gen 2020 | 2nd Gen 2021 | 3rd Gen 2022 | 4th Gen 2024

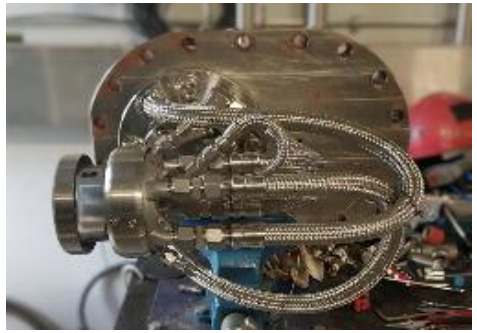
100% H2

100% NG



High Pressure Validation at “E” Class GT Conditions

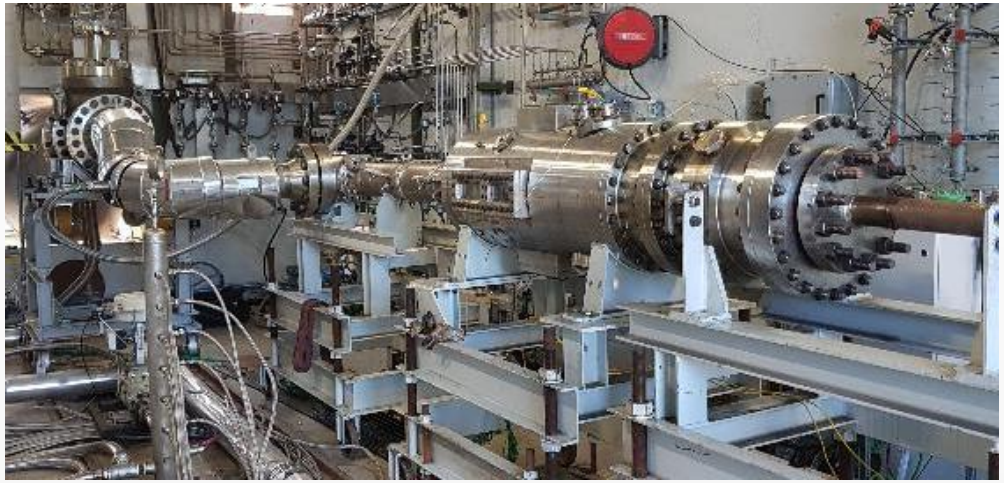




High Pressure/Temperature Test Rig

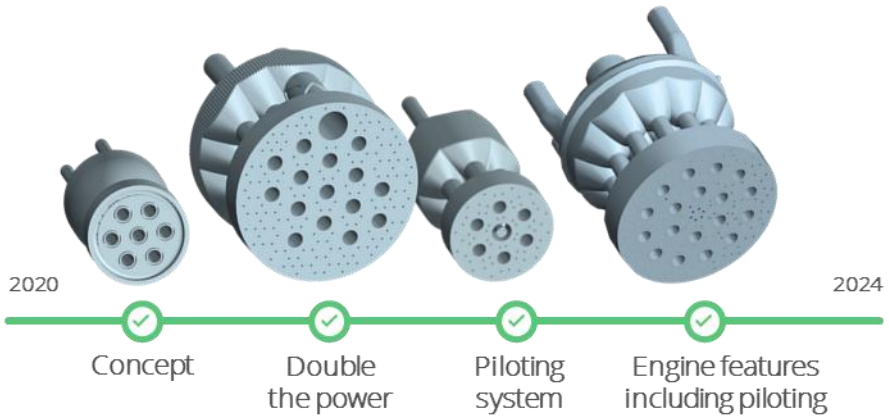
Integration of:

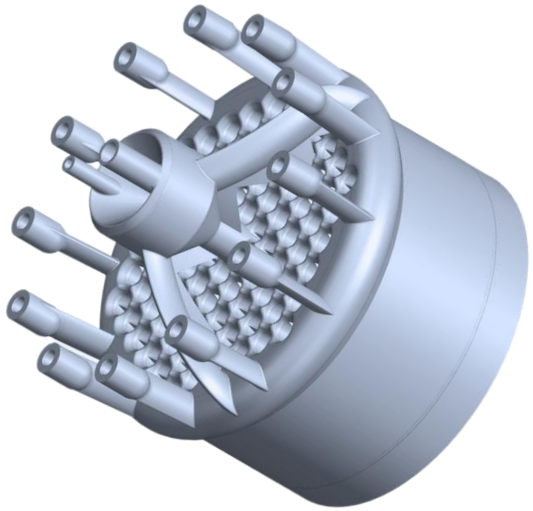
- **Combustor based on engine layout**
- **H2R® Burner prototypes with engine-relevant features**
- **Two Burners tested during the validation campaign**



- **Operated from 100% Natural Gas to 100% Hydrogen**
- **All critical to quality parameters measured in terms of emissions (NOx, CO, etc) and are within regulatory compliance**
- **Low combustion dynamics throughout the testing**

H2R® Burner: Tested & Validated





Engine Ready Burner

- Burner concepts & development tested 2021 through to 2024
- High pressure tests completed at full “E” Class GT conditions
- Over 12 burners with critical to quality features tested and are within regulatory compliance
- Engine ready burners for Avon & Frame 5 completed
- Suitable for Multiple GT Types and multiple fuels ➔ Nat. Gas, H2, Methanol, SYNGAS and other future fuels

Developed together with

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

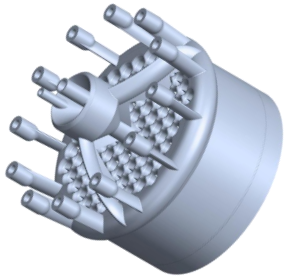
Swiss Federal Office of Energy SFOE

Fachhochschule Nordwestschweiz

SESTA LAB
Setup Your Combustion

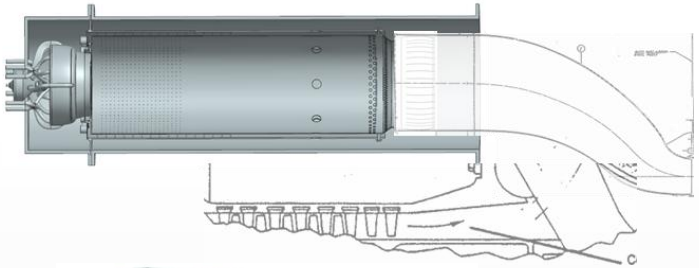
ILTecnologie.

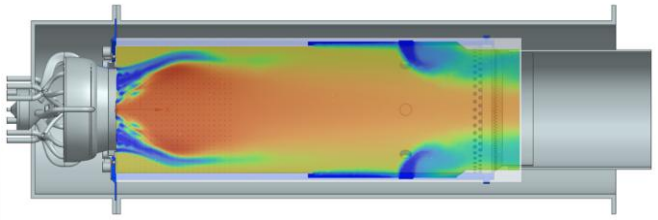
H2R® Adaptation and Engine Implementation

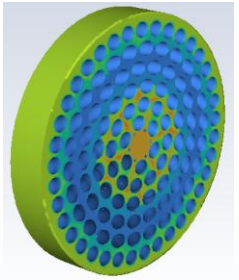


- Burner & Combustor designed and integrated with minimal system changes
- Development supported by Computer Aided Engineering & high pressure tests

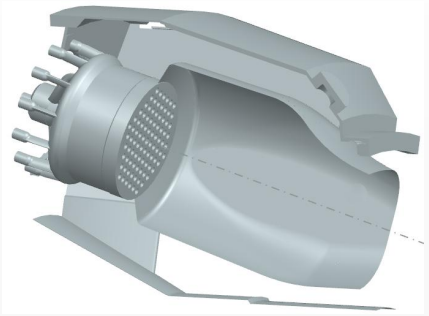
Frame 5

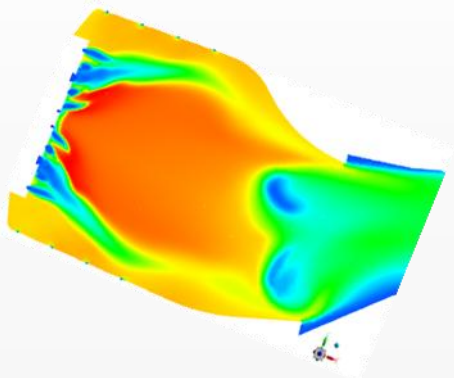


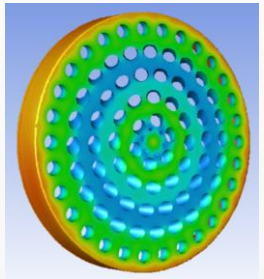




Avon





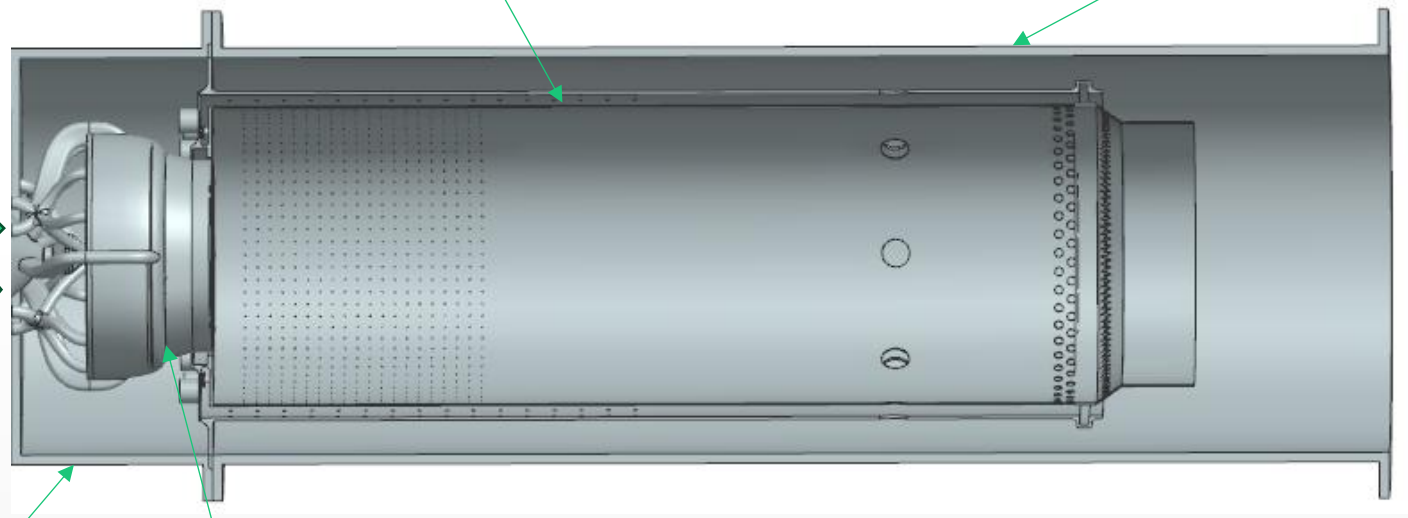


The Frame 5 Product

Frame 5 Scope of Change : Combustion System

Combustor
Includes combustion dynamics mitigations

Combustor case (based on hours of operation)



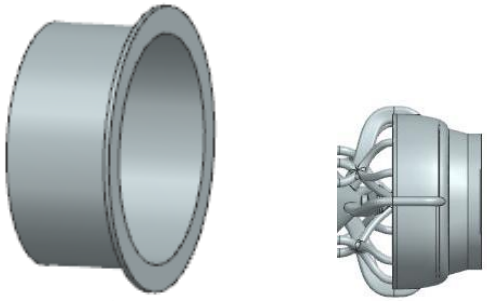
2 controlled fuel lines
- **Pilot**
- **Main**

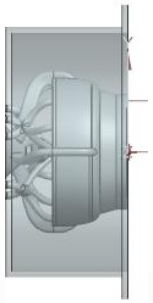
End cover

Burner

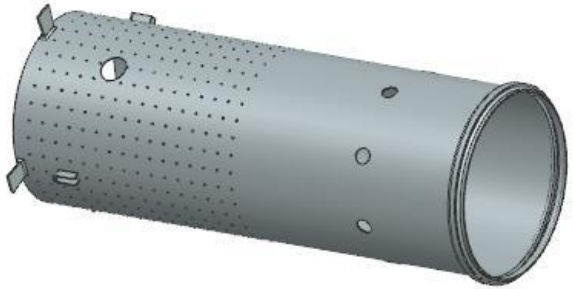
<u>Additional items</u>
- **Crossfire tubes**

Frame 5 : Combustion System Assembly

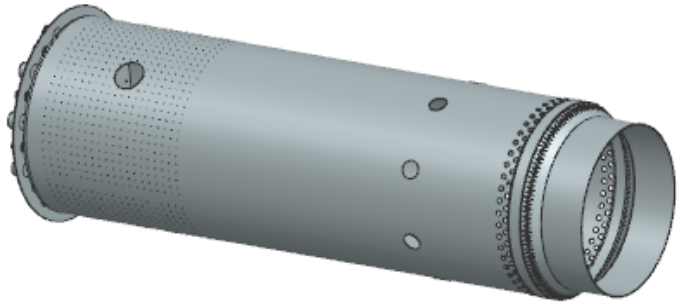


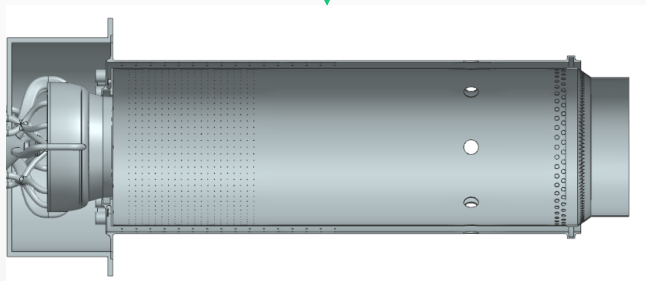


Head end assembly

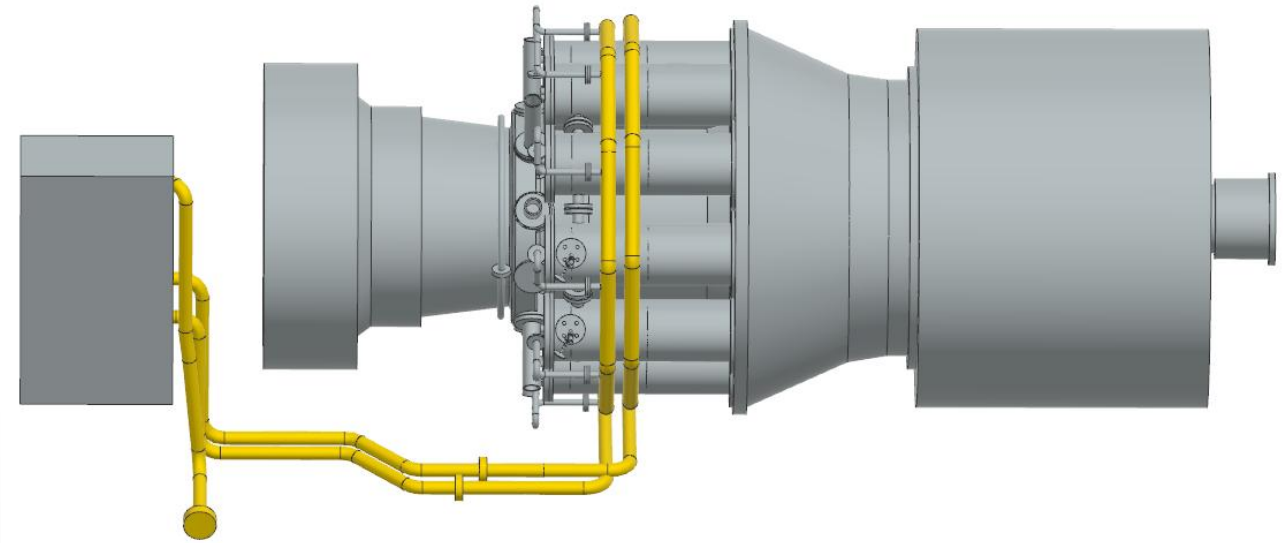


Liner assembly





Frame 5 Scope of Change : Auxiliaries and Controls (Natural Gas only)



Fuel system

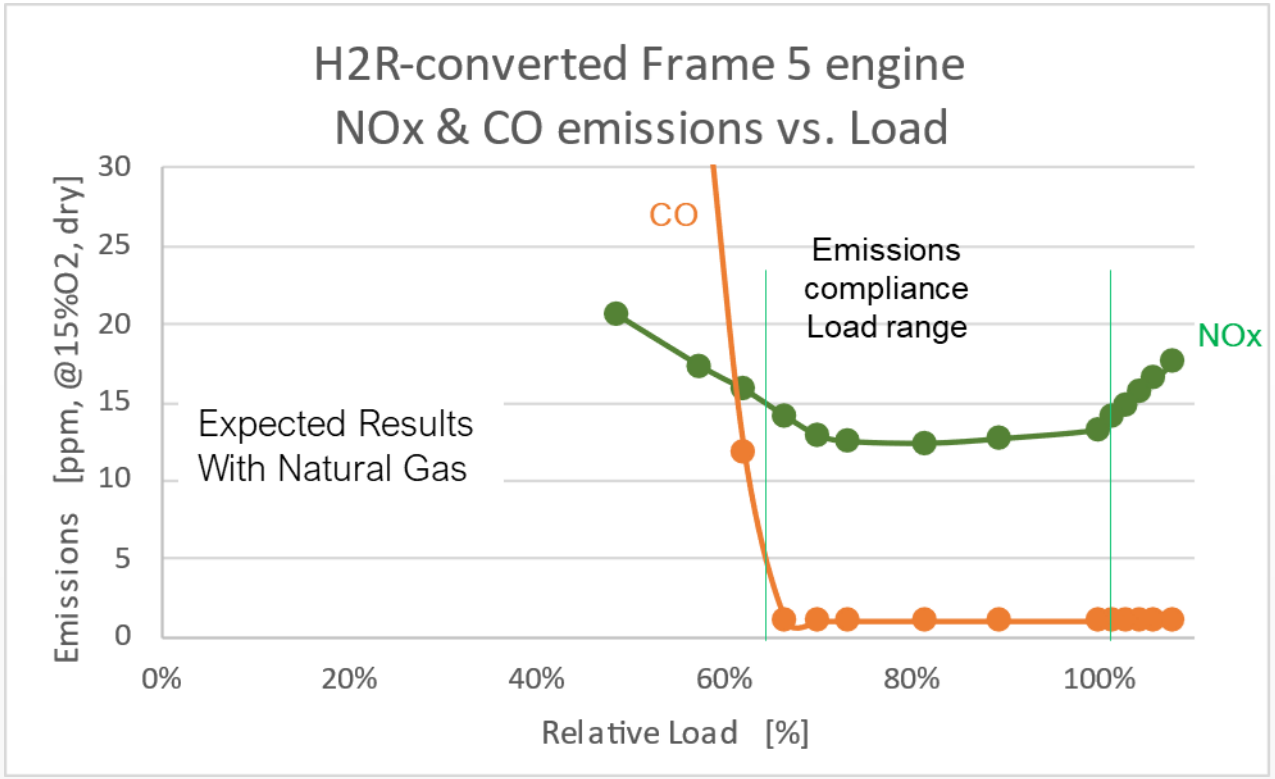
- Additional fuel manifold for pilot
- Additional fuel line & control valve connected to QCV
- New connections from manifolds to burners

Controls & electricals system

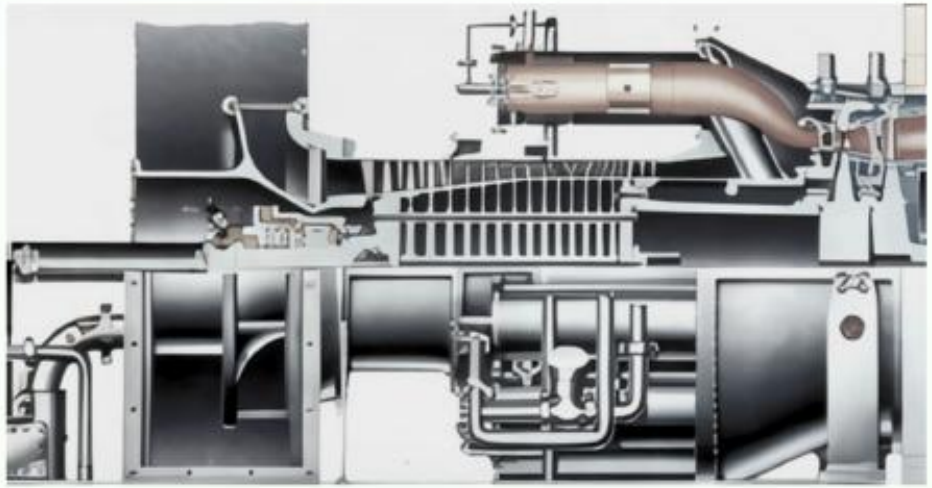
- Allow control of two gas fuel lines
- Operating concept
- Low voltage line modification (PLC & GCV)

H2R® Customisation for the Frame 5

- **DLE for natural gas**
- **Retrofitted during the major combustion overhaul of a gas turbine**
- **No modifications to the gas turbine housing, enclosure or craneage**
- **NOx below 15ppm with 100% Natural Gas**
- **Turndown to 65% load**



Engine Customisation for the Frame 5



DLE solution with wide emission compliant load range
NOx (dry) reduction to sub-15 ppm with Natural Gas

Component durability improved with better cooling, materials & coatings

Drop-in combustor
Minimal adaptions to auxiliary parts

with 100% Hydrogen:
Nox below 25ppm, CO2 reduction up to 145,000 T/yr

With 100% Hydrogen:
Efficiency increase of ~1%

With 100% Hydrogen:
Power increase of ~1MW

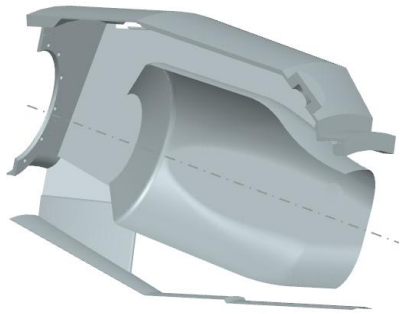
Low-Emissions Retrofit solution for the Frame 5
H2-ready. Asset Life Extension

The Avon Product

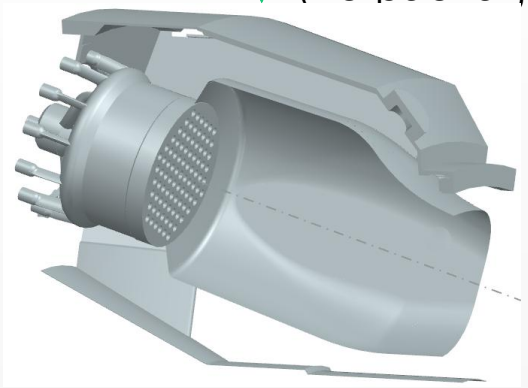
Avon Scope of Change : The H2R® burner

Crosstown scope

Business partner, Sulzer, scope



In-line DLE solution
(no package implications)



Sulzer has designed & tested the DLE combustor, in engine, with a different DLE burner

It is expected that the H2R® burner will be implemented in the same combustor

Fuel system

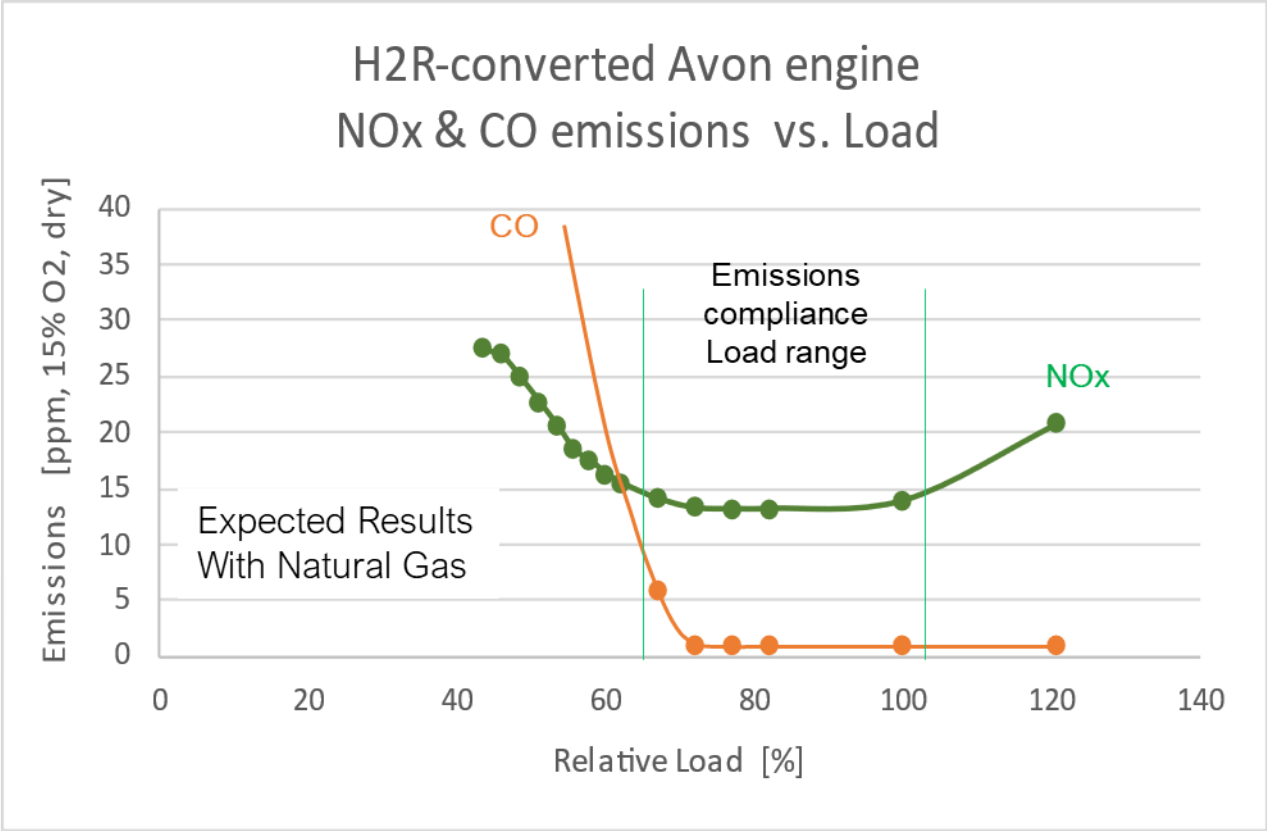
- Additional fuel manifold for pilot
- Additional fuel line & control valve connected to QCV
- New connections from manifolds to burners

Controls system

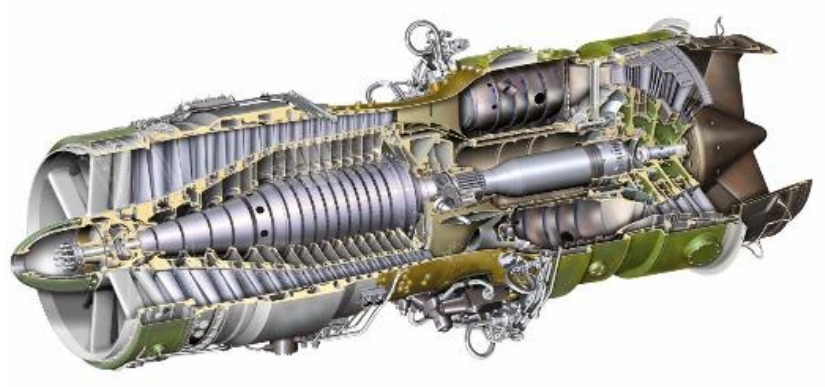
- Allows control of two gas fuel lines
- Operating concept
- Low voltage line modification (PLC & GCV)

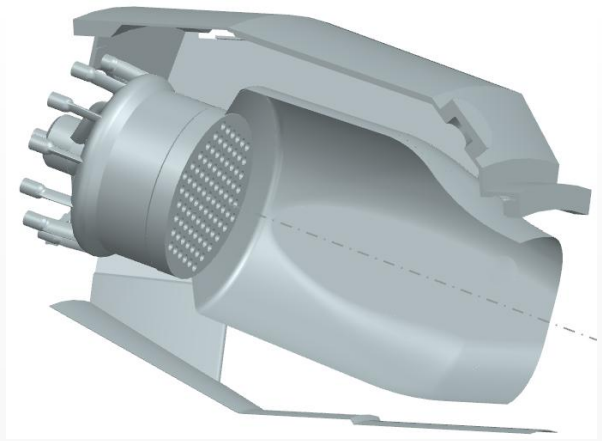
H2R® Customisation for the Avon

- DLE for NG
- Retrofitted during the major combustion overhaul of a gas turbine
- No modifications to the gas turbine enclosure or craneage
- NOx below 15ppm with 100% Natural Gas
- Turndown to ~ 65% load



H2R® Burner: Avon Gas Turbine Expected Results





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NOx (dry) reduction to sub-15 ppm with Natural Gas

Component durability improved with better cooling, materials & coatings

In-Line solution
Maintaining existing Enclosure & Craneage

with 100% Hydrogen:
Nox below 25ppm, CO2 reduction up to 85,000 T/yr

With 100% Hydrogen:
Efficiency increase of ~1%

With 100% Hydrogen:
Power increase of ~0.5MW

Low-Emissions Retrofit solution for the Avon
H2-ready. Asset Life Extension.

Product Launch Program: Frame-5 & Avon

Market introduction time plan

Frame 5

- Some Site-Specific scoping assessments already conducted
- Limited number of slots remain for Site Specific scoping assessments to be started in 2025, followed by full FEED
- Installation from 2026 onwards
- Progressively increase H_2 allowed following running experience – no change of burner hardware required all the way to 100% H_2

Market introduction time plan

Avon

- To be confirmed together with our business partner, Sulzer


Our tech enables gas turbines to run 100% on renewables – Today
CROSSTOWN H2R