HYFLEXPOWER Hydrogen Project

Power-H_2-Power Pilot CO_2-Free Green Energy with H_2 GT

Siemens Energy

HYFLEXPOWER Power-H2-Power Project

Overview

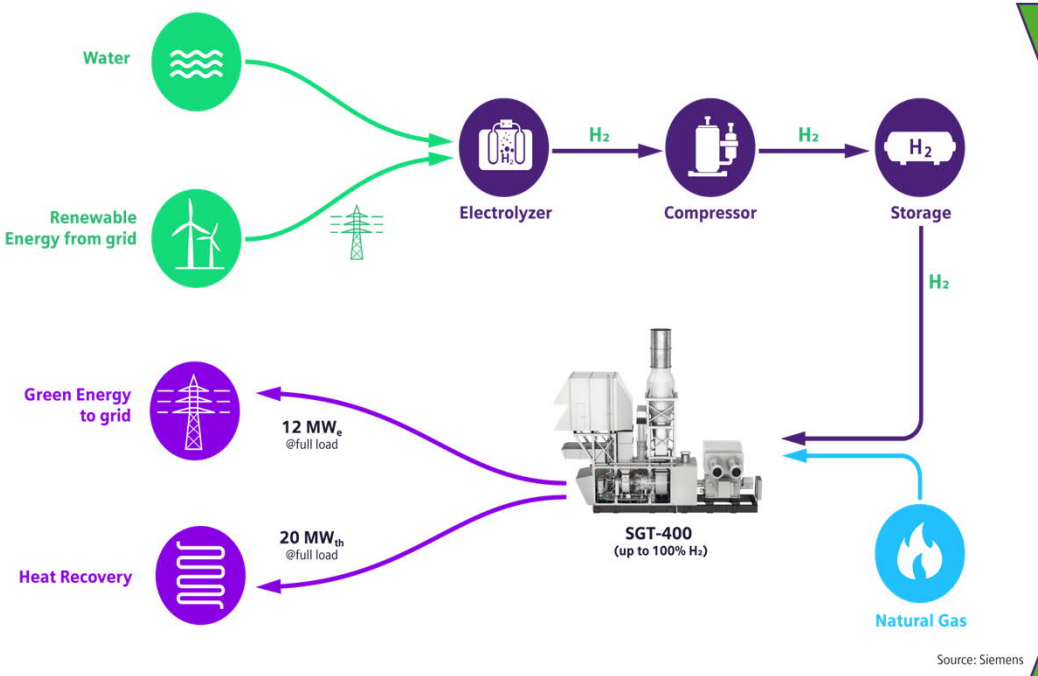
World-first demonstration of a **power-to-H_2-to-power path for CO_2-free** power generation pilot including an advanced **H_2 gas turbine**

- Decarbonizing papermill by modernizing combined heat and power plant in Saillat-sur-Vienne, France.
- Siemens Energy led consortium with project volume of 15.2 M€
- Project Start: May 1st, 2020 - Duration: 4 years
- Partners include: Engie Solutions, Centrax, Arttic, German Aerospace Center, Universities: Duisburg-Essen, Lund-Sweden, University College London, National Technical University of Athens

Customer, academia and OEM formed strong consortium demonstrating CO2-free power generation

EU Framework Horizon 2020: HYFLEXPOWER

Project Concept



Smurfit Kappa plant in Saillat-sur-Vienne, France: Pilot Cogeneration SGT-400 Plant

- **Engie:** Develop advanced plant concept with H_2 storage and supply
- **Siemens**: Development H_2 SGT-400; Electrolyser
- **Centrax**: H_2 gas turbine package upgrade
- **Academia:** DLR, Universities UCL, Duisburg-Essen and Lund to support H2 GT technology development
- **NTUA:** Economic, environmental social assessments
- **Arttic:** Support in PM and communication activities
- **EU:** Significant funding ~70% from EU Framework H2020

Significant EU funding for world-first power-H_2-power pilot with advanced H_2 GT

HYFLEXPOWER H2 Project

Key Milestones - Expected Results & Impact

2021

- Installation of the **H_2 production, storage** & supply facility at site

2022

- Initial demonstration of **advanced plant concept** with NG/ H_2 mixtures

2023

- Pilot up to **100% H_2 for carbon-free energy production** from stored excess renewable energy (CO2 saving 65,000t/yr.)

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Expected Results & Impacts

- Industrial scale power- H_2 -power solution pilot
  - Importance of H_2 as long-term energy storage technology on high renewable grid
  - Decoupling renewable energy generation from electricity demand and enabling additional revenue stream
  - Utilization of existing assets to produce green energy & heat
- Validation of SGT-400 dry low emissions (DLE) high-H_2 technology with up to 100% H_2
- Economic, environmental & social assessments for business case evaluation, carbon footprint, & policy recommendations

HYFLEXPOWER has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 884229

Siemens Hydrogen Gas Turbines for our sustainable future

The mission is to burn 100% hydrogen

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Gas turbine model	Power Output[1]	H_2 capabilities in vol. %
SGT5-9000HL	593 MW	30
SGT5-8000H	450 MW	30
SGT5-4000F	329 MW	30
SGT5-2000E	187 MW	30
SGT6-9000HL	405 MW	30
SGT6-8000H	310 MW	30
SGT6-5000F	215 to 260 MW	30
SGT6-2000E	117 MW	30
SGT-A65	60 to 71/58 to 62 MW	15 – 100
SGT-800	48 to 62 MW	50
SGT-A45	41 to 44 MW	100
SGT-750	40/34 to 41 MW	40
SGT-700	33/34 MW	55
SGT-A35	27 to 37/28 to 38 MW	15 – 100
SGT-600	24/25 MW	60
SGT-400	10 to 14/11 to 15 MW	10 – 65
SGT-300	8/8 to 9 MW	30
SGT-100	5/6 MW	30 – 65
SGT-A05	4 to 6 MW	2 – 15

DLE burner WLE burner Diffusion burner with unabated NOx emissions

Heavy-duty gas turbines Industrial gas turbines Aeroderivative gas turbines

1 ISO, Base Load, Natural Gas; Version 3.4, July 2020

Values shown are indicative for new unit applications and depend on local conditions and requirements. Some operating restrictions/special hardware and package modifications may apply.

Technology Gap exists in providing 100% H2 fuel capability with a Dry Low Emissions combustion system

DLE : Dry Low Emissions
WLE : Wet Low Emissions

2020-12-15

Zero Emissions via Hydrogen Combustion
Some physics to be handled in the system

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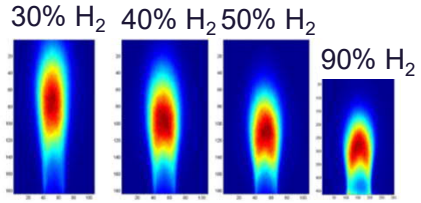
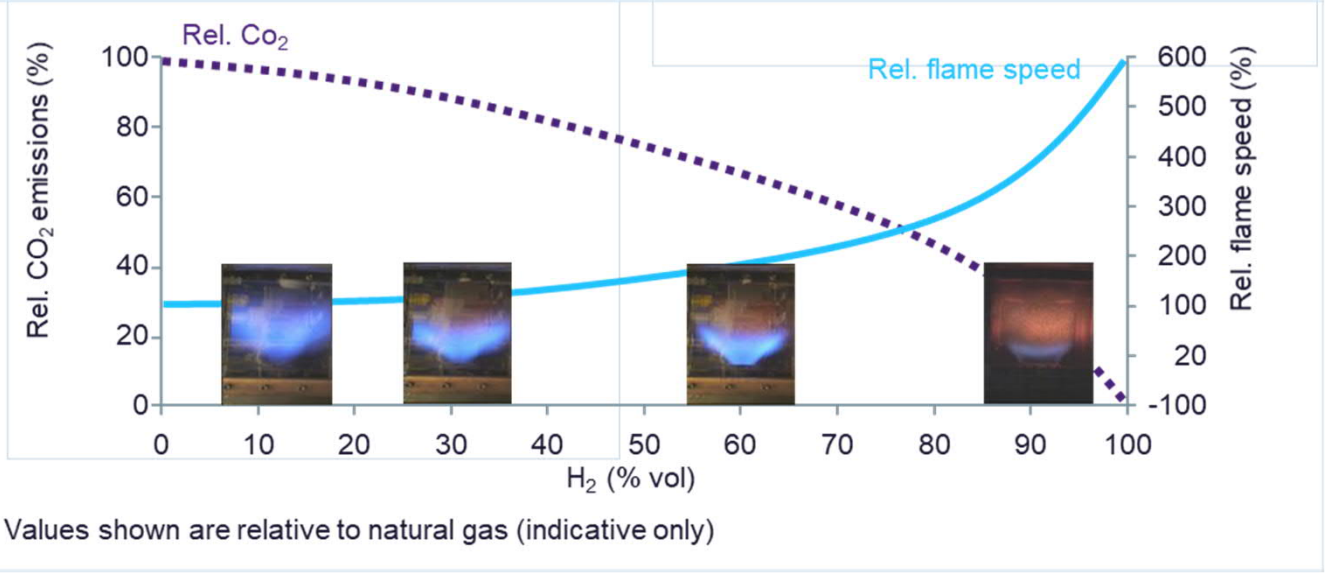
Differences of hydrogen and natural gas as a fuel in gas turbines

Physics of hydrogen

- 3x energy content per kg than Natural Gas … but 1/8th the density
- Flame location closer to the burner …increases risk of flashback

Hydrogen flame





Values shown are relative to natural gas (indicative only)

Challenges

- **Higher diffusivity** requires re-certification of sealing. Upgrade to stainless steel materials …
- **Lower volumetric energy content** requires larger flows to be handled by fuel system
- **Higher reactivity** pushes flame towards burner and increases risk of explosion or flashback
- **Higher flame temperature** can lead to local hotspots if imperfectly mixed and thus increased NOx emissions

Siemens Solution for different H_2 levels
Expected changes

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Differences in Design between "standard" and H_2-Gasturbines:

System/Procedures	H_2 Volume Impact on Package		
	0% – 10% – 30%[1]	10% – 30%[1] – 50% – 70%[1]	50% – 70%[1] – 100%
Burners and combustion chamber	No change	Modified burner may be required	New burner design
Combustion monitoring system	n.a.	n.a.	n.a.
Fuel supply system	No change	Ensure all components Stainless Steel	Pipe diameter increase
Control/protection systems	No change	Additional gas detection	All hazardous area electrical equipment to Gas Group IIC
O&M Procedures	No change	Leak check of gas fuel system after maintenance inspections	Start-up/shutdown on conventional fuel
	No modifications needed	**Smaller modifications may be required**	**Modifications needed**

1 Percentage varies from GT model to model and emission limit requirements

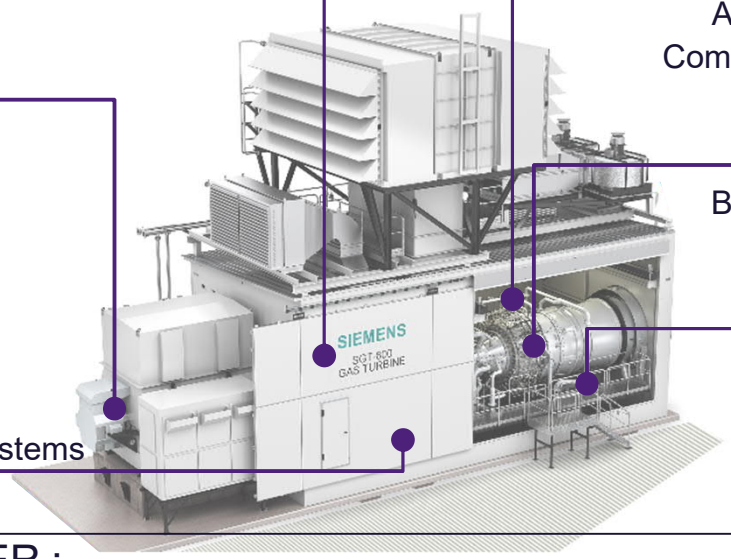
High Hydrogen Modifications for Industrial Gas Turbines

Main systems requiring modification when upgrading to higher H_2 content

Fire Protection System

Gas Group IIC electrical equipment

H_2 compatibility of plant auxiliary and peripheral systems



Additional Flame Control and Combustion Monitoring Systems

Burner Adjustment/Exchange

Fuel Gas System material and set-up

Consequences and solution

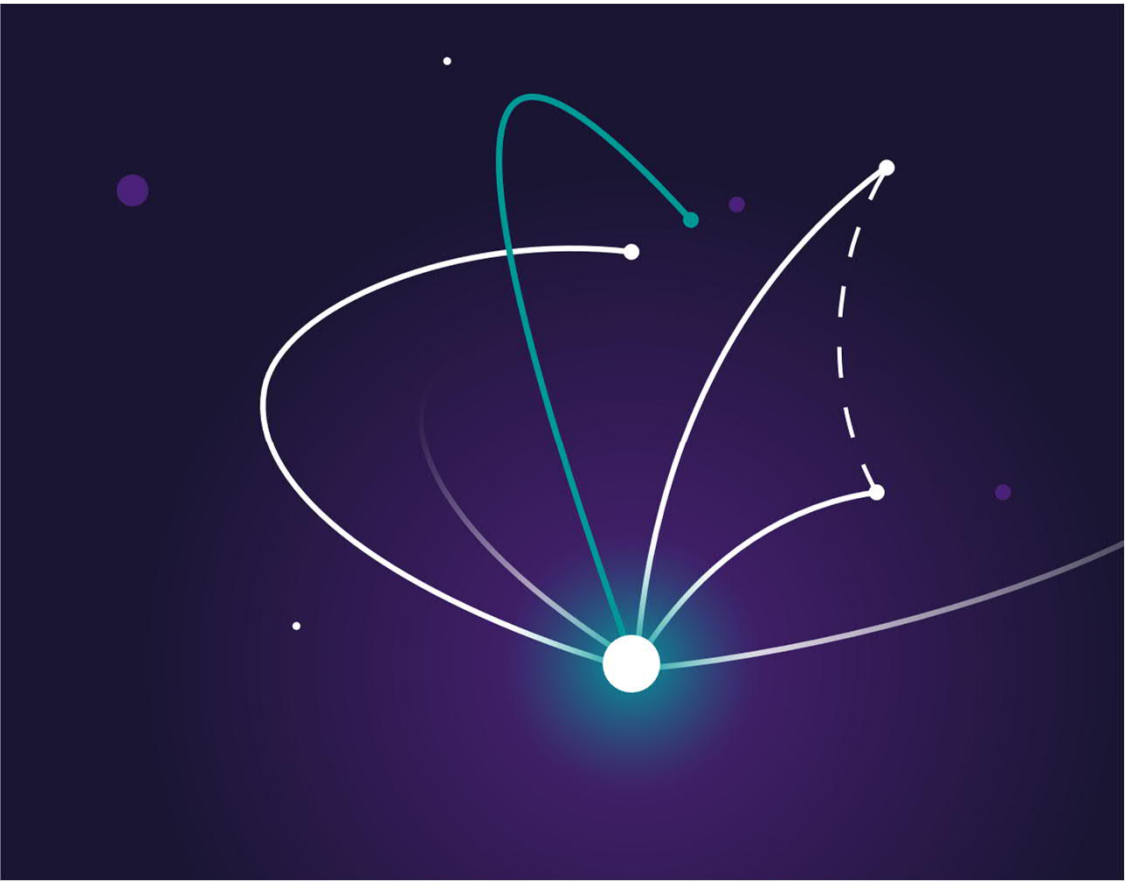
- Project specific evaluation and decision on required modifications
- Power output control to ensure compliant NOx emission levels
- Conventional/non-H_2 fuels may be required for start-up and shutdown
- Re-certification with respective authorities might be required

In HYFLEXPOWER ;

Centrax will modify the package of the installed unit

Siemens Energy will develop the new combustor technology and controls for retrofit.

Contact



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