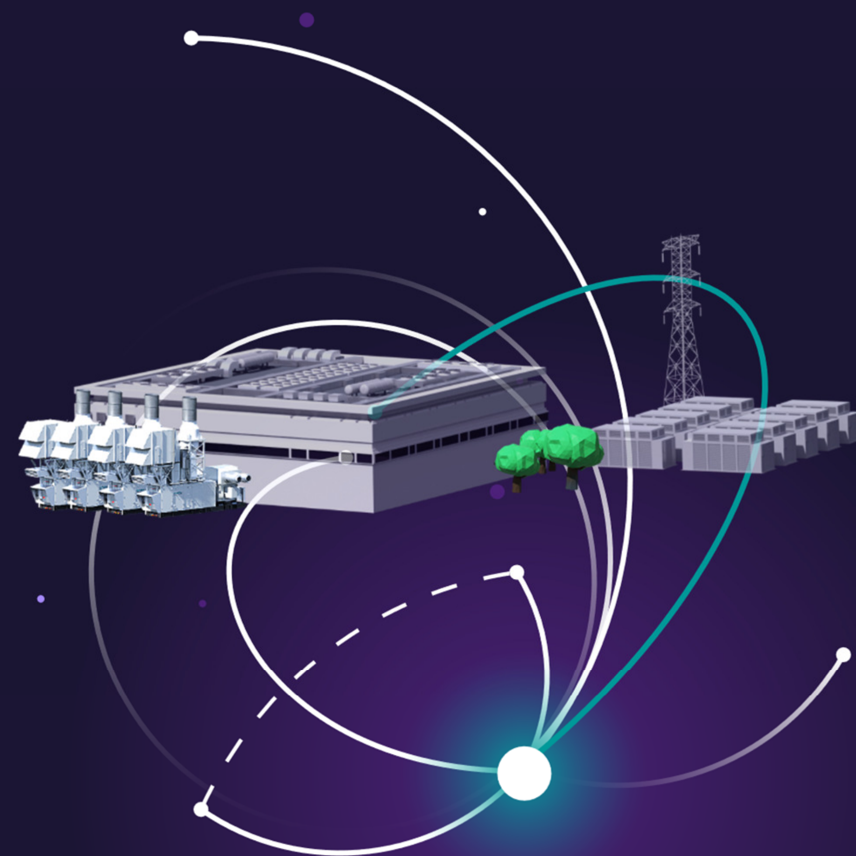

IDEA2021
Powering the Future: District Energy/CHP/Microgrids
Sept. 27-29 | Austin Convention Center | Austin, Texas

IDEA2021
Powering the Future: District Energy/CHP/Microgrids
Sept. 27-29 | Austin Convention Center | Austin, Texas

SIEMENS energy

Deep Decarbonization of CHP using Hydrogen as a Fuel

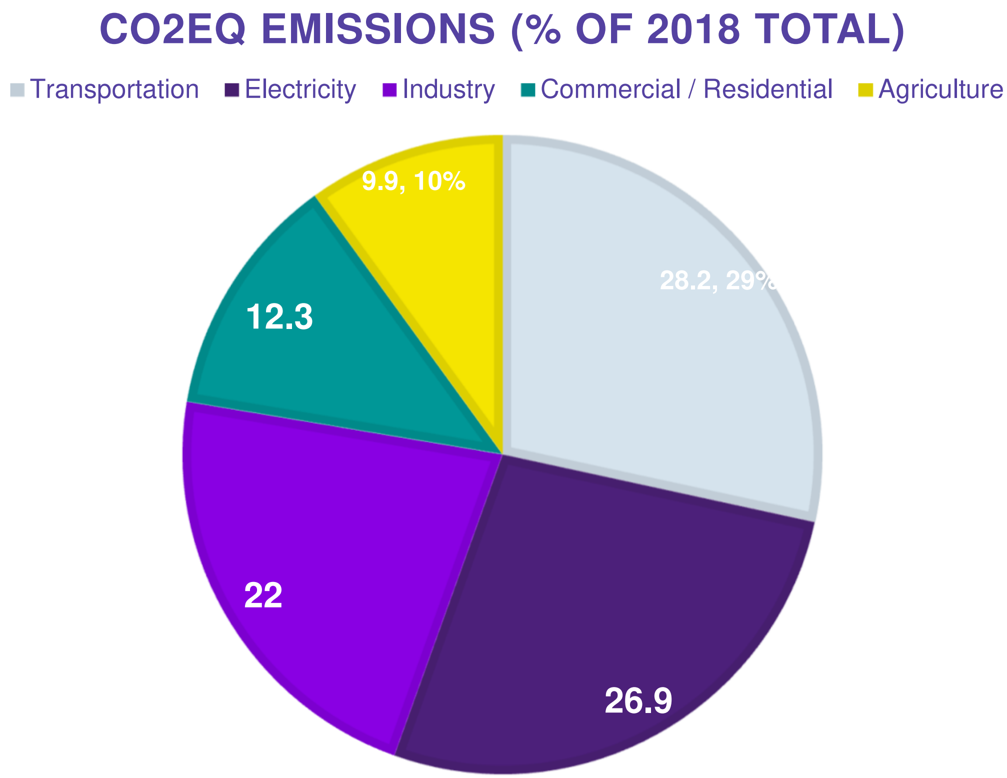


Douglas Willham, Head of Engineering, SGT-A05

September 2021

Energy Production is responsible for ~ 60% of CO_{2EQ} emissions in the United States

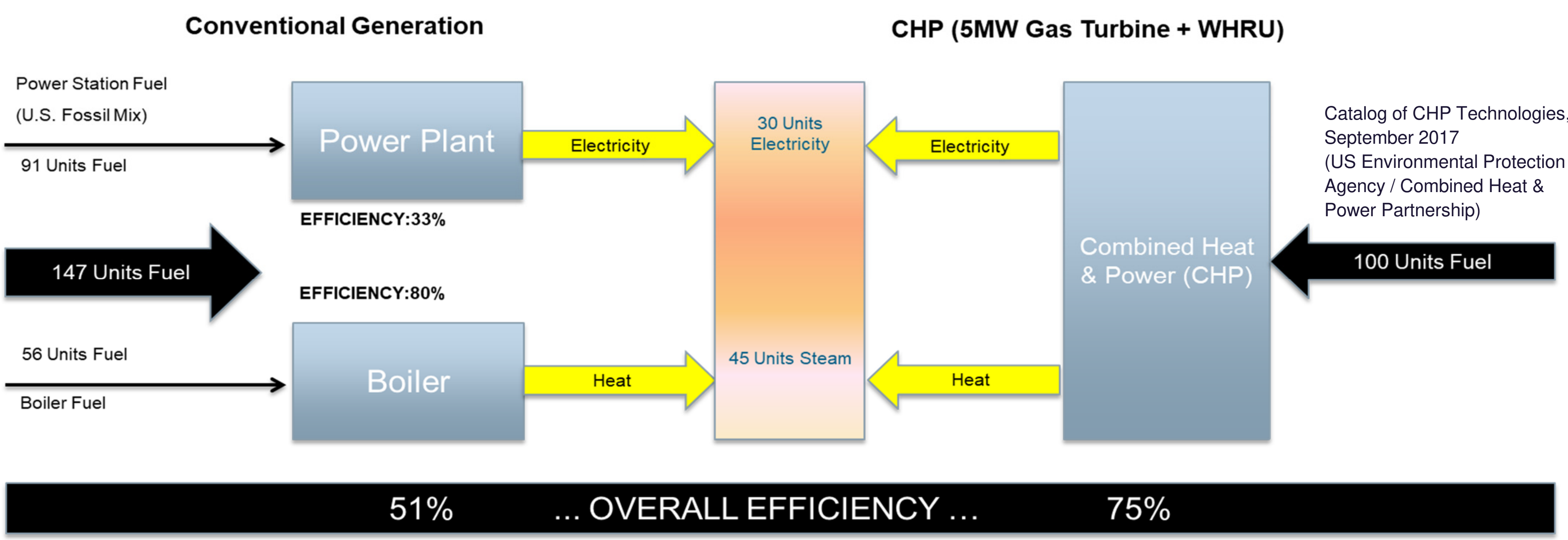
- In 2018, US CO_{2EQ} emissions were 6677 million metric Tonnes
- Combustion of fossil fuels for energy is the single biggest GHG contributor
  - Electricity
  - Heat



Source: US EPA website:
Sources of Greenhouse Gas Emissions

CHP is the most efficient way to produce both electricity and heat (or cooling)

High Efficiency and Low Carbon Content Fuels enable energy production with the lowest Carbon Intensity



Even CHP cannot meet aggressive CO_2 Intensity or Net Zero CO_2 targets using fossil fuels

The concept of 75% efficient CHP scheme produces 5MW of electricity and 7.5MW of heat

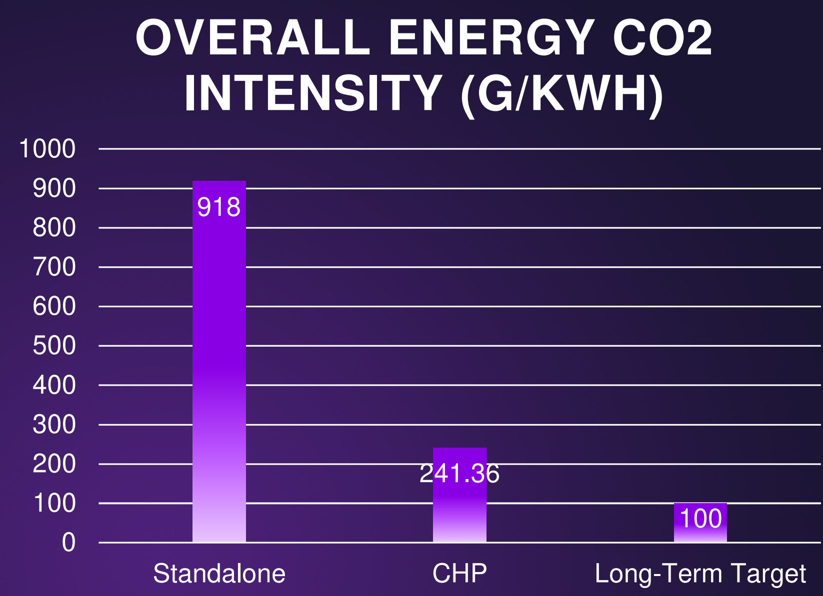
- Carbon Intensity of 241.4g/kWh energy produced

Long-term goals are for < 100g/kWh and 'net zero' by 2050 in many countries

- Even 100% efficiency can only reach 181g/kWh

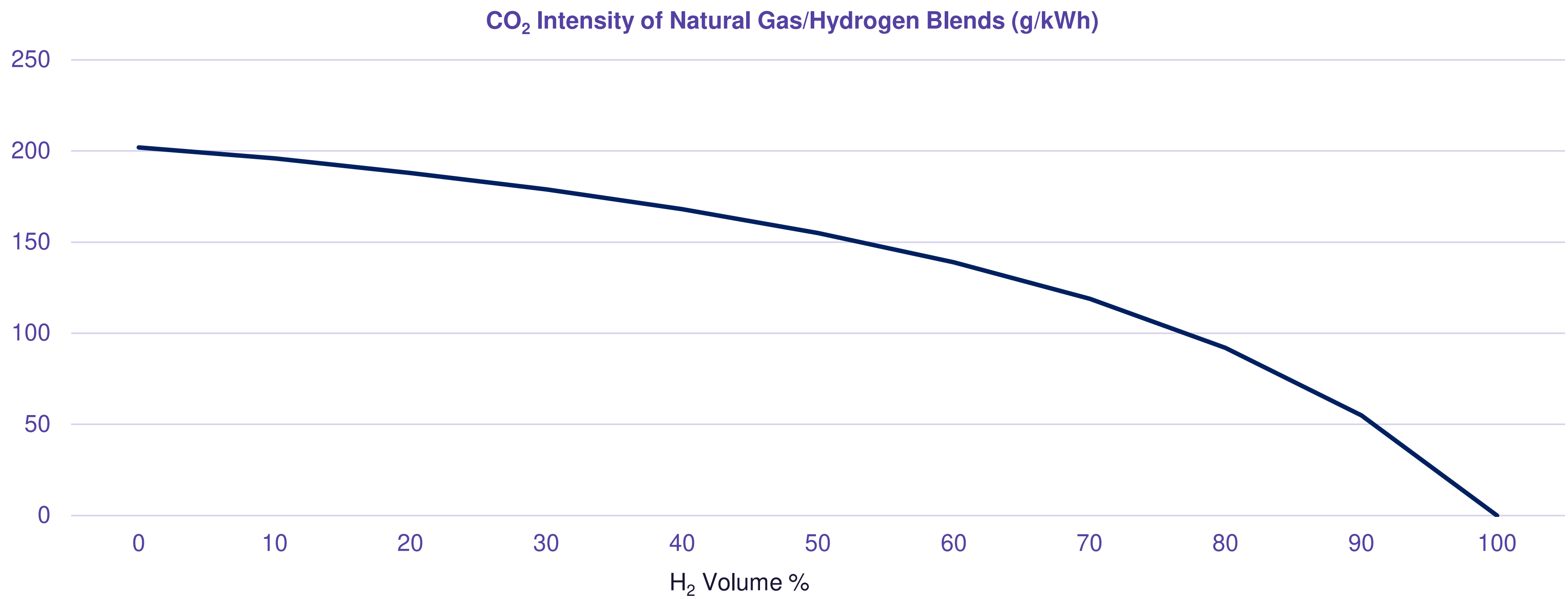
How to achieve 'net zero' CO_2 ?

- Carbon Capture
  - Not 100% efficient and CO_2 disposal challenge
- Zero carbon fuels (e.g.: Hydrogen)



US EIA: Carbon Intensity of Power Generation 2019 = 418g/kWh.
Carbon Intensity of Natural Gas = 181g/kWh

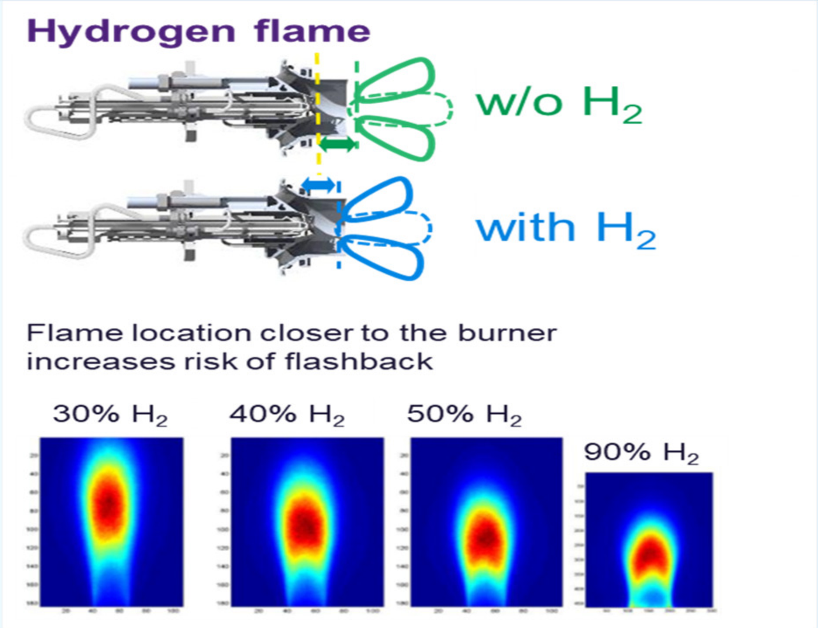
Using 100% Hydrogen or blending Hydrogen into Natural Gas can reduce fuel Carbon Intensity



>75% Hydrogen blended into natural gas can help achieve long-term CO2 reduction goals.

Can I use Hydrogen in Gas Turbines ?

Gas turbines have gained millions of operating hours experience on high H2 fuels.



Hydrogen creates several challenges compared to Methane:

1. Combustion System
   - Fuel volumes (Wobble Index)
   - NOx
   - Flame Speed → Flashback Potential

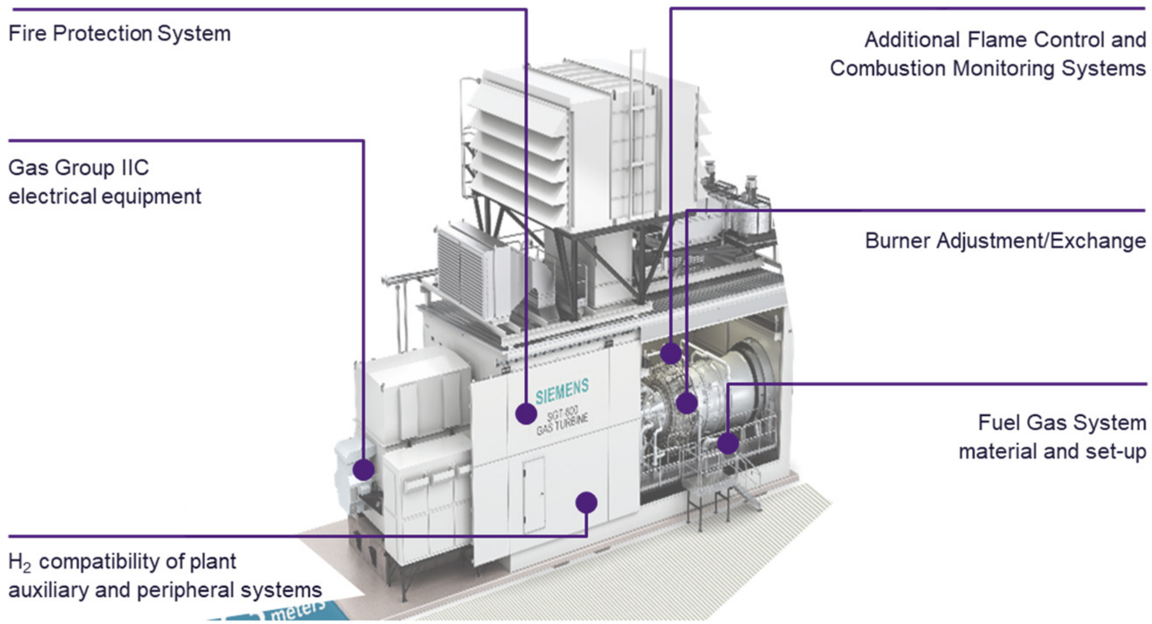
2. Package
   - Material selection
   - Fire & Gas detection
   - Hazardous Area certification of electrical equipment
     - Natural Gas: IIA/B
     - > 25% Hydrogen: IIC

The Required changes for high H_2 operation

Modifications are well-understood:

1. Very little change < 25% H_2

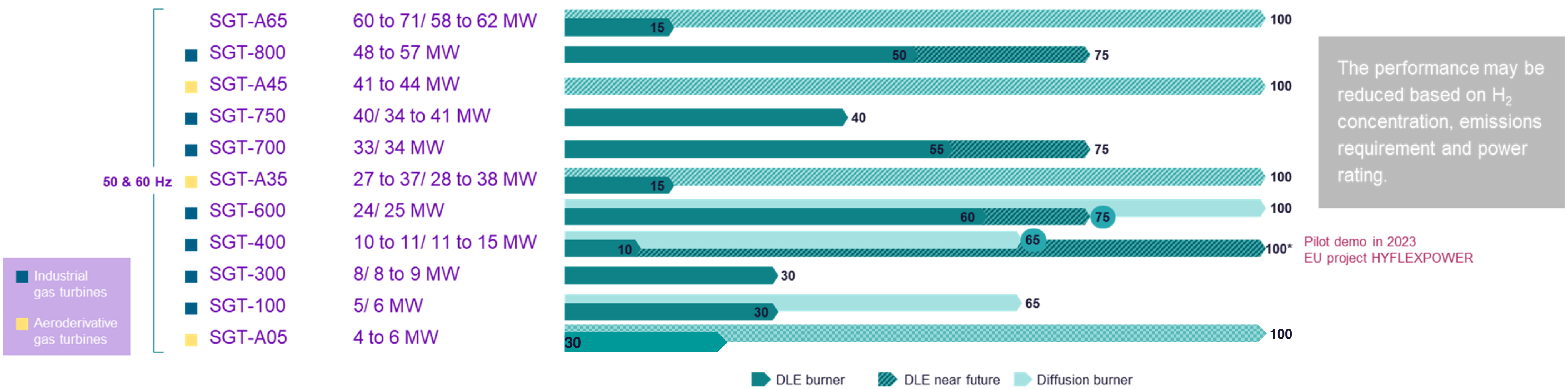
2. Higher H_2 contents
    - Burner changes
    - Electrical equipment
    - Fire & Gas systems
    - Materials
    - Operational philosophy
        - Start-up / shutdown



Hydrogen capability of DLE Combustion systems is improving at a rapid rate

EU OEM Declaration:

- < 20% by 2020: Already there for many GT models
- Commercial availability of models with up to 100% H2 capability by 2030
- Already achieved for Diffusion combustors on some models

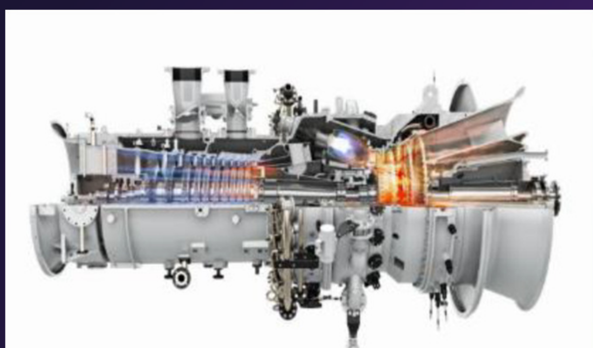


Case Study

BRASKEM, Brazil

Scope

- 9 x SGT-A05 Dual fuel WLE



Siemens Energy SGT-600 Gas Turbine

Project

- Upgrade of Braskem CHP plant
- 2 x 25MW class gas turbines providing power and steam
- Fuel is a H2-rich residual gas with nominally 60% H2 (vol)
  - Variable H2 content
- DLE combustors for low NOx production

Customer

Data Center

- Petrochemical complex in Sao Paulo, Brazil

Timeline

- Commercial operation 2021

Case Study

HyflexPower, France

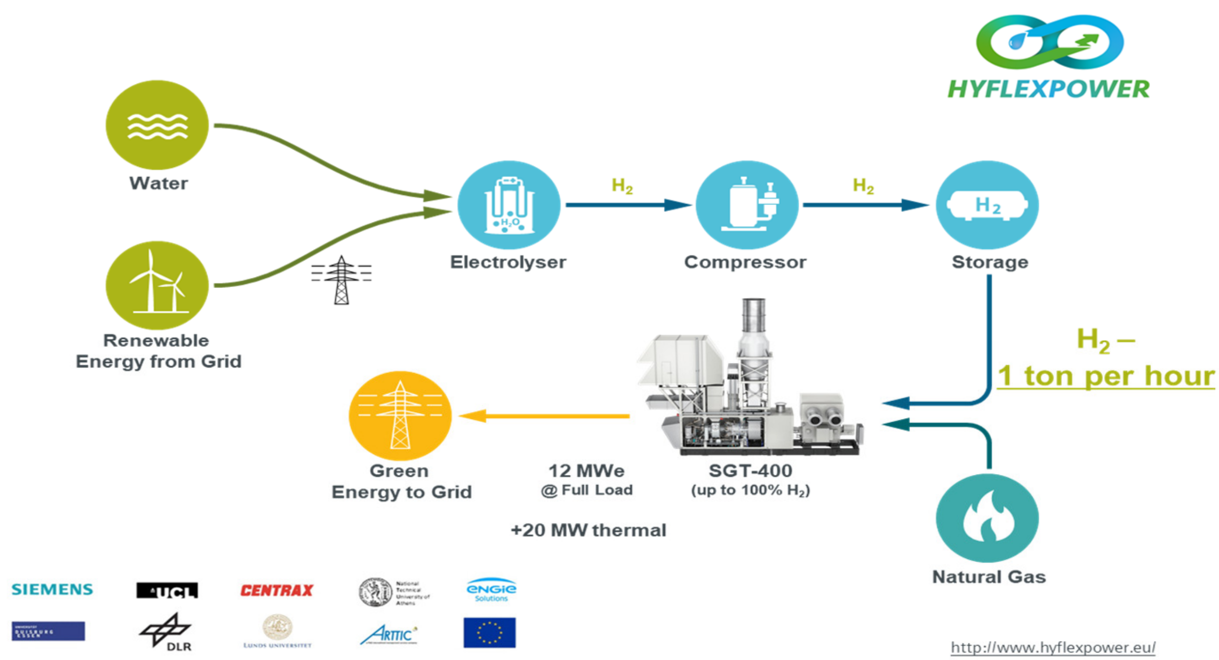
Scope

- 100% H2 Retrofit of the existing CHP Plant in Paper Industry

Timeline:

1. Installation of the hydrogen production, storage and supply facility at pilot demonstration site in 2021
2. Installation of the gas turbine for NG/H2 mixture and initial demonstration of advanced pilot plant concept in 2022
3. Pilot demonstration with up to 100 H2 for carbon-free energy production from stored excess renewable energy

Goal is to develop combustion technology able to operate between 100% natural gas and 100% H_2

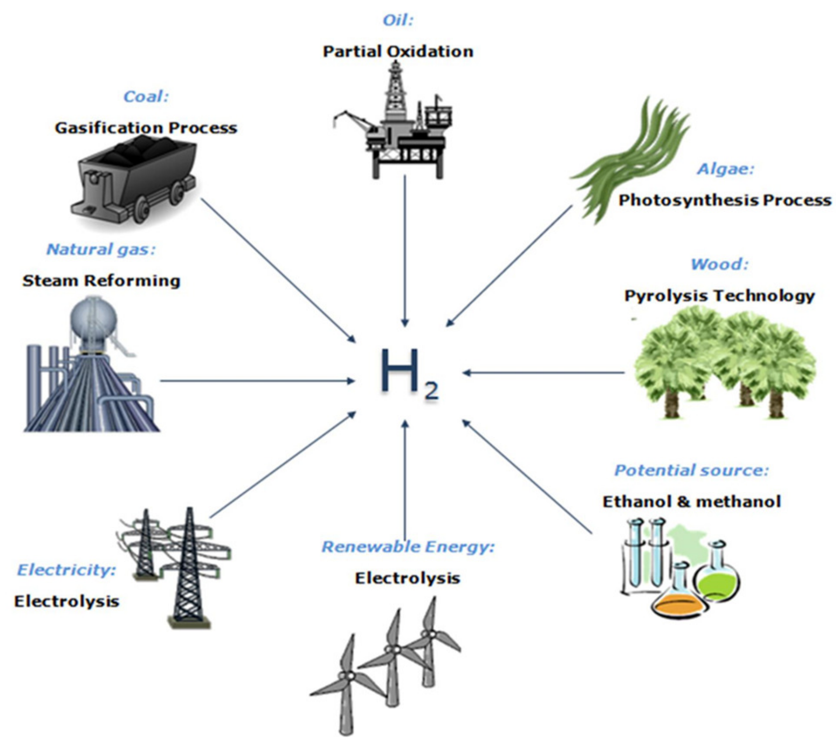


How much Hydrogen will I need?
Where will the Hydrogen come from?

- Most H_2 used as fuel in Gas Turbines today is part of a process offgas (Petrochemicals, chemicals, Coke Oven Gas)
- Produced 'pure' Hydrogen comes in many colours !
  - Black / Gray: Steam Methane Reforming (SMR) or similar
  - Blue: SMR or similar plus Carbon Capture
  - Green: Electrolysis using Renewable Electricity

Current Global Production ~ 70 million Tonnes/year

- Hydrogen has a calorific value of 120MJ/kg
- A 12MW class Gas Turbine needs around 1100kg/hour of H_2 for 100% H_2 operation
- A 50MW class Gas Turbine needs around 3750kg/hour of H_2 for 100% H_2 operation



Producing 'Blue' or 'Green' Hydrogen

Blue Hydrogen — **Green Hydrogen** — **Cost Challenge**

'**Blue**' **H_2** can be produced using natural gas and current H_2 production technologies, but by adding CO_2 capture

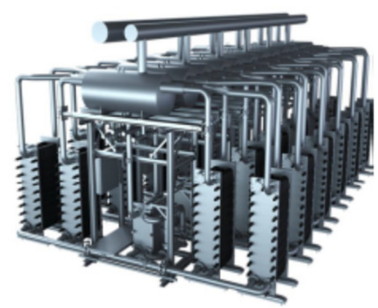
- 1kg H_2 produces 8 – 10kg of CO_2
- 95% CO_2 capture plus storage or utilisation

Green H_2 uses renewable electricity and electrolysis, plus possible H_2 storage to 'timeshift' renewable energy utilization

- Silyzer 300: 17.5MW input → 340kg/h H_2
- 51.5MWh of renewable energy to get 12MWh from a gas turbine

Cost challenge of H_2:

- 3 to 10 times as expensive as natural gas on a US$/mmbtu basis today
- Low cost 'green' electricity and carbon taxes will help improve competitiveness



Silyzer 300 – module array (24 modules)

Creating the volumes of Hydrogen required to fully displace natural gas will be a challenge

The Hydrogen economy will take time to develop.

US natural gas consumption in 2019 was 31Tcf (US EIA). To provide the same amount of energy using H_2 would need 261.9 million tonnes. Almost 4 times current ***global*** production

To produce this much 'green' H_2 using renewable electricity would require 13480TWh of electrical energy

- Total US electricity consumption in 2018 was 4289TWh (IEA)

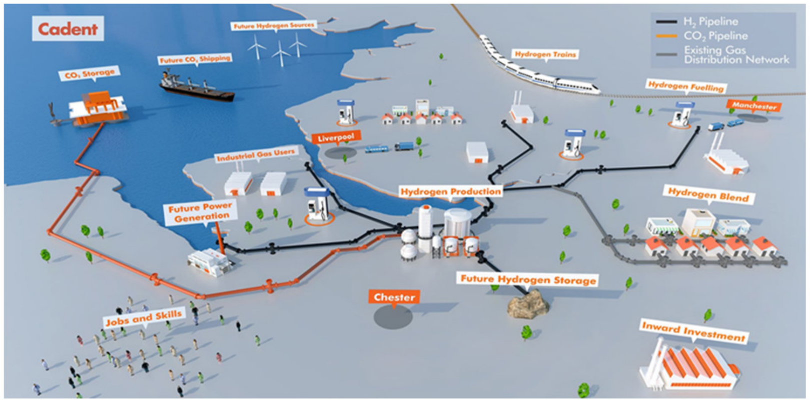
How will the Hydrogen economy develop?

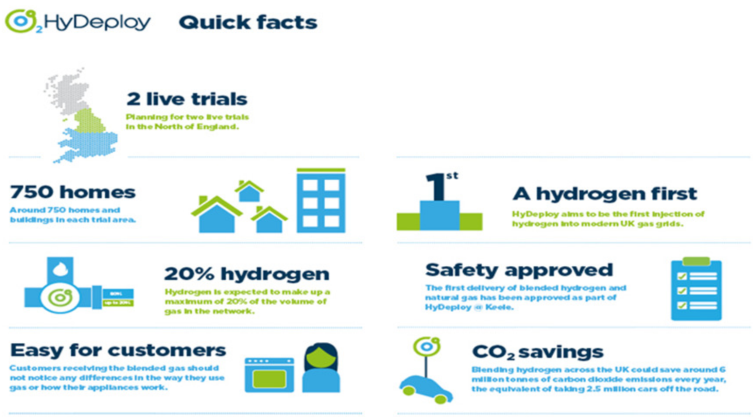
Huge potential in numerous areas for ‘green’ and ‘blue’ H_2:

- Transportation
- Chemicals
- Steel
- Energy Production

Dedicated H_2 production and pipelines for large scale industrial decarbonisation /power plant / CHP (e.g. HyNet project)

Use of surplus renewable electricity to increase H_2 content in natural gas pipelines (e.g. HyDeploy 20% H_2, Keele University, UK)





Conclusions

1 Hydrogen can improve the **environmental benefits** of CHP by further reducing CO_2 emissions

2 Gas Turbines can operate on **H2-rich fuels today**, with combustion developments in the pipeline:

- Both new-build and retrofits
- Future-proofing of assets

3 Greatest challenge is increasing **H2 supply volumes and cost reduction**

- Dedicated H2 production for large facilities
- Natural gas / H2 blending for pipelines
- Natural gas as a transport vector with local reforming and distribution

Douglas Willham

Head of Engineering, SGT-A05

Email: douglas.willham@siemens-energy.com

Phone: +1 317.373.9465