

# Hydrogen as part of our value chain

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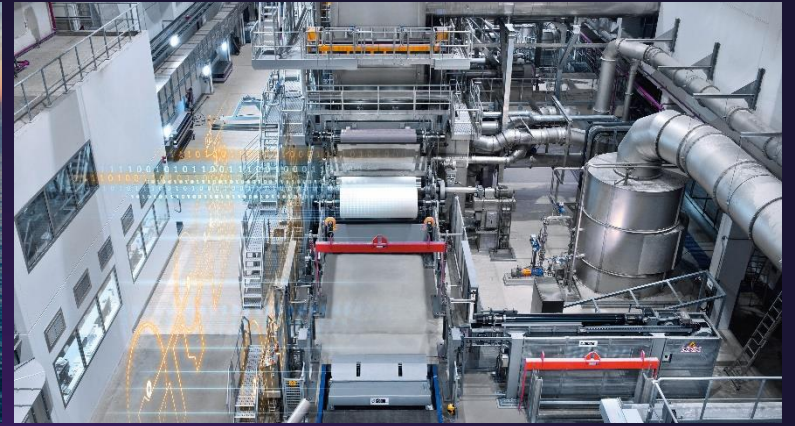
# Three pillars to support our strategy



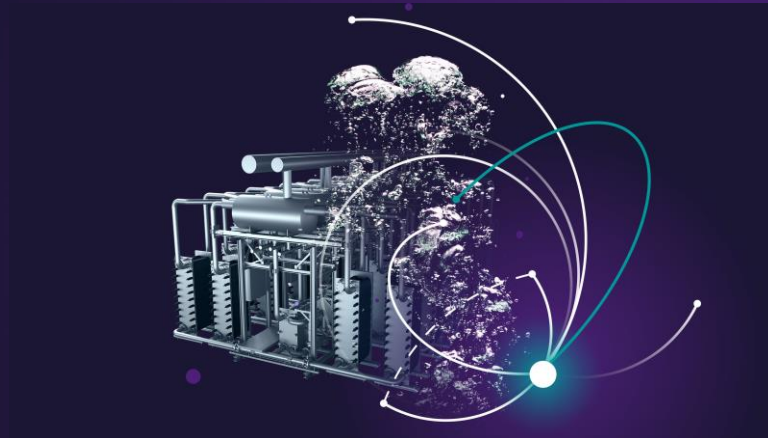
Low- or zero-emission  
power generation



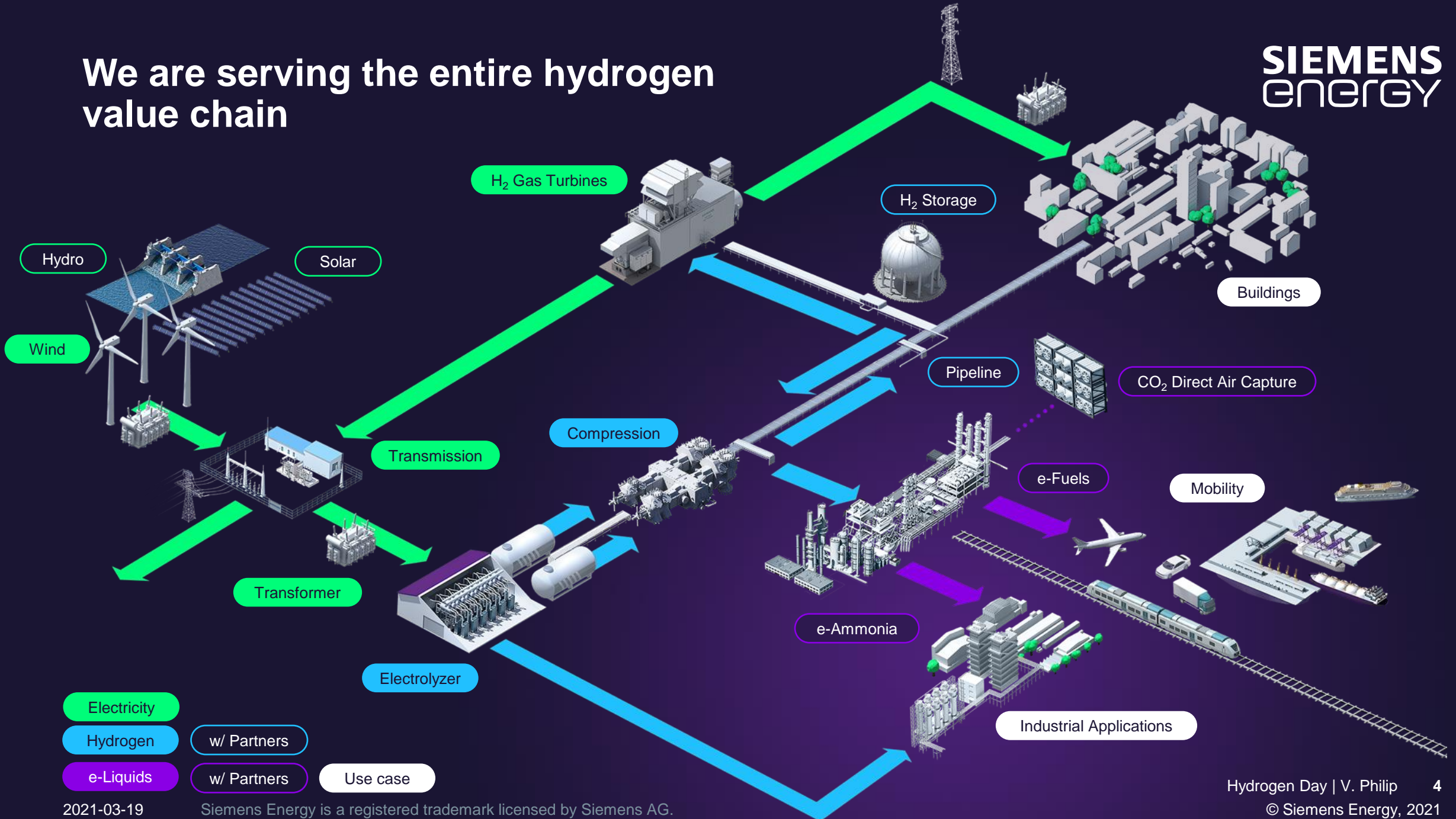
Transport of electricity  
and storage



Reducing CO<sub>2</sub> footprint and energy  
consumption in industrial processes



















# We are serving the entire hydrogen value chain





- Electricity
- Hydrogen
- e-Liquids
- w/ Partners
- w/ Partners
- Use case


# Vast compression product portfolio for the entire hydrogen value chain with more than 1,500 operating compressors



	Green Hydrogen 	Grey/Blue Hydrogen 	Hydrogen pipelines 	Hydrogen storage 	Hydrogen liquefaction 	Hydrogen Synthesis gas 
RECIPROCATING Compressors						N/A <sup>1</sup>
TURBO Compressors	N/A <sup>1</sup>	N/A <sup>1</sup>			N/A <sup>1</sup>	
GEARED Compressors			N/A <sup>1</sup>	N/A <sup>1</sup>	N/A <sup>1</sup>	N/A <sup>1</sup>

 Under commercial operations

 Existing relevant portfolio currently being introduced into new market applications

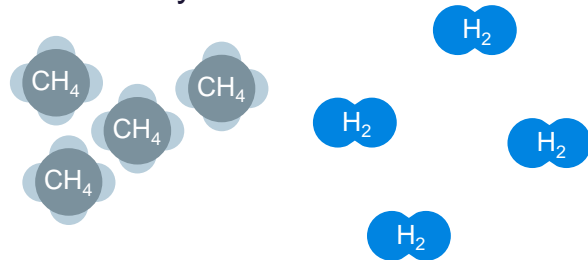
 Ongoing development to further improve efficiency in low mole weight gas compression (H<sub>2</sub>)

<sup>1</sup> Not used today or applicable for current and foreseen volumes and pressure levels

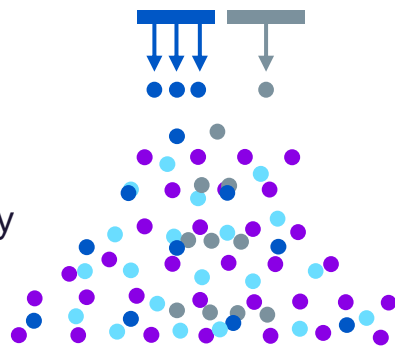
# Our advanced technologies successfully manage the challenging characteristics of hydrogen combustion

## Physics of fuel molecules

Lower density

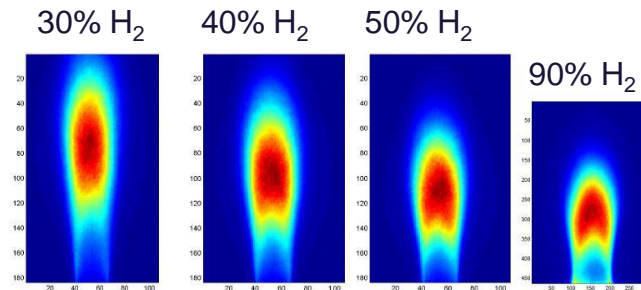


Higher diffusivity



● H<sub>2</sub> ● CH<sub>4</sub> ● O<sub>2</sub> ● N<sub>2</sub>

## Flame kinetics



More challenging flame characteristics require more complex combustor design

## Additive Manufacturing for better mixing and cooling

Performance enabled by **Additive Manufacturing**

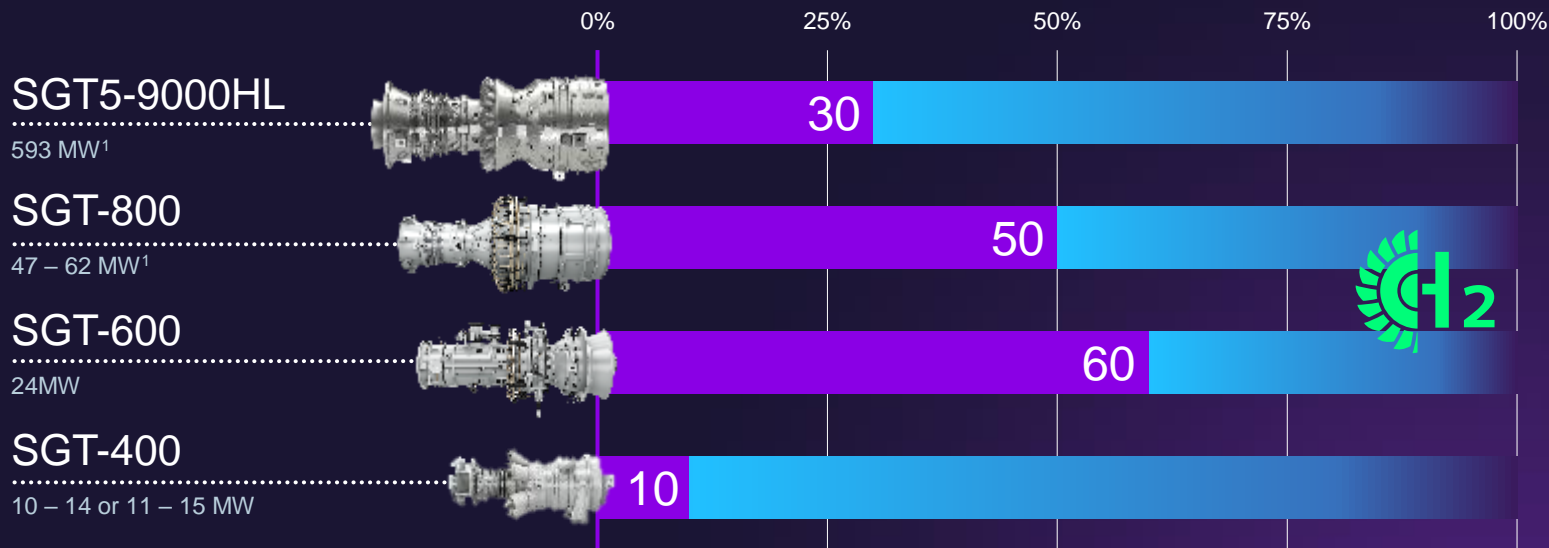
- Optimized mixing for flash-back resistance
- Improved tailored cooling
- Rapid prototyping and testing



Eight burner fronts on printing plate SGT-600, SGT-700 and SGT-800

# Hydrogen capabilities apply across the entire gas turbine range

## The pathway to burn 100% hydrogen



until **2023** – 100% H<sub>2</sub> in  
Industrial Gas turbines

until **2030** – 100% H<sub>2</sub> in  
Heavy Duty Gas turbines

Released hydrogen capability    Ongoing Development

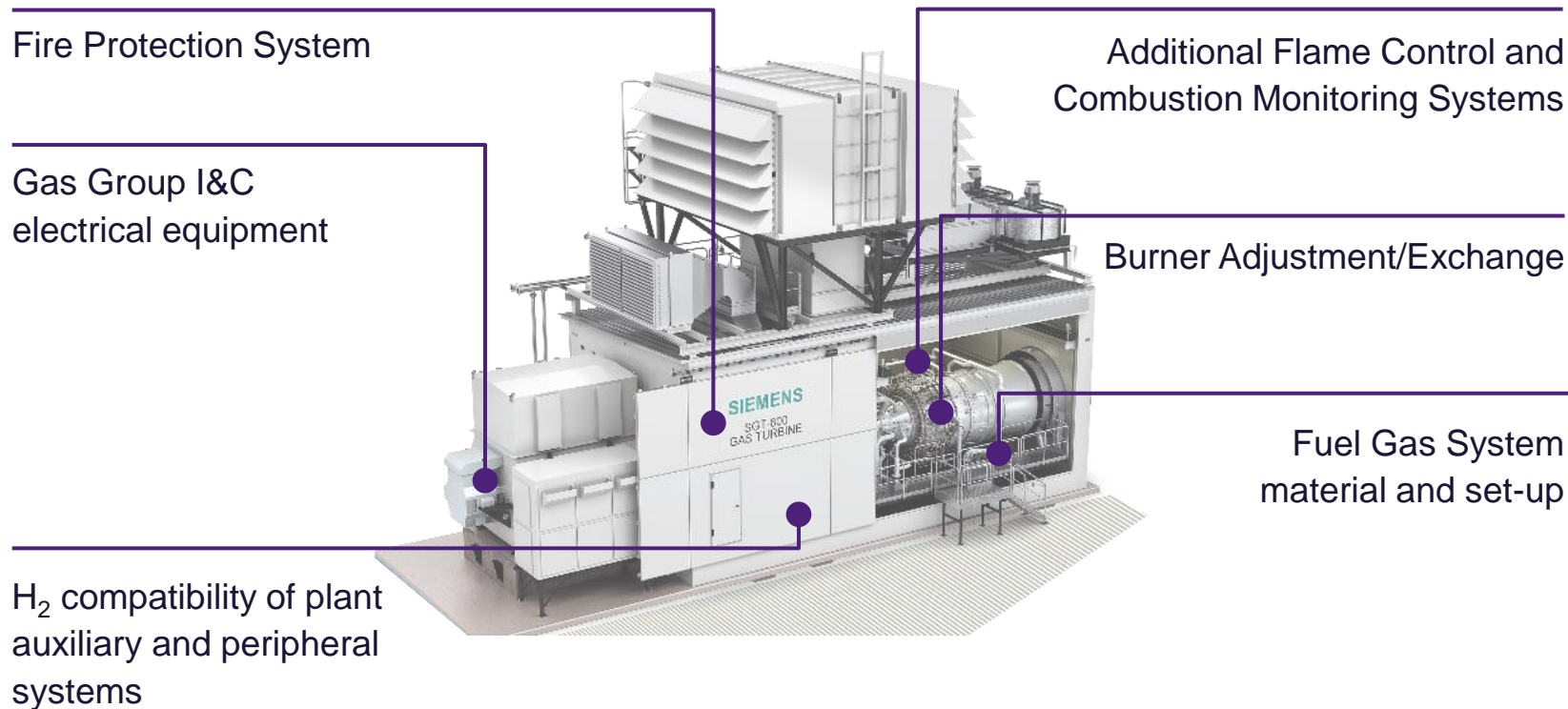
Investments for upgrading the global fleet of **gas turbines** by making them a **key technology for transitioning** to a decarbonized world

- **Large GTs:** >45 years of accumulated experience on H<sub>2</sub> (syngas) combustion
- **Medium GTs:** >10 years experience based on H<sub>2</sub> admixture
- **Small GTs:** ≈1 m OH of high hydrogen combustion experience
- **Aero GTs:** >100k hours of recorded operation on high hydrogen fuels (**up to 78 vol%**)

<sup>1</sup> The performance may be reduced based on H<sub>2</sub> concentration, emissions requirement and power rating

# Our technologies and systems are designed for upgradability to support the decarbonization of the installed base

## Main systems requiring modification when upgrading to higher H<sub>2</sub> content



## Consequences and solution

- Project specific evaluation and decision on required modifications
- Power output control to ensure compliant NO<sub>x</sub> emission levels
- Conventional/non-H<sub>2</sub> fuels may be required for start-up and shutdown
- Re-certification with respective authorities might be required





## Customer example: providing clean energy to Braskem, Brazil



up to 60% H<sub>2</sub>

Co-Firing in combined cycle solution, providing 38 MW and 160 tons of steam per hour

### Scope

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- 2 x SGT-600
- 3 x Reciprocating Compressors
- E-houses
- Extension of HV Substation
- Advanced load-shedding System
- Software for plant control

### Features

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- Co-Generation plant fueled by residual process gas with **high hydrogen content**
- **6.3% CO<sub>2</sub>** and **11.4% water consumption reduction**
- **100% plant availability** through redundant design
- 15 year contract to build, own & operate the cogeneration plant

## STRONG SIEMENS ENERGY FOOTPRINT:



Present in  
**>90** countries

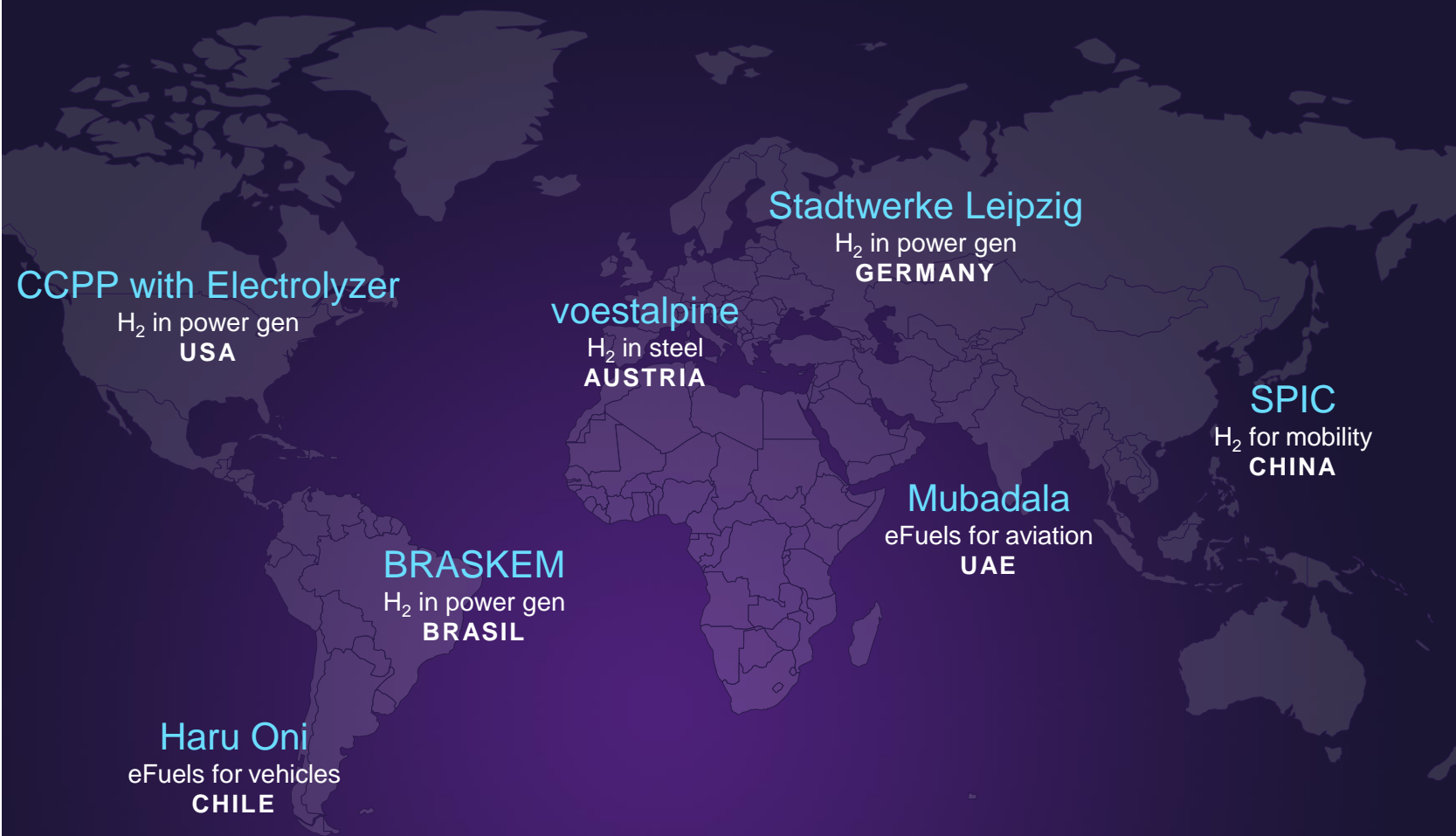


**~90** Sales and  
Execution offices



**~75**  
Service centers

# Siemens Energy's global setup enables global engagement in hydrogen projects



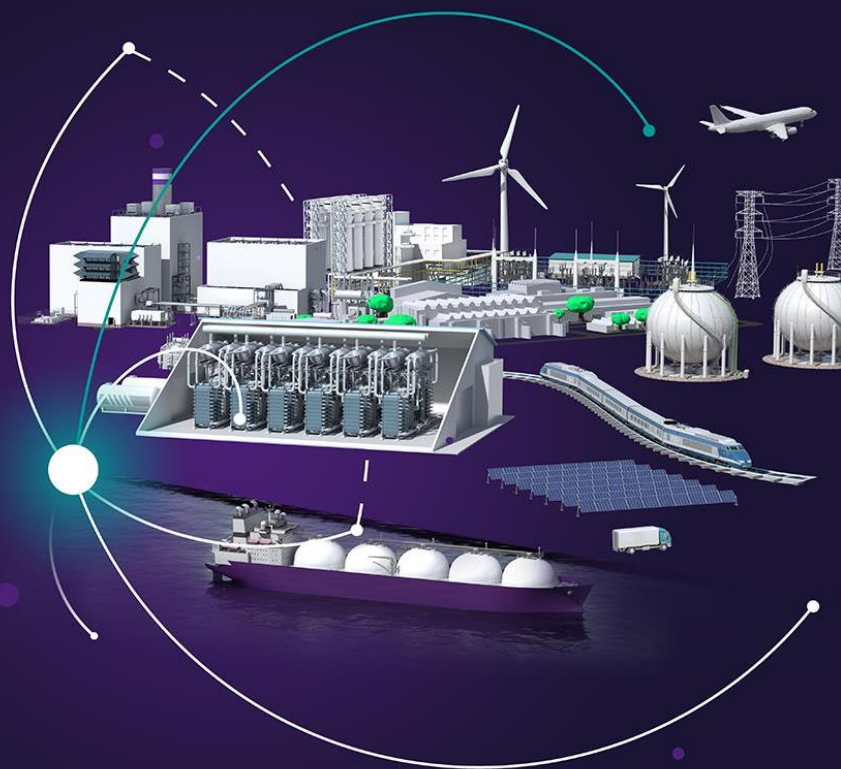


Over **53 units** and **2.5 million** operating hours worldwide across different industries and power ranges **since 1979**

# World fleet experience on high H<sub>2</sub> syngases



# Conclusions



- 1** **Unique combination** of global presence, service networks, solutions know-how, partner ecosystems and customer relations **to enable the Hydrogen Economy.**
- 2** **Unmatched set of technologies**, products and systems **supports entire hydrogen value chain** for both brownfield and greenfield applications.
- 3** **Proven operational experience** of green hydrogen solutions across production, compression and application around the world.
- 4** **The partner-of-choice** in the transition to a global Hydrogen Economy.