

Solar® Turbines

A Caterpillar Company

Powering the Future Through Sustainable, Innovative Energy Solutions

HYDROGEN EXPERIENCE AND CAPABILITIES LEADING THE ENERGY TRANSFORMATION

Hydrogen (H₂) in gas turbine operation enables carbon reduction opportunities across a broad range of applications and industries. Gas turbines provide a stable base load and support increased renewable penetration. Solar Turbines has been providing solutions for H₂ rich fuels since 1985 and has logged over two million hours of operation, some units today using as much as 80% H₂ content.

In order to meet increasing energy demands from customers as well as carbon reduction targets set by companies and countries, increased global usage of H₂ is paramount. Solar is committed to continue increasing our H₂ capabilities and investing in H₂ technology, offering energy solutions that are clean, safe and reliable.

Within pipeline gas applications, H₂ will displace some portion of the natural gas in the pipeline. It is expected that the H₂ content of the gas will not exceed 20% for the near future. Within the industrial process market, H₂ content is greater than 20% and as high as 100%. This market may include fuel gas with significant levels of other gases than methane, leading to careful consideration of safety,



2+ Million Operating Hours



High H₂ Experience Since 1985



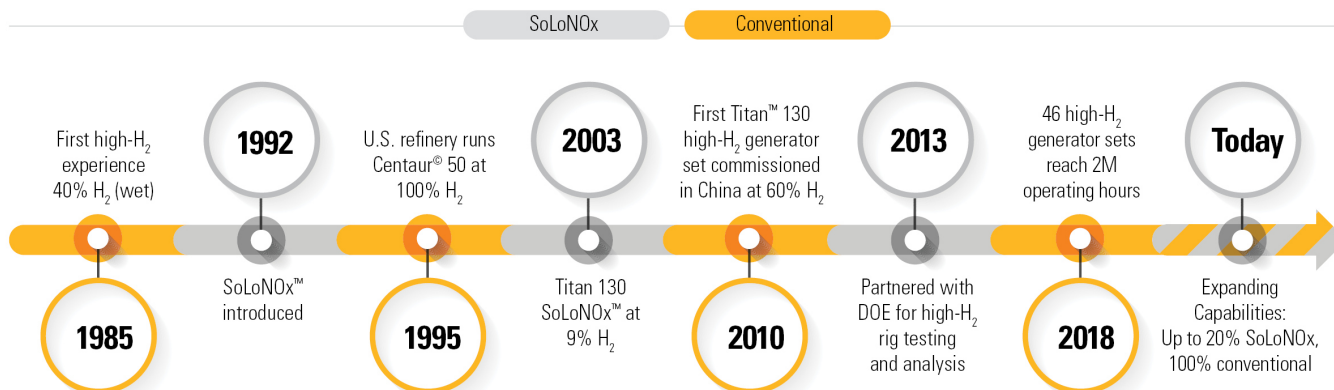
Carbon Reduction

especially for high carbon monoxide. The best solution candidate today for this market/fuel gas is a conventional combustion system.

Solar's H₂ Technology Experience

Solar has extensive experience and is a leader among turbine manufacturer's in high H₂ technology. As part of this experience, 46 generator set packages are operating with nearly two million hours of accumulated experience and up to 65% H₂. Solar also has H₂ experience in refineries with over 40,000 hours with up to 37% H₂ in a conventional combustion system and with SoLoNO_x[™] (dry low emissions combustion) using fuel with H₂ content up to 20%.

SOLAR'S H₂ TECHNOLOGY EXPERIENCE (55 UNITS WITH 2M OPERATING HOURS)



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Solar H₂ Capabilities

Solar's gas turbines, packages and compressors are available for H₂ blend fuel now for both conventional and SoLoNOx combustion. Solar is committed to supporting the industry with a comprehensive development program leading to 100% capability on SoLoNOx by the year 2030 or earlier. The percent of H₂ blended with natural gas can have an impact on the gas turbine's emissions signature. For conventional combustion, the impact on NOx emission varies by the percent of H₂ and the other fuel constituents and will be determined on a project-by-project basis. For SoLoNOx combustion systems at the 15 ppm NOx (and

higher) warranty level, H₂ concentrations up to 20% should not impact the emissions warranty.

Customer Services

Solar Turbines provides continuing support for our customers to ensure their success with package upgrades, controls retrofits and engine and compressor modifications for hydrogen blend operation. In addition, Solar's Fleet Assessment Services (FAS) provides a consultative assessment and recommendation for hydrogen blend and carbon reduction fleet opportunities and asset optimization.

SOLAR'S H₂ CAPABILITIES



SOLONOX Up to 20% H₂

- Refineries in United States Up to 20% H₂
- Chemical Plant Applications in China and Europe Up to 20% H₂



CONVENTIONAL COMBUSTION Up to 100% H₂

- Steel Industry Applications in China Up to 65% H₂
- Propane Dehydrogenation Applications in Belgium Up to 83% H₂
- Refinery Applications in the United States Up to 37% H₂

Corporate Contact Information

Web: www.solarturbines.com

Email: infocorp@solarturbines.com Phone: +1-619-544-5352