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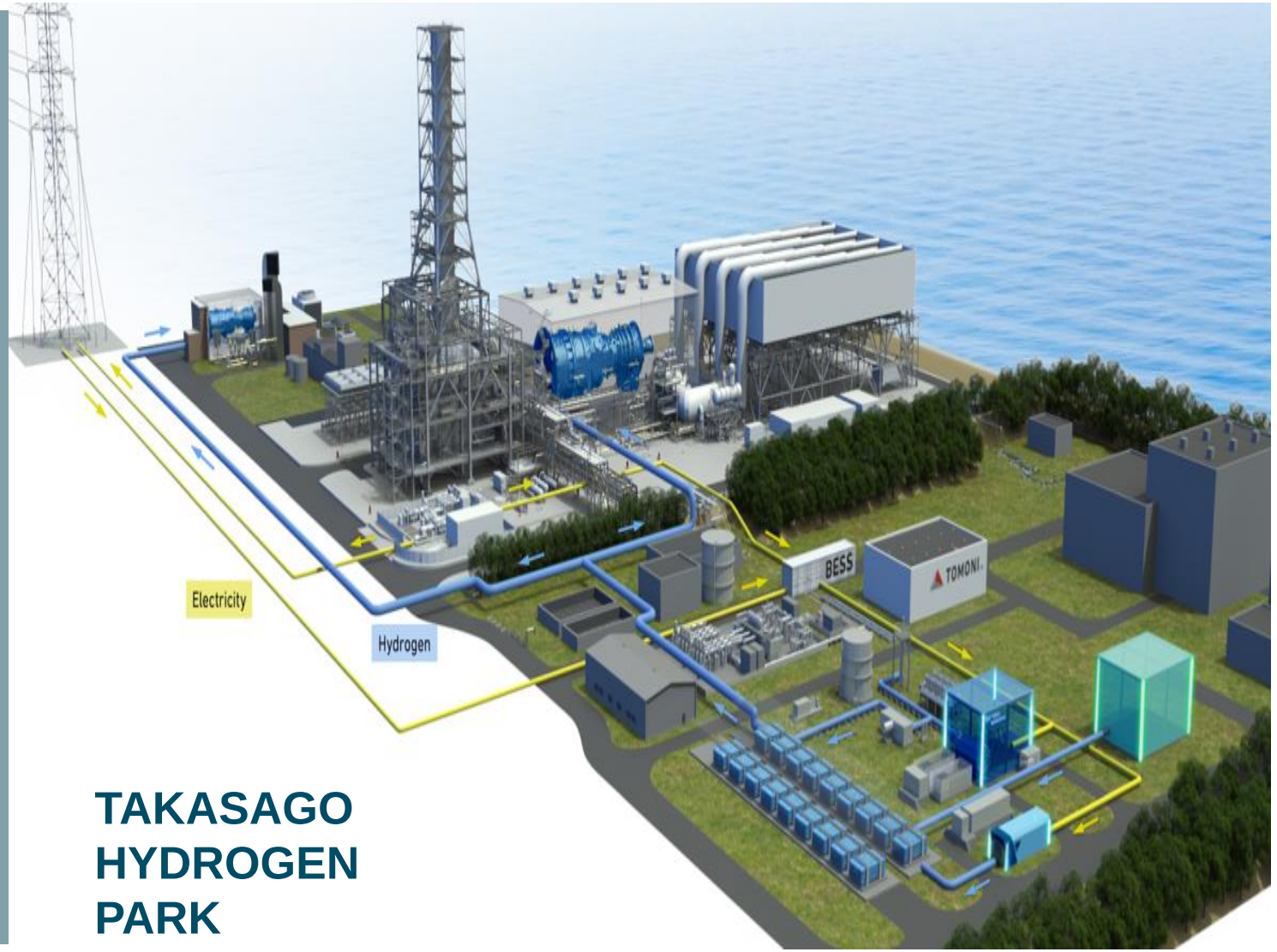
MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP

Combustion of Hydrogen Blends in Mitsubishi *Gas Turbines*

CALIFORNIA ENERGY COMMISSION
Potential Growth of Hydrogen Workshop
Sep 8, 2023



TAKASAGO HYDROGEN PARK

MITSUBISHI POWER

Agenda

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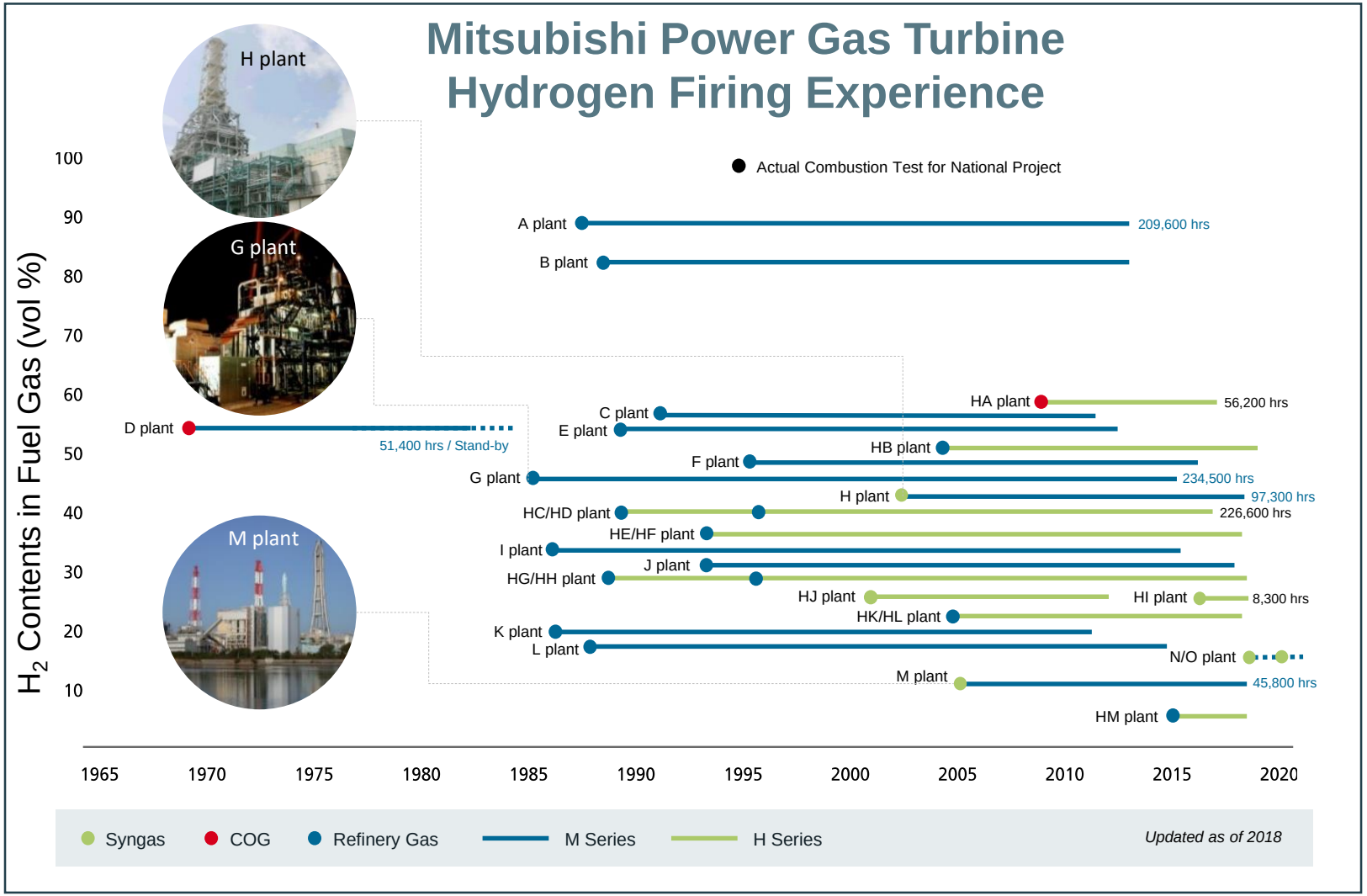
1. Industry and Insurance Concerns on Handling Hydrogen
2. Hydrogen co-firing in Gas Turbine Long and Successful History
3. Diffusion vs Dry Low NOx (DLN) Hydrogen Combustion in Gas Turbines
4. Successful Demonstrations co-firing Hydrogen with DLN Combustors
5. Takasago Hydrogen Park Concept
6. Questions

Four Million hours of Hydrogen Co-Firing Experience

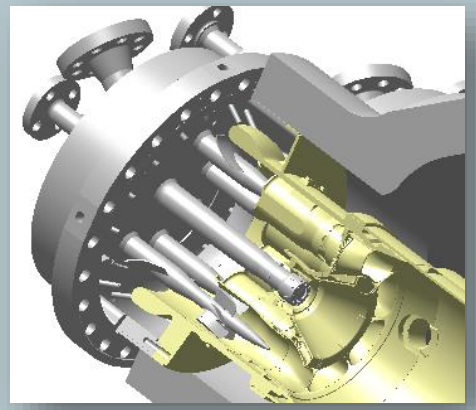


Fast Facts: Hydrogen Generation

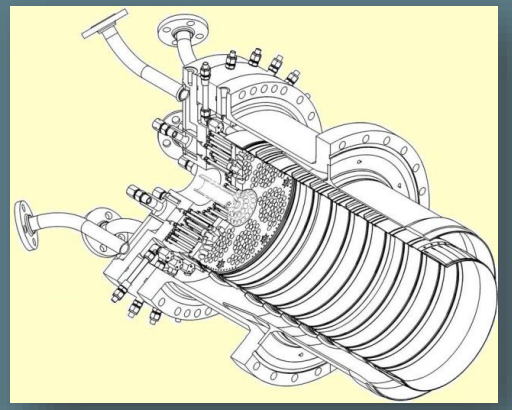
- Long history **(50 years)** of operating on Hydrogen fuel blends in gas turbines
- Numerous projects in the range of **50%** hydrogen co-firing
- Projects with **over 80% hydrogen** with hundreds of thousands of hours of operation
- Many projects with different fuel characteristics
- Over 4 million hours of experience with hydrogen fuels on gas turbines
- Impacts to piping and gas turbine materials are well understood with decades of experience

Hydrogen-Fired DLN Gas Turbine Combustor Development

Current DLN combustor can Operate up to 30% Hydrogen



Multi-Cluster Technology Will Operate on 100% Hydrogen



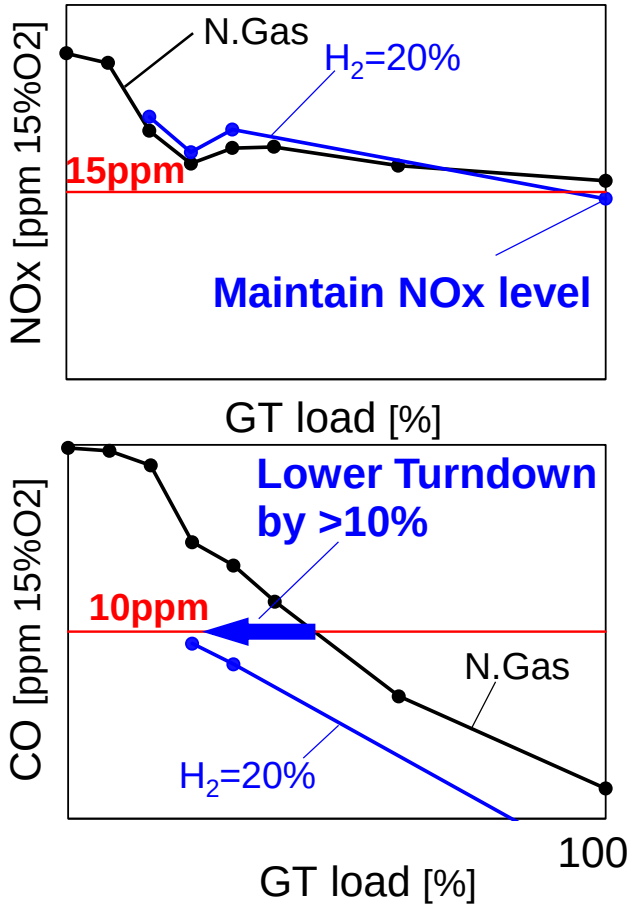
3D Printed Part

Two DLN combustor technologies that can operate on hydrogen and achieve low plant emissions levels without water or steam injection

M501G Base Load Hydrogen co-firing Test at McDonough Power Station

Georgia Power McDonough
Advanced Class GT (1,500 ºC) Power Station

Base Load NOx Emission Remained Unchanged with H2 > 20%



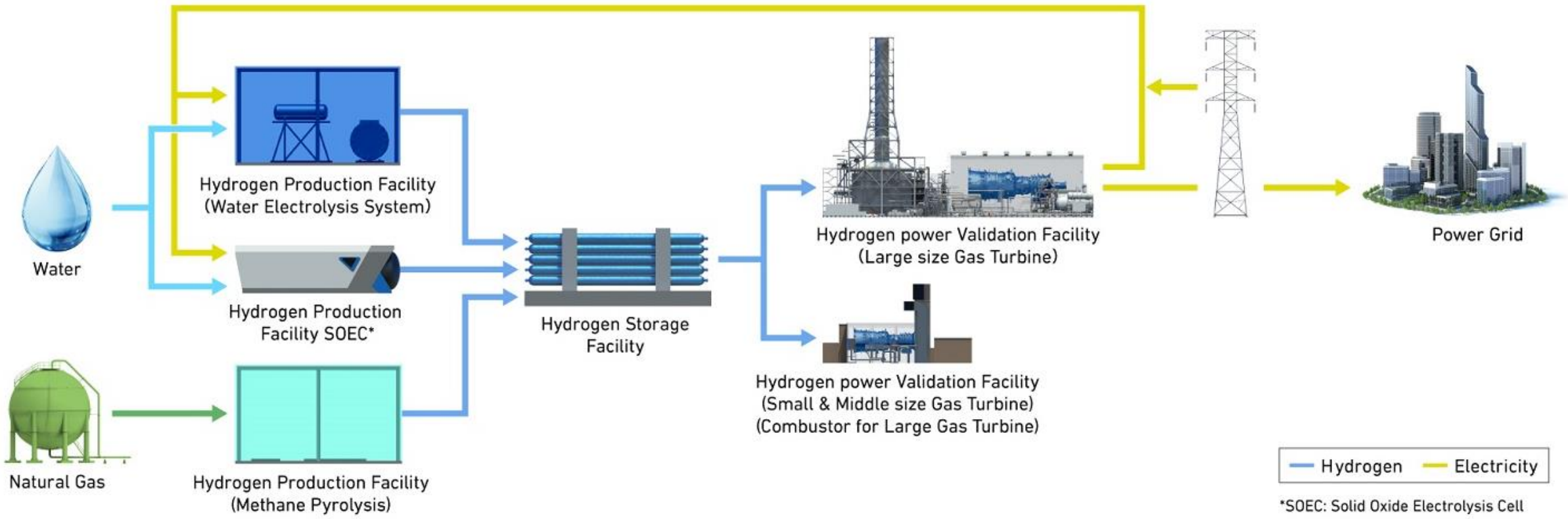
Turndown reduced by 10%

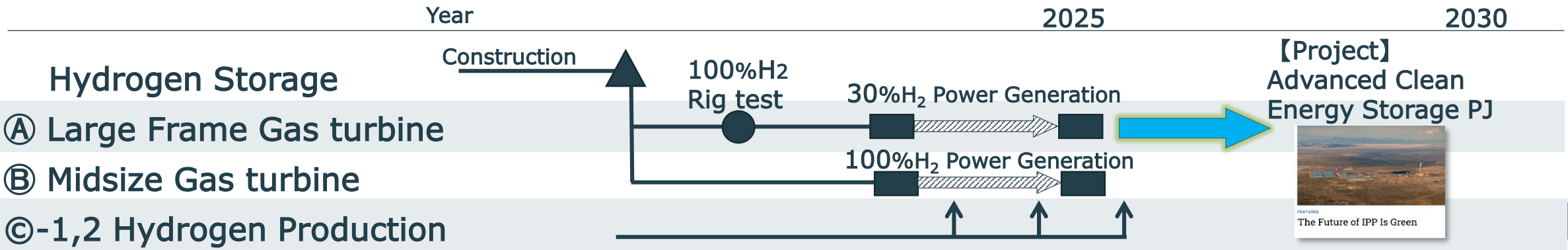
Takasago Hydrogen Park: Verification of Hydrogen Technology

Image figure (Partly different from the actual layout and configuration)

*1 SOEC: Solid Oxide Electrolysis Cell
*2 BESS: Battery Energy Storage Systems

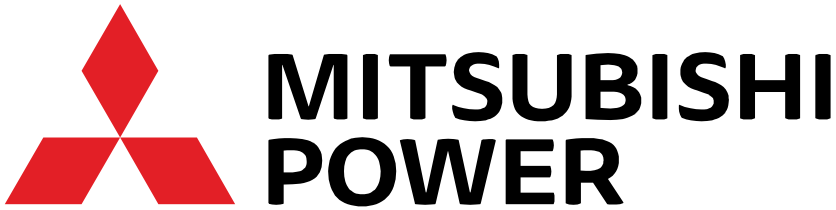
Takasago Hydrogen Park: Verification of Hydrogen Technology





Summary

- Mitsubishi Power Gas Turbines have accumulated decades of Hydrogen co-firing operation using diffusion combustors
- Successful hydrogen combustion tests have demonstrated that 30% hydrogen and natural gas co-firing can be applied without significant changes to the existing DLN natural gas turbine facilities
- A successful hydrogen co-firing demonstration at Georgia Power 1,500 ºC Advanced Class Gas Turbine indicates that existing NOx Emissions levels can be maintained or even improved.
- Mitsubishi Power Validation facility T-Point 2 is being retrofitted with hydrogen generation equipment that will allow ON-DEMAND validation of hydrogen technology (***Hydrogen Park*** facility).
- The experienced derived from the Takasago Hydrogen Park operation will facilitate optimization of future hydrogen projects, including ACES.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