

Hydrogen Technologies Virtual Factory Tour

June 14, 2021

1. Introduction (1/3)

- MHI is pursuing three main initiatives related to the Energy Transition.
- This presentation focuses on the decarbonization of existing infrastructure and building a hydrogen solutions ecosystem.

Decarbonize existing infrastructure



Build a hydrogen solutions ecosystem

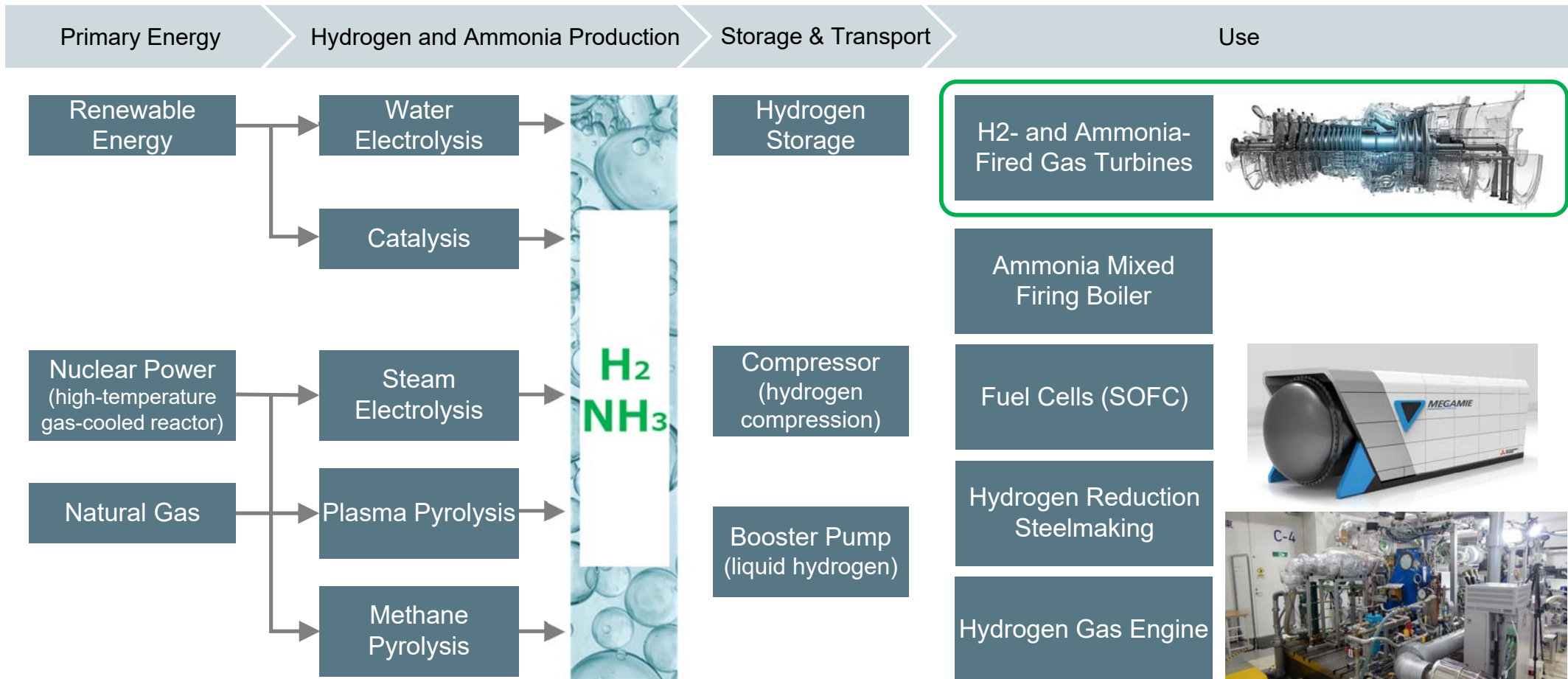


Build a CO₂ solutions ecosystem



1. Introduction (2/3)

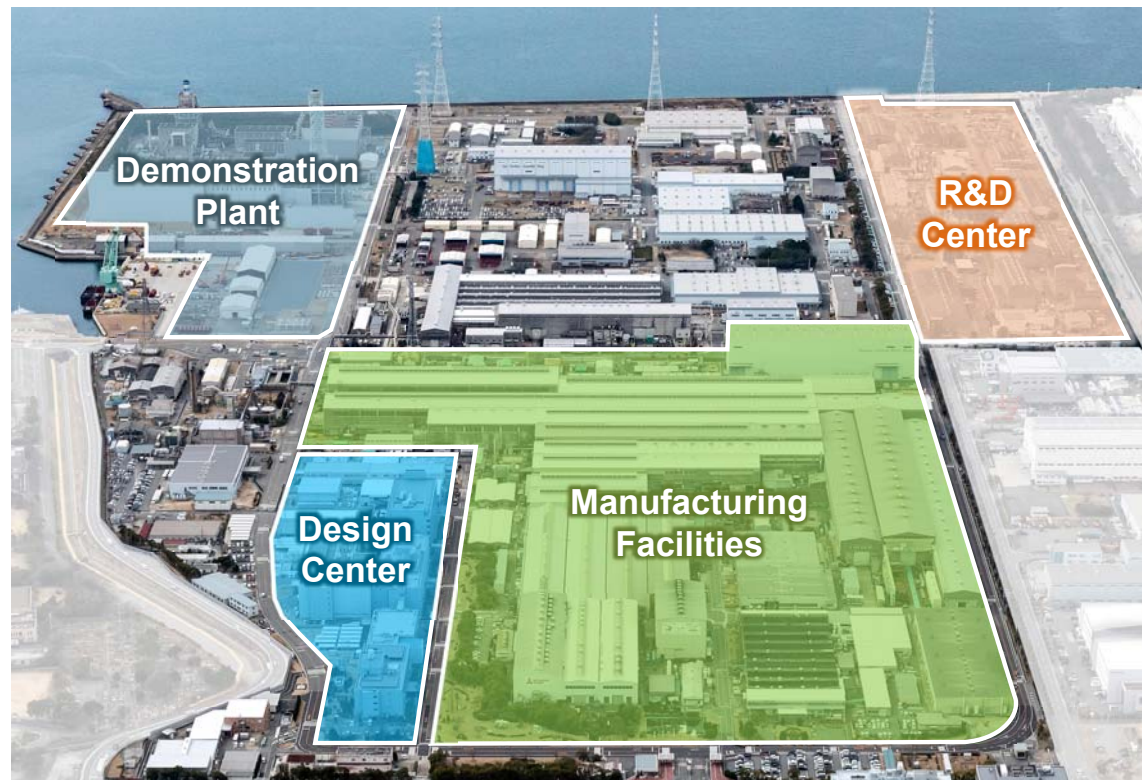
- Hydrogen is a secondary energy source produced using primary energy sources such as natural gas, nuclear power, and wind power.
- Establishing an ecosystem that covers hydrogen production to utilization is essential to popularize this powerful decarbonization tool.



Part of this presentation includes development results from the National Laboratory New Energy and Industrial Technology Development Organization (NEDO) program.

1. Introduction (3/3)

- Hydrogen gas turbine technology development is advancing rapidly and nearly ready to be commercialized. The ability to retrofit existing natural gas-fired power plants to use this carbon-free fuel will greatly contribute to the decarbonization of existing assets and will be an important building block in the ecosystem by introducing demand for hydrogen.
- Mitsubishi Power Takasago Works is working on the development, design, manufacture, and demonstration of hydrogen gas turbines. In the near future, hydrogen production equipment will be installed to enable validation of the hydrogen ecosystem concept.
- Please join us on a virtual tour of Takasago Works, which features the actual facilities where hydrogen gas turbine development is taking place.



2. Takasago Works Virtual Tour (1/9)

- Gas turbine technical development, manufacture, and validation are all carried out at Takasago Works, located in Hyogo Prefecture, Japan.



Our Takasago Works facility, where hydrogen gas turbine development is underway.










2. Takasago Works Virtual Tour (2/9)

- This facility is world-renowned for housing the world's only Gas Turbine Combined Cycle (GTCC) demonstration power plant, which is currently operating at 64% efficiency.
- Gas turbine technical development is pursued utilizing this demonstration plant as well as a wide array of other equipment and facilities.



2. Takasago Works Virtual Tour (3/9)

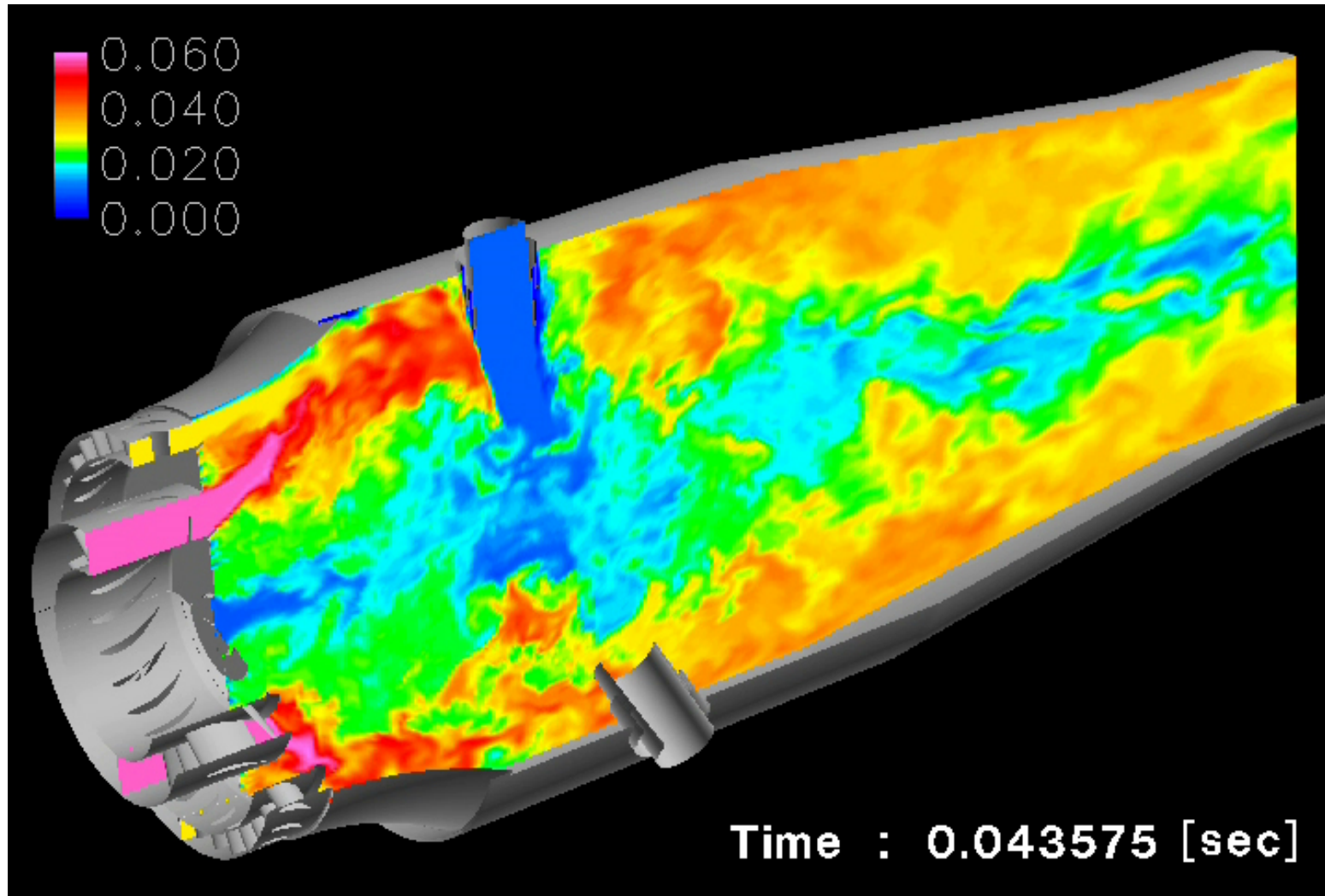
- MHI has already obtained a voluminous amount of real-world data on hydrogen combustion using existing combustion technology. Now we are working to develop a new combustion method to achieve a low NOx, high efficiency, 100% hydrogen-fired heavy duty gas turbine.

	Combustion Method	Low NOx technologies	Hydrogen Content	Development/Operation Status
Existing technologies	Diffusion combustion 	N2 dilution Water/ Steam addition		
	Premixed combustion (Dry low NOx technology) 	Dry		 <p>Verification of 30% H2 mixed firing with established combustor technology</p>
Under development	Multi-cluster (Dry low NOx technology) 	Dry		 <p>Verification completed up to 80% H2 mixed firing Development of 100% H2 firing combustor slated for completion</p>

*Part of this presentation includes development results from the National Laboratory New Energy and Industrial Technology Development Organization (NEDO) program.

2. Takasago Works Virtual Tour (4/9)

- During the first phase of development, simulations are performed using computational models. After calculating temperature and flow rate distributions, a design's theoretical performance is evaluated.



2. Takasago Works Virtual Tour (5/9)

- After computational modeling, technical elements are evaluated individually.
- Because hydrogen flames cannot be seen with the naked eye, a specialized camera is used to perform observations.



2. Takasago Works Virtual Tour (6/9)

- The high pressure elemental combustion test facility is used to validate technical designs using scaled-down models at the same pressures and temperatures as real equipment.
- The multi-cluster combustor is now being tested.



Testing the new multi-cluster hydrogen combustor

2. Takasago Works Virtual Tour (7/9)

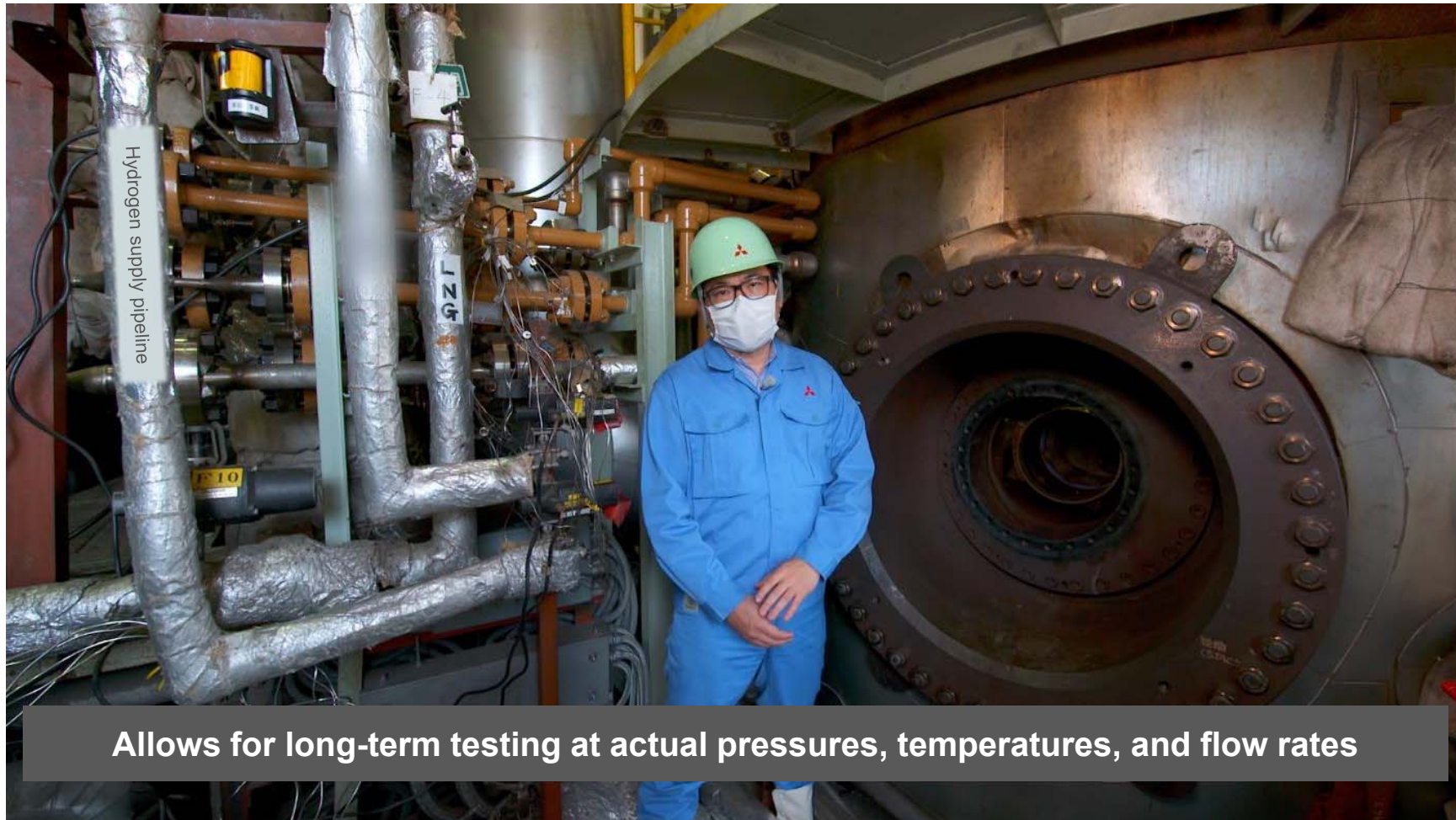
- The actual pressure combustion test facility is used to test operation when combining technical elements.



Actual pressure combustion test facility

2. Takasago Works Virtual Tour (8/9)

- As the last step before testing new designs in an actual gas turbine, long-term testing is performed under the same conditions as those experienced in the real world.
- We have already completed verification of 30% hydrogen mixed firing at this facility using the premixed combustion method.



2. Takasago Works Virtual Tour (9/9)

- MHI has developed the world's highest efficiency hydrogen gas turbine. The future is here.



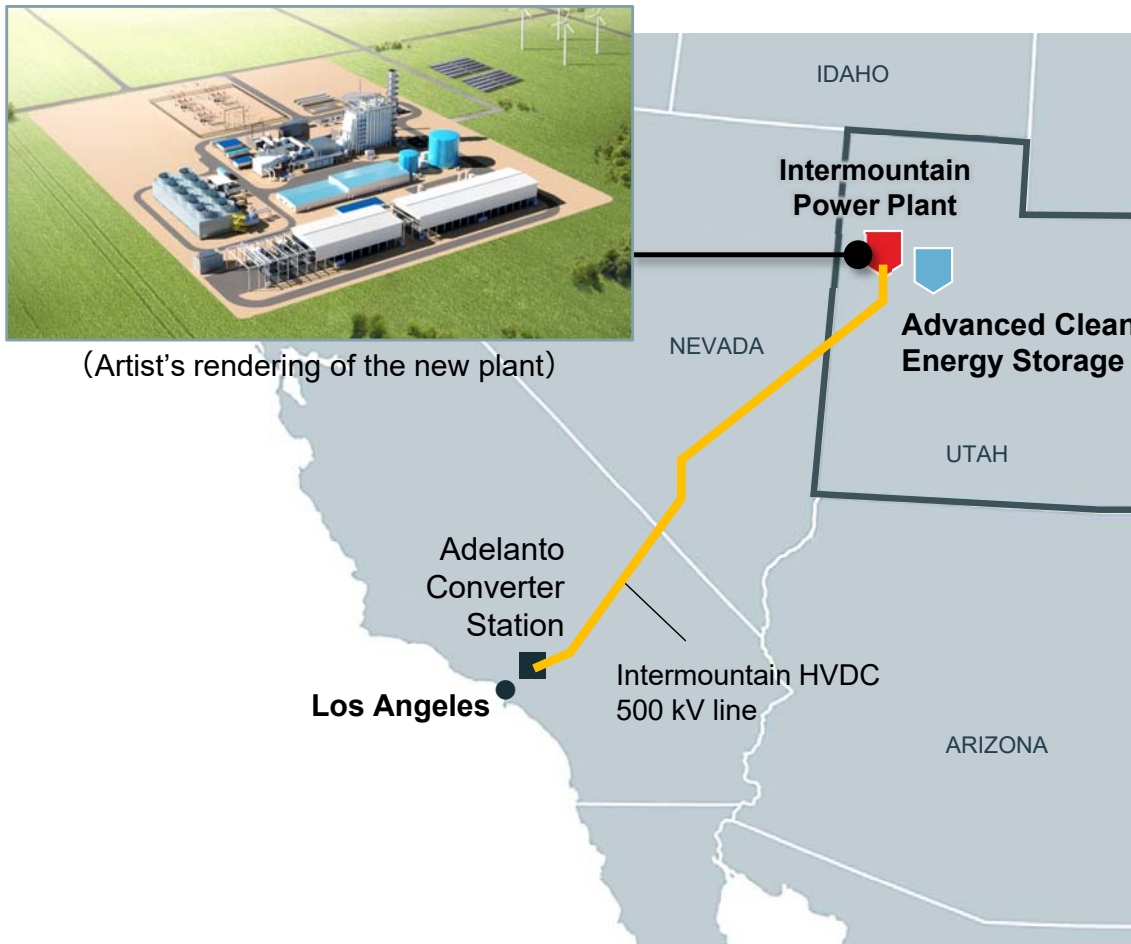
2. Takasago Works Virtual Tour

- Please watch the video available at the URL below.

<https://www.mhi.com/finance/library/et>

3. Conclusion (1/4)

- Building a hydrogen ecosystem is an essential step towards achieving carbon neutrality.
- While certain technical challenges remain, MHI is participating in cutting-edge projects around the globe which seek to create hydrogen ecosystems.



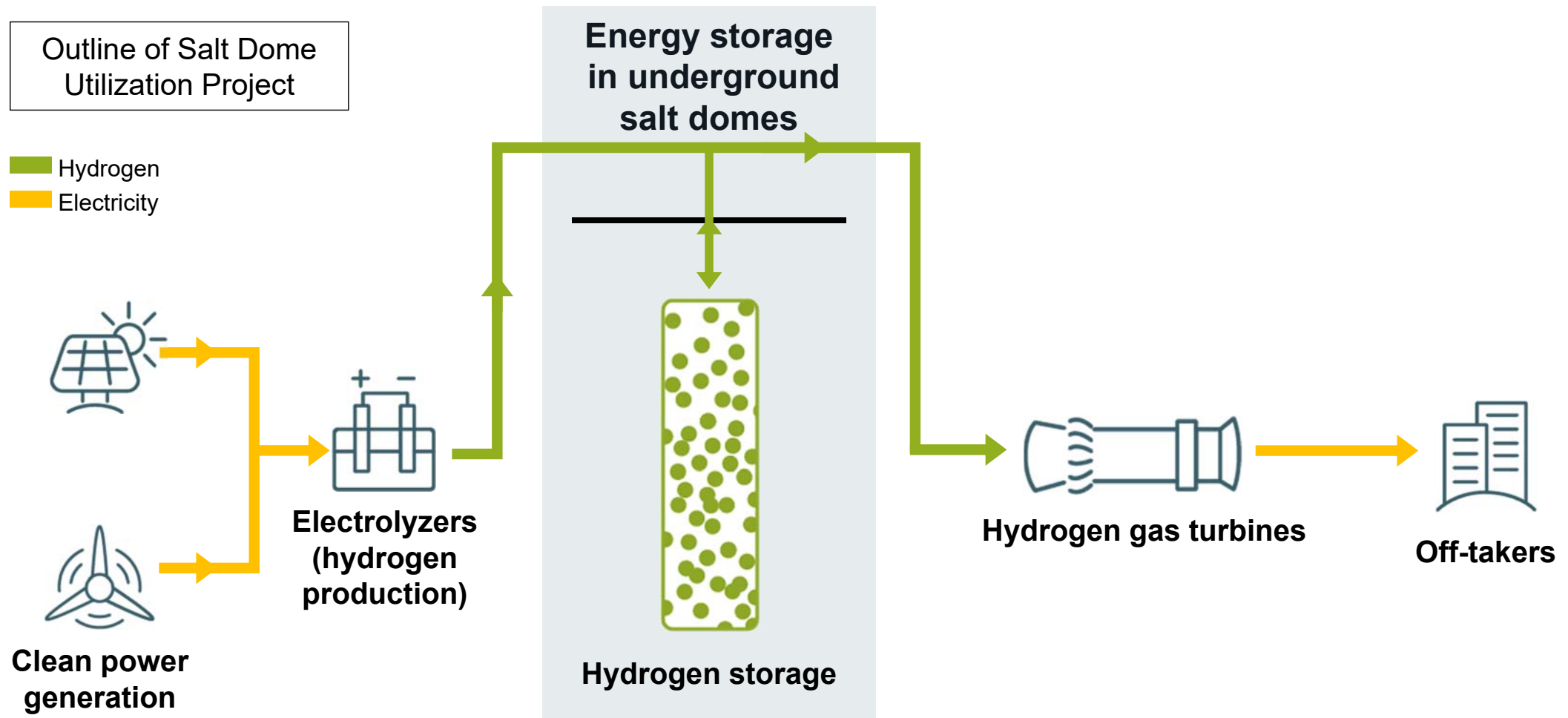
(Artist's rendering of the new plant)

Gas Turbine	M501JAC
Output (CC)	840 MW (2 GTCCs)
Location	USA (Utah)

- Replace coal-fired power plants with GTCC technology
- Reduce CO₂ emissions by up to 4.6 million tons per year with 30% hydrogen mixed firing
- Supply generated power to California and Utah

3. Conclusion (2/4)

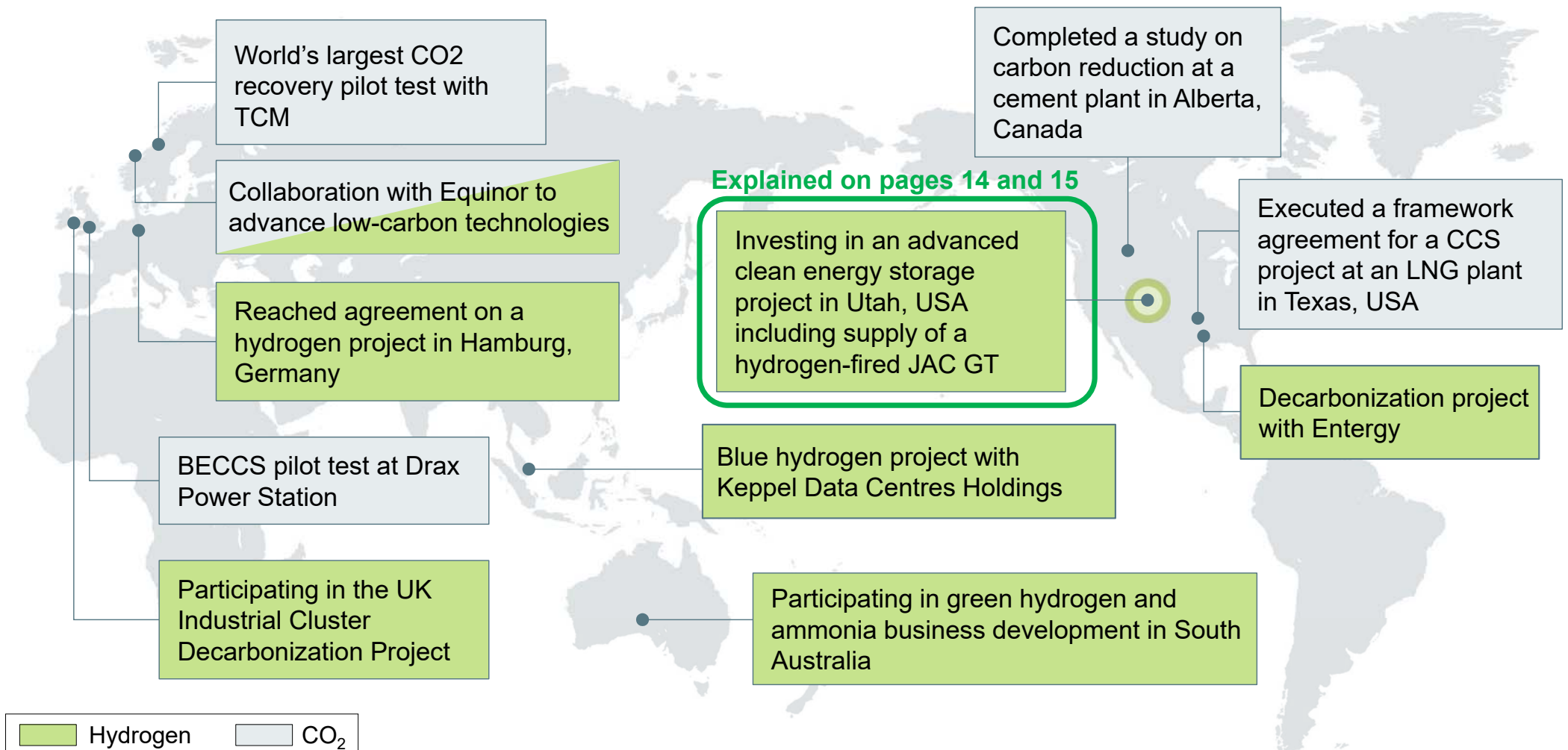
- The Utah project involves all aspects of green hydrogen: production, storage, transport, and use.
- The facility will begin operation in 2025 with a 30% hydrogen mixed firing JAC-class turbine manufactured by MHI.



3. Conclusion (3/4)

- Other hydrogen ecosystem projects are underway around the world.

Major global projects in which MHI is participating



3. Conclusion (4/4)

- During the next event, we will introduce initiatives related to building a CO₂ solutions ecosystem, another key to achieving carbon neutrality.

