SAND2021-7374C

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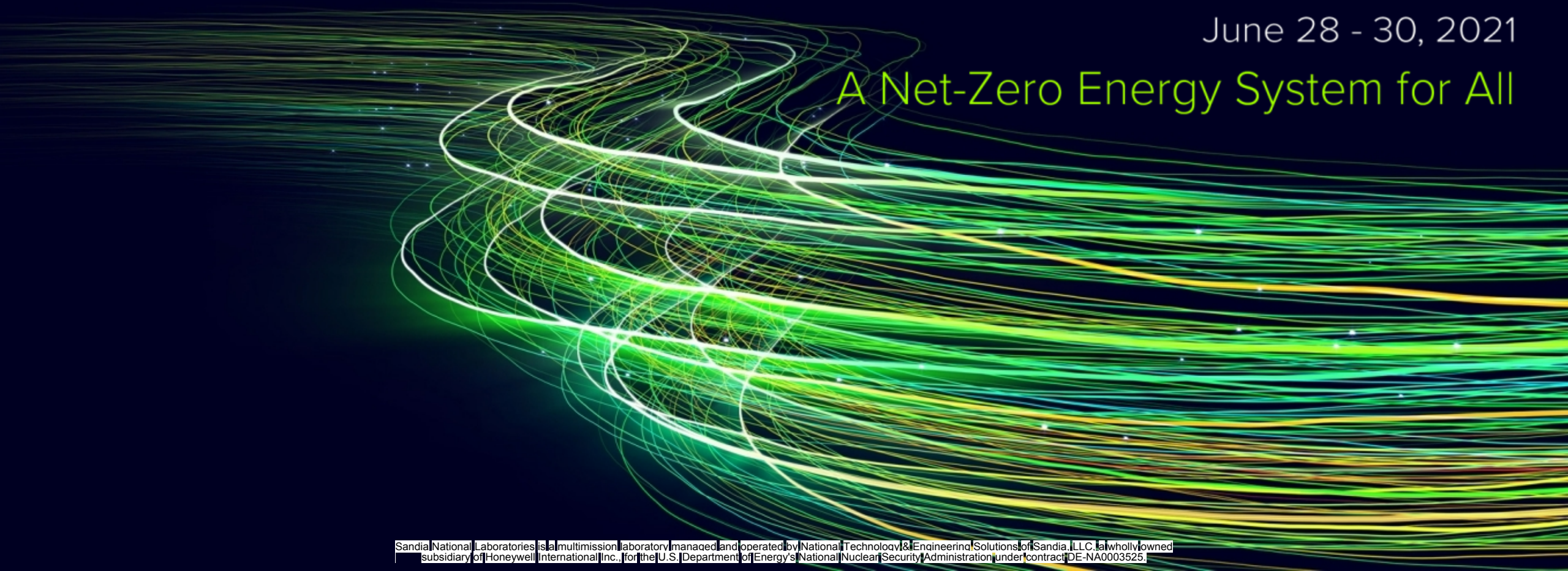
VIRTUAL FORUM SERIES

Real Solutions for a Net-Zero World



June 28 - 30, 2021

A Net-Zero Energy System for All

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

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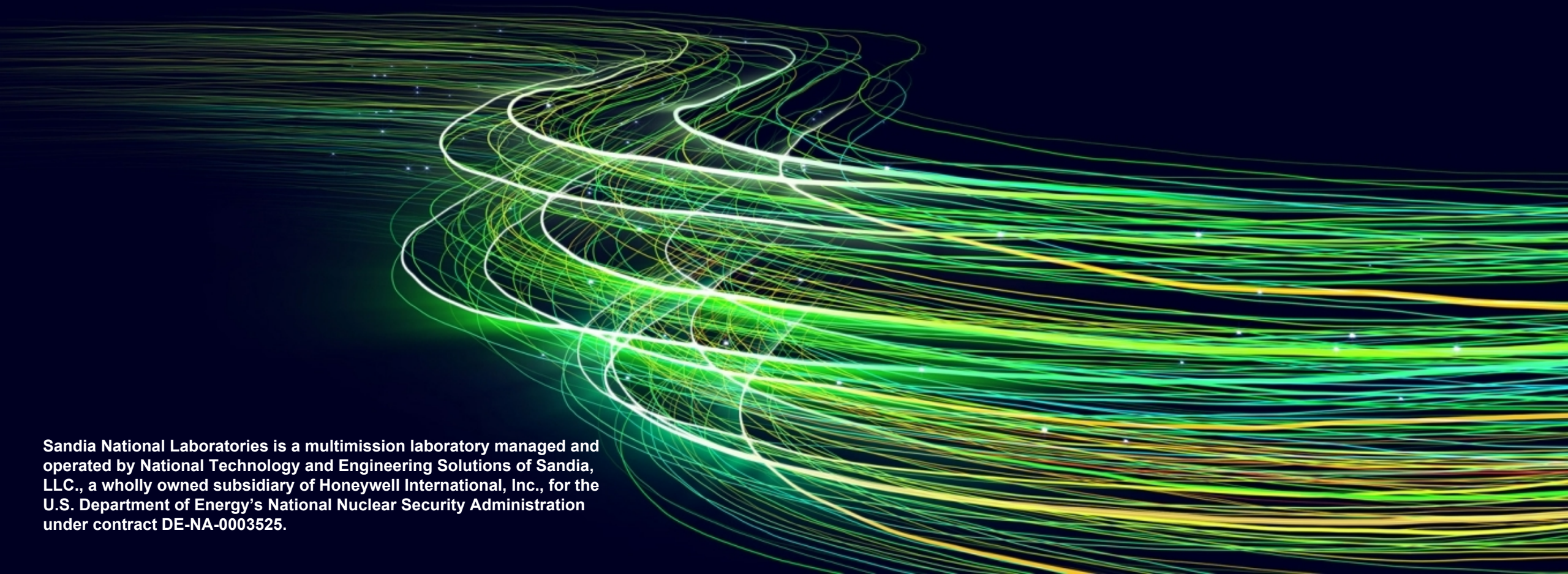
Hydrogen's Role in a Decarbonized Future

Chris San Marchi
Sandia National Laboratories, Livermore CA



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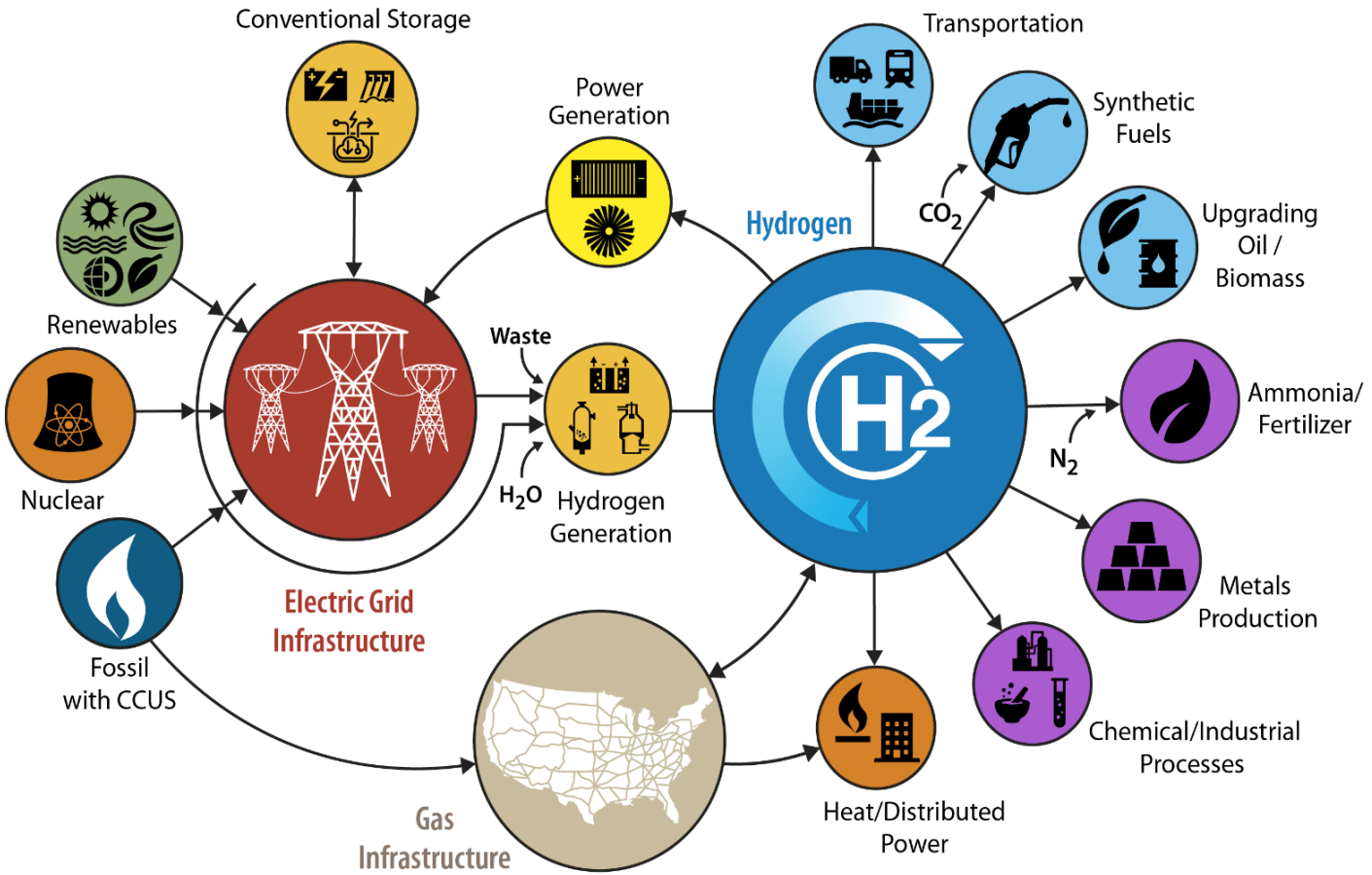
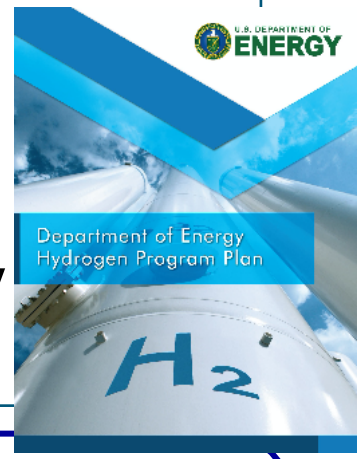
Hydrogen has utility across sectors

H2@Scale is the DOE guiding framework to realize potential of H_2



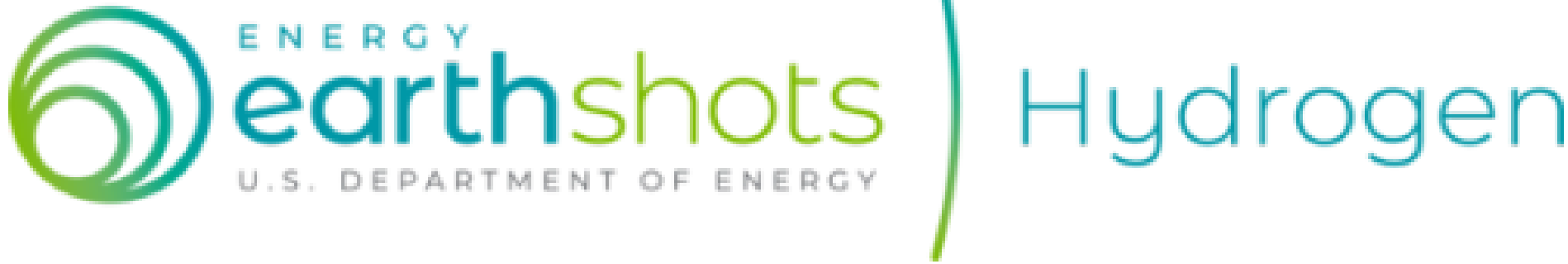
Hydrogen Program Plan is a partnership within DOE

- EERE
- Nuclear Energy
- Office of Science
- Fossil Energy
- Office of Electricity
- ARPA-E



1 H 1.008 =
- simple
- clean
- flexible

Source: U.S. DOE Hydrogen and Fuel Cell Technologies Office, https://www.energy.gov/eere/fuelcells/h2scale



1 1 1
Hydrogen for
$1 per 1 kg in 1 decade

Announced by DOE Secretary Granholm, June 6, 2021

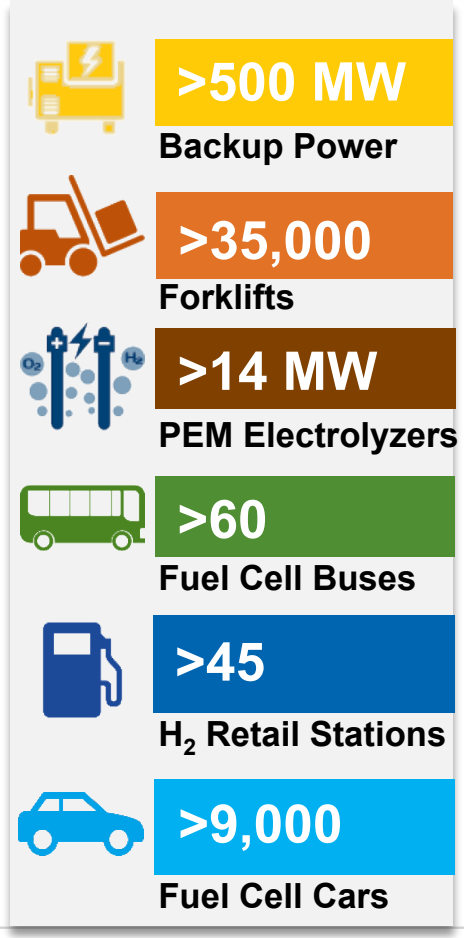
What are the challenges of hydrogen?

- **Hydrogen technologies are not new**
  - Cornerstone of astronautics
  - "Chemical" hydrogen is used extensively (10B kg/yr in US)
  - Hydrogen pipelines exist to serve industry (>1,500 km in US)
- **Commercial uses are expanding**
  - Fuel cell cars, buses, trains, boats, back-up power, etc.
  - H_2-powered materials handling equipment

safety economics

- **Non-industrial (green) hydrogen is too expensive**
  - Supply chain for non-industrial use is nascent
  - Infrastructure at scale cannot be replaced/developed overnight
- **Hydrogen is managed as chemical, not as energy/fuel**
  - We need "*non-hardhat*" relationship with hydrogen

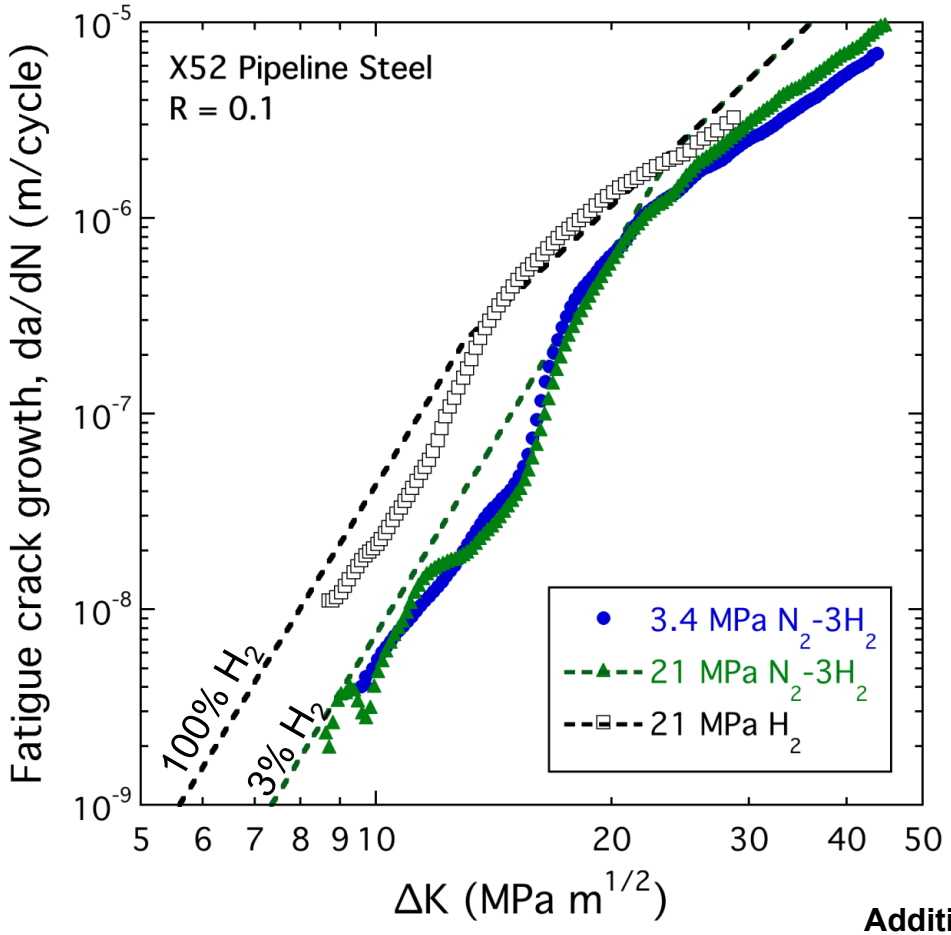
Example hydrogen technology deployment in the US



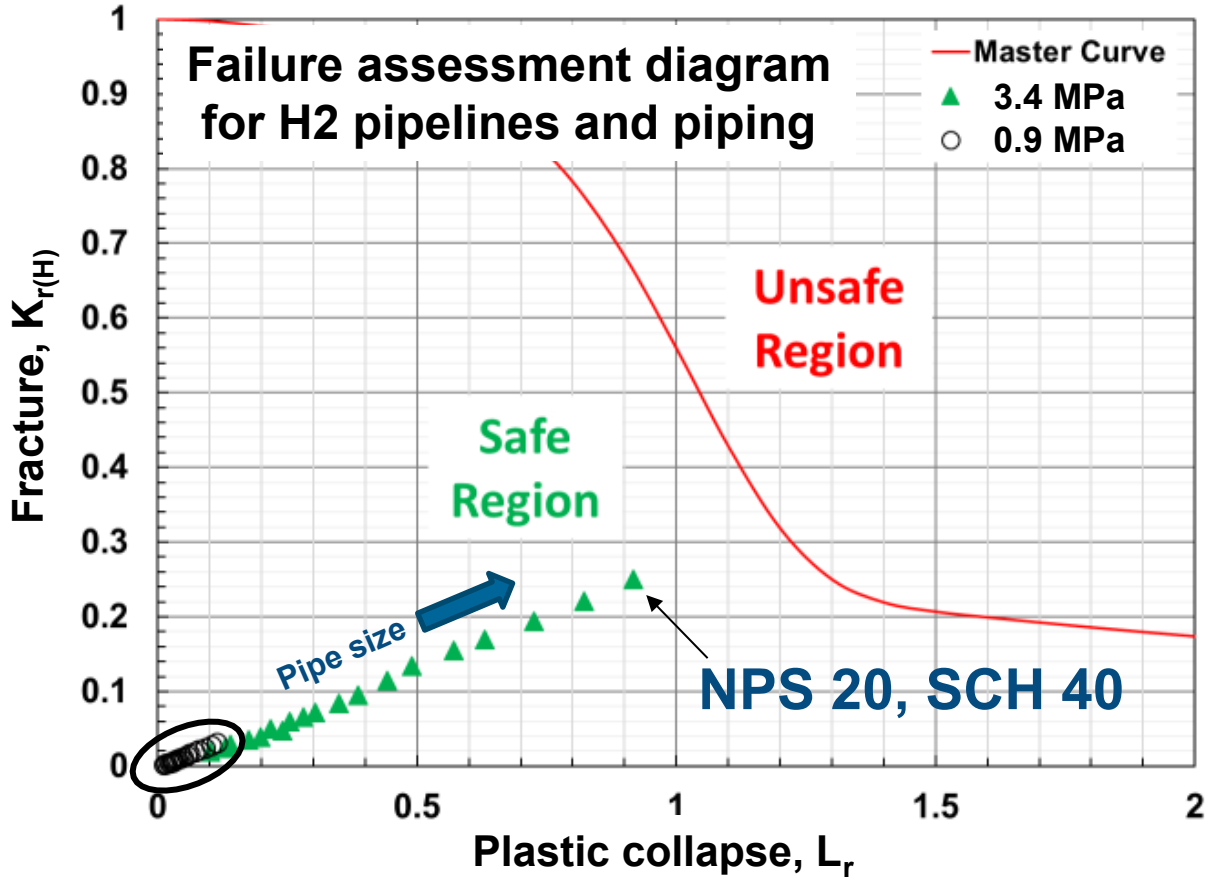
Numbers from DOE HFTO Annual Merit Review (June 2021)

Hydrogen conveyance @Scale

Materials perspective: H_2 affects steels even at low partial pressure



Structural perspective: Effects of H_2 can be managed in infrastructure



Additional details: see SAND2021-6869 PE

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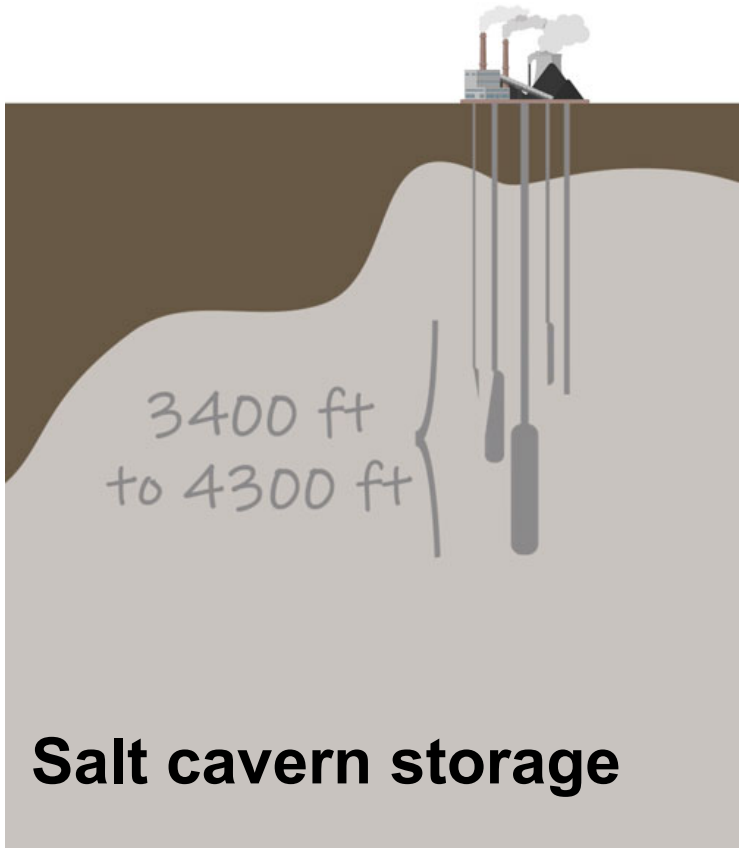
Hydrogen storage @Scale



Salt cavern storage

Image from:
https://www.ipautah.com/ipp-renewed/

- How is energy stored @Scale?
- How can hydrogen be stored @Scale?

- H2@Scale will require diverse solutions to store vast amounts of hydrogen
  - Salt caverns
  - Geologic formations (depleted reservoirs, etc)
  - Lined-manufactured caverns
  - Liquefaction (LH2)
  - Hydrogen carriers

In principle, hydrogen is stored in the same way fossil fuels are stored