HFTO Workshop: Hydrogen Infrastructure Strategies to Enable Development in High-Impact Sectors

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ExxonMobil Hydrogen Pipeline Transport

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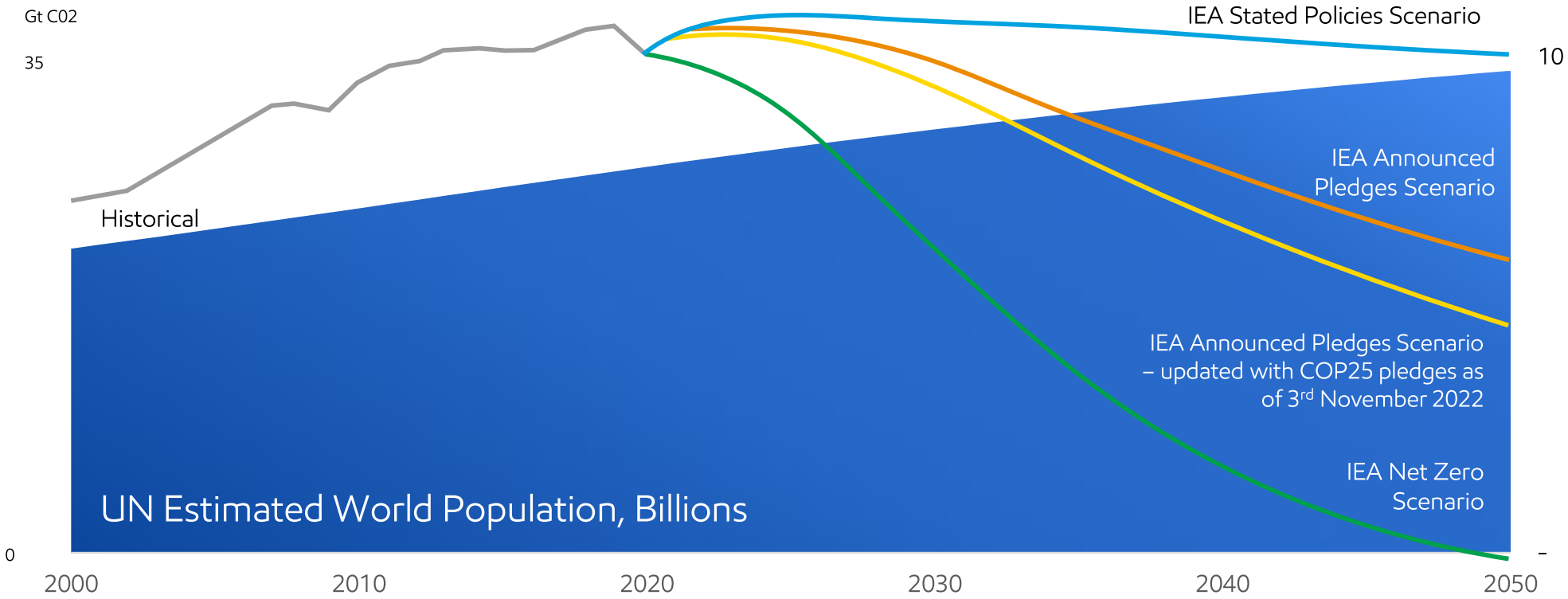
The Dual Challenge

Deliver reliable, affordable energy to world's growing population while lowering emissions



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ExxonMobil Low Carbon Solutions:

Accelerating the world's path to net zero AND building a compelling new business

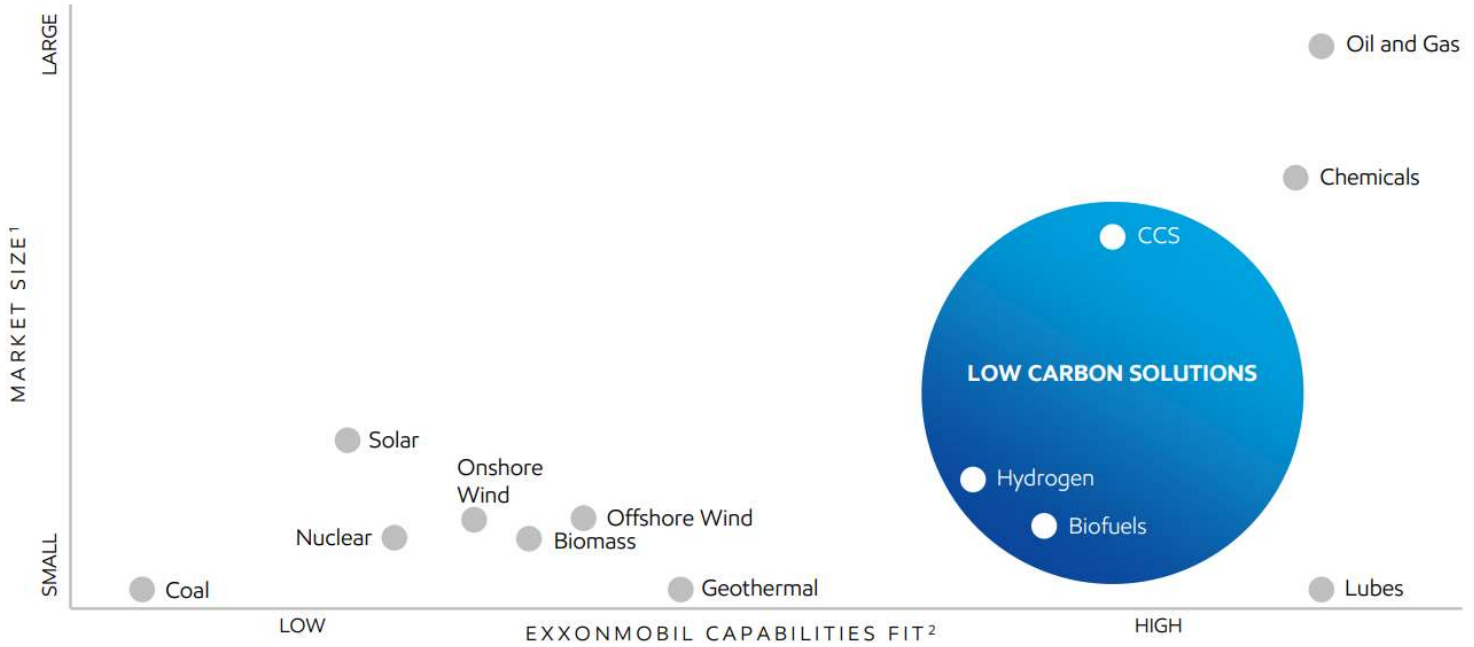

Chart source: ExxonMobil analysis of IPCC SR 1.5 scenario explorer data; and McKinsey & Company report, "The big choices for oil and gas in navigating the energy transition;" March 10, 2021.
See Supplemental Information for footnotes and definitions.

- Key objective to provide decarbonization solutions in hard-to-abate sectors
- Focus on carbon capture & storage (CCS), hydrogen, lower emission fuels
- Engaging on climate policy with key stakeholders across industries, governments, communities, etc.

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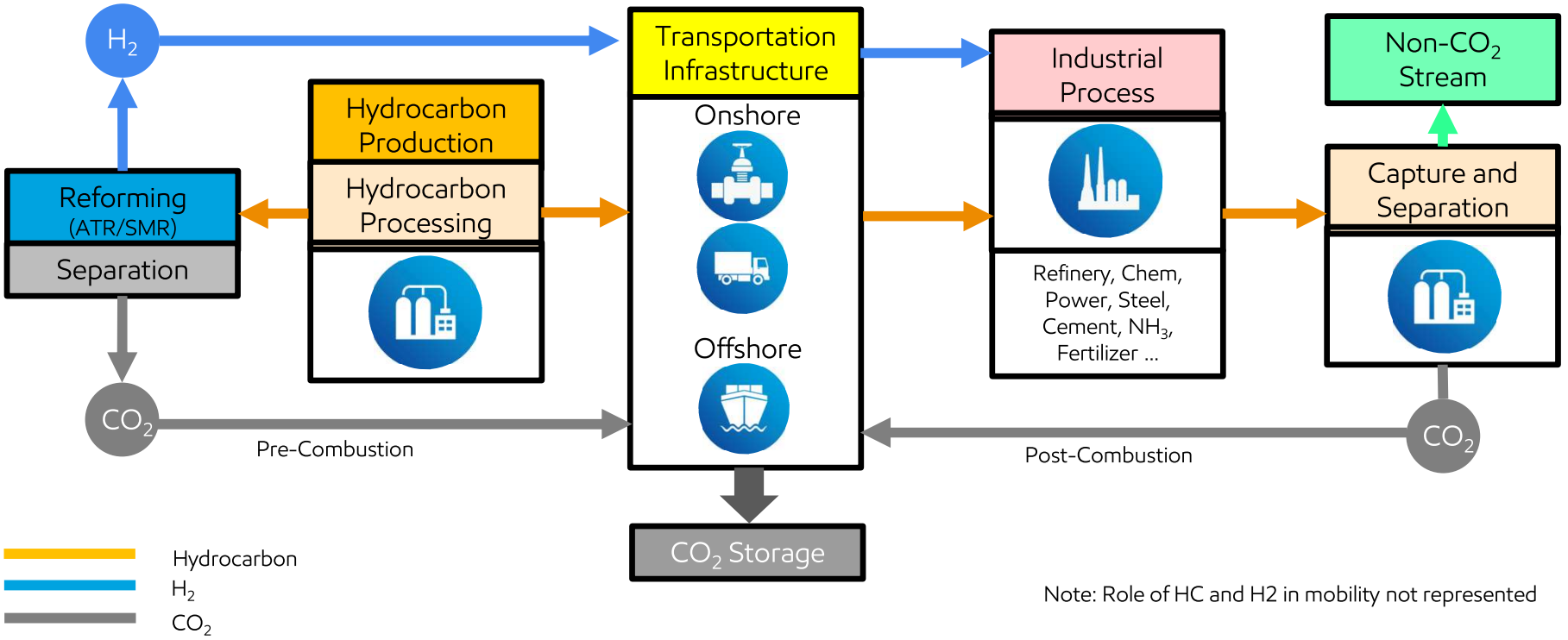
Transportation Infrastructure: Integral to H_2 and CCS Value Chains



Note: Role of HC and H2 in mobility not represented

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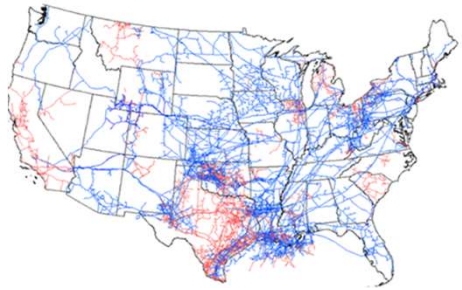
H_2 Pipeline Transport

Gulf Coast H Pipeline Network

US NG Pipeline Network



Background / Current Status

- ~ 1,600 miles of hydrogen pipelines are currently operating in US
- Largest global network; ~ 56% located along the Gulf Coast
- 87% are operated at 0.5 of Design Factor; 0.72 DF typical for NG

Drivers / Opportunities

- Hydrogen expected to play a key future role as energy carrier
- Near term: Blending H_2 into NG infrastructure (>360,000 miles of NG transmission pipelines in US)
- Longer term: Re-purposing / Dedicated (w. higher pressure) H_2 pipeline infrastructure

Key Challenges

- Pipeline Integrity Challenge (Blended with NG or 100% H_2)
  - Hydrogen Embrittlement (HE): Key consideration for transmission pipelines (e.g. carbon steel pipelines)
  - Compatibility with hydrogen: valves, fittings, gaskets, elastomers, etc
  - Assessing the condition of the existing NG P/Ls is challenging including vintage lines (<1980)
- Conservative H_2 pipeline design codes (e.g. ASME B31.12, etc)
- Assess the performance of existing / developing inspection technologies in the presence of hydrogen
- Potential impact radius of H_2 releases, and implications
- Emergency procedures for leakage and repairs

Ref: PRCI/EFI, H2 SOTA, Gap Analysis, Future Project Roadmap (2020)

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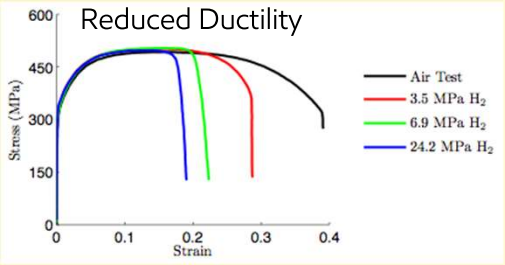
Current efforts to understand and manage integrity threats

Hydrogen Embrittlement (HE):
Absorbed H atoms reduce fracture resistance (smaller critical flaws) and accelerate fatigue

Xu and Rana: 2008 Int'l Hydrogen Conference

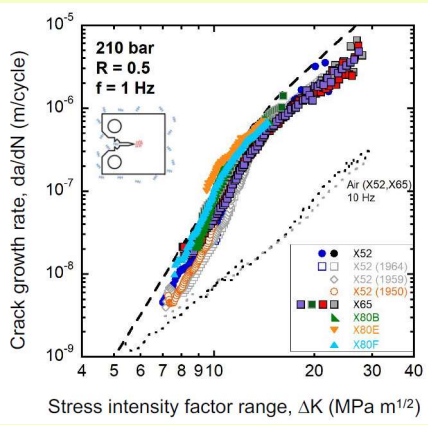


HyBlend U.S. DEPARTMENT OF ENERGY

NREL · Sandia National Laboratories · Pacific Northwest National Laboratory

Argonne National Laboratory · Oak Ridge National Laboratory · National Energy Technology Laboratory

+ Industry Partners



- Pipeline Blending CRADA – A HyBlend™ Project
  - Significant progress of structural integrity for H_2 gas infrastructure as well as LCA/TEA analysis (phase I)
  - Further R&D (phase II) to accelerate the deployment of H_2 infrastructure

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Code and Standard for H_2 infrastructure

ASME B31.12-2019
(Revision of ASME B31.12-2014)

Hydrogen Piping and Pipelines

ASME Code for Pressure Piping, B31

$$P = \frac{2St}{D} FETH_f$$

ASME B31.8-2022
(Revision of ASME B31.8-2020)

Gas Transmission and Distribution Piping Systems

ASME Code for Pressure Piping, B31

- ASME B31.12
  - Overly-conservative H_2 pipeline design code
    - Conservative design / mat'l performance factor
    - More stringent hardness requirement v. sour service
  - Un-realistic sampling requirement to repurpose line
  - Ongoing activities to generate supporting data
- Being consolidated into ASME B31.8 as a new chapter
  - Requirements are being modernized
  - Close collaboration with pipeline code bodies in Europe, Canada and Australia

Broad activities are ongoing: gov's funded projects, industry activities, and Joint Industry Project (JIP) to accelerate the deployment of H_2 transport infrastructure

Summary

- Background and Drivers
  - Net zero emission requires problem solving at immense scale
  - Hydrogen economy is a key enabler to achieve deep decarbonization
  - Transportation infrastructure (e.g. pipeline) is an integral element of H_2 value chain
- H_2 Pipeline Infrastructure Challenges
  - Pipeline integrity in the presence of hydrogen (e.g. hydrogen embrittlement, mat' compatibility, etc.)
  - Codes and standards: overly-conservative / costy requirements for H_2 infrastructure
  - Industrial practices/ technologies for commercial scale hydrogen pipeline transport
- DOE support stimulates the collaboration (RD&D) between national labs, academy and industry, and will be a key enabler to accelerate the deployment of hydrogen infrastructure


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