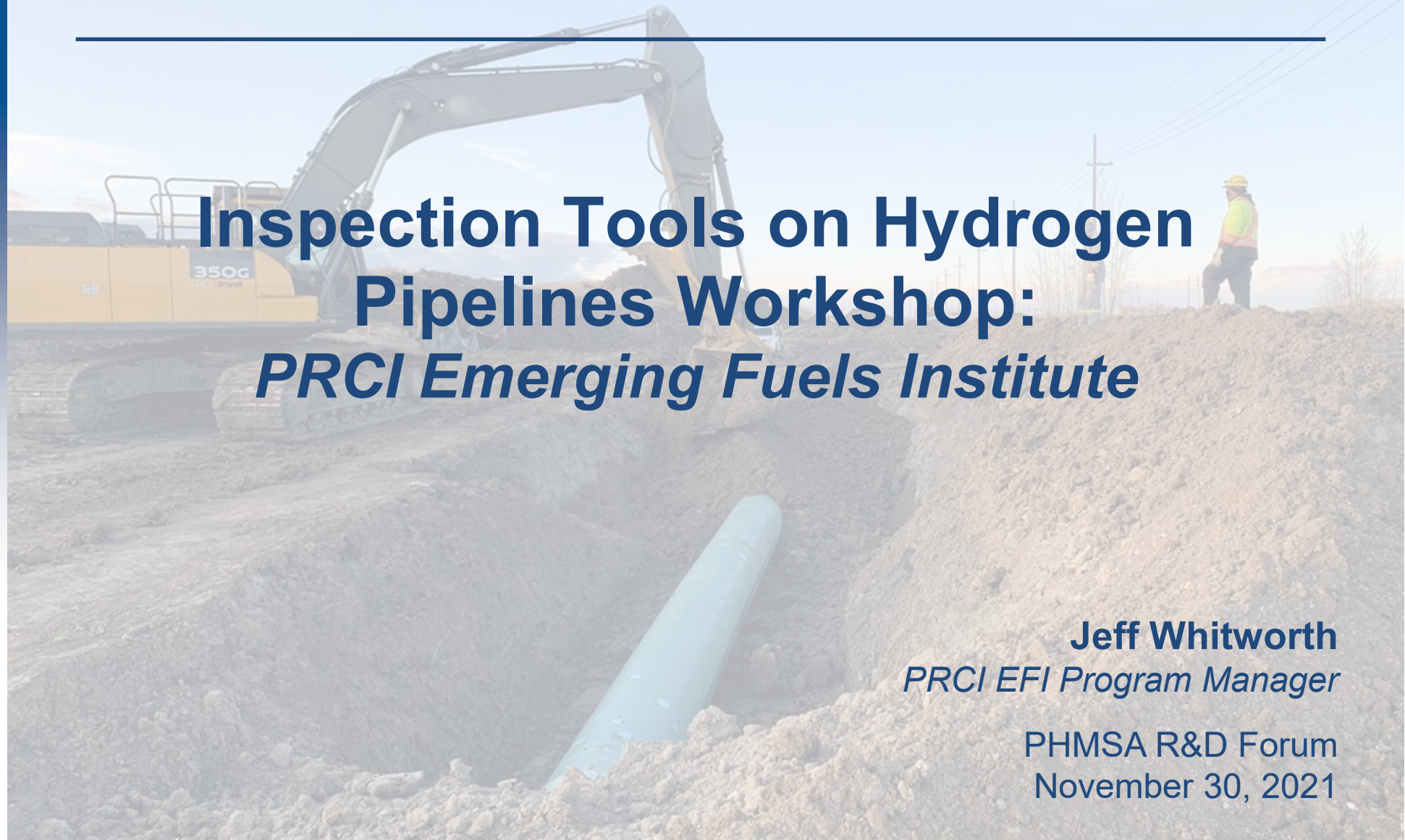
Pipeline Research Council International

Inspection Tools on Hydrogen Pipelines Workshop:

PRCI Emerging Fuels Institute



Jeff Whitworth
PRCI EFI Program Manager

PHMSA R&D Forum
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PRCI™

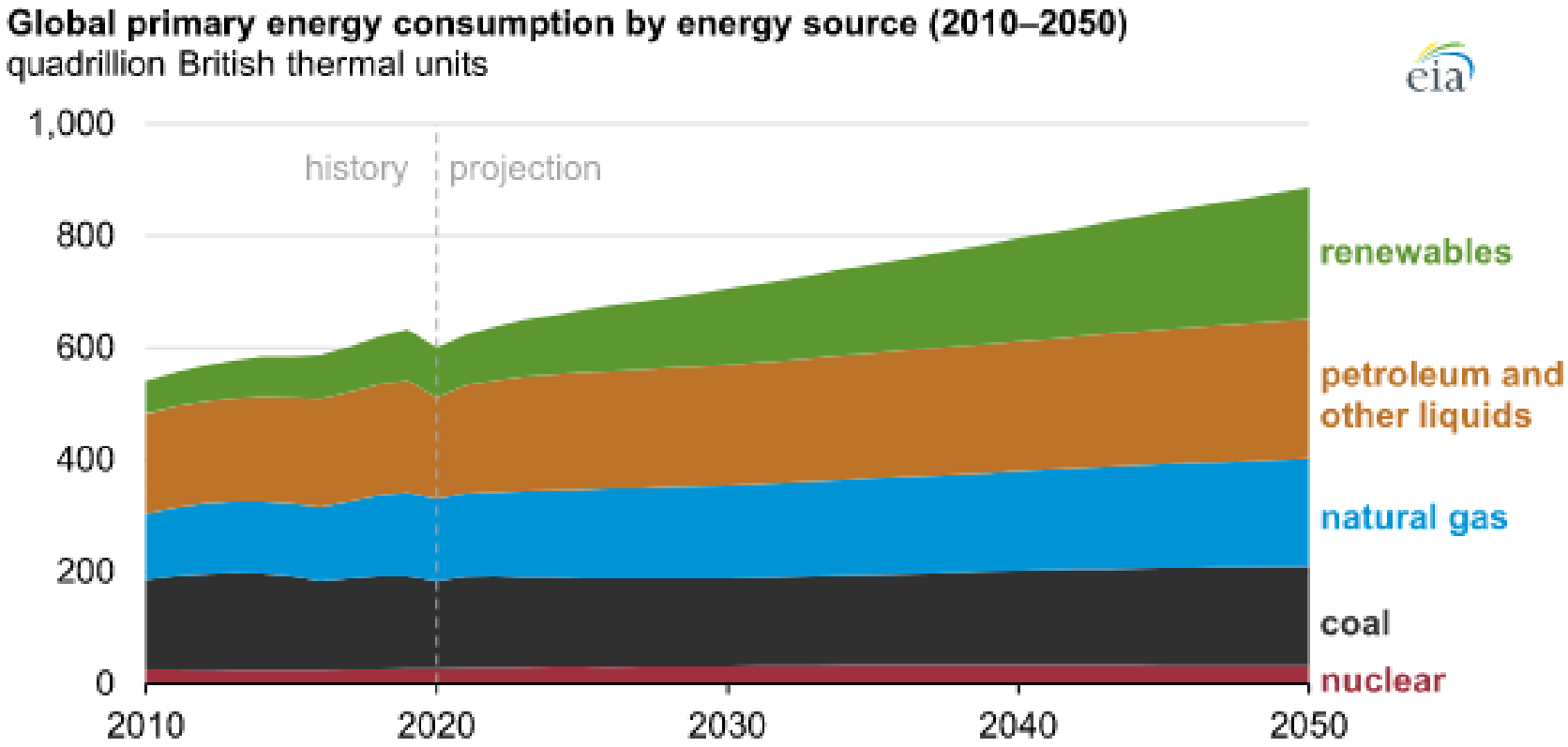
LEADING PIPELINE RESEARCH

Our Mission

To collaboratively deliver relevant and innovative applied research to continually improve the global energy pipeline systems.

U.S. Energy Information Administration

The US EIA projects a nearly 50% increase in world energy usage by 2050, led by a growth in renewables.



Next Generation of Fuels

Hydrogen

- A non-carbon gaseous fuel.
- Ignoring water vapor, it does not contribute as a greenhouse gas.
- Can provide a means of storing surplus electrical power in the form of a clean chemical energy.

Renewable Natural Gas (RNG)

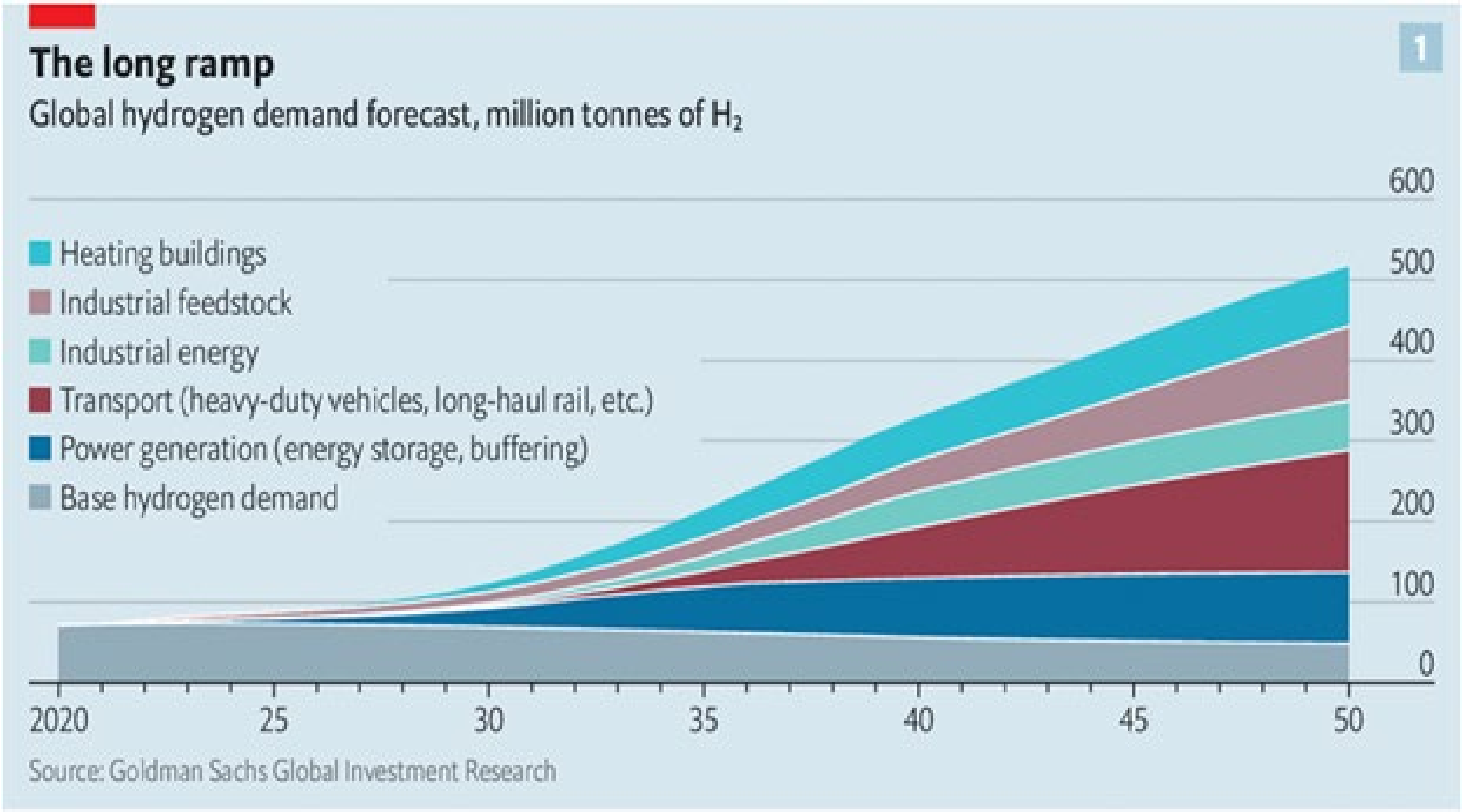
- Offsets methane emissions that would have otherwise gone into the atmosphere.
- Methane is many times more potent as a greenhouse gas than CO_2
- Is generally similar to conventional natural gas in combustion characteristics.

Other

- Other products that could be transported via the pipeline infrastructure that can offset greenhouse gas emissions.
- Gases with high concentrations of CO made from renewable sources still produce CO_2 emissions, but those CO_2 emissions are subsequently reabsorbed by vegetation used to make CO and synthetic methane.
- Not necessarily limited to gases:
  - Ethanol
  - Bio-diesel
  - Ammonia
  - CO_2 for sequestration

Hydrogen Demand 2020-2050

- Hydrogen, when blended with natural gas, is a key component of a sustainable energy society.
- Many governments are planning and / or mandating a transition to renewable energy sources in order to achieve their stated goals of stabilizing the climate.



Emerging Fuels Background

- **2020 PRCI State -of- the- Art Report on transportation and storage of emerging fuels.**
- **Research to safely transport and store fuels to support a sustainable global energy strategy.**
  - Hydrogen
  - Renewable Natural Gas
  - Biofuels
  - Ammonia
  - Carbon Capture and Sequestration
- **PRCI created the EFI in March 2021 to provide a platform for PRCI members/non-members to conduct specific research related to the decarbonization transition.**

Opportunities for the Emerging Fuels Institute

Develop a guide to safely convert and operate pipeline systems for the next generation of fuels.

- Address the technical challenges and gaps in the storage and transportation elements of the emerging fuels transition.
- Manage an evergreen roadmap for the ongoing industry work across all continents.

Collaboration

Partnering with peer research associations :

- Australian Pipeline and Gas Association (APGA)
- European Pipeline Research Group (EPRG),
- European Gas Research Group (GERG)
- Future Fuels Collaborative Research Center (FFCRC)
- Gas Technology Institute (GTI)

Coordinates efforts with governmental agencies :

- Canada Energy Regulator (CER)
- U.S. Department of Energy (DOE)
- U.S. Pipeline and Hazardous Materials Safety Administration (PHMSA)

Coordinates efforts with industry associations:

- Association of Oil Pipelines (AOPL)
- American Petroleum Institute (API)
- Interstate Natural Gas Association of America (INGAA)
- Canadian Standards Association (CSA)
- American Society of Mechanical Engineers (ASME)

Insuring Safe and Efficient Transport and Storage

What we know from the SOTA:

- Even relatively low hydrogen partial pressures result in increases in crack growth rates
- Degradation of currently acceptable defects may require repairs or shortened re-inspection intervals.
- Improvement of current inspection technologies will increase confidence to make better decisions to ensure process safety.

What we don't know – gaps from the SOTA:

- Although existing crack detection tools can characterize crack length and depth, they do not measure the degree of hydrogen permeation in front of the crack tip into the crystalline structure that drives increased crack growth rates.
- How will the number of critical defects in pipelines increase as a function of hydrogen partial pressure and metallurgy/vintage for a given pipeline system?
- Will criteria for assessing defects need to be more robust under conditions of hydrogen blending?
- What criteria will be used to determine presumed increased inspection interval?

Insuring Safe and Efficient Transport and Storage

We are closing these gaps:

- NREL HyBlend Project on operational and performance impacts to pipeline materials when blending hydrogen into the existing natural gas infrastructure.
- DNV Guidelines for Integrity Management of hydrogen pipelines focuses on materials impacts.
- ASU / PHMSA Competitive Academic Agreement Program (CAAP) focuses on development of knowledge-based system for integrity management of aging pipelines in hydrogen blend service
- EPRG's full scale materials testing in hydrogen service

More work needed:

- Enhanced ILI tools to increase crack sizing capabilities
- Impacts of hydrogen on ILI tool components
- Crack growth prediction models based on full scale testing in hydrogen blend service
- Inspection and fitness for service guidance as a function of operations and materials properties
- Develop general corrosion models on different API 5L steels exposed to hydrogen
- Guidance on in-service welding NDE in a hydrogen blend environment (e.g. taps and sleeves)

QUESTIONS