Utilizing Existing Pipeline Infrastructure in CO2 & H2 Service

Bill Olson
Sr VP Operations
Gulf Interstate Engineering

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IPLOCA

01 Introduction & Credentials

Sr. VP of Operations – Gulf Companies

Bill Olson

- 43-year career in oil & gas industry
- 25 years experience in CO2 transport systems
- Chair of ASME B31.4/11 (liquid pipelines including dense CO2)
- Member of ASME B31.8 Task Group for gaseous CO2
- Member of API Task Force developing new RP-11CO2
- Contributor to PRCI CO2 Task Force
- Contributor to PRCI Hydrogen Task Force
- Corresponding member of ASME B31.8 Task Group for Hydrogen

Gulf's History – Founded in 1953

1950s

Gulf Interstate Gas Pipeline (USA)

1960s

Transwestern Gas Pipeline (USA)

Ammonia Pipeline (USA)

1970s

Owner's Engineer TransAlaska Pipeline (USA)

Strategic Petroleum Reserve (USA)

Alaska Natural Gas Transport System (USA)

1980s

Shedgum-Yanbu NGL Pipeline (Saudi Arabia)

Gas Gathering Projects (Saudi Arabia)

Jungle Production Facilities (Peru)

Marib Export Pipeline & Facilities (Yemen)

1990s

PGT-PG&E Pipeline Expansion (USA)

Shaybah Pipeline & Terminal Facilities (Saudi Arabia)

Hawiyah Gas Development (Saudi Arabia)

Masila Export Pipeline & Facilities (Yemen)

2000s

OCP Pipeline (Ecuador)

Camisea Gas & NGL Pipelines (Peru)

East West Gas Pipeline (India)

Rockies Express Pipeline (USA)

2010s

CPG MXP / GXP (USA)

Sabal Trail Pipeline (USA)

Crude Oil Export Pipeline (East Africa)

Targa Grand Prix (USA)

Flanagan South Pipeline (USA)

2020s

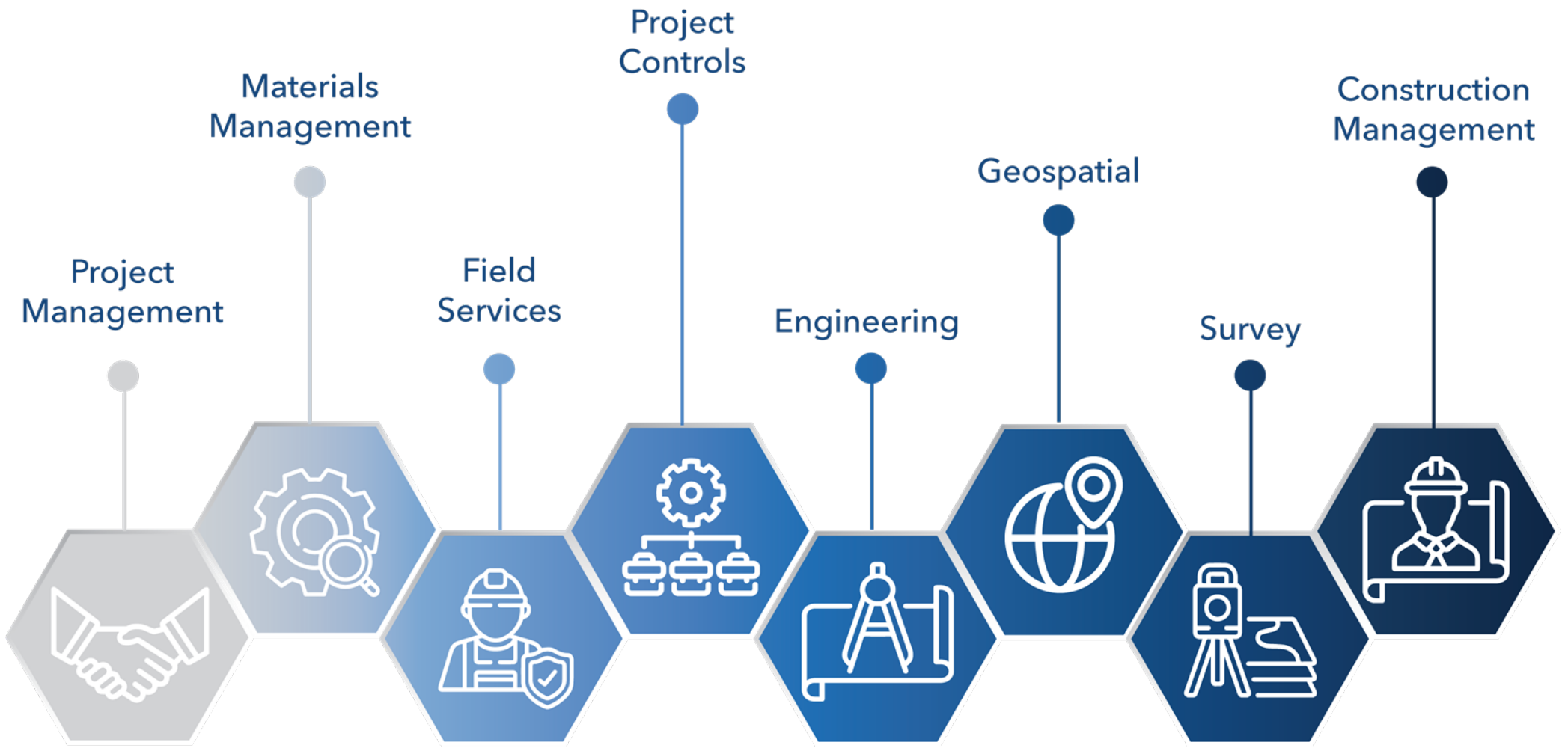
MCE CO2 Capture & Sequestration Project

Gator Express Pipeline, Venture Global (USA)

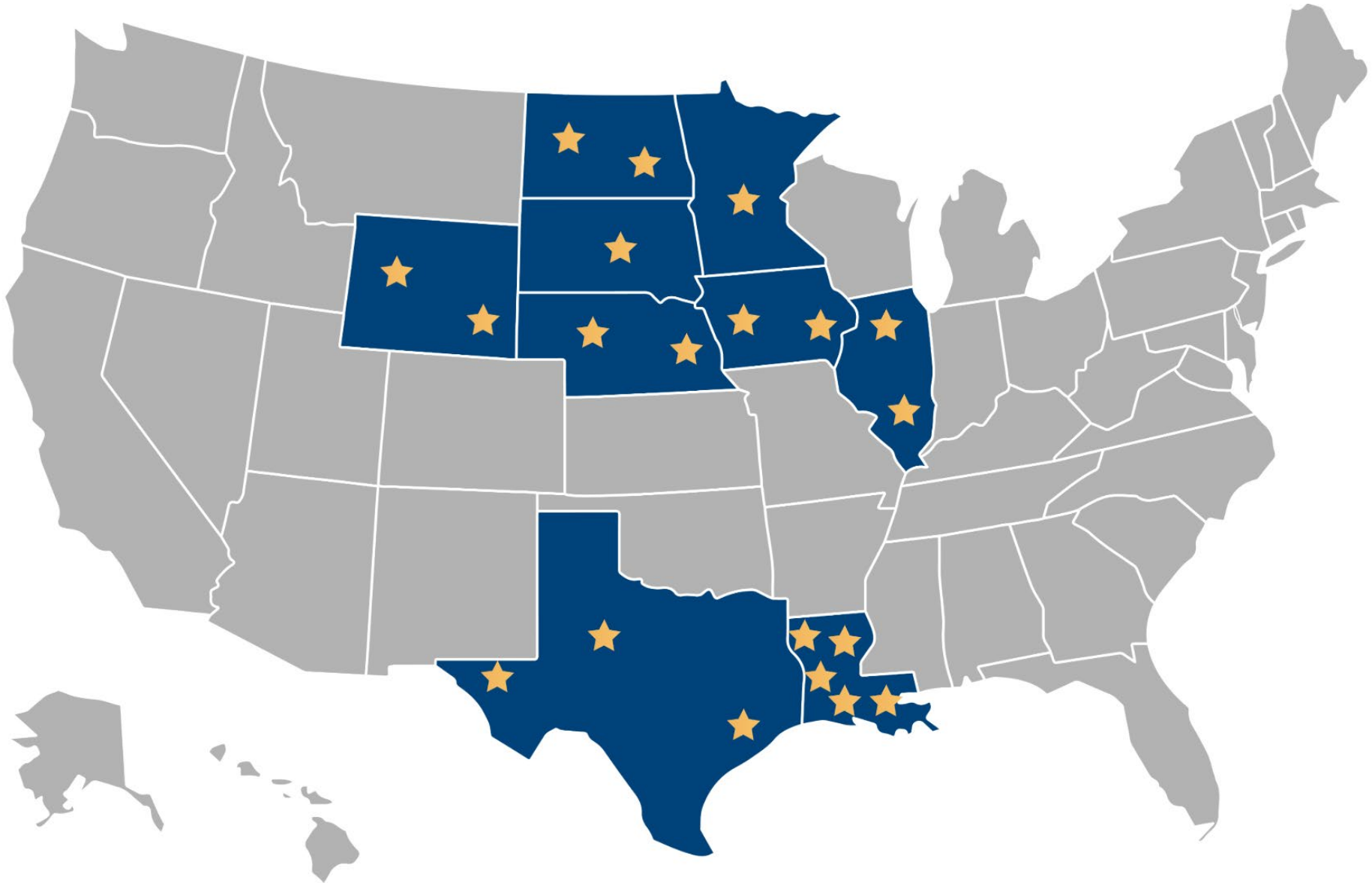
Golden Pass LNG Export ExxonMobil (USA)

Hearne to Taylor Pipeline Project, Valero (USA)

Gulf Companies Suite of Services



Gulf's Current CO_2 "Footprint" in the US

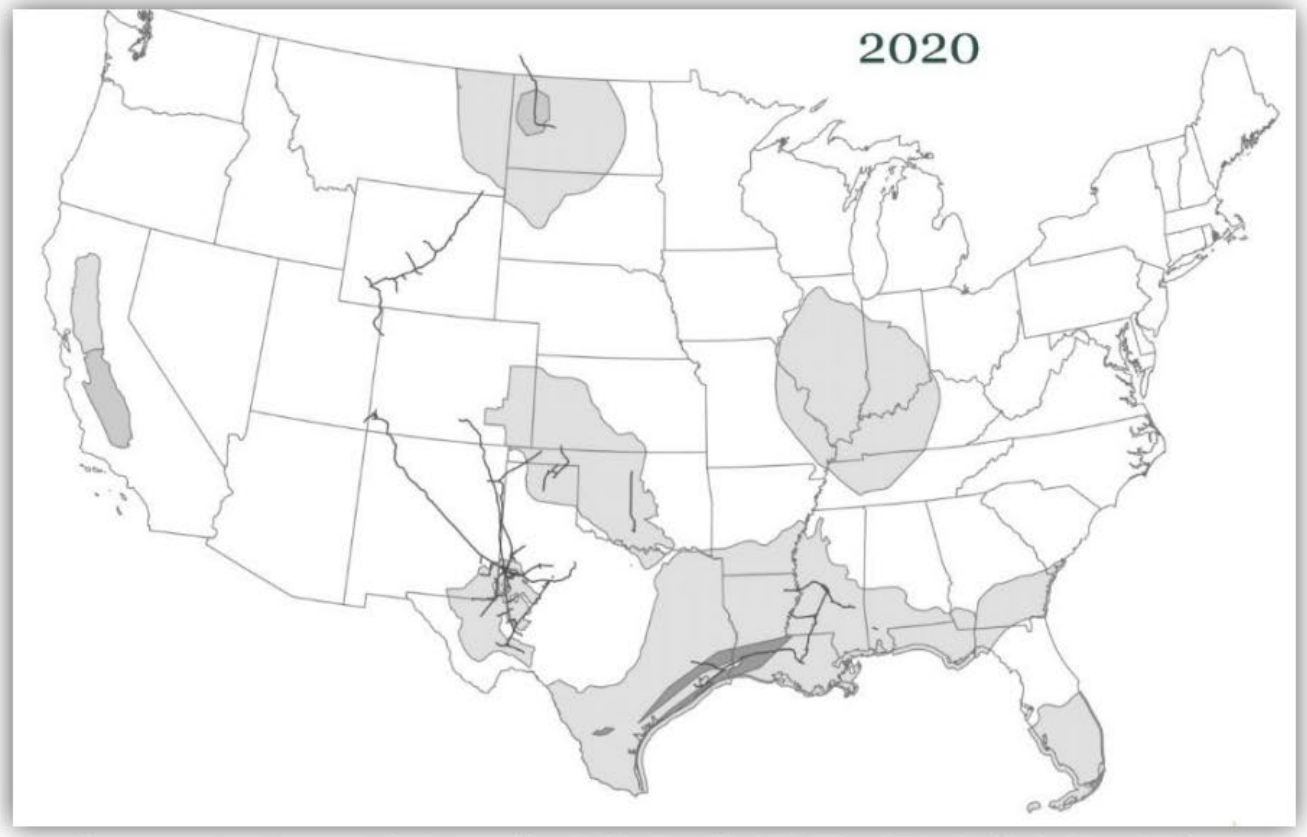


02

CO_2 Pipelines – Today

The "Why?": Potential Large Increases in CO_2 Pipelines

- Currently ~6,000 miles of CO_2 pipelines globally
- ~5,300 miles of CO_2 pipelines in USA



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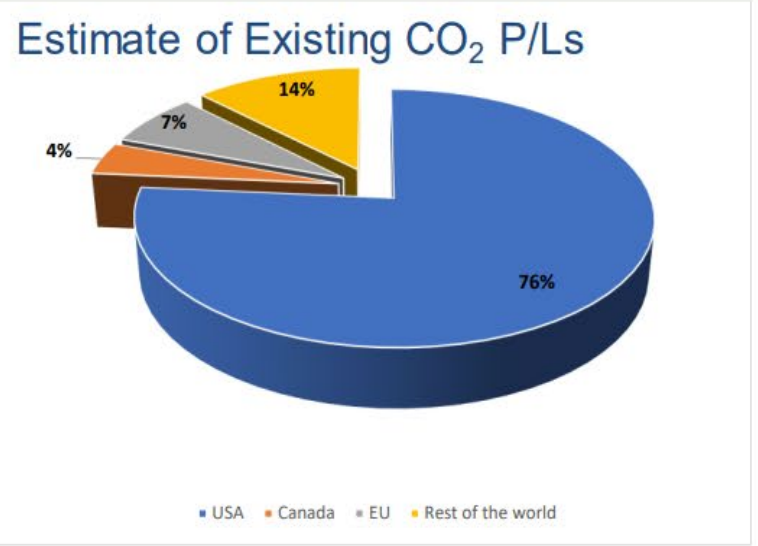

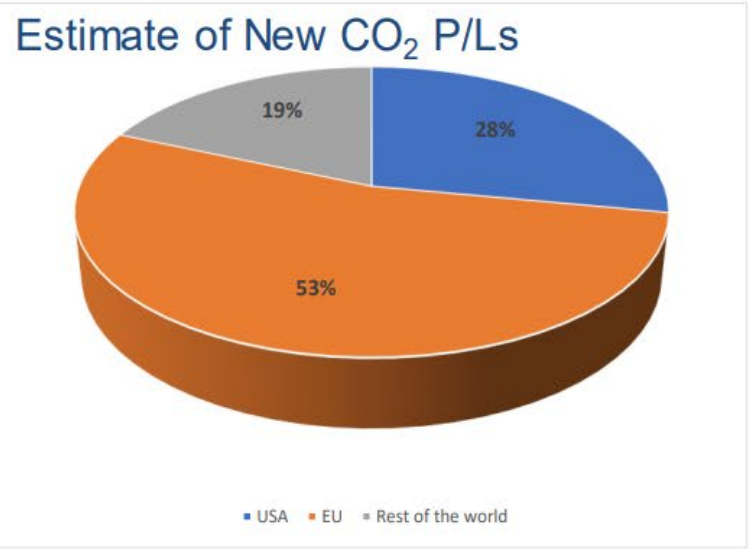

US CO_2 Pipelines : Where Are We & How Did We Get Here?

- **Almost all current systems serve oil fields (EOR)**
- **EOR was subsidized by Federal Government to reduce reliance of foreign oil in the 70's**
- **The major systems built in late 70's to early 80's transport geologically sourced CO2**
- **Several systems built in late 90's and 2010's to transport anthropogenic (man made) CO2**
- **Majority of CO2 currently transported in US systems originates from geologic sources**

Note: these systems all transport CO2 in dense phase (S.G. ~0.7 or 70% density of water)

Our CO_2 Challenge: Lack of Knowledge

Most existing CO2 pipelines are in remote areas serving the oil fields (EOR)

These systems have been operating steadily and reliably for >40 years

There have been no significant failures until 2020 (Denbury system in Mississippi)

There have been no fatalities, serious injury, or significant property loss due to failures

“Out of Sight – Out of Mind”…. Until Now!

CO_2 Pipelines: What is Changing?

- Infrastructure Renewal Act of late 2022 directed federal subsides toward sequestration of anthropogenic CO_2
- Private equity has flooded the market
- BoDs of major industrial CO_2 emitters have set goals for massive carbon reduction
- CCTS (carbon capture, transport & storage) projects are proliferating across US and internationally
- Most new CO_2 pipeline systems target sequestration (versus EOR)
- Many new systems are near or within industrial & more densely populated/developed areas

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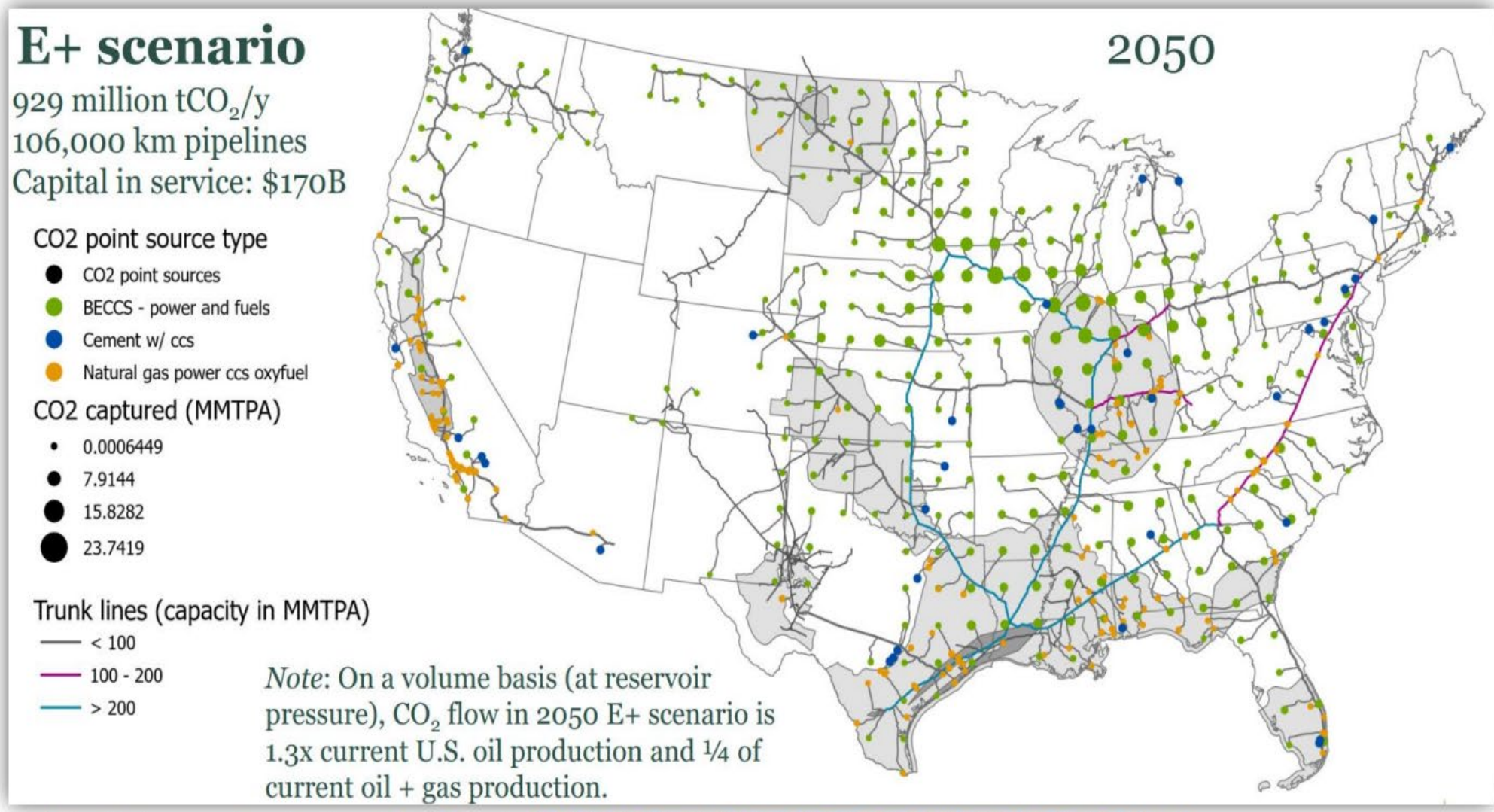
LEADING PIPELINE RESEARCH

The "Why?": Potential Large Increases in CO_2 Pipelines

NOTES:

- E+: high electrification
- ~13,000 miles of trunklines
- ~53,000 miles of spur lines



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03 Impacts to Existing Pipeline Infrastructure

Do Existing Pipelines Represent Opportunities?

- Targeting man-made sources of CO_2 focuses on industrial areas
- Industrial areas tend to be innervated with existing pipelines
- Some of this infrastructure is idle or under-utilized
- Can this pipeline infrastructure be utilized for CCTS purposes?

Do Existing Pipelines Represent Opportunities?

- The answer to this question requires both a technical and commercial analysis:
  - A given diameter pipeline can transport ~300-400 times more mass of CO_2 in dense phase vs. gaseous, but…
  - Most existing pipeline infrastructure is not rated for dense phase operating pressures (generally > 1500 PSI)
- The question then becomes whether the existing pipe can economically carry a sufficient mass of CO_2 in a gaseous state?
- If the answer to this question is yes, then what guidance exists to safely implement this conversion of service?

What Modifications May Be Needed to Convert an Existing Pipeline Systems to CO2 Service?

- Significant pipe replacement (MOP, latent defects, metallurgy)
- Possible installation of crack arrestors on older pipes
- Replace all MLVs, add new MLVs, add Line break detection
- Replace all/most compressors and pumps
- Upgrade SCADA system and leak detection
- Replace metering systems
- Replace all pressure/flow control devices
- Air monitoring of enclosed spaces and buildings

04

Unfolding Technical & Regulatory Guidance

“Minding the Gaps”

ASME Undertakings

B31.8 Task Group has drafted a new chapter addressing transportation of gaseous CO2. On track to be published in the 2024 edition later this year. It will address key areas in changing natural gas pipelines to gaseous CO2.

B31.4 – A new Task Group is being formed to update/enhance the “liquid” CO2 guidance in time for the 2025 edition.

Updates are in progress for DNV “CO2PipeSafe”, CSA Z662, ISO standards.

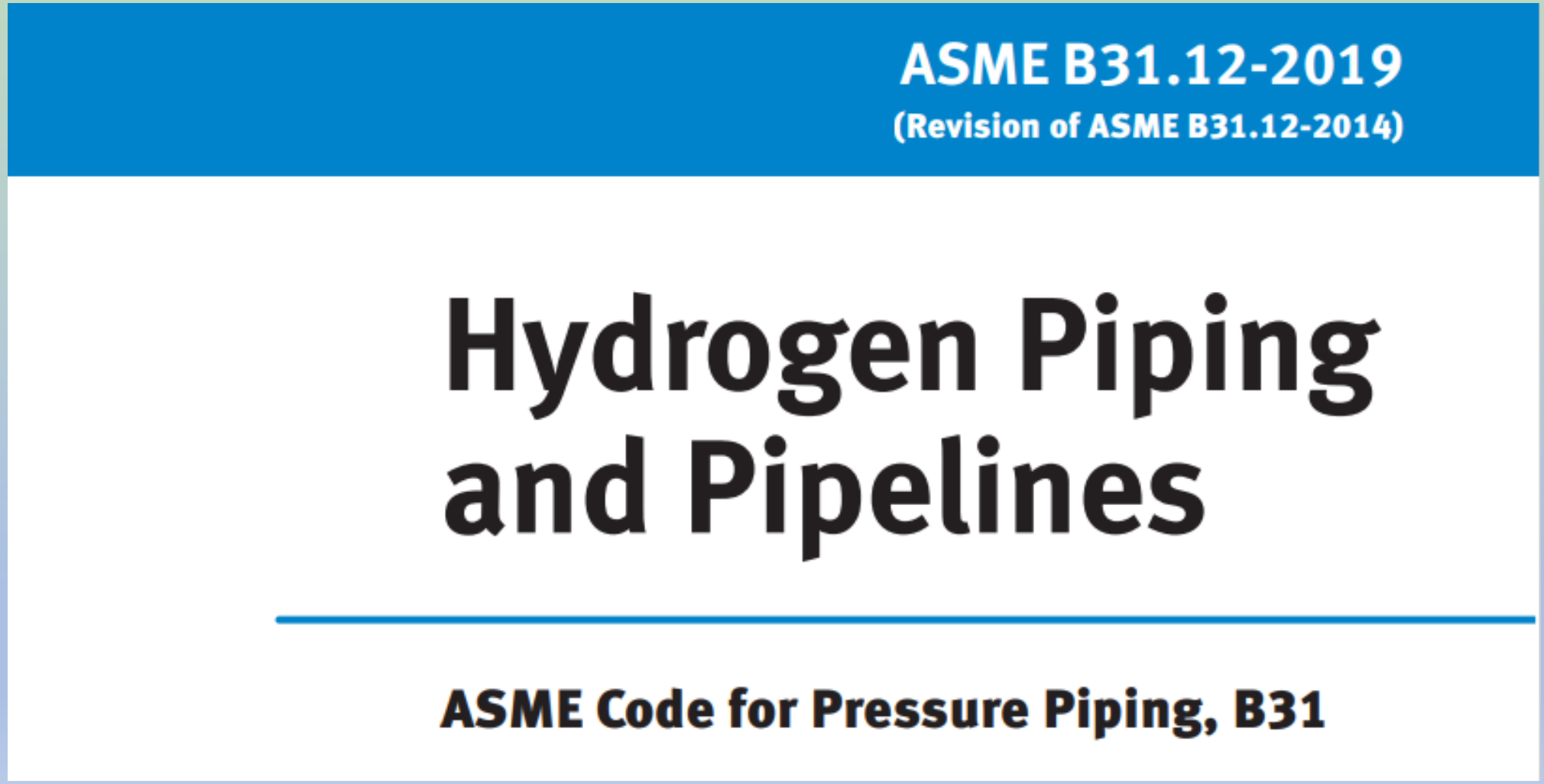
API RP11CO2, “CO2 Transportation by Pipeline” – recently formed Task Group to address “gaps” between all the above-mentioned codes.

PHMSA rulemaking response to Sartartia, Miss. failure scheduled for Q2 issuance

US DOE research funding via NETL and many national laboratories

04 Hydrogen Developments

Extra Credit: Developments in Pipeline Transport of H2



Developments in Pipeline Transport of H2

Rapid development of a new ASME B31.8 chapter for hydrogen pipelines for 2026 edition, with concurrent withdrawal of B31.12

PRCI Emerging Fuels Institute (EFI) will develop and fund a project to write the new chapter of ASME B31.8 on ASME's behalf. This work will include contributions from national labs and other international research groups in its execution.

Similar efforts are underway in Canada, Europe, Australia.

H_2 : Do Existing Pipelines Represent Opportunities?

- Somewhat like our CO2 scenario, the answer to this question requires both a technical and commercial analysis:
  - At the same pressure, a given diameter pipeline can only transport ~40% of the BTUs in H_2 versus the same pipe transporting natural gas
  - Blending H2 into natural gas may “win” carbon offset credits, but it does very little to truly decarbonize the energy economy
- Transporting H2 as ammonia or methanol will be more efficient, but seem to limited in scale to significantly impact the energy market.
- While there are many technical concerns about using existing pipelines in pure H2 service, it appears economical considerations will eliminate many such scenarios

Can We Utilize Existing Pipeline Systems in H_2 Service?

TBD

Gulf Companies
16010 Barkers Point Lane, Suite 600 | Houston, Texas 77079
www.gulfcompanies.com