

# Life Cycle Analysis of ONE Future's Supply Chain Methane Emissions

## Final Project Summary



Presented by: Timothy J. Skone, PE

ONE Future Methane & Climate Strategies Event, Houston, TX: May 15, 2018



Solutions for Today | Options for Tomorrow





# Mission

Discover, integrate and mature technology solutions to enhance the Nation's energy foundation and protect the environment for future generations

EFFECTIVE RESOURCE  
DEVELOPMENT

EFFICIENT ENERGY  
CONVERSION

ENVIRONMENTAL  
SUSTAINABILITY



# NETL Competencies by Site

Multiple Sites Operating as 1 LAB System



- Materials Performance
- Alloy Development/Manuf
- Geospatial Data Analysis



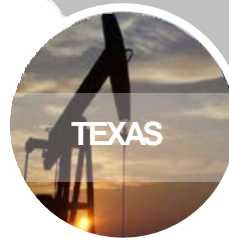
- Process Systems Engineering
- Decision Science
- Functional Materials
- Environmental Sciences



- Energy Conversion Devices
- Simulation-Based Engineering
- *In-Situ* Materials Characterization
- Supercomputer Infrastructure



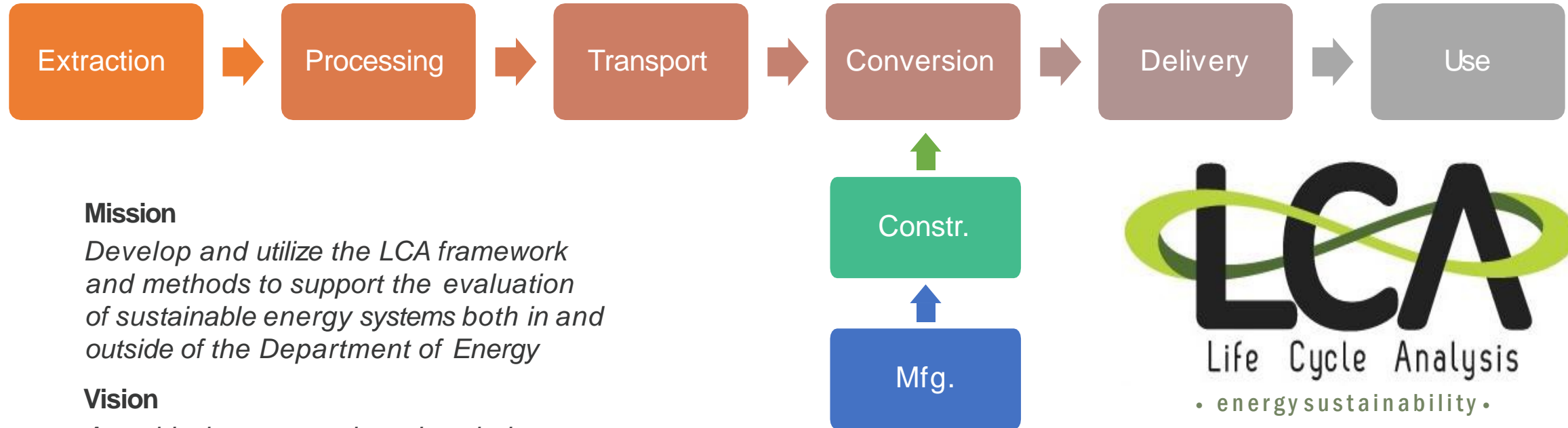
Oil and Gas  
Strategic Office



Oil and Gas  
Strategic Office

# Energy Life Cycle Analysis

*Cradle -to-grave environmental footprint of energy systems*



## Mission

*Develop and utilize the LCA framework and methods to support the evaluation of sustainable energy systems both in and outside of the Department of Energy*

## Vision

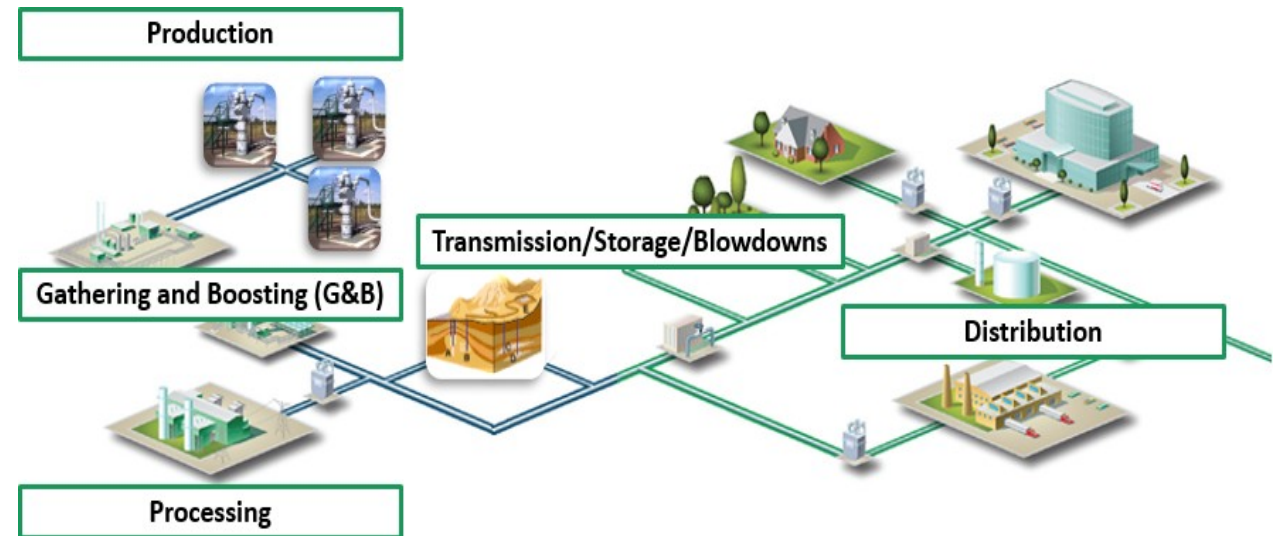
*A world -class research and analysis team that integrates results which inform and recommend sustainable energy strategy and technology development*



# Collaboration Between DOE and industry

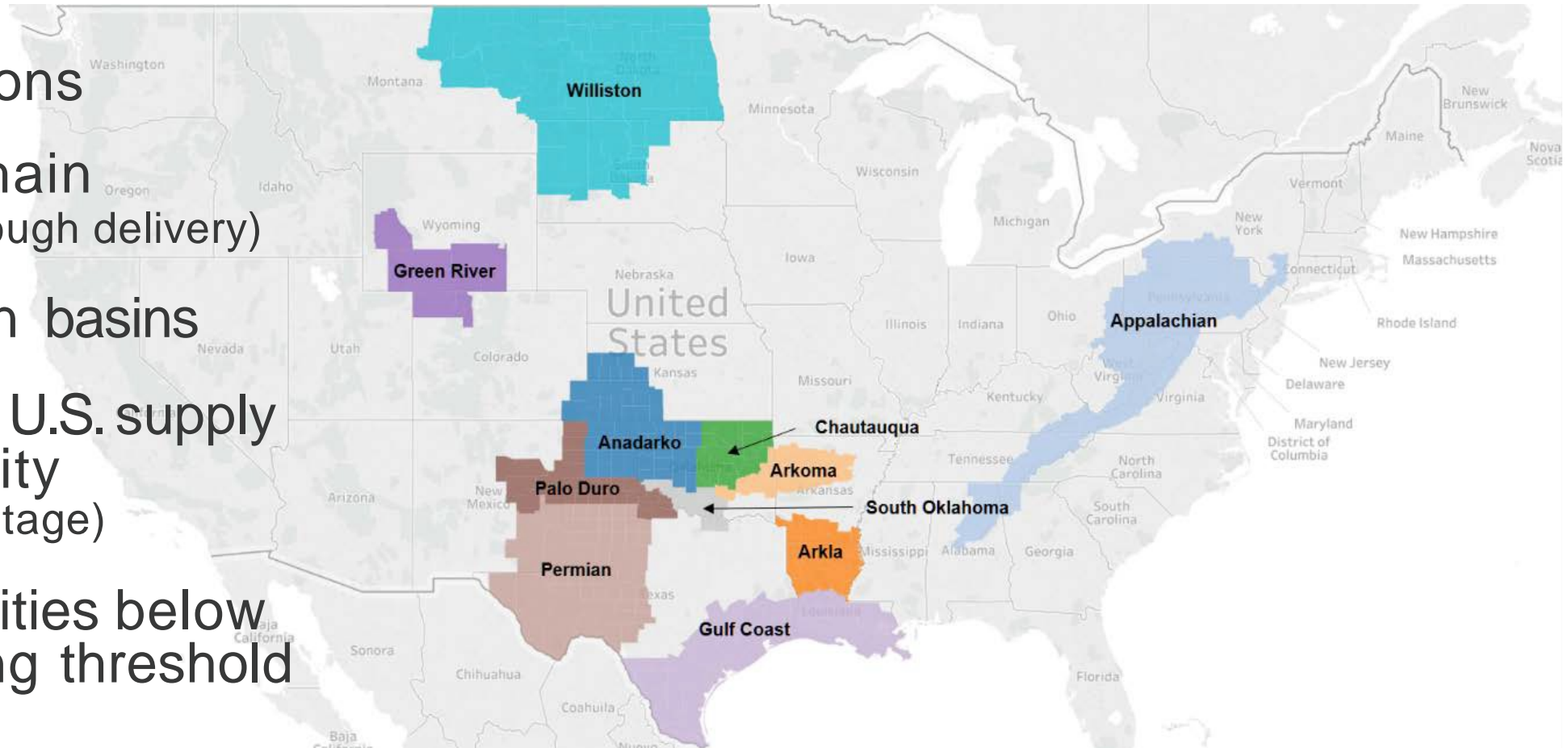


- **NETL** supports DOE's mission to advance U.S. energy security and conducts a broad spectrum of research and development programs
- **ONE Future** is a group of leading natural gas companies focused on reducing methane ( $\text{CH}_4$ ) emissions across the supply chain
- **Study objective:** Characterize ONE Future's supply chain greenhouse gas (GHG) emissions and evaluate opportunities for improvement



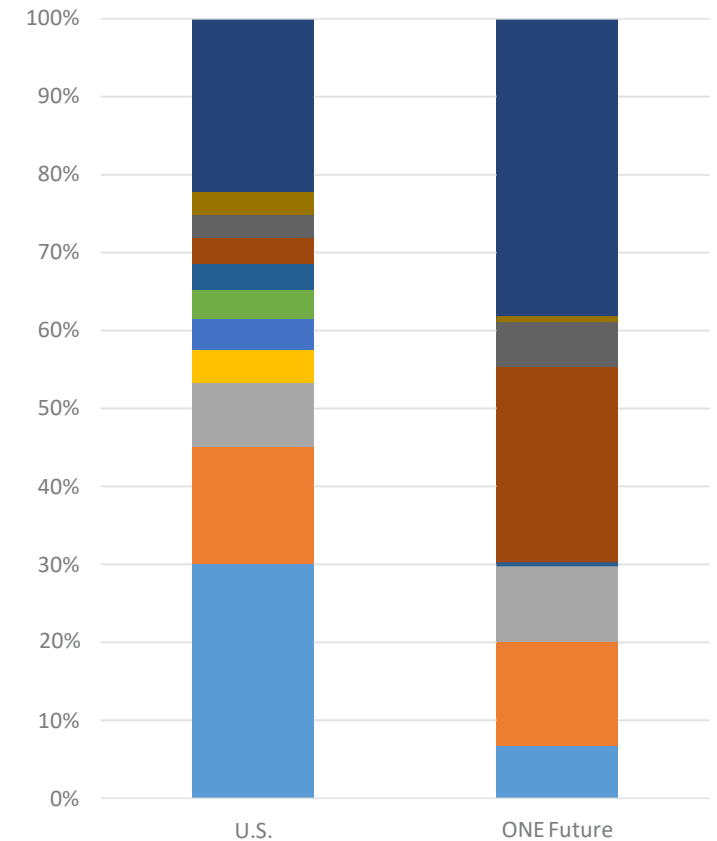
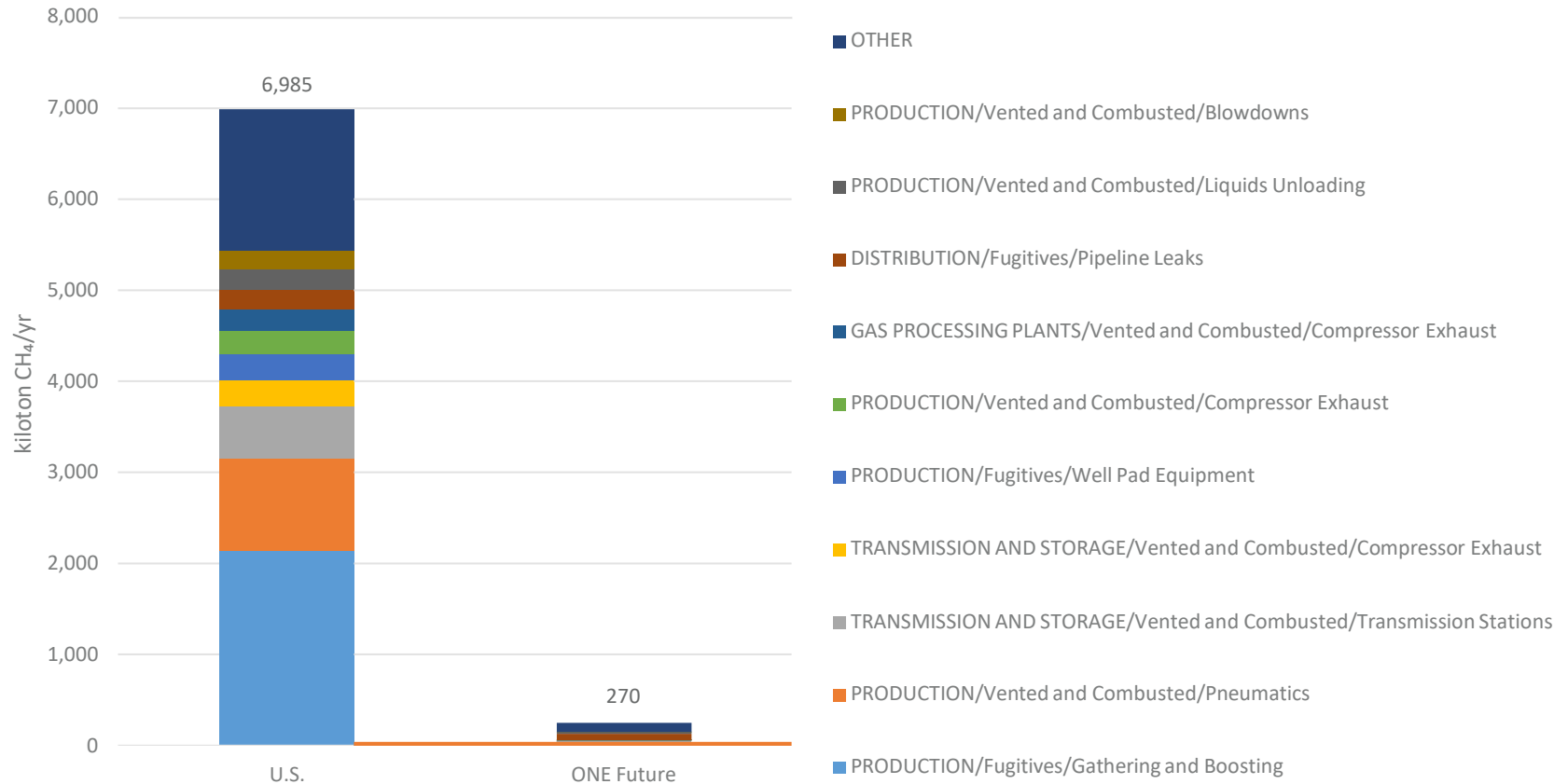
# ONE Future's Data Representativeness

- 2016 operations
- Full supply chain (production through delivery)
- 11 production basins
- 5% to 12% of U.S. supply chain capacity (depending on stage)
- Includes facilities below EPA's reporting threshold



# Emission Inventories vs. LCA

*LCA allows direct comparisons between U.S. and ONE Future*

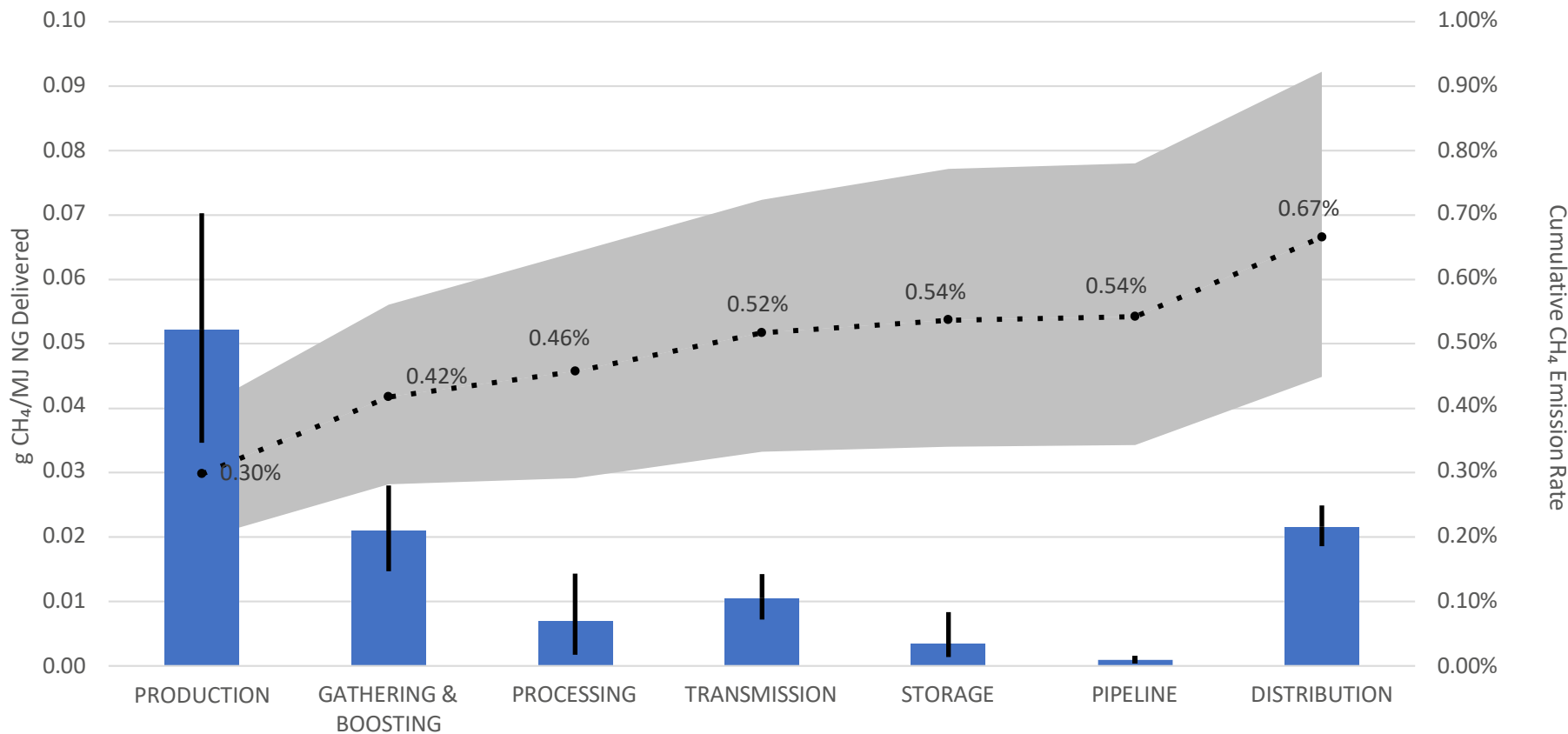


- Inventory does not facilitate comparisons per unit of delivered fuel (e.g., 1 MJ delivered natural gas)
- LCA is necessary to model and integrate ONE Future's assets into a balanced supply chain



# ONE Future's Life Cycle CH<sub>4</sub> Emissions

Representative of a hypothetical, vertically integrated ONE Future supply chain

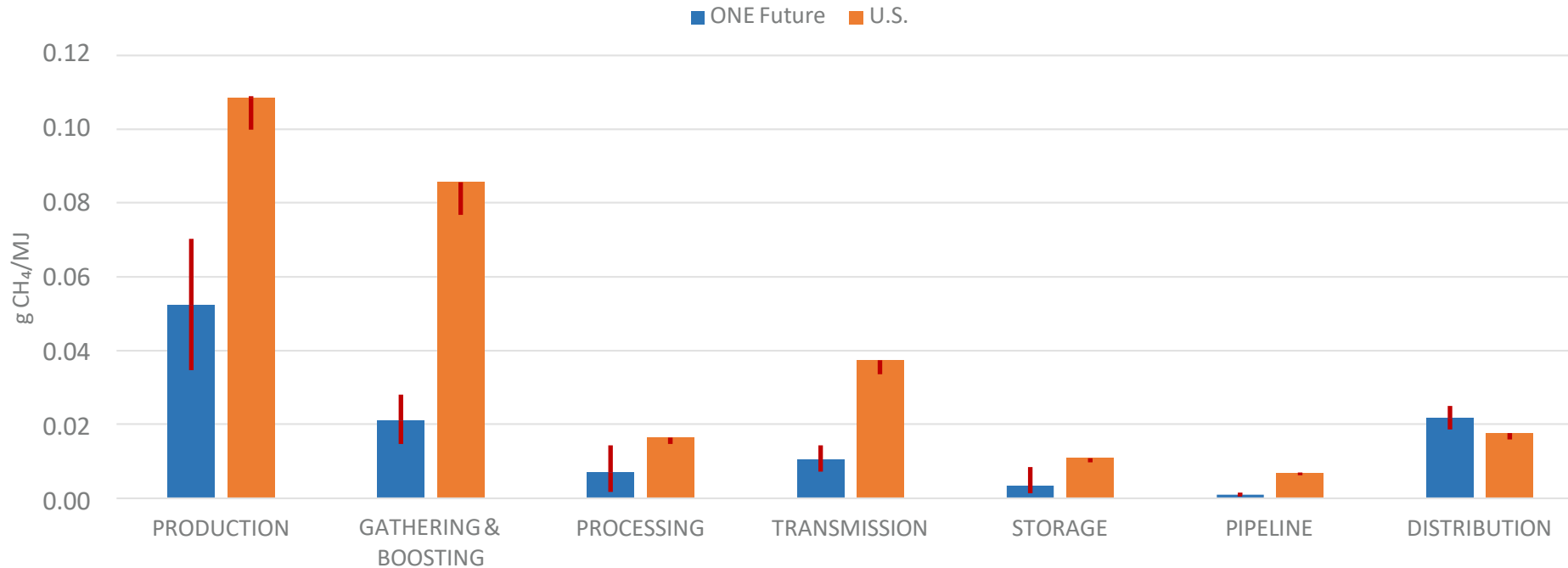


- 0.10 g CH<sub>4</sub>/MJ delivered natural gas (can be as high as 0.20 g CH<sub>4</sub>/MJ )
- 0.67% CH<sub>4</sub> emission rate (can be as high as 0.92%)
- 2015 U.S. average emission rate is 1.62%; equivalent to a 240 Bcf /yr reduction



# ONE Future Comparison to U.S. Average

2015 U.S. average natural gas compared to 2016 ONE Future operations

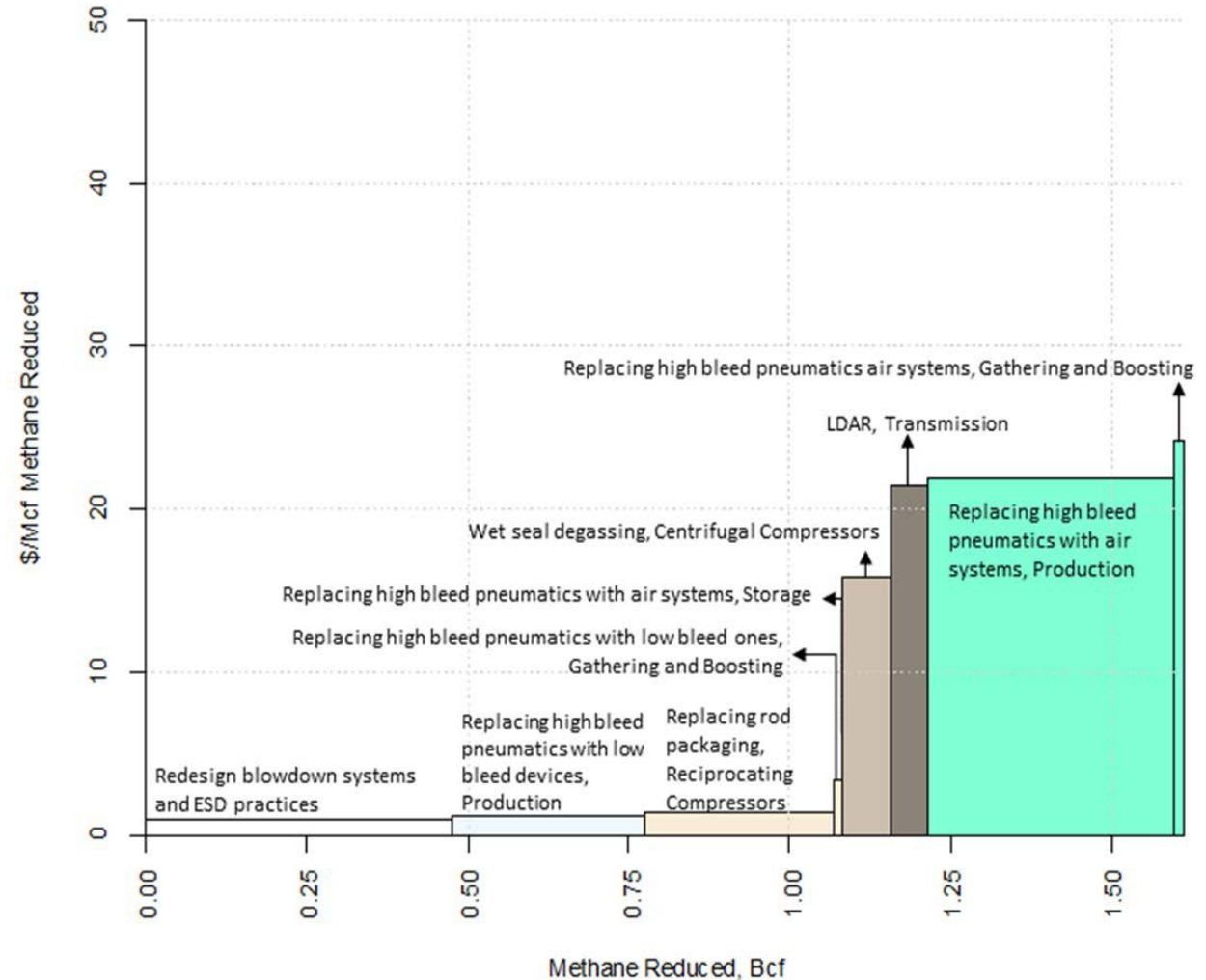


- ONE Future total CH<sub>4</sub> emissions are lower than U.S.
- Distribution is only stage where ONE Future has higher emissions than U.S.
- Greater uncertainty for ONE Future a function of data representativeness and stage connectivity

# Marginal Abatement Costs

Used as a companion analysis tool that represents assets within ONE Future's control

- Mitigation options available to ONE Future are different than for the entire natural gas supply chain
- Low cost opportunities result in 1.1 Bcf in annual CH<sub>4</sub> emission reductions
- Most opportunities have recovery costs that exceed natural gas market value





# Findings and Recommendations

- Compressors
  - A significant emission source represented by all supply chain stages
  - More data and analysis could give us a mechanistic understanding of compressor emissions
- Episodic emissions
  - Liquids unloading variability is a top driver of uncertainty
  - Further research and analysis on episodic variability could inform the discussion on top -down vs. bottom -up emissions
- MAC
  - Complements LCA with a cost and scale perspective
  - Further development of MAC method could lead to regional and operator -specific recommendations for emission reductions

# Potential Next Steps

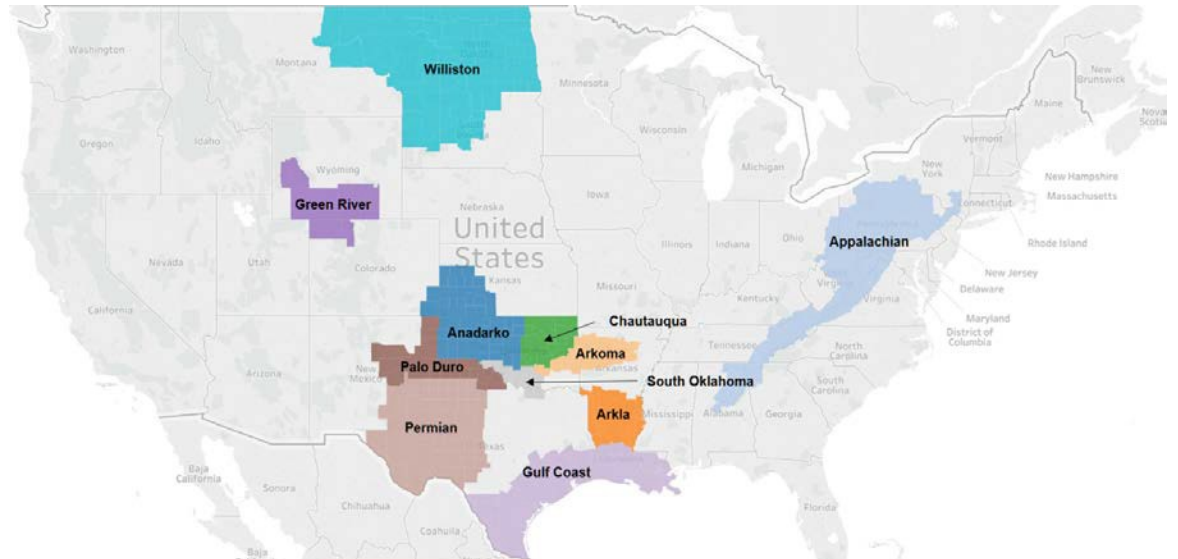
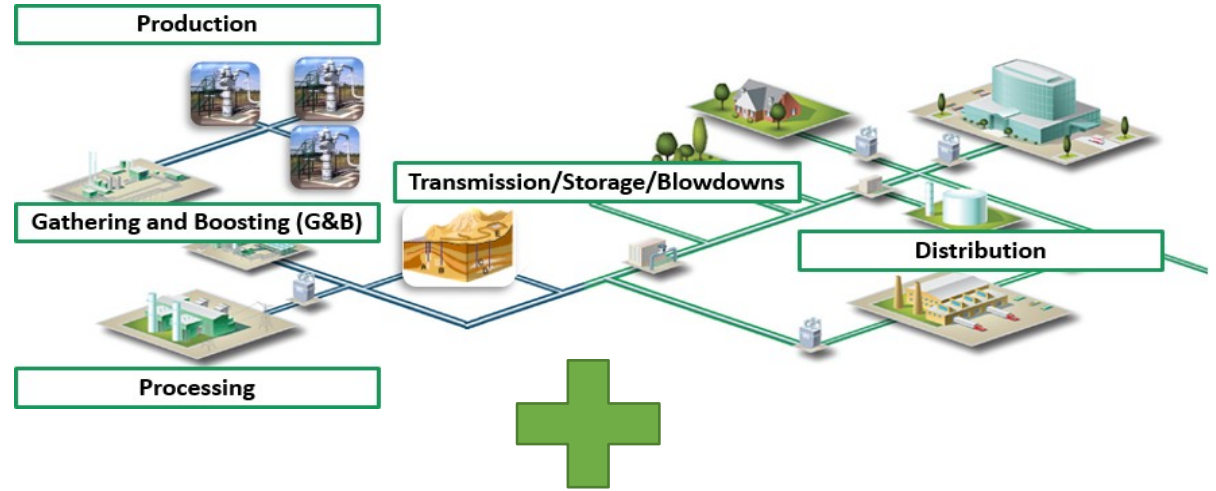
Moving from national and aggregated ONE Future perspectives to regional and sector assessments

- **Value**

- Cost effective methane reduction opportunities vary by region and industry sector – one-size-fits-all national perspectives can over and underestimate real world methane reduction opportunities
- Improved transparency of both methane emissions and market viable reduction opportunities to investors/shareholders
- Ability to benchmark and report methane emissions performance on an equivalent delivered unit of gas basis while appropriately accounting for the movement of gas from production to delivery to the end customer

- **Keys to Success**

- Phase II private -public partnership between ONE Future and NETL to inform regional differences by operator
- Company results blinded and reported at the basin level by industry sector
- Combined LCA and MAC analysis to inform future methane reduction potentials
- Comparison to U.S. regional averages by sector to benchmark and communicate methane reduction opportunities



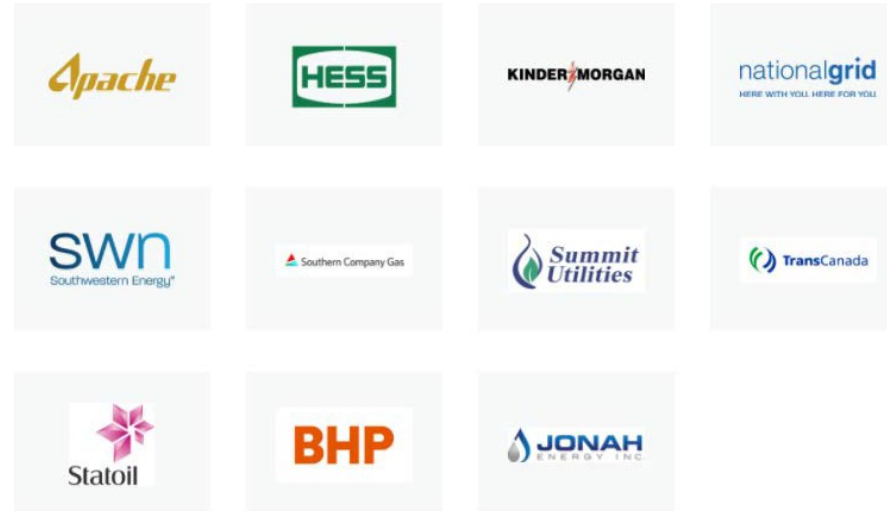


# Acknowledgments

- DOE Office of Fossil Energy
  - Tim Reinhardt - HQ Director of Supply & Delivery
  - Christopher Freitas - HQ Senior Program Manager



- ONE Future
  - Fiji George
  - Richard Hyde



- AECOM
  - Terri Lauderdale
  - Matt Harrison



# Report Access

**INDUSTRY PARTNERSHIPS AND THEIR ROLE IN REDUCING NATURAL GAS SUPPLY CHAIN GREENHOUSE GAS EMISSIONS**

May 1, 2018  
DOE/NETL-2018/1884

Contribution to Total CH <sub>4</sub> Future Emissions	Stage	Emission Category	Emission Source	Difference between CH <sub>4</sub> Future and U.S.	
				g CH <sub>4</sub> /M <sup>3</sup>	Percent**
1.6%	Gathering & Boosting	Fugitives	Gathering system (equipment leaks)	-7.05E-02	-9%
4.5%	Production	Vented & Combusted	Pneumatic device (intermittent bleed)	-2.77E-02	-84%
13%	Gathering & Boosting	Vented & Combusted	Combustion exhaust (compressor driver and other combustion of natural gas)	1.47E-02	N/A
2.2%	Transmission	Fugitives	Reciprocating compressors	-9.00E-03	-79%
18%	Production	Vented & Combusted	Liquids unloading (adder)	-8.79E-03	-29%
			Combustion exhaust (compressor driver and other combustion of natural gas)	7.29E-03	86%
			Combustion exhaust (engine)	-7.15E-03	-77%
			Liquids unloading (plunger)	-5.76E-03	-62%
			Well leaks	5.13E-03	116%
			Combustion Exhaust (compressor)	-4.24E-03	-43%
			Well leaks	-3.73E-03	-43%
			Well leaks	-3.64E-03	-54%
			Pneumatic device (intermittent bleed)	3.06E-03	778%
			Well leaks	1.98E-03	N/A
			Well leaks	1.43E-03	N/A
			Combustion exhaust (engine)	-7.14E-04	-14%
			Combustion exhaust (engine)	3.12E-04	38%

g CH<sub>4</sub>/M<sup>3</sup> NG delivered

<https://netl.doe.gov/research/energy-analysis/search-publications/vuedetails?id=2637>



# Contact Information



Timothy J. Skone, P.E.

Senior Environmental Engineer • Strategic Energy Analysis  
(412) 386-4495 • [timothy.skone@netl.doe.gov](mailto:timothy.skone@netl.doe.gov)

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James Littlefield

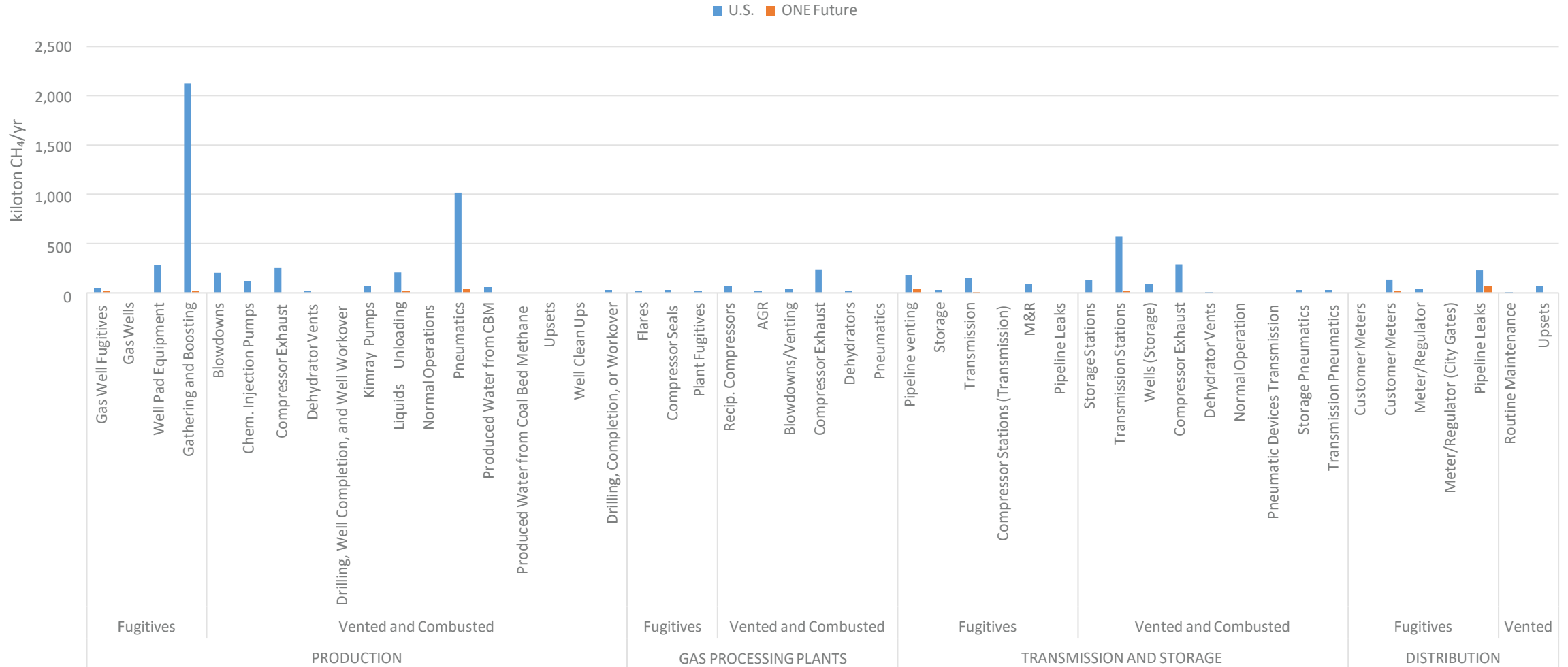
Senior Engineer • KeyLogic  
(412) 386-7560 • [james.littlefield@netl.doe.gov](mailto:james.littlefield@netl.doe.gov)

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# Supporting Material: Inventory Perspective

Greenhouse Gas Inventory (GHGI) shows emissions on an annual basis



# Supporting Material: Multi-faceted Results

Interpretations can be made from more than one perspective



- **Comparisons**

- Within ONE Future
- ONE Future vs. U.S.

- **Level of detail**

- Supply chain stages
- Specific emission sources

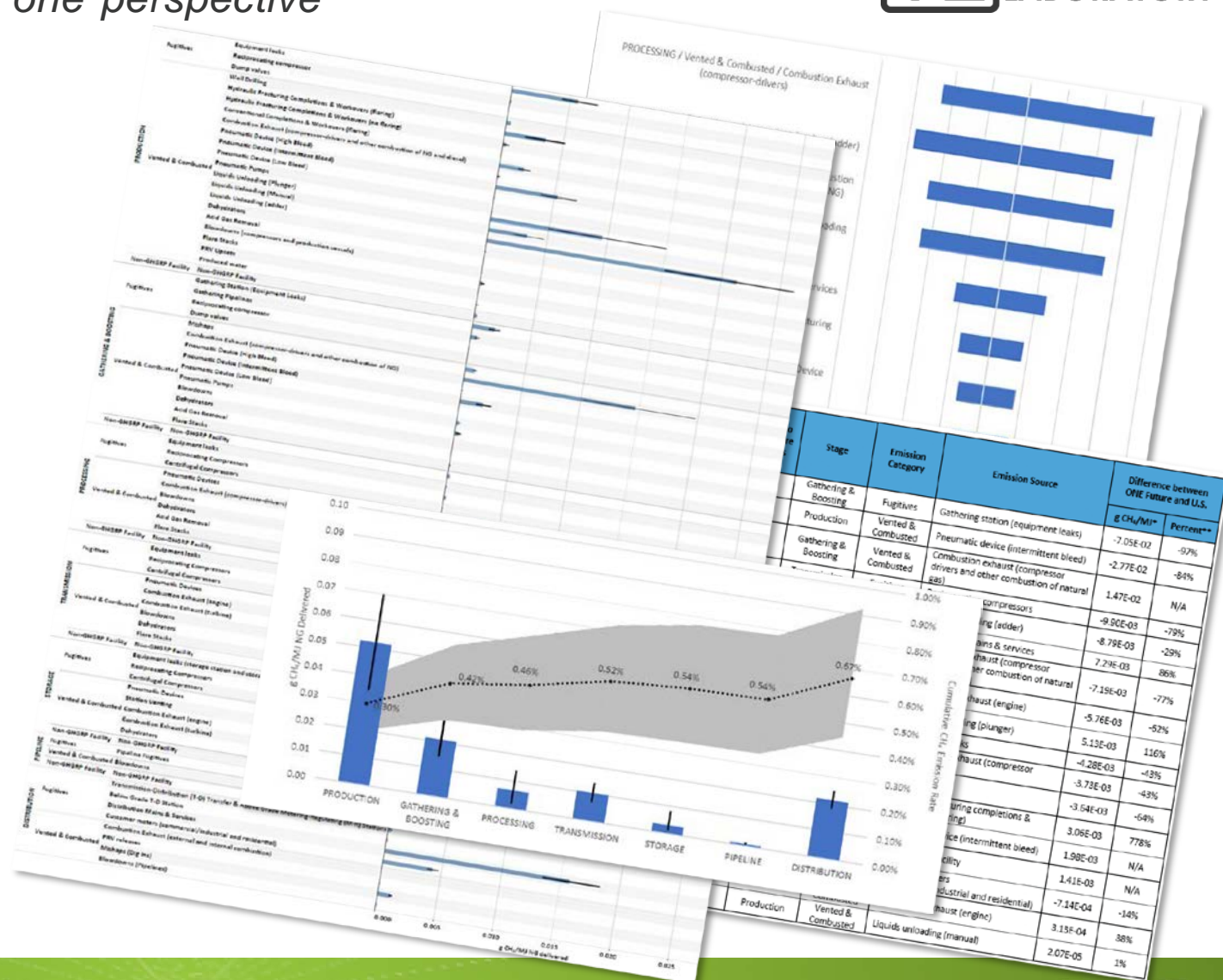
- **Metrics**

- Mass of CH<sub>4</sub> and other GHGs
- Emission rate of CH<sub>4</sub>

- **Magnitude**

- **Uncertainty**

- Variability
- Data gaps





# Supporting Material: Compressor CH<sub>4</sub>

All supply chain stages have compressor systems with fugitive and exhaust CH<sub>4</sub>

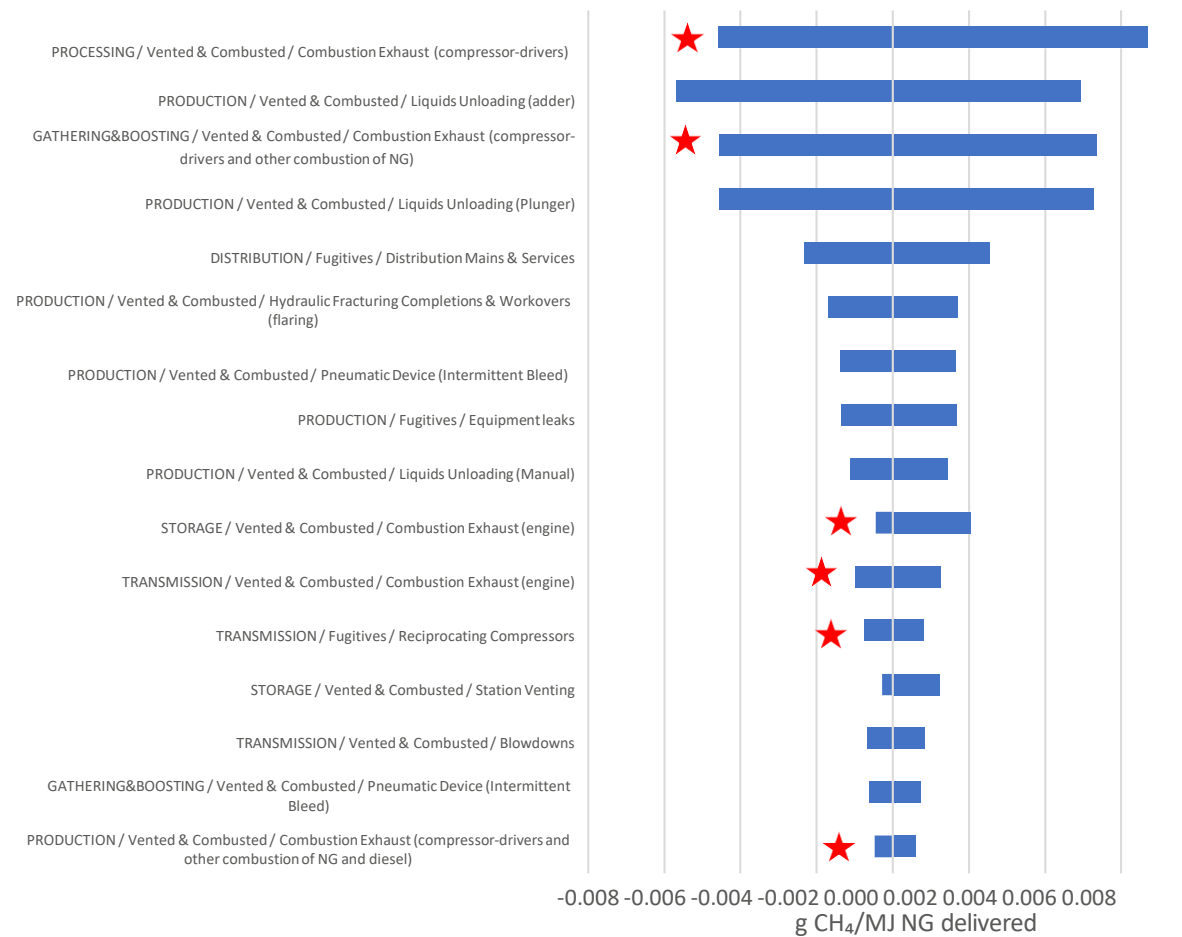
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## CH<sub>4</sub> Emission Contributions

Contribution to total ONE Future CH <sub>4</sub> Emissions	Stage	Emission Category	Emission Source
18%	Production	Vented & Combusted	Liquids unloading (adder)
14%	Distribution	Fugitives	Distribution mains & services
★ 13%	Gathering & Boosting	Vented & Combusted	Combustion exhaust (compressor-drivers and other combustion of natural gas)
8.3%	Production	Vented & Combusted	Liquids unloading (plunger)
4.9%	Production	Fugitives	Equipment leaks
4.5%	Production	Vented & Combusted	Pneumatic device (intermittent bleed)
★ 4.3%	Processing	Vented & Combusted	Combustion exhaust (compressor-drivers)
3.6%	Distribution	Fugitives	Customer meters (commercial/industrial and residential)
★ 3.0%	Transmission	Vented & Combusted	Combustion exhaust (engine)
3.0%	Production	Vented & Combusted	Hydraulic fracturing completions & workovers (flaring)
2.8%	Production	Vented & Combusted	Liquids unloading (manual)
★ 2.2%	Transmission	Fugitives	Reciprocating compressors
★ 1.8%	Production	Vented & Combusted	Combustion exhaust (compressor-drivers and other combustion of natural gas and diesel)
1.7%	Transmission	Vented & Combusted	Blowdowns
1.7%	Gathering & Boosting	Vented & Combusted	Pneumatic device (intermittent bleed)
1.6%	Gathering & Boosting	Fugitives	Gathering station (equipment leaks)
1%	Transmission	Non-GHGRP Facility	Non-GHGRP facility
★ 1.0%	Storage	Vented & Combusted	Combustion exhaust (engine)

## CH<sub>4</sub> Emission Uncertainties

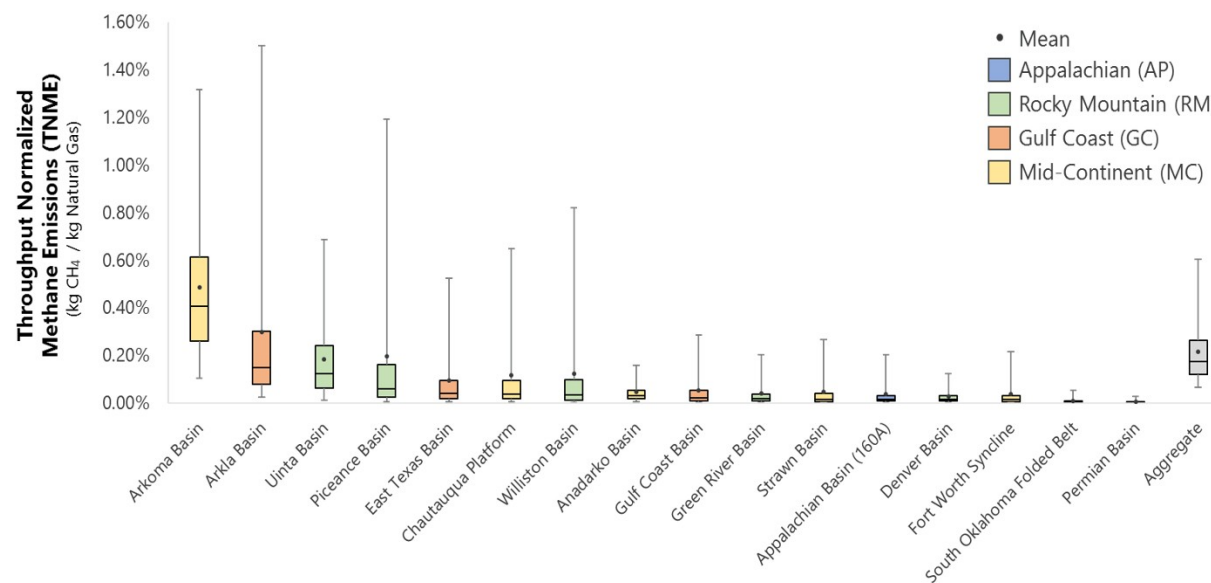


# Supporting Material: Liquids Unloading & Distribution Mains

Some ONE Future emission sources are significant drivers of total emissions and are significantly different than the U.S. average.

## • Liquids unloading adder

- 18% of ONE Future CH<sub>4</sub>
- 29% lower than U.S. CH<sub>4</sub>
- Driven by regional differences in reported and simulated liquids unloading



## • Fugitives from distribution mains

- 14% of ONE Future CH<sub>4</sub>
- 86% higher than U.S. CH<sub>4</sub>
- ONE Future has more cast iron pipe in its infrastructure (a known issue being addressed by pipe replacement programs)