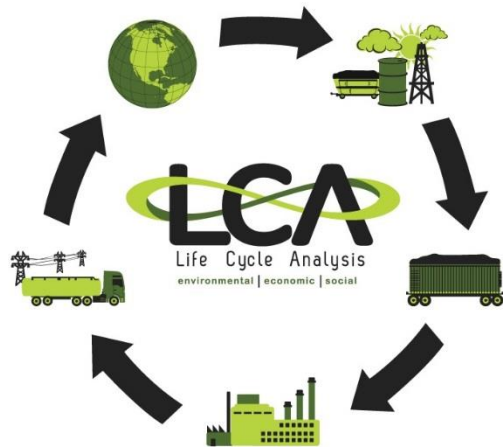




Driving Innovation ♦ Delivering Results



Life Cycle Greenhouse Gas Emissions: *Natural Gas and Power Production*

Timothy J. Skone, PE

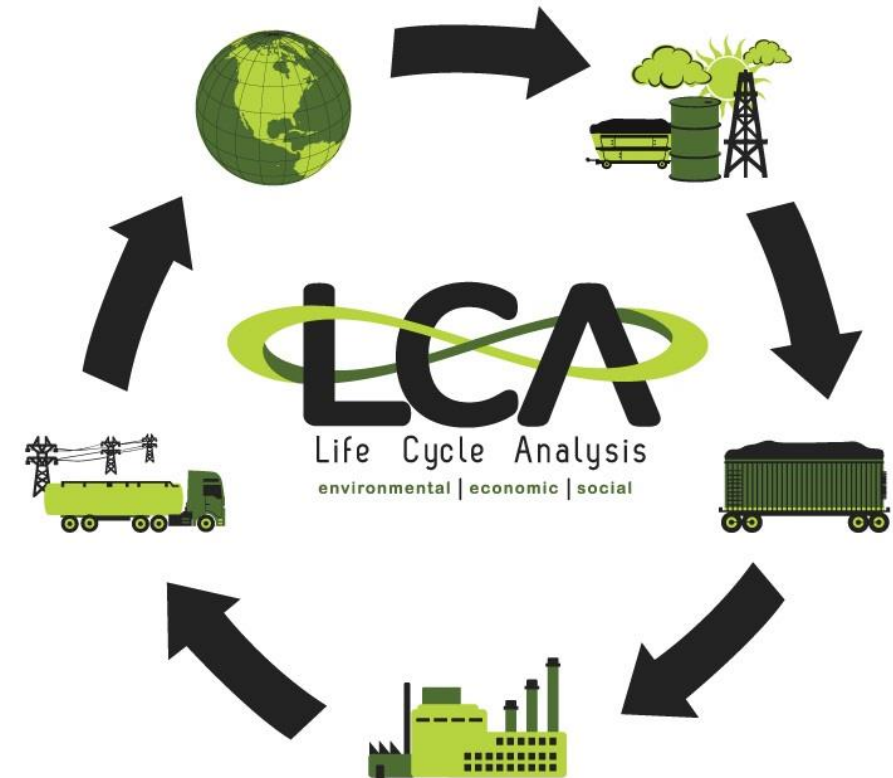
2015 EIA Energy Conference, Washington, D.C.
June 15, 2015



U.S. DEPARTMENT OF
ENERGY

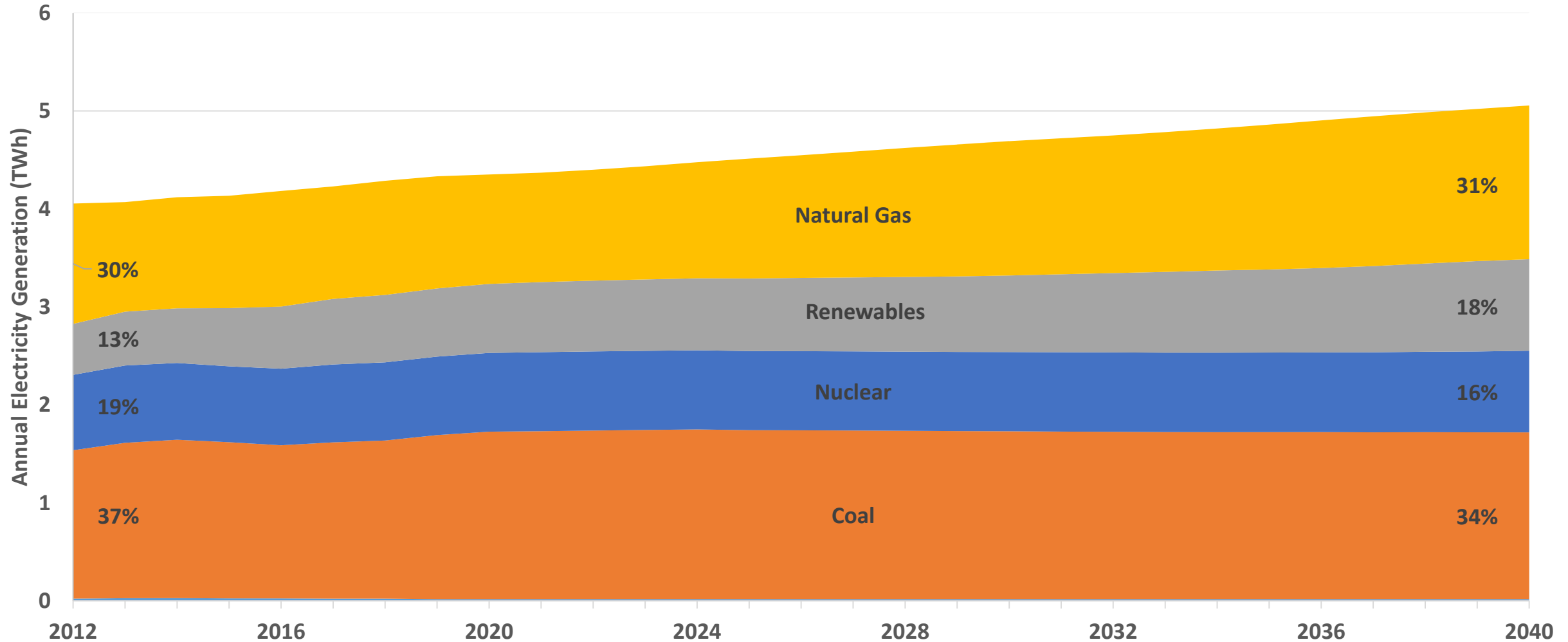
National Energy
Technology Laboratory

- Importance of Understanding GHG Emissions from the Power and Natural Gas Sectors
- Understanding the Life Cycle GHG Emissions of Natural Gas
- Understanding the Life Cycle GHG Emissions of Power Production

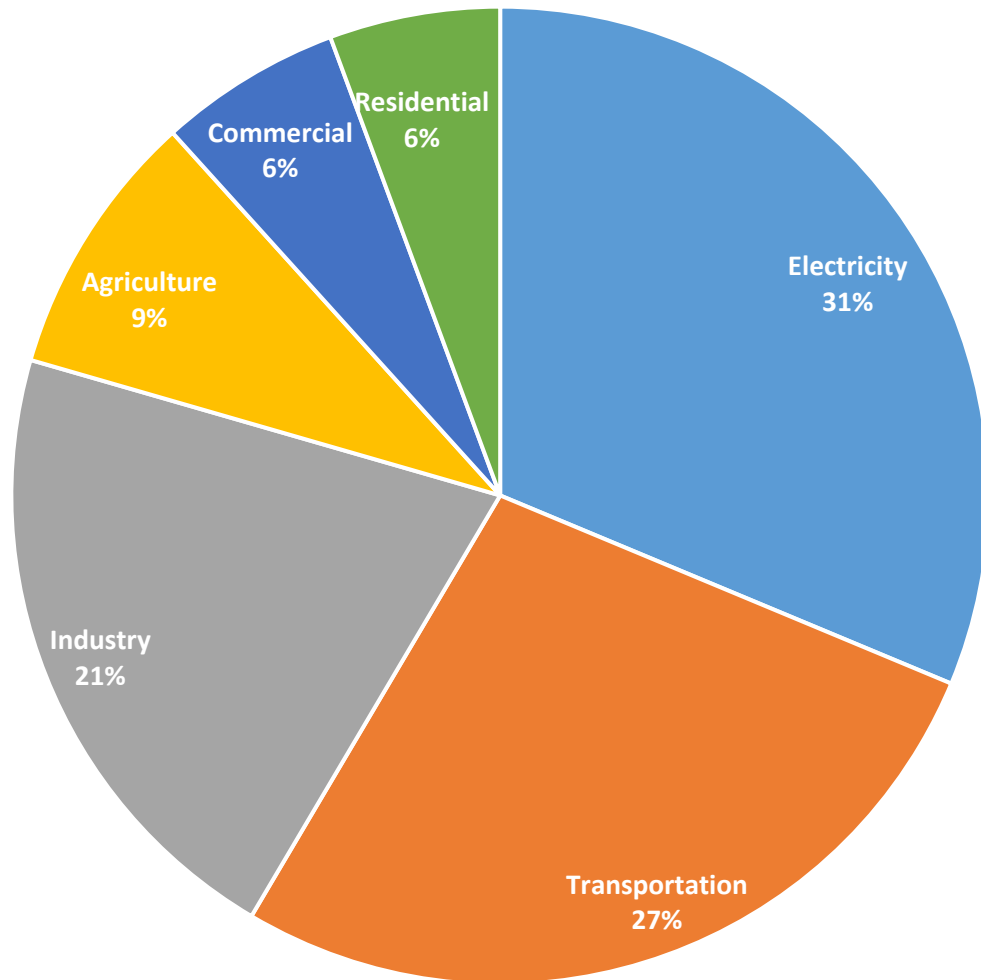


Electricity Generation Forecast: 25% Growth in Next 20 Years

EIA, AEO 2015: Reference Case

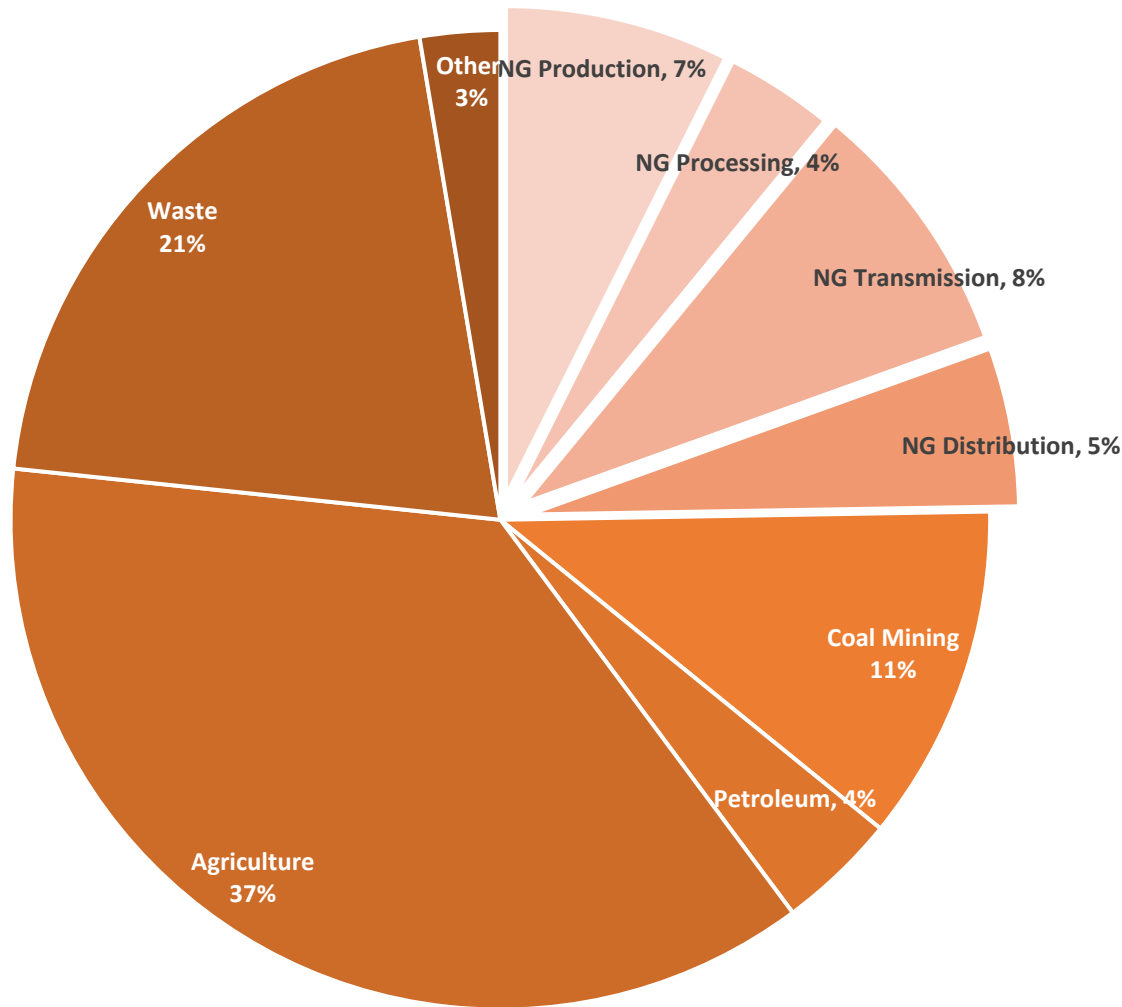


U.S. 2013 GHG Emissions, by Economic Sector



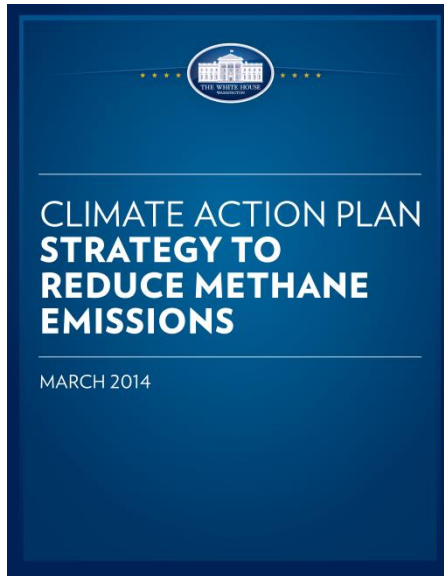
- **6,673 Million Metric Tons CO₂e (AR4 GWP) in 2013**
 - 82% Carbon Dioxide
 - 10% Methane
 - 5% Nitrous Oxide
 - 3% Fluorinated Gases
- **Electricity Sector**
 - 98.2% Carbon Dioxide
- **GHG Emissions are 9% below 2005 Levels**

U.S. Anthropogenic Methane Emissions, 2013



- Methane emissions are 10% of total 2013 U.S. GHG emissions (in AR4 CO₂e)
- Current U.S. fossil fuel related methane emissions are ~ 40% of U.S. anthropogenic methane emissions
 - Natural Gas: 25%
 - Coal Mining: 11%
 - Petroleum Systems: 4%

President's Climate Action Plan



“Curbing emissions of methane is critical to our overall effort to address global climate change. ... To achieve additional progress, the Administration will”:

- Develop a comprehensive Interagency Methane Strategy – *July 2014*
- *Initiated* a collaborative approach with state governments as well as the private sector and cover all methane emitting sectors

Three Pillars

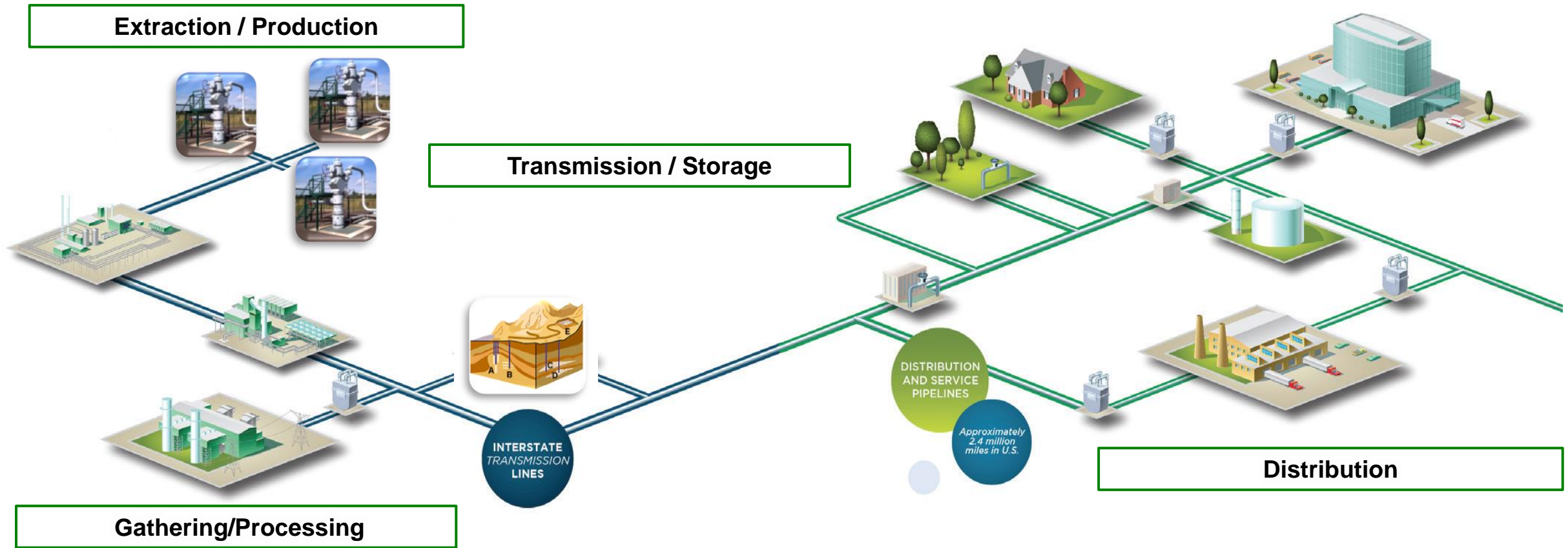
Assessing Current
Emissions Data and
Addressing Data Gaps

Identifying
Technologies and Best
Practices for Reducing
Emissions

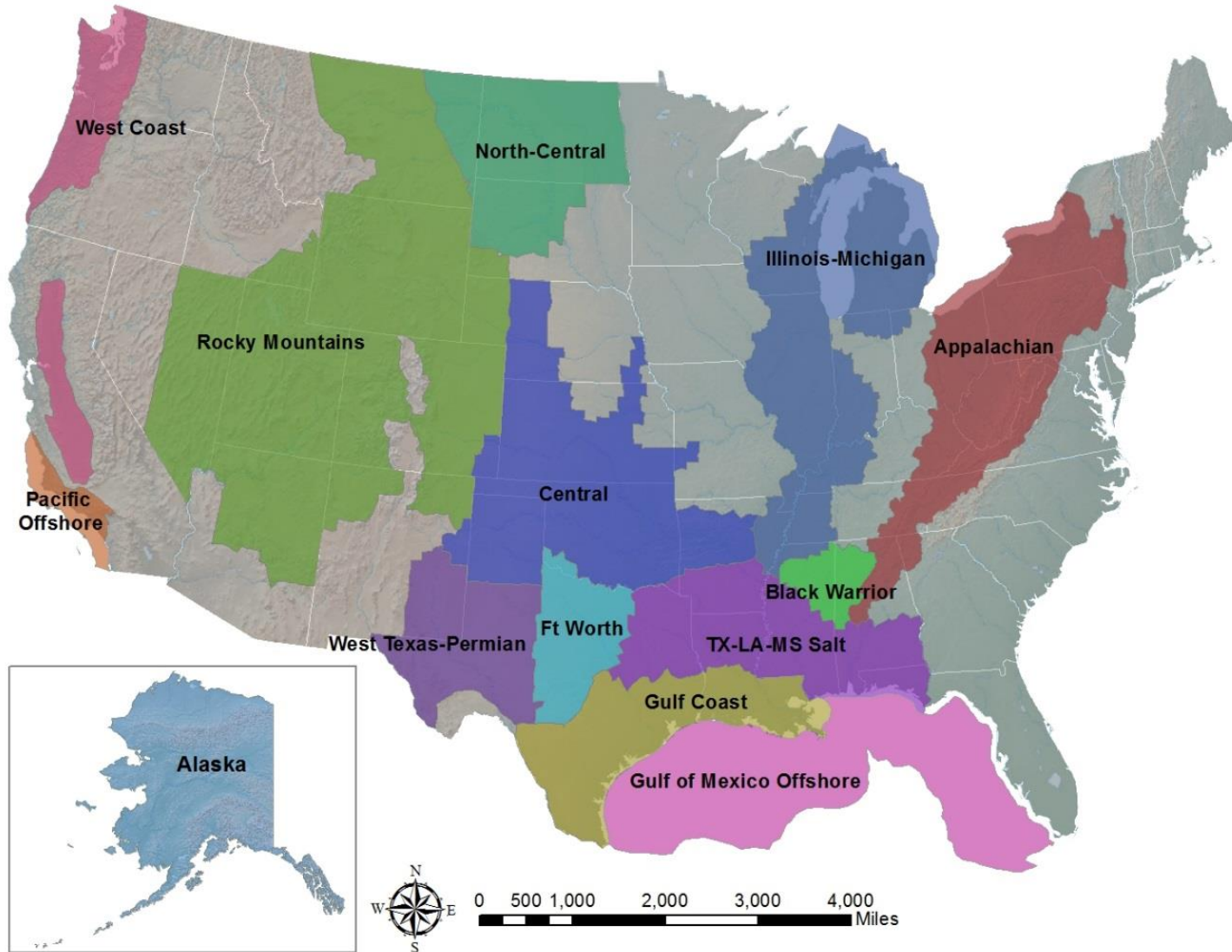
Identifying Existing
Authorities and
Incentive-based
Opportunities for
Reducing Emissions



Understanding the Life Cycle GHGs of Natural Gas



NETL Techno-Regions and Natural Gas Boundaries



Region	Basin	Shale Play
Alaska	-	-
Alaska Offshore	-	-
Appalachian	Appalachian	Marcellus
Black Warrior	Black Warrior	-
Central	Anadarko, Ardmore, Cherokee Platform, Palo Duro	Woodford, Fayetteville
Fort Worth	Ft. Worth	Barnett
Gulf of Mexico	-	-
Gulf Coast	Western Gulf	Eagleford
Illinois-Michigan	Illinois, Michigan	Antrim, New Albany
North-Central	Williston	Bakken
Pacific Offshore	Ventura	-
Rocky Mountains	Bighorn, Denver, Greater Green River, Paradox, Piceance, Powder River, Raton, San Juan, Unita, Wind River, Wyoming Thrust Belt	Niobrara
TX-LA-MS Salt	Arkoma, TX-LA-MS Salt	Haynesville
West Coast	Sacramento	-
West Texas-Permian	Permian	Barnett-Woodford



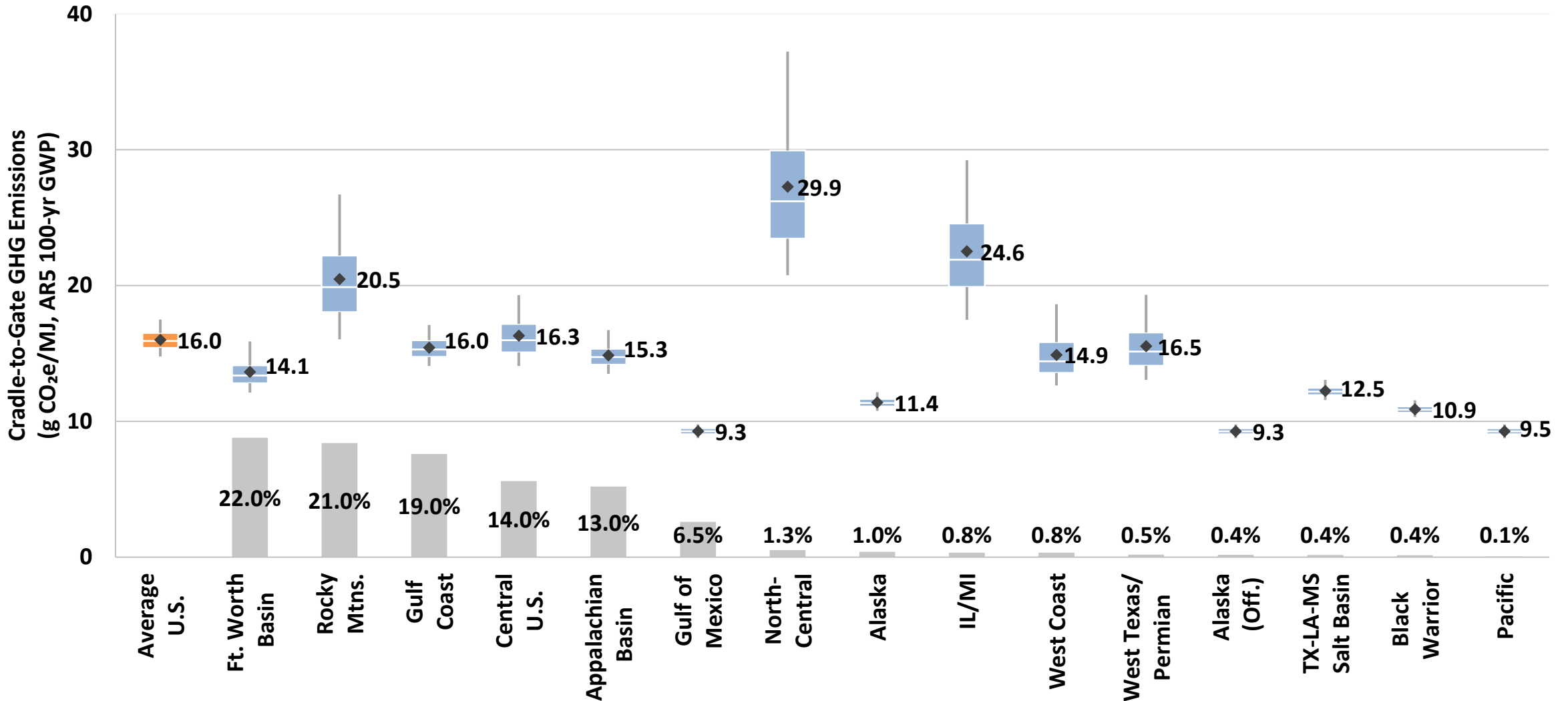
2012 Production Mix for Techno-Regions



Region	Technology						Total
	CBM	Onshore Conventional	Offshore Conventional	Oil Wells	Shale	Tight Gas	
Alaska	-	0.31%	-	0.70%	-	-	1.0%
Alaska Offshore	-	-	0.14%	0.31%	-	-	0.44%
Appalachian	0.44%	2.8%	-	0.050%	9.1%	0.32%	13%
Black Warrior	0.37%	-	-	-	-	-	0.37%
Central	0.41%	5.4%	-	0.21%	6.0%	1.6%	14%
Fort Worth	-	-	-	-	22%	-	22%
Gulf of Mexico Offshore	-	-	4.6%	2.0%	-	-	6.5%
Gulf Coast	-	9.2%	-	1.8%	-	7.8%	19%
Illinois-Michigan	-	0.34%	-	0.018%	0.44%	0.038%	0.84%
North-Central	-	0.087%	-	0.40%	0.75%	0.026%	1.3%
Pacific Offshore	-	-	0.063%	0.071%	-	-	0.13%
Rocky Mountains	4.7%	4.6%	-	0.093%	0.89%	10%	21%
TX-LA-MS Salt	-	0.15%	-	0.049%	-	0.21%	0.41%
West Coast	-	0.42%	-	0.21%	0.22%	-	0.84%
West Texas-Permian	-	-	-	0.21%	0.25%	-	0.46%
Total	6.0%	23%	4.8%	6.1%	39%	20%	100%

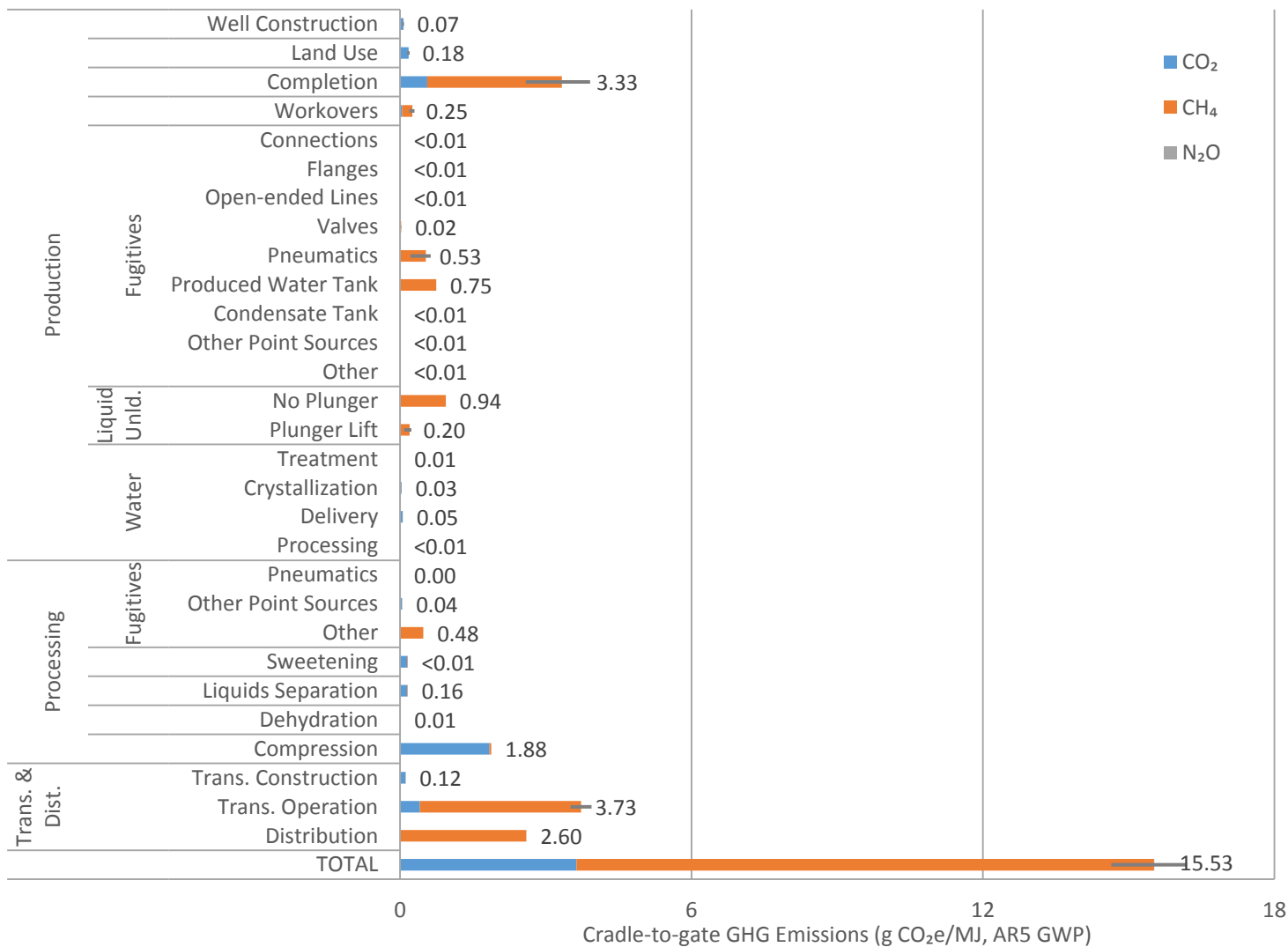
Regional Variability is Reduced at National Level

(16.0 g/MJ CO₂e, 1.86% CH₄ Emission Rate thru Distribution)



Detailed GHG Results for Appalachian Basin

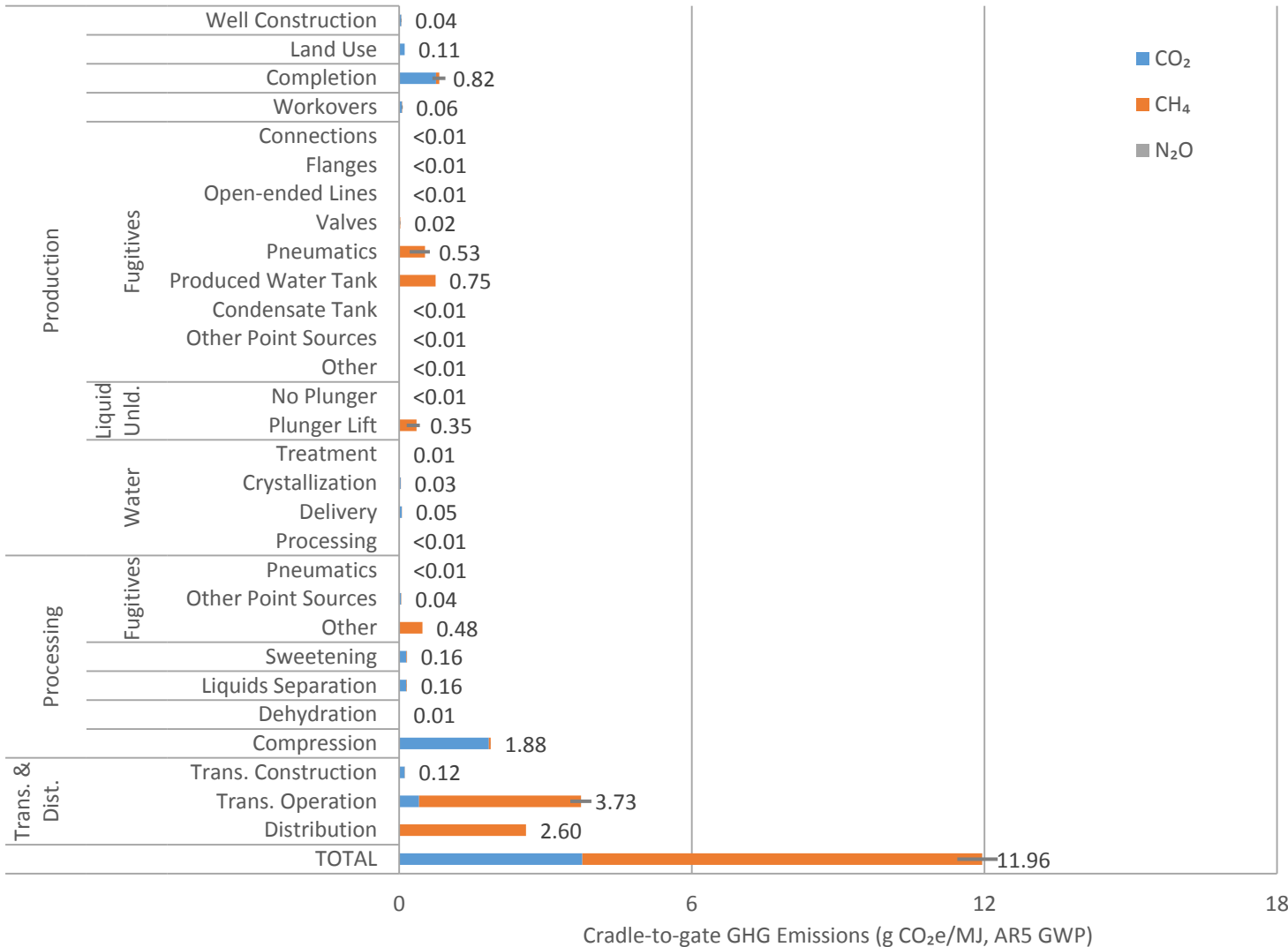
(15.5 g CO₂e/MJ, 1.8% CH₄ Emission Rate thru Distribution)



- **CH₄ makes up 77% of the GHG footprint**
 - 73% of this comes from Distribution, Transmission and Completions
 - 97% from 8 sources in the system
- **62% of CO₂ emissions come from the operations of compressors**
- **These limited set of sources represent significant opportunities for improvement**

Detailed GHG Results for Next Appalachian Well

(12.0 g CO₂e/MJ, 1.1% CH₄ Emission Rate thru Distribution)



- **Next Well: Post-January 2015 NSPS implementation & increased recovery efficiency**
- **GHG footprint reduced by 22%**
- **Improvements to operations reduce the contribution of CH₄ to 69%**
 - Over 72% from TS&D
 - 98% now come from 6 sources

DOE Actions to Reduce Methane Emissions

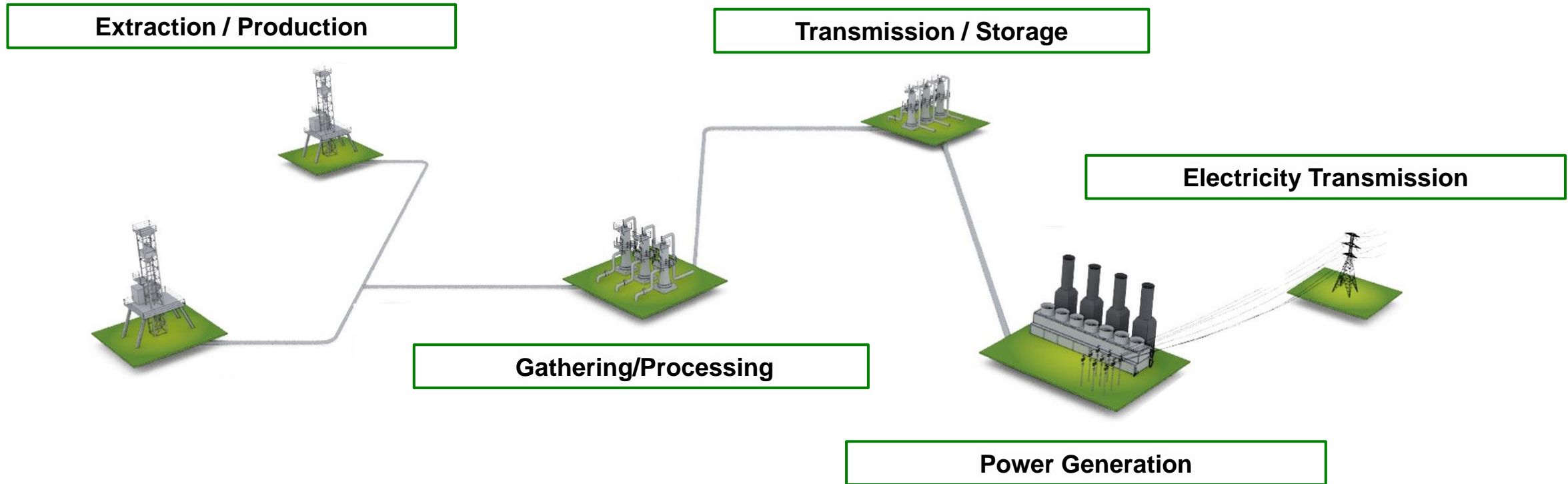


- **Fossil Energy funded methane emissions quantification research**
- **Conducted public meeting on energy efficiency standards for natural gas compressors**
- **Working with FERC on Incentives: Requested efforts to provide certainty for cost recovery for natural gas infrastructure modernization**
- **NARUC Partnership on Infrastructure Modernization**
- **Natural Gas Modernization R&D strategy across DOE:**
 - Pipeline Efficiency Research, Development & Demonstration Program (FE)
 - Advanced Natural Gas System Manufacturing R&D Initiative (AMO)
 - Loan Guarantees for Adv. FE Projects that Reduce Methane Emissions (LPO)
 - Investing in Technologies for Leak Detection & Measurement (ARPA-E)
 - Developing a clearinghouse of information on technologies, policies, and strategies (EPSA)

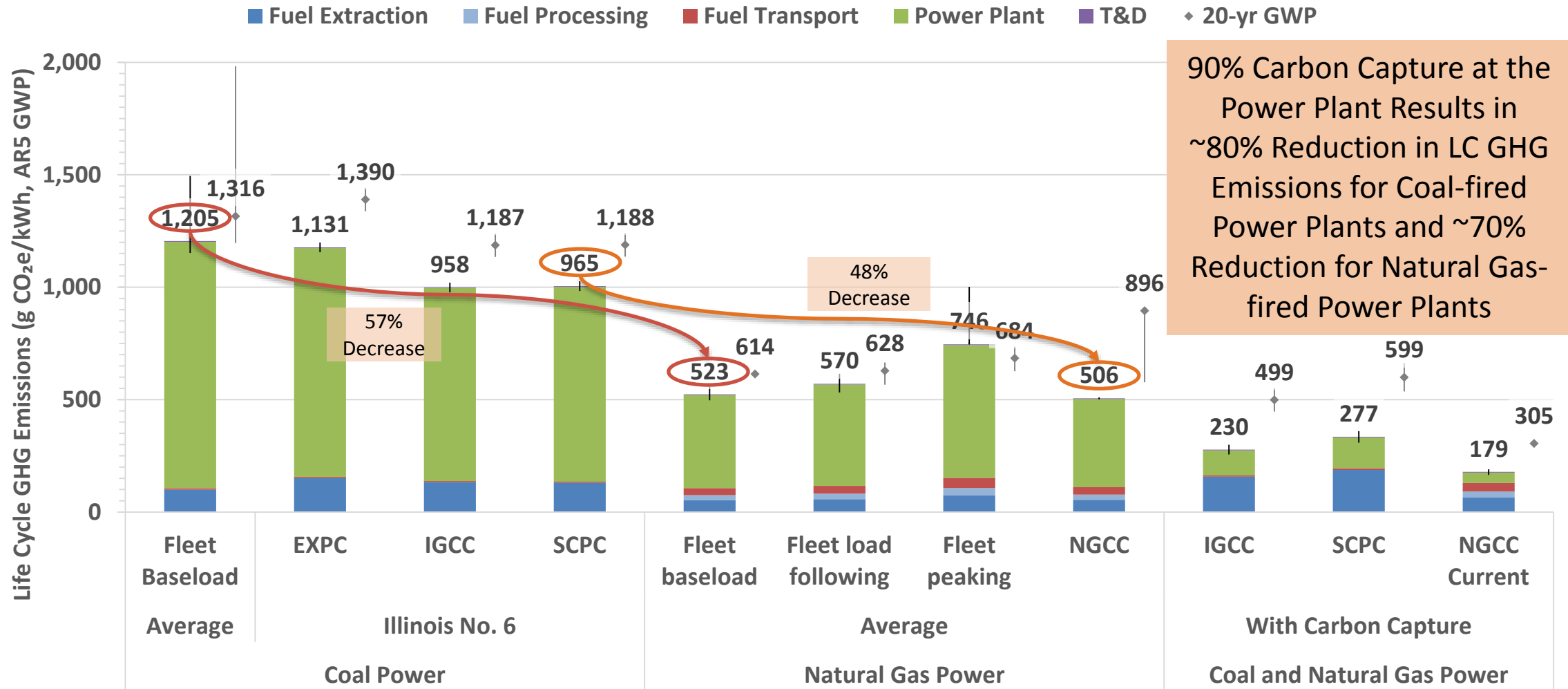
Action Items



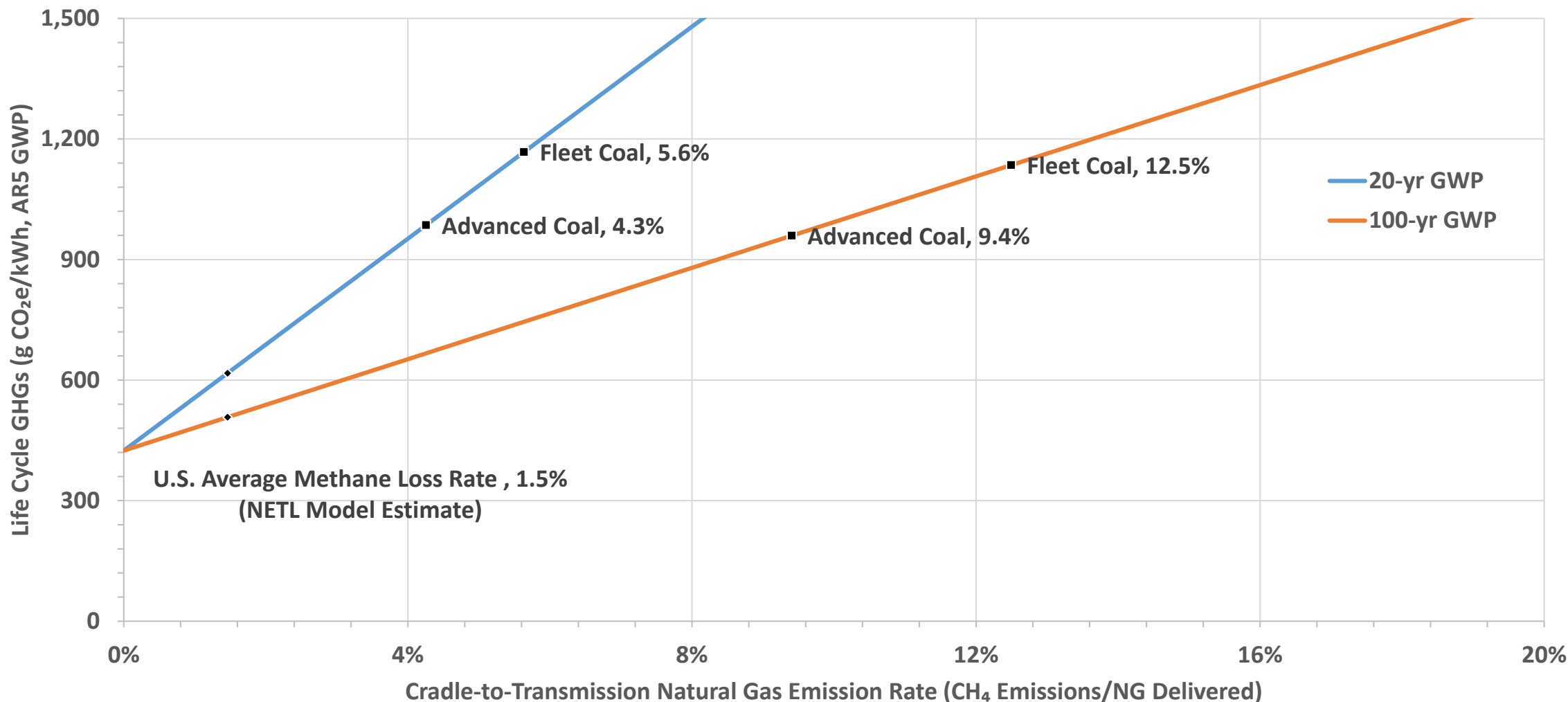
Understanding the LCA of Power Production



GHG Emission Profiles for Fossil Power Production

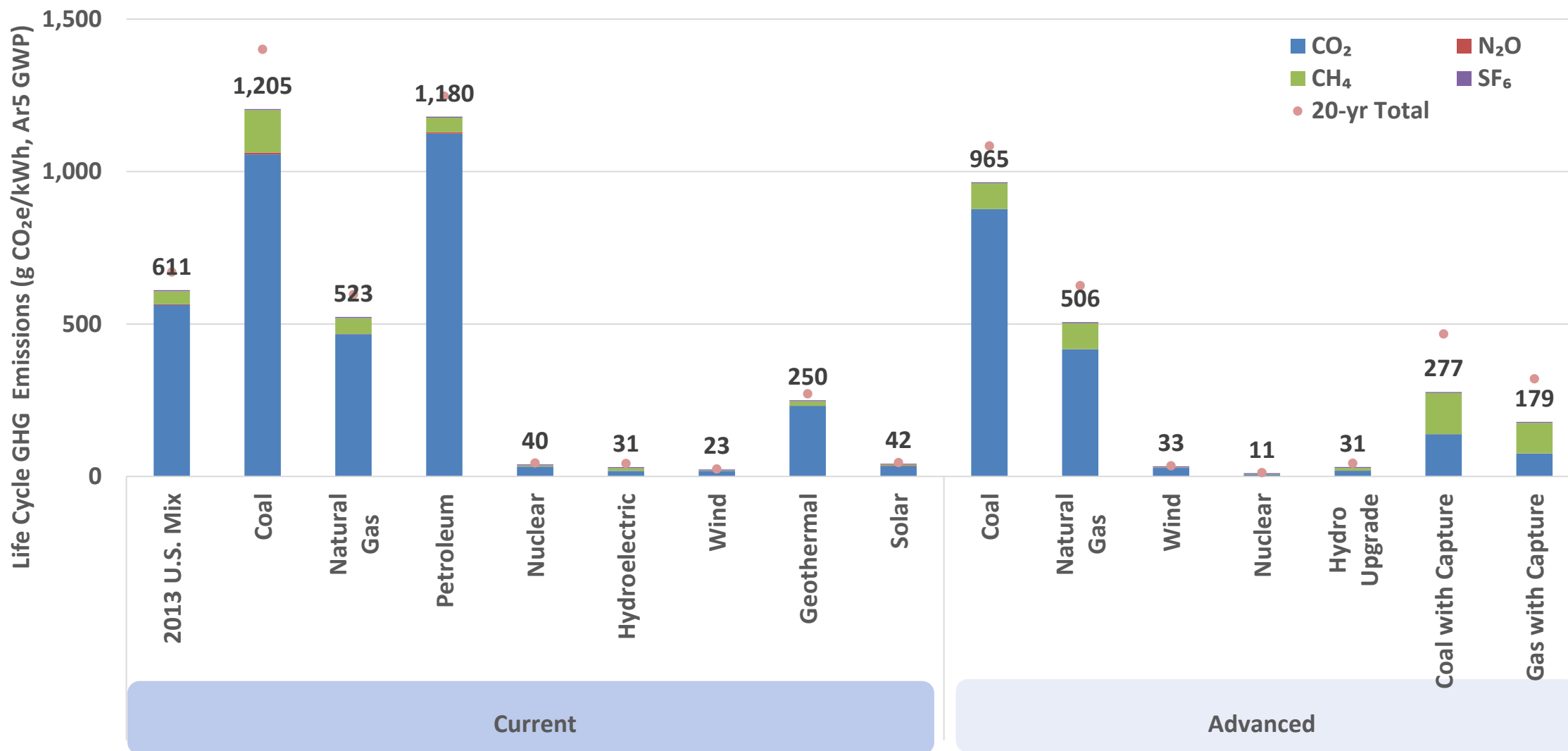


Could Natural Gas be Worse than Coal if Methane Losses are Higher than we Estimate?



GHG Emission Profiles for Power Production

Current & Advanced Technology



- Reducing CO₂ from fossil power production is critical to achieving greenhouse gas reduction goals
- Reducing both CH₄ and CO₂ across the life cycle of power production is achievable thru CCS, nuclear, and renewable power technology
- Knowledge of CH₄ emissions continues to improve as new measurements and analysis are performed – reduction strategies will be adjusted accordingly

Advancing energy options to fuel our economy, strengthen our security, and improve our environment!

Timothy J. Skone, P.E.

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