

# Overview of Energy Life Cycle Analysis at NETL



Tim Skone, Joe Marriott, James Littlefield

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U.S. DEPARTMENT OF  
ENERGY

# 2016 LCA Work

- **Journal Publications (inc. Pending)**
  - Boundary selection in NG systems
  - Coal exports from the U.S.
  - Petroleum baseline update
  - Methane emission synthesis
  - Low-carbon fuels from EOR
- **Major Reports & Tools**
  - Update to Natural Gas LCA
  - Baseline Power Updates
  - Solid-oxide fuel-cell Power LCA
  - Update to Grid Mix Explorer & Upstream Dashboard
- **Ongoing Work**
  - Support for EPA GHGI of NG Systems
  - Support for Federal LCA Commons
  - Support for DOE Loan Program Office
- **Emerging Work**
  - Development of an Electricity Baseline for the U.S.
  - Implementation of Consequential LCA for Energy Systems
  - Development of Social LCIA Metrics & MCDM frameworks
  - Creation of Power System Construction Inventories



Work can be accessed at:  
[www.netl.doe.gov/lca](http://www.netl.doe.gov/lca)

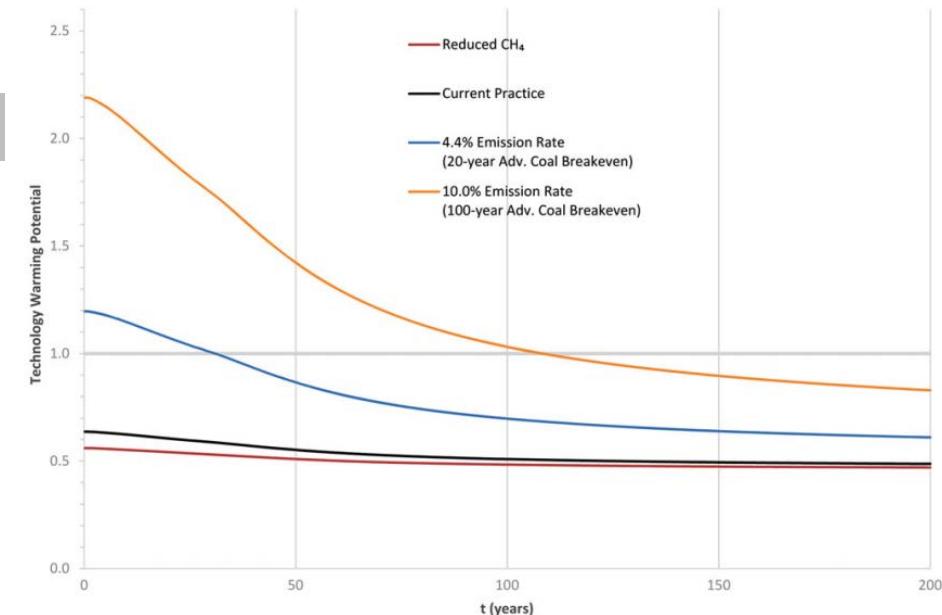
# Using Common Boundaries to Assess CH<sub>4</sub> Emissions: a Life Cycle Evaluation of Natural Gas & Coal Power Systems

James Littlefield, Joe Marriott, Greg Schivley, Tim Skone



- Emphasizes the importance of boundary selection when expressing CH<sub>4</sub> emission rates and comparing NG to other energy sources
- Includes use of technology warming potential as a method for comparing cumulative radiative forcing

Boundary	Upstream Emissions (g CH <sub>4</sub> )				NG Exiting Boundary (g)	Loss Rate	Emission Rate			
	Extraction	—	Processing	—	Transmission	—	Distribution			
Cradle-to-Extraction	4.7							1,086	0.5%	0.43%
Cradle-to-Processing	4.7	+	2.6					1,020	6.6%	0.71%
Cradle-to-Transmission	4.7	+	2.6	+	5.2			1,005	7.9%	1.24%
Cradle-to-Distribution	4.7	+	2.6	+	5.2	+	4.5	1,000	8.4%	1.70%
Processing Only (GtG)			2.6					1,020	6.1%	0.25%
Transmission Only (GtG)					5.2			1,005	1.5%	0.52%
Distribution Only (GtG)						4.5		1,000	0.5%	0.45%



Journal of Industrial Ecology, January 2016, <http://onlinelibrary.wiley.com/doi/10.1111/jiec.12394/pdf>



# Understanding the Contribution of Mining & Transportation to the Total Life Cycle Impacts of Coal Exported from the U.S.

Michele Mutchek, Greg Cooney, Gavin Pickenpaugh, Joe Marriott, Tim Skone



## • Background:

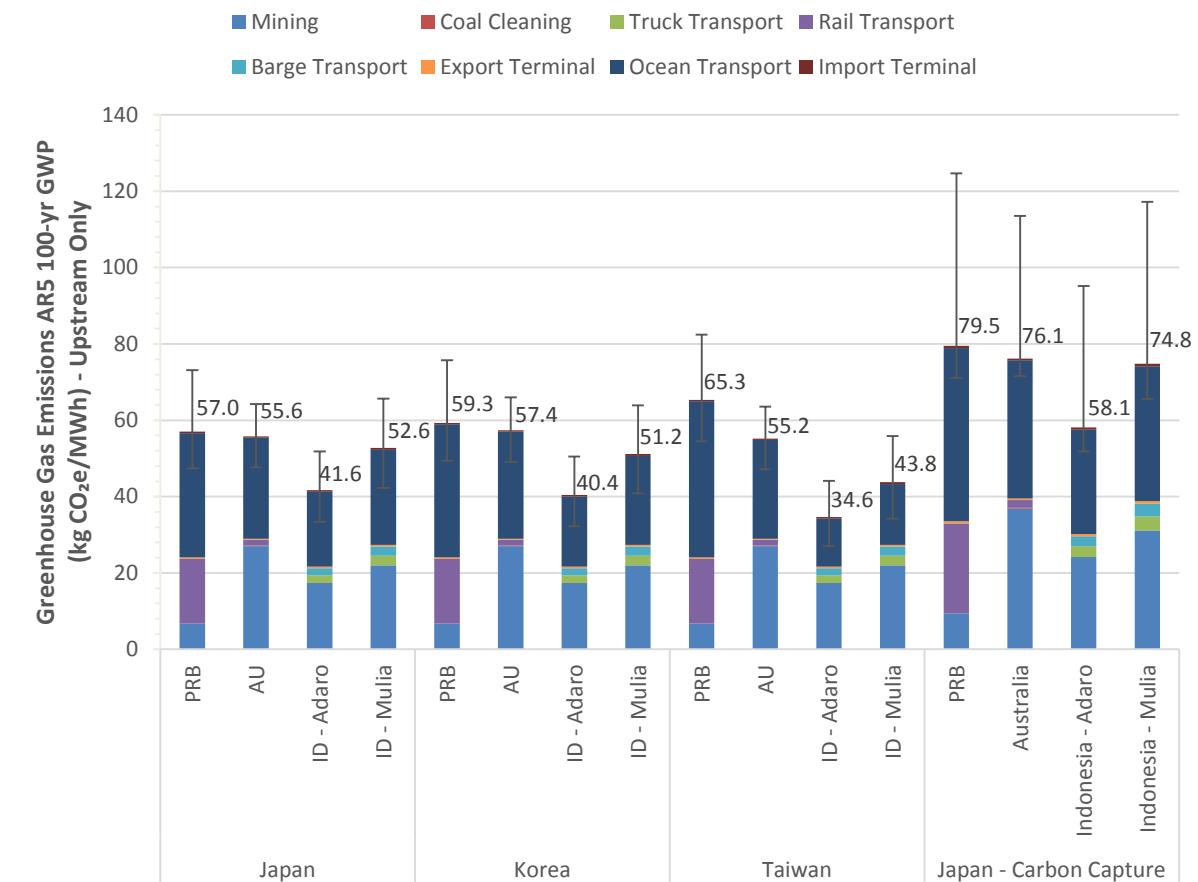
- Sources: U.S. (PRB), Australia, Indonesia
- Destinations: Japan, Korea, Taiwan

## • GHG Analysis:

- Emissions associated with coal mining activities are much more significant in Australia and Indonesia than PRB
- PRB disadvantages: longer transport distance (mine to terminal, terminal to plant) and lower heating value

## • TRACI 2.1 Analysis:

- Global Warming Potential (GWP) is the only impact category where the coal sources are essentially even
- Non-GWP impact categories are driven by emissions from diesel combustion (transport and mining) and affected by differences in diesel regulations between exporting countries



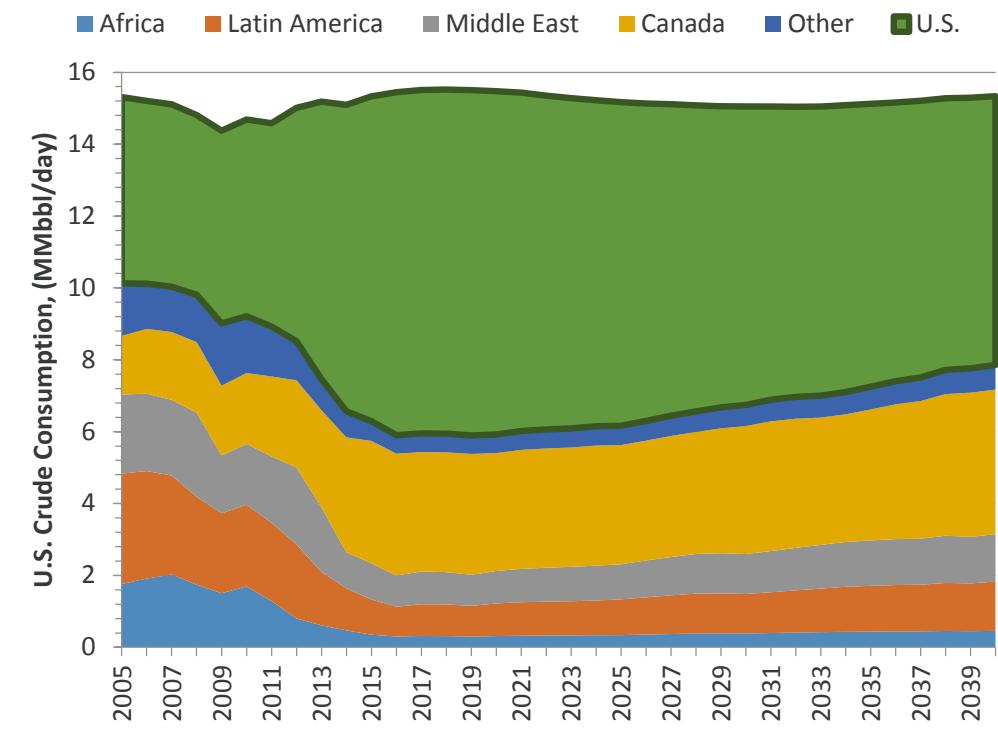
Energies, July 2016, <http://www.mdpi.com/1996-1073/9/7/559/pdf>

# Updating the U.S. Life Cycle GHG Petroleum Baseline to 2014 with Projections to 2040 Using Open-Source Engineering-Based Models

Greg Cooney, Matt Jamieson, Joe Marriott, Joule Bergerson, Adam Brandt, Tim Skone



- Significant changes since 2005 baseline analysis:
  - Known changes to crude oil mix (source, extraction method, and quality)
  - Transition to ultra low sulfur diesel, increasing refinery hydrogen demand
- Utilize publicly available and peer-reviewed tools to inform the life cycle impacts of extraction and refining (OPGEE and PRELIM)
- Evaluate to understand uncertainty in long-term comparisons of alternative fuels projects to the petroleum baseline
- Potential policy implications (EISA Section 526; RFS2)



- U.S. domestic share peaks at 62% in 2016
- Tight oil accounts for 50% of U.S. domestic production by 2015
- EOR share of production doubles over the forecast period
- Canadian imports increase; all other imports drop off

Revising for Environmental Science & Technology

# Synthesis of recent ground-level CH<sub>4</sub> emission measurements from U.S. natural gas supply chain

James Littlefield, Joe Marriott, Greg Schivley, Tim Skone



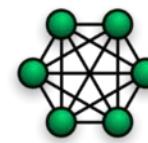
- Challenges
  - Compilation of new data with legacy data
  - Extrapolation of geographically-specific data to broader boundaries
  - Managing skewed emission distributions
- Our overall conclusions about supply chain *have not* changed, but our understanding of actors within supply chain *have* changed



Measure



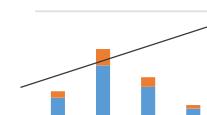
Estimate



Model



Validate

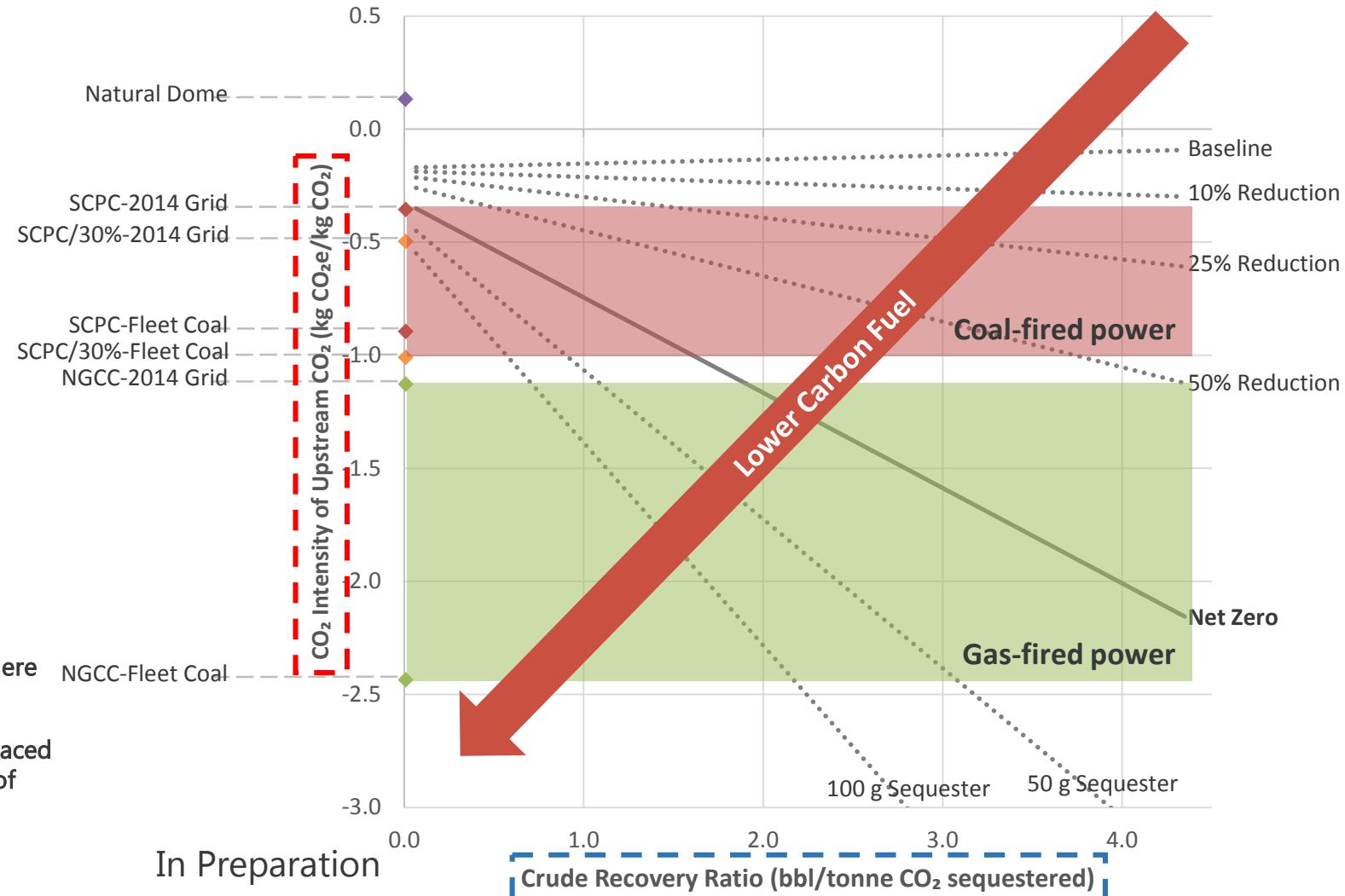
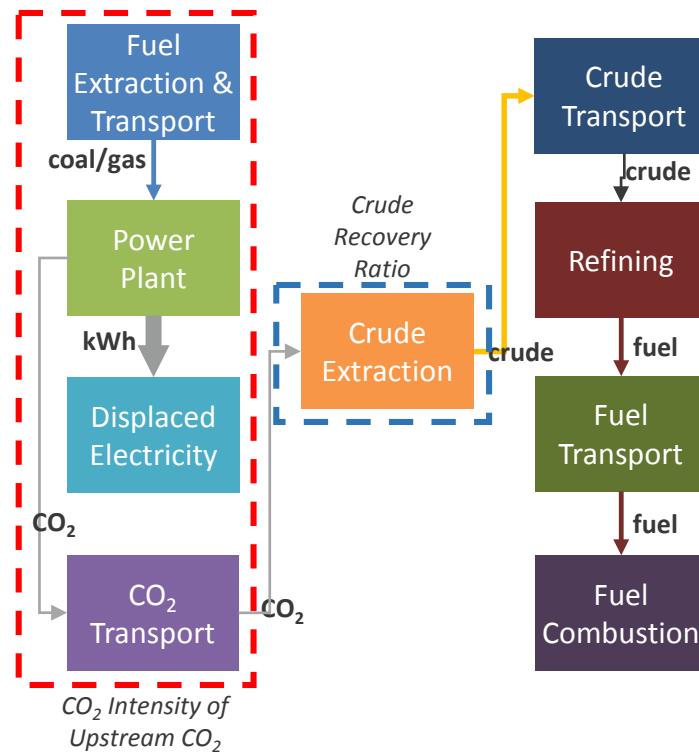


Communicate

Submitted to Journal of Cleaner Production

# EOC for GHG Reduction: Achievable low-carbon fuel targets are dependent on the intersection of CO<sub>2</sub> source GHG intensity & crude recovery efficiency

Greg Cooney, Joe Marriott, Matt Jamieson, Sean McCoy, Tim Skone



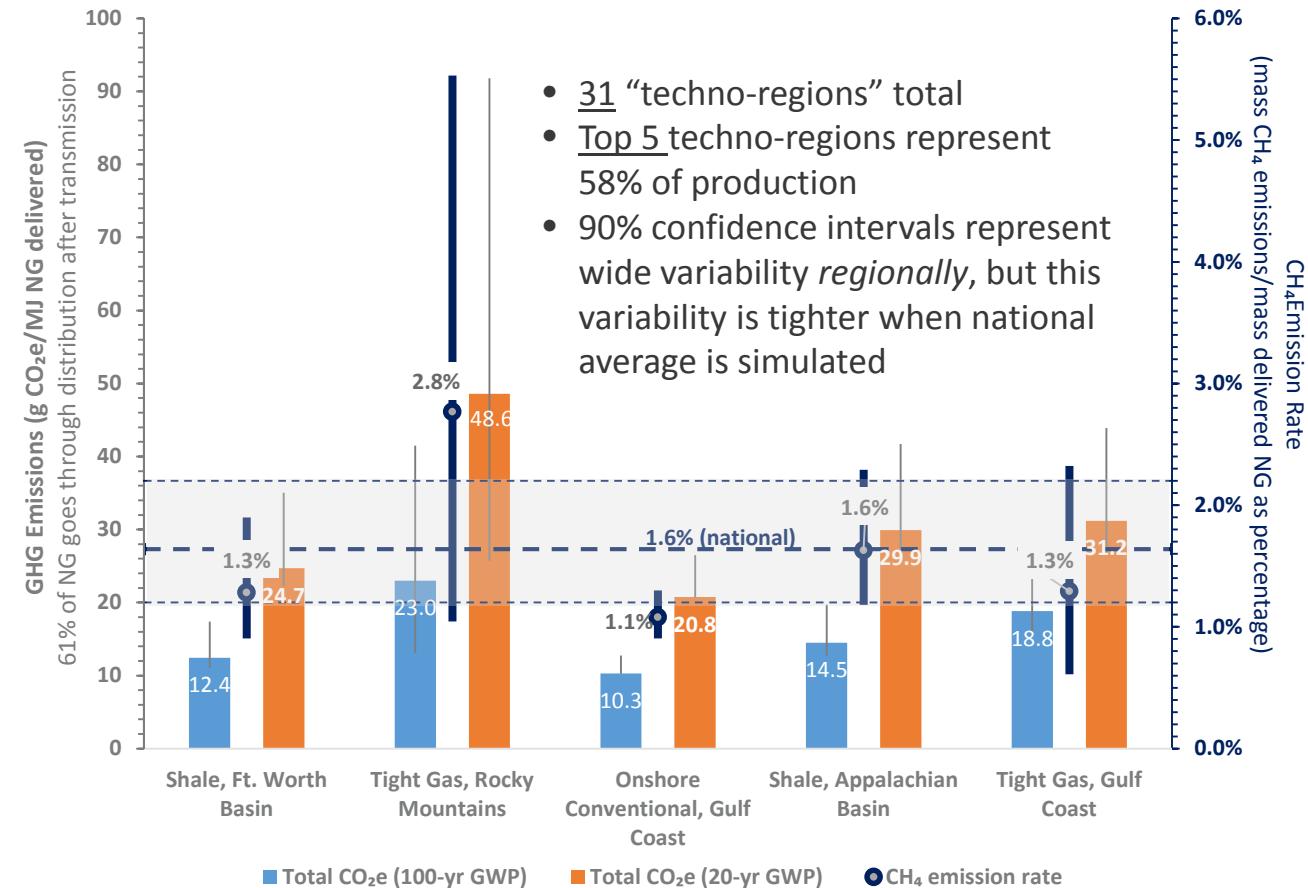
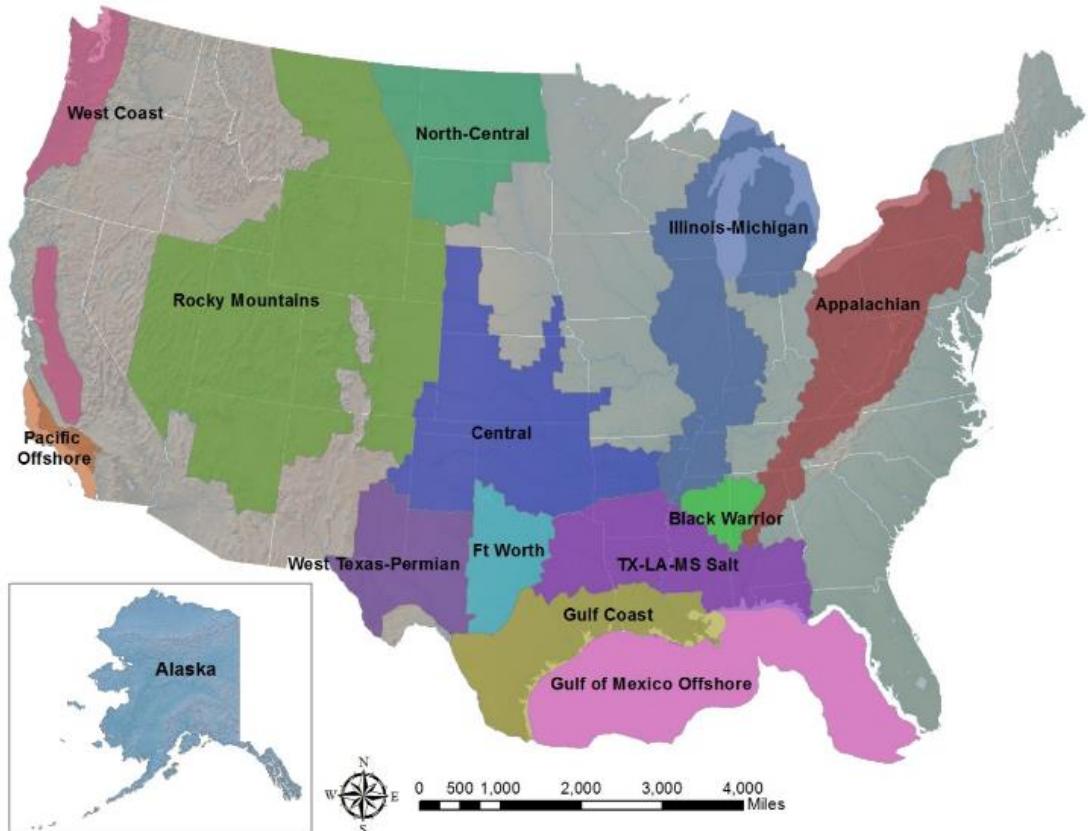
In Preparation



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# Natural Gas Modeling Updates

Technological & regional variability managed with a stochastic GHG model



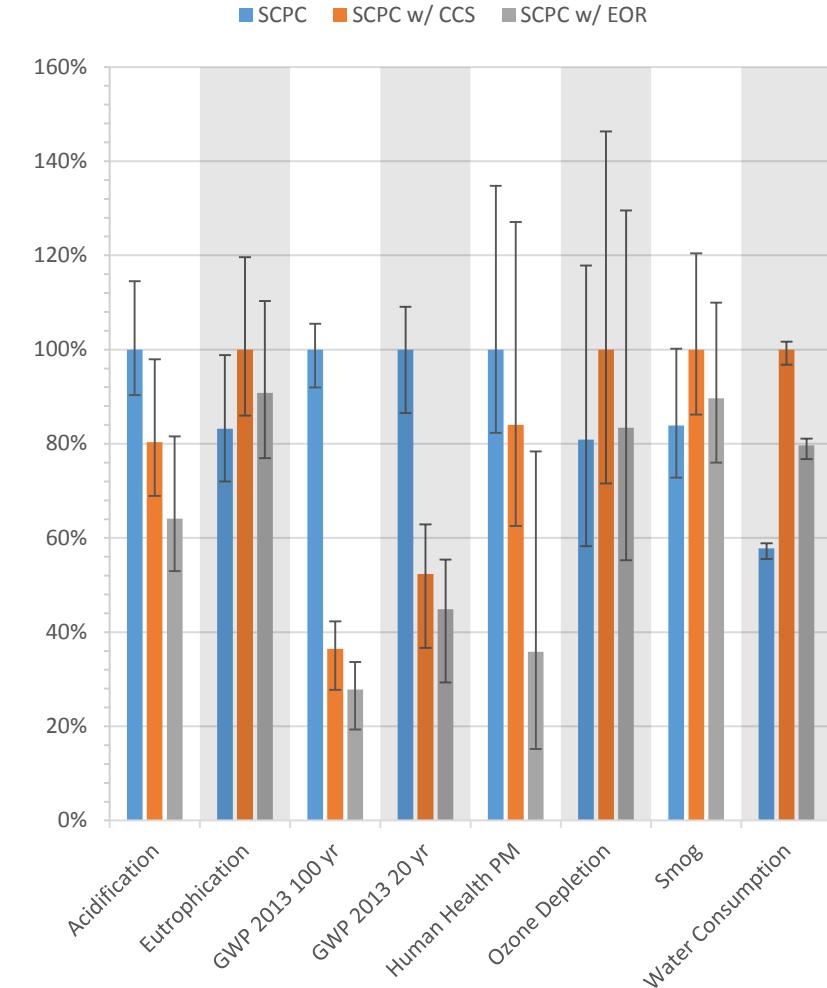
2016 version of *LCA of Natural Gas Extraction and Power Generation* is available on NETL's Energy Analysis site:  
[www.netl.doe.gov/energy-analysis/temp/LifeCycleAnalysisofNaturalGasExtractionandPowerGeneration\\_083016.pdf](http://www.netl.doe.gov/energy-analysis/temp/LifeCycleAnalysisofNaturalGasExtractionandPowerGeneration_083016.pdf)

# Advanced Fossil Power Baseline LCAs



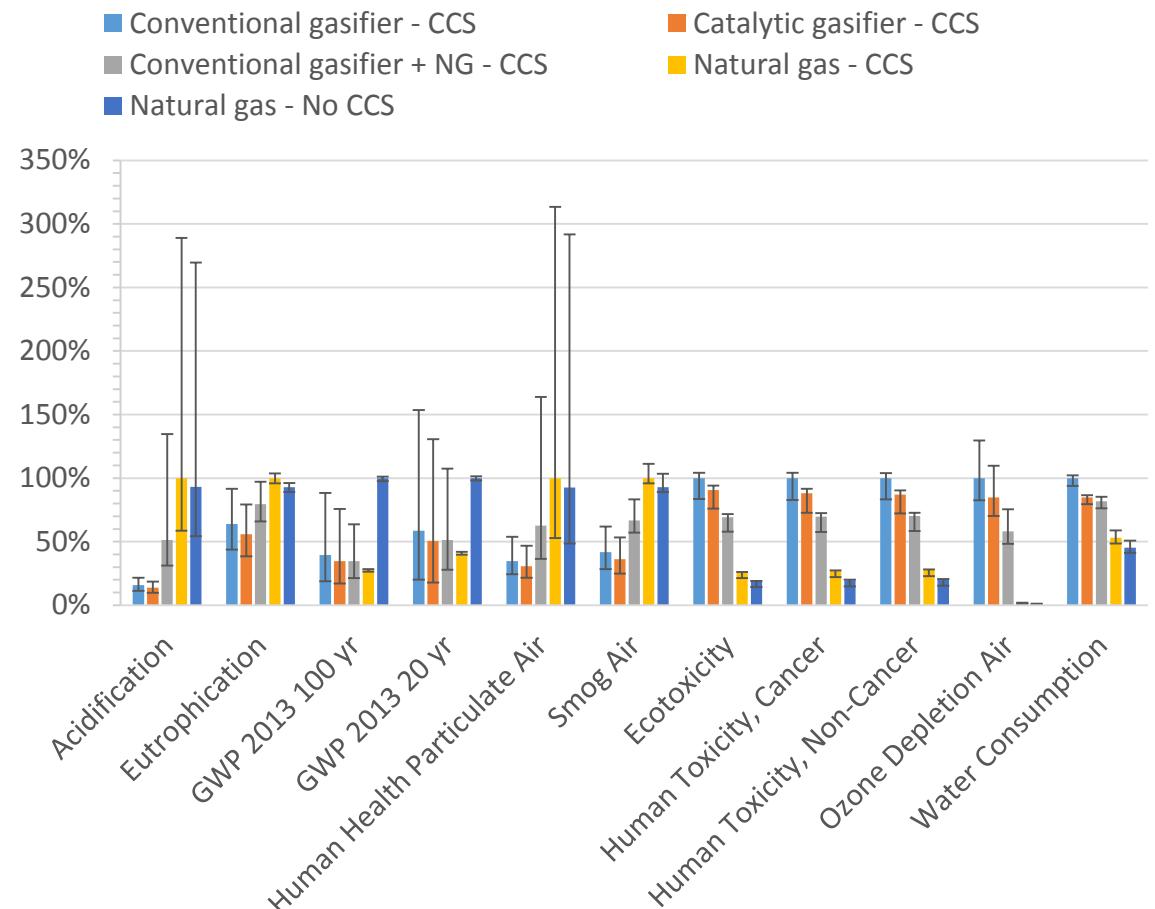
- NETL has updated power plant baseline studies – the baseline LCA studies have been updated based on the new reports:
  - Sub-critical pulverized coal
  - Supercritical pulverized coal
  - Natural gas combined cycle
  - Oxycombusted pulverized coal
- New LCA studies include life cycle impact results

All four reports available soon at: [www.netl.doe.gov/lca](http://www.netl.doe.gov/lca)



# Solid Oxide Fuel Cell LCA

- Fuel cell LCA includes different technologies and feedstocks
  - Conventional and catalytic gasifiers
  - Coal, natural gas, and coal with natural gas
- TRACI 2.1 impacts + water consumption
- Stochastic cost of electricity results
- Normalized environmental results are shown here



# EPA Greenhouse Gas Inventory - Natural Gas

## Uncertainty and Time Series Review

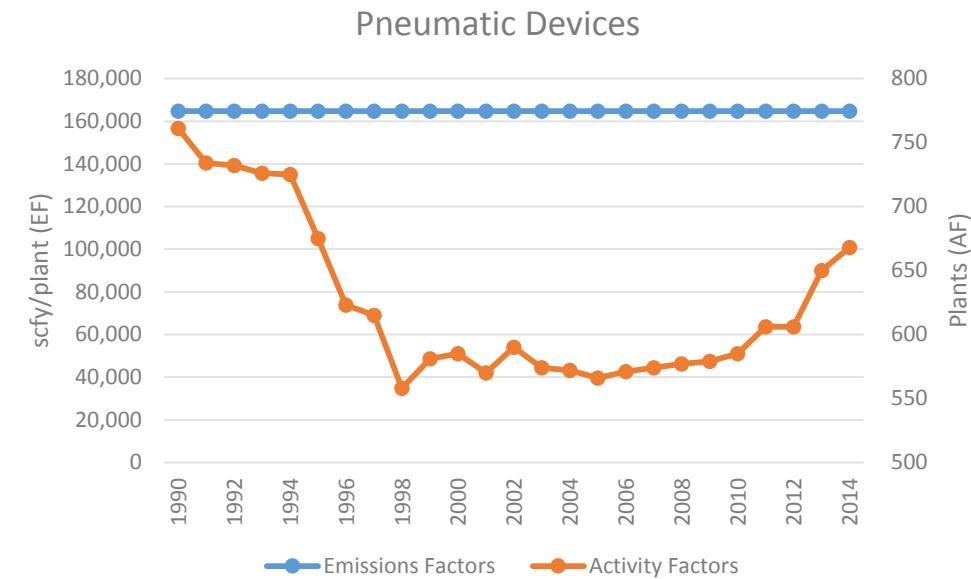


### • Time Series

- Review of 1990-2010 GHG Inventory Data for top 80% of GHG Emissions (21 largest sources)
  - Check interpolation assumptions
  - Look for alternative data sources

### • Uncertainty

- Subject Matter Experts for ERG Analysis of GHG Inventory
  - Provide 90 confidence intervals for inputs
  - Select distribution type for inputs



Example of emissions and activity factors from GHGI time series data between 1990 and 2014

# Federal LCA Commons



- The Federal LCA Commons is a collaboration among U.S. federal agencies to combine their LCA inventories and tools into an open access, usable product ([lcacommons.gov](http://lcacommons.gov))
- NETL is working with NREL and USDA to translate NETL's unit processes into openLCA format and publish the database on the LCA Federal Commons.

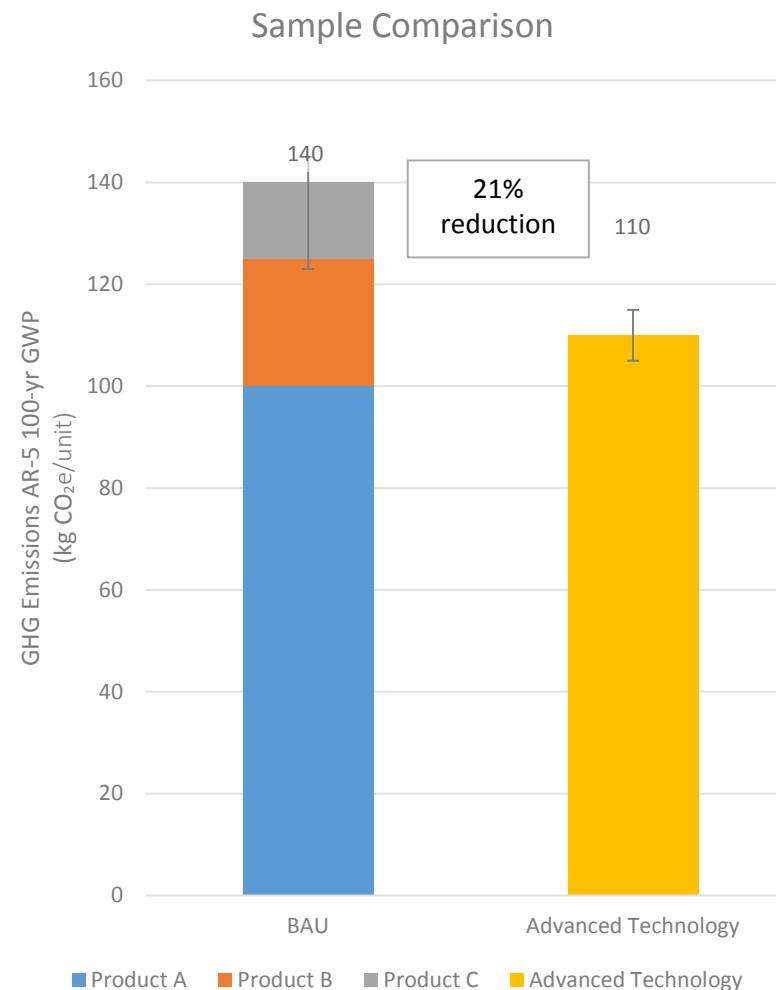


# DOE Loan Program Office GHG Analysis

<http://energy.gov/lpo/innovative-clean-energy-projects-title-xvii-loan-program>

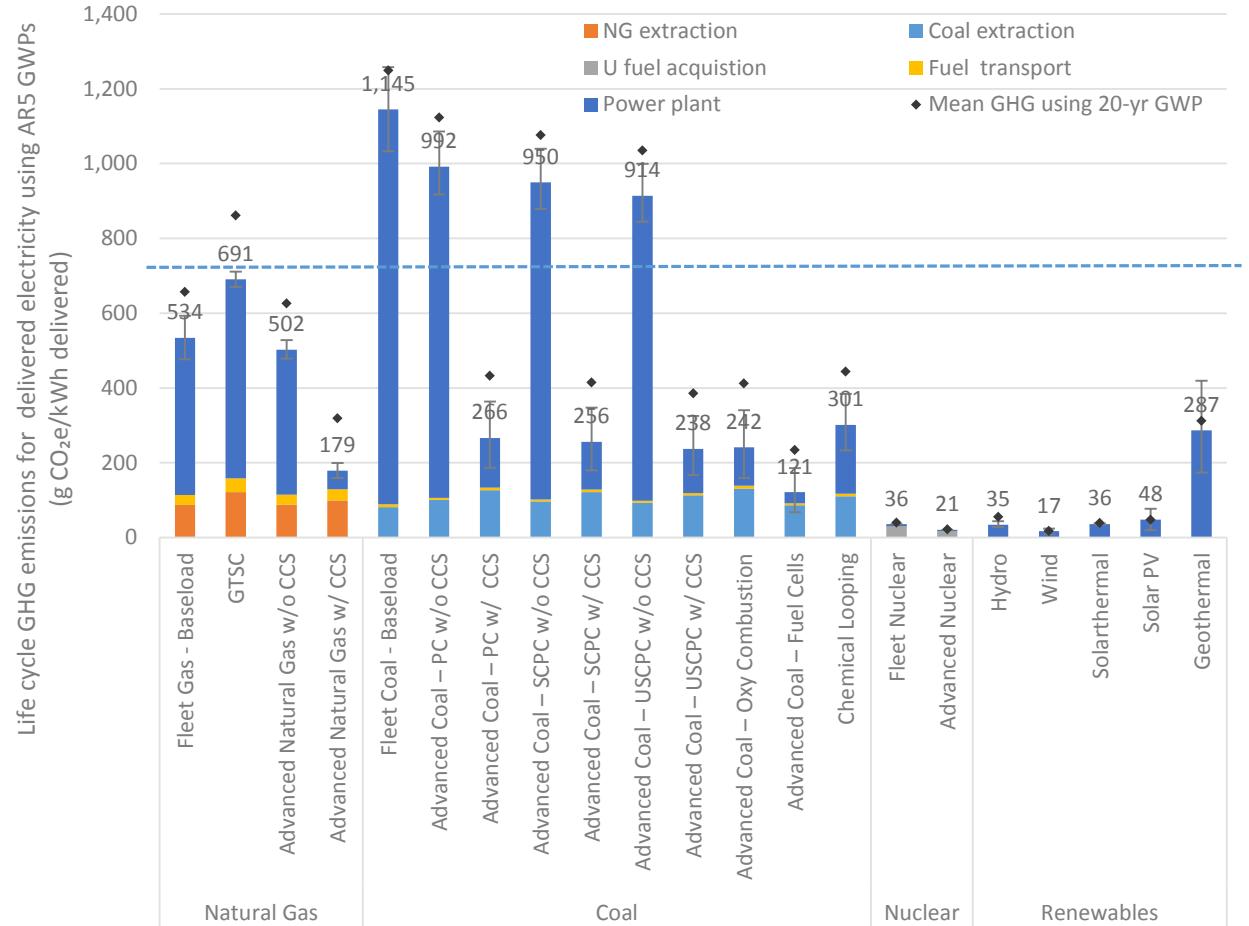


- **Background:**
  - Applicants must “avoid, reduce, or sequester” GHG emissions
    - Advanced Fossil
    - Renewable Energy and Efficient Energy
  - Compares GHG emissions to a business-as-usual (BAU) scenario
- **Analysis:**
  - Suggest BAU product or technology
  - Calculate life cycle GHG emissions for the applicant and BAU
  - Include all products in the comparison
- **NETL provided analysis for over a dozen projects in the past year**



# Emerging Work: Power Baseline

- We've characterized life cycles of >95% of components of U.S. electricity grid
- Calculating a national value for current year is straightforward
- Key questions:
  - How does our answer change with temporal and technology shifts?
  - What data and modeling capabilities are required to make a power baseline more useful?



# Other Emerging Work

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- Implementation of Consequential LCA for Energy Systems
- Development of Social LCIA Metrics & MCDM frameworks
- Creation of Power System Construction Inventories

# 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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Joe Marriott

Principal Engineer • KeyLogic

[joseph.marriott@netl.doe.gov](mailto:joseph.marriott@netl.doe.gov)

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James Littlefield

Senior Engineer • KeyLogic

[james.littlefield@netl.doe.gov](mailto:james.littlefield@netl.doe.gov)



[netl.doe.gov/LCA](http://netl.doe.gov/LCA)



[LCA@netl.doe.gov](mailto:LCA@netl.doe.gov)



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