

Overview of Energy Life Cycle Analysis at NETL



Tim Skone, Joe Marriott, James Littlefield

LCA XVI, Charleston, SC

September 27, 2016



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

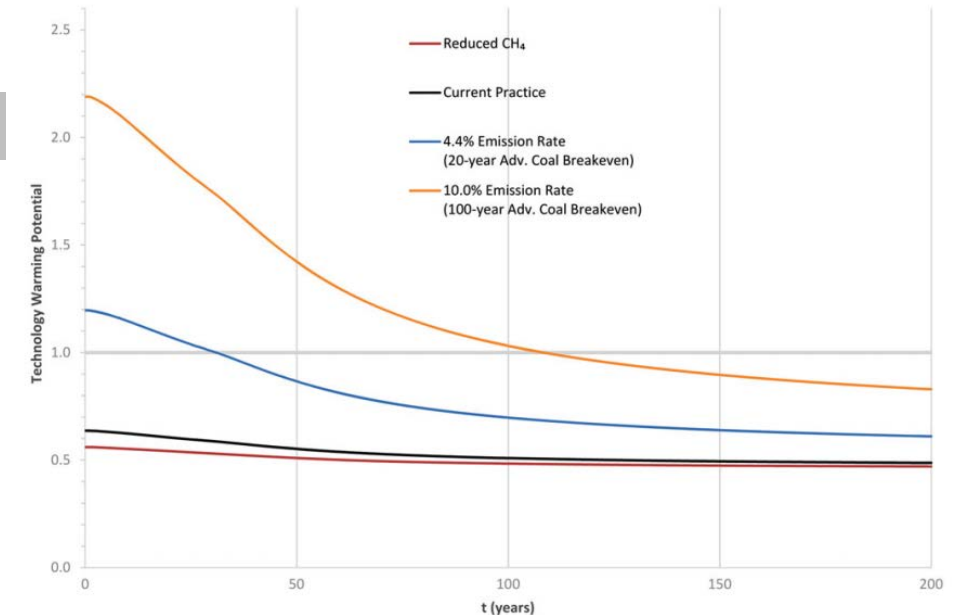
Using Common Boundaries to Assess CH₄ Emissions: a Life Cycle Evaluation of Natural Gas & Coal Power Systems

James Littlefield, Joe Marriott, Greg Schivley, Tim Skone



- Emphasizes the importance of boundary selection when expressing CH₄ 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 ₄)				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%
Numerator					Denominator		



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:**

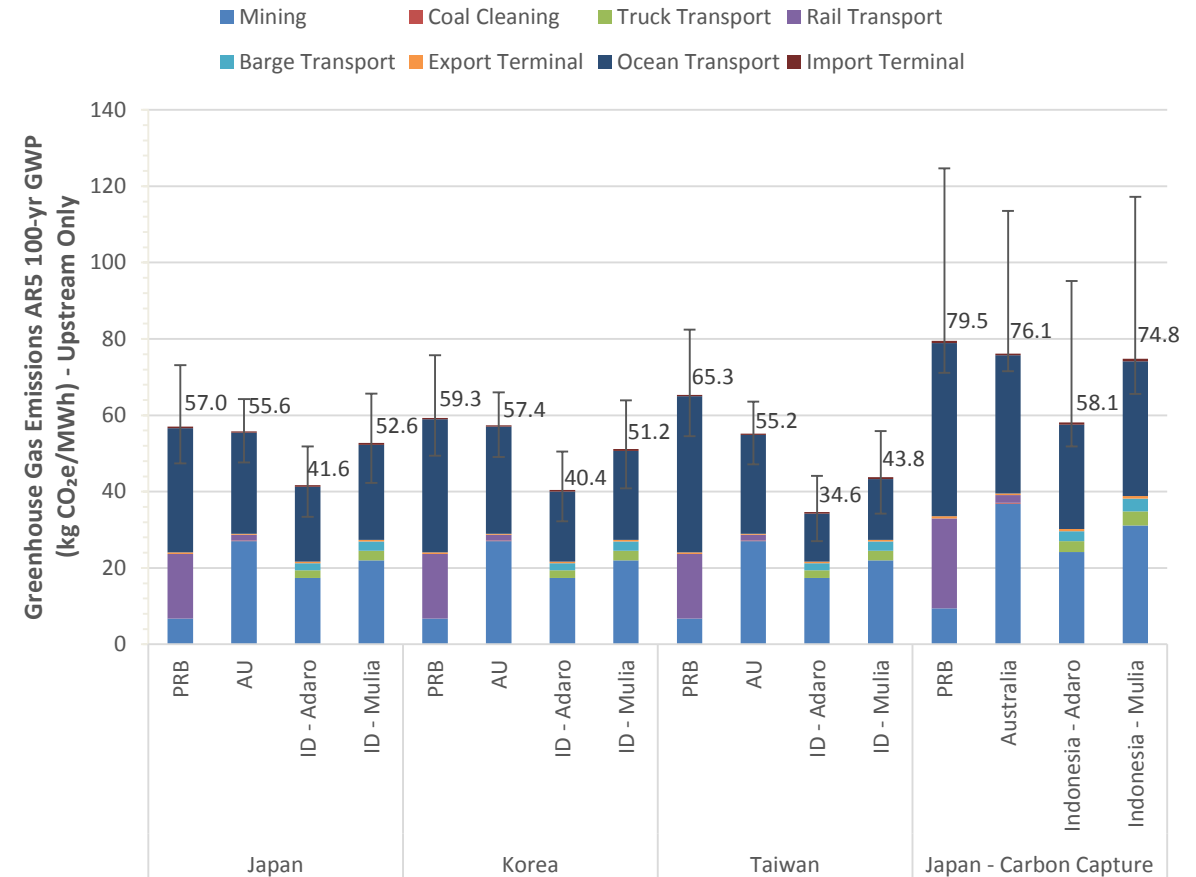
- Sources: U.S. (PRB), Australia, Indonesia
- Destinations: Japan, Korea, Taiwan

- **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



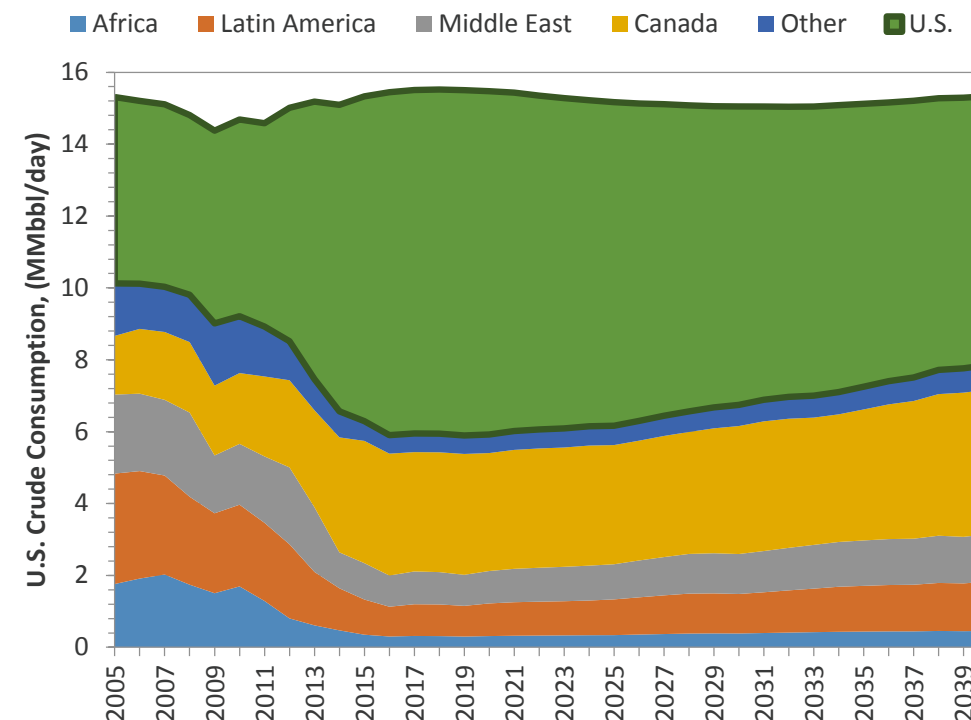
Energies, July 2016, <http://www.mdpi.com/1996-1073/9/7/559/pdf>

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 CH₄ 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



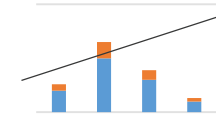
Estimate



Model



Validate

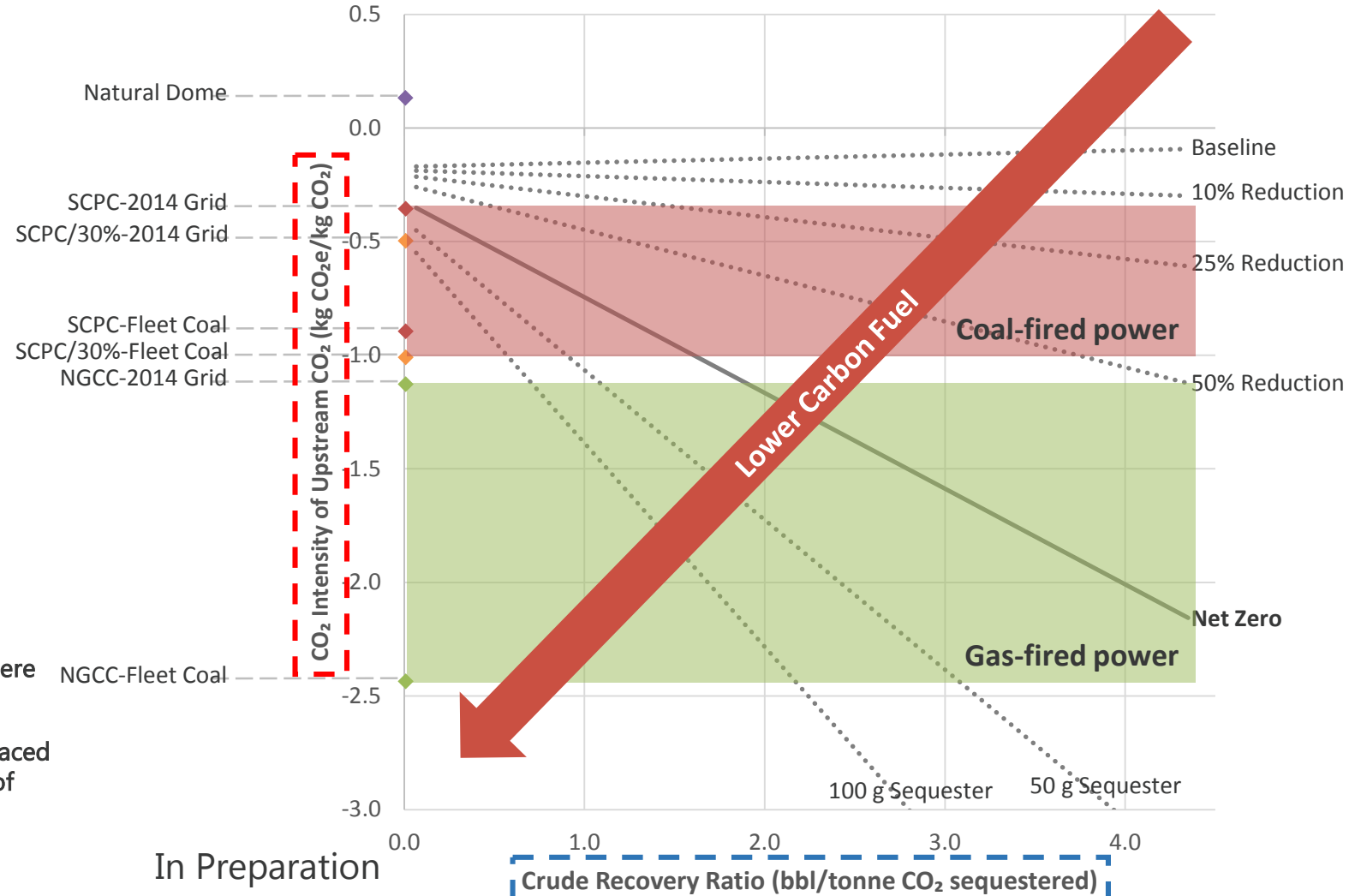
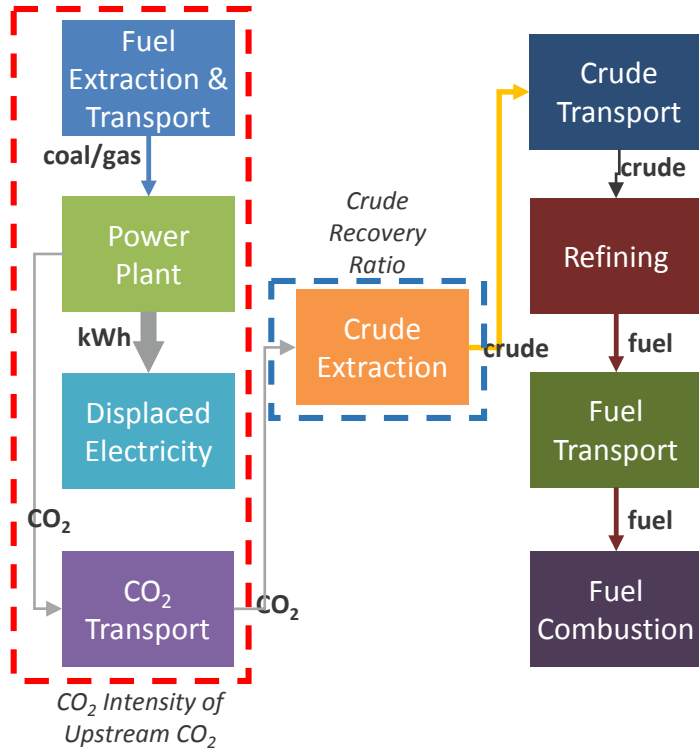


Communicate

Submitted to Journal of Cleaner Production

EOR for GHG Reduction: Achievable low-carbon fuel targets are dependent on the intersection of CO₂ source GHG intensity & crude recovery efficiency

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

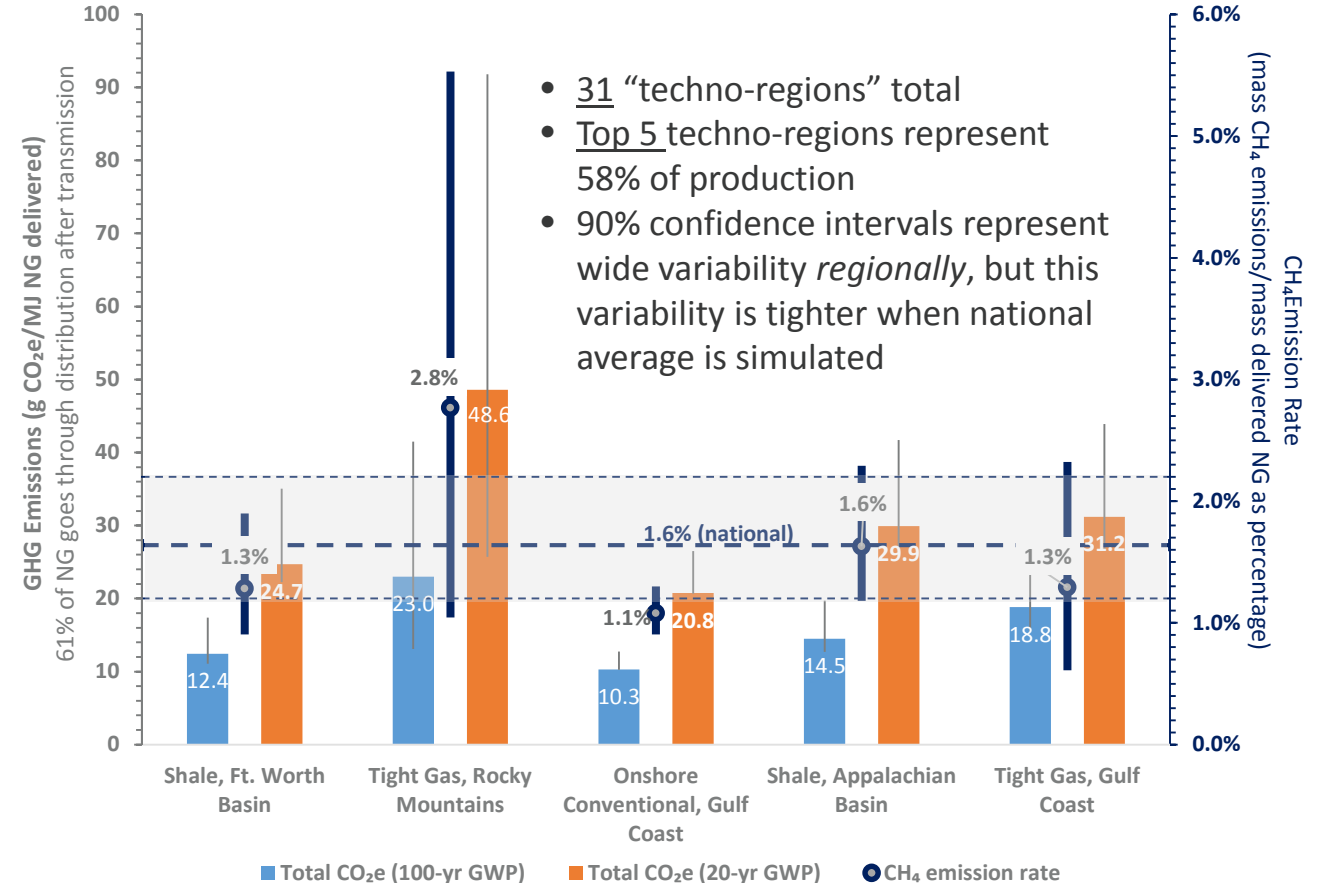
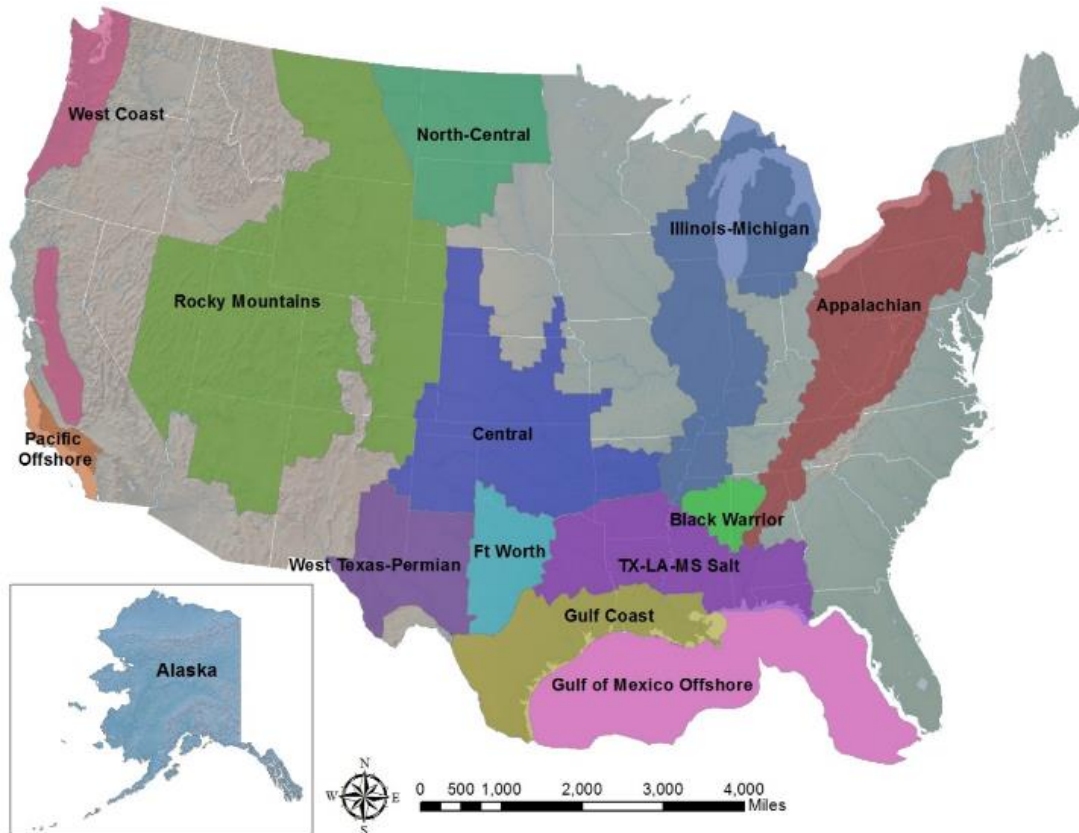


In Preparation

Crude Recovery Ratio (bbl/tonne CO₂ sequestered)

Natural Gas Modeling Updates

Technological & regional variability managed with a stochastic GHG model



- 31 “techno-regions” total
- Top 5 techno-regions represent 58% of production
- 90% confidence intervals represent wide variability *regionally*, but this variability is tighter when national average is simulated

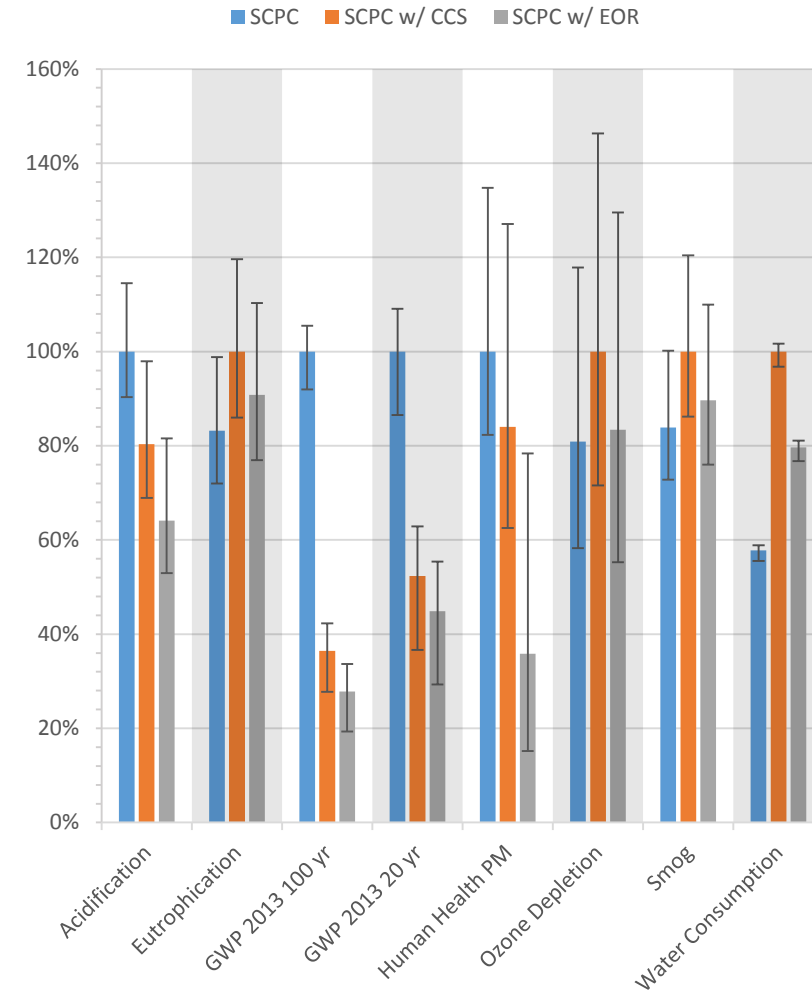
2016 version of *LCA of Natural Gas Extraction and Power Generation* is available on NETL’s Energy Analysis site:

www.netl.doe.gov/energy-analysis/temp/LifeCycleAnalysisofNaturalGasExtractionandPowerGeneration_083016.pdf

Advanced Fossil Power Baseline LCAs

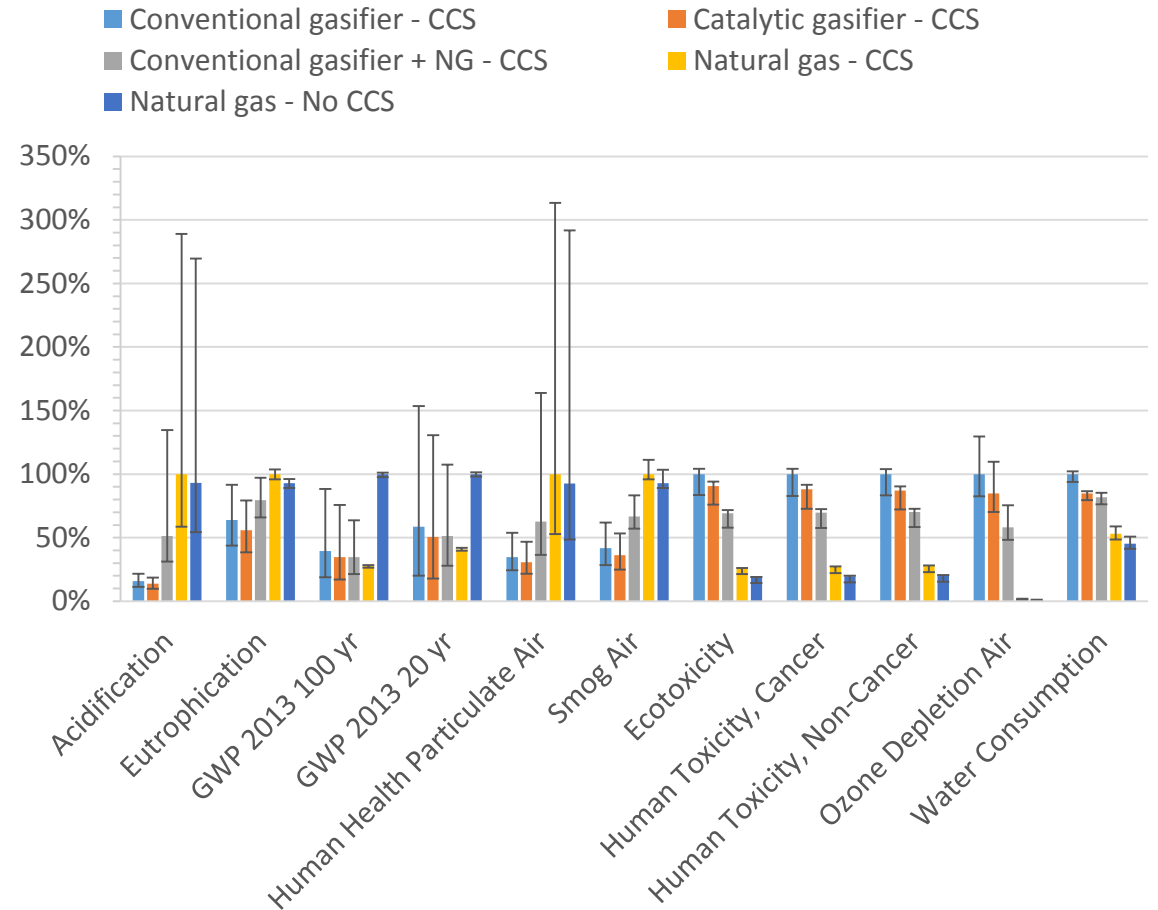
- NETL has updated power plant baseline studies – the baseline LCA studies have been updated based on the new reports:
 - Sub-critical pulverized coal
 - Supercritical pulverized coal
 - Natural gas combined cycle
 - Oxycombusted pulverized coal
- New LCA studies include life cycle impact results

All four reports available soon at: www.netl.doe.gov/lca



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

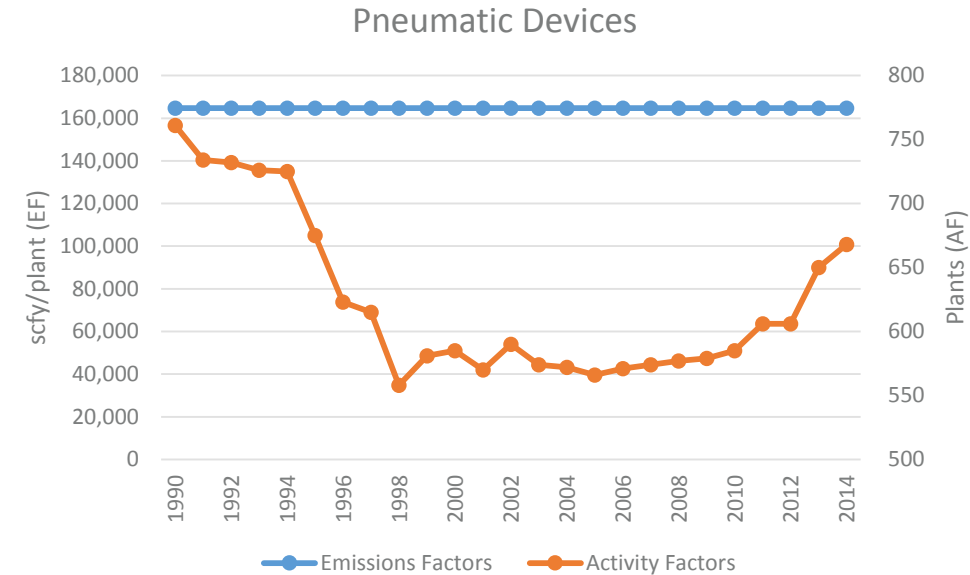


- **Time Series**

- 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)
- 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:**

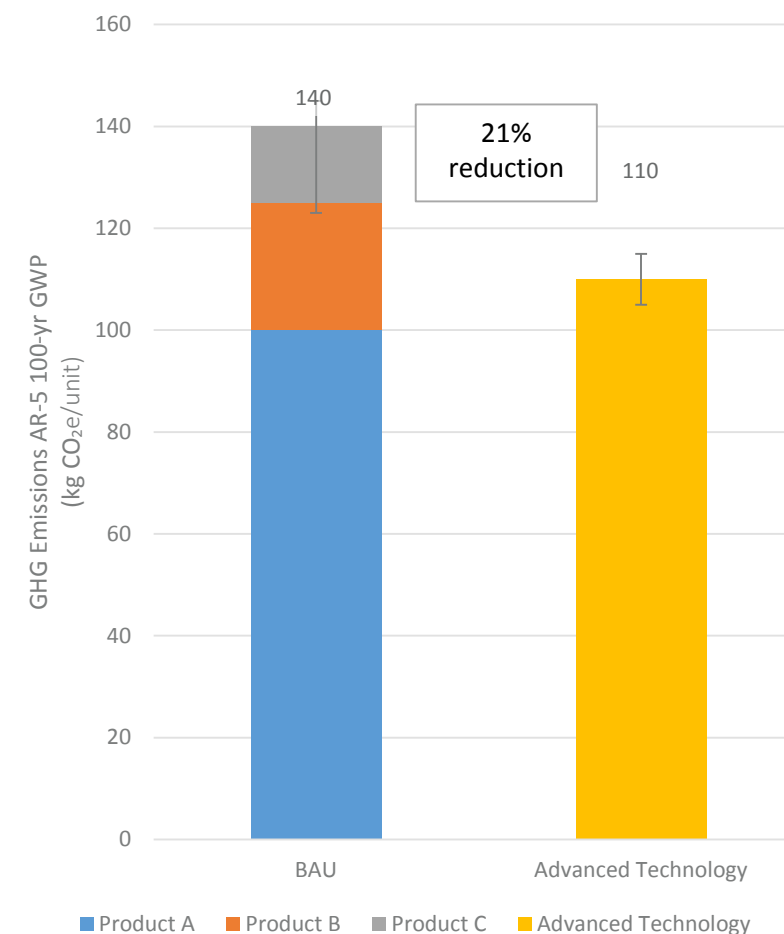
- Applicants must “avoid, reduce, or sequester” GHG emissions
 - Advanced Fossil
 - Renewable Energy and Efficient Energy
- Compares GHG emissions to a business-as-usual (BAU) scenario

- **Analysis:**

- Suggest BAU product or technology
- Calculate life cycle GHG emissions for the applicant and BAU
- Include all products in the comparison

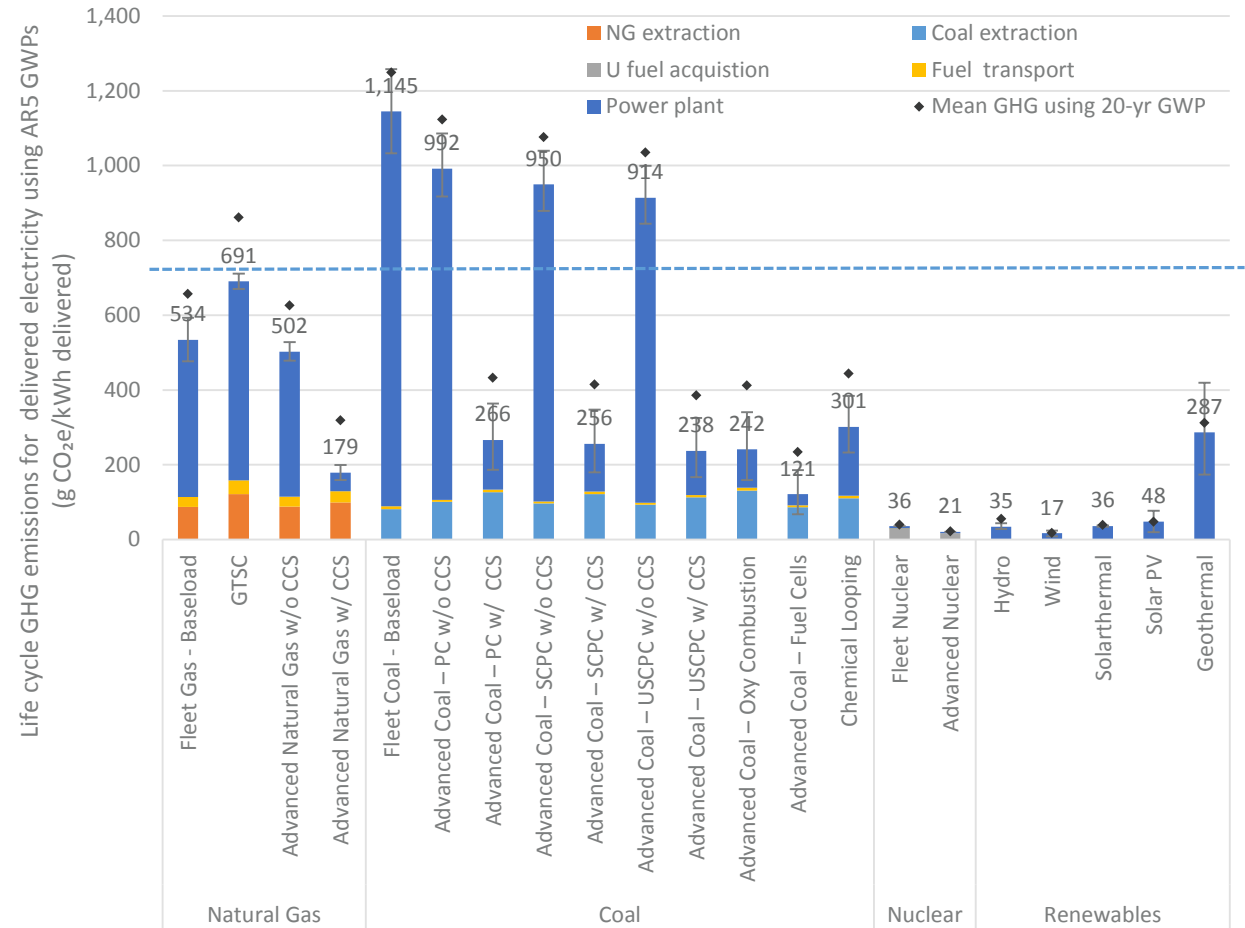
- **NETL provided analysis for over a dozen projects in the past year**

Sample Comparison



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

- 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

Joe Marriott

Principal Engineer • KeyLogic
joseph.marriott@netl.doe.gov

James Littlefield

Senior Engineer • KeyLogic
james.littlefield@netl.doe.gov



netl.doe.gov/LCA



LCA@netl.doe.gov



[@NETL_News](https://twitter.com/NETL_News)