U.S. DOE/NETL LCA of LNG: Overview & Key (LCA) Challenges

Presented by: Timothy J. Skone, P.E.

LNGnet, SWG2-Mtg1, July 1, 2021

Estimating methane and CO_2 emissions along LNG supply chains – what role for the Life Cycle Assessment Approaches?

U.S. DEPARTMENT OF ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Agenda

- **Overview of LCA at NETL**
- **Upstream Natural Gas Model**
- **LNG Life Cycle Model**
  - LNG Scenarios
  - LNG Key Parameters
  - LNG Results
- **Key (LCA) Challenges – Lessons Learned**

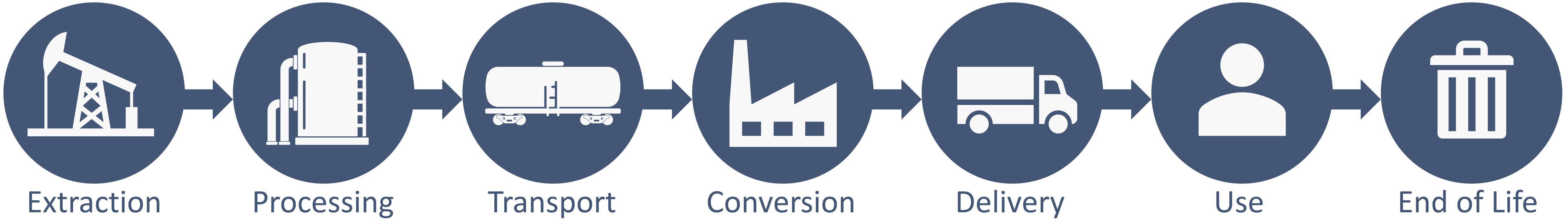
What is Life Cycle Assessment/Analysis (LCA)?

LCA is a technique that helps people make better decisions to improve and protect the environment by accounting for the potential impacts from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (i.e. cradle-to-grave).

Energy Life Cycle Analysis (LCA)

Cradle-to-grave environmental footprint of energy systems

NATIONAL ENERGY TECHNOLOGY LABORATORY



Mission

Evaluate existing and emerging energy systems to guide R&D and protect the environment for future generations

Vision

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

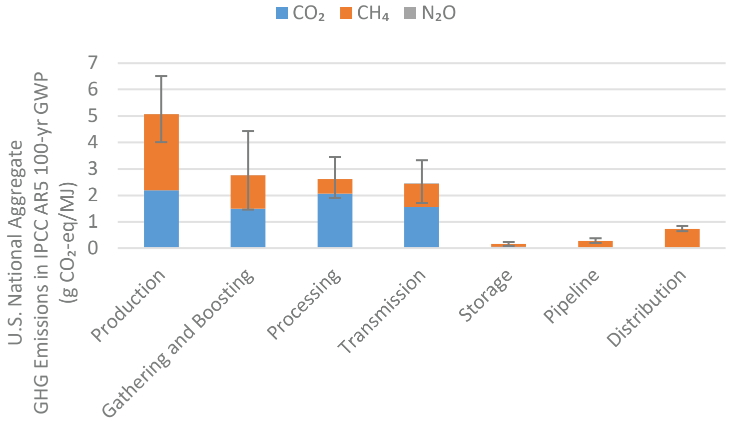
LCA
Life Cycle Analysis
• energy sustainability •

netl.doe.gov/LCA LCA@netl.doe.gov @NETL_News

Upstream Natural Gas Model

U.S. Natural Gas Baseline

(Year 2016 Data, later updated to 2017 data in the ONE Future Phase 2 report)

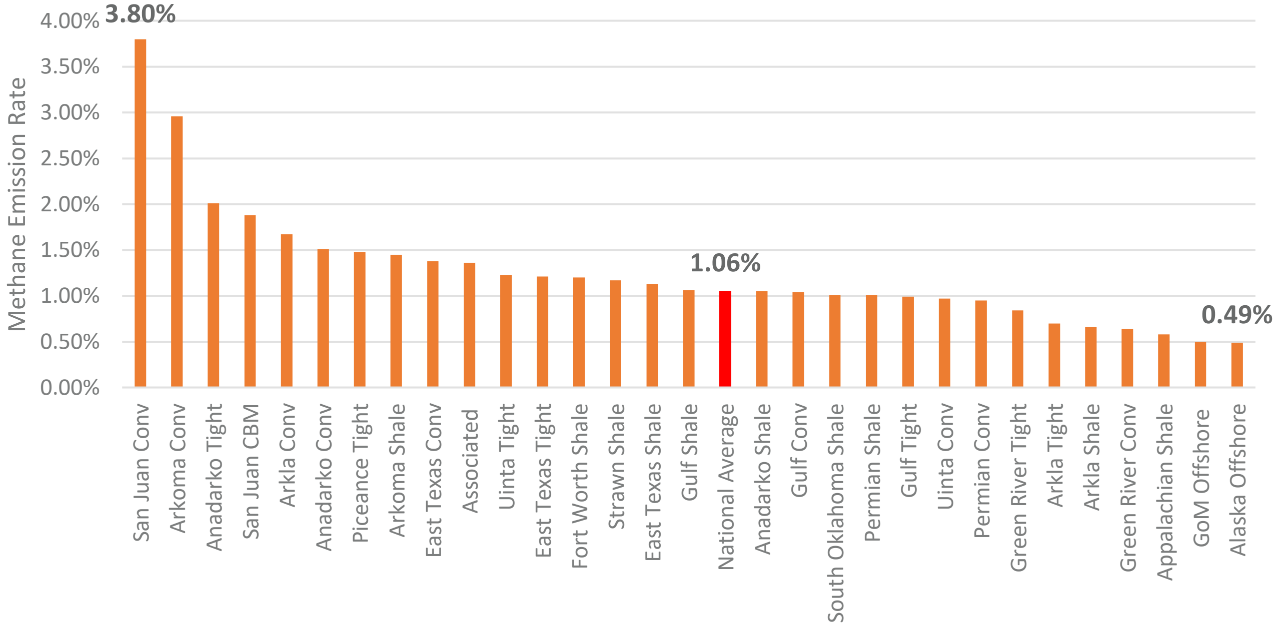


Scope Overview

- Cradle-to-gate analysis including all activities involved in natural gas extraction, intermediate gathering, processing, transportation, and distribution to end users
- Scenarios include 27 onshore scenarios (14 onshore production basins with their respective extraction technologies), 2 offshore production scenarios, and 1 associated gas scenario

Highlights

- National average life cycle GHG emissions from the natural gas supply chain are 14.1 g CO_2e/MJ (with a mean confidence interval of 10.0 to 19.2 g CO_2e/MJ)
- CH_4 emission rate for the national average is 1.06%, with a 95% confidence interval ranging from 0.75 to 1.46%

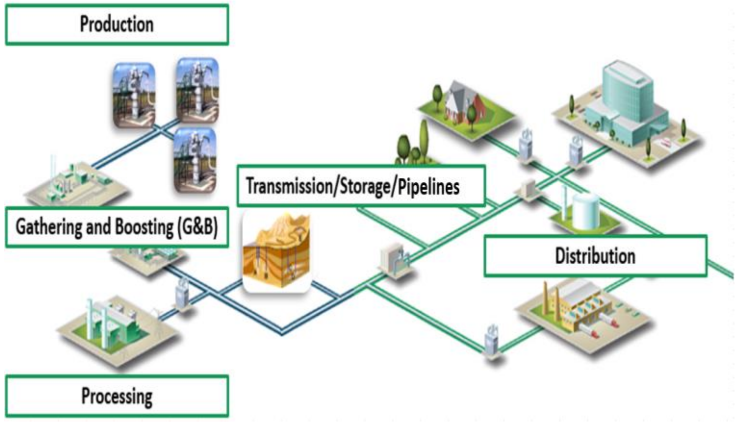


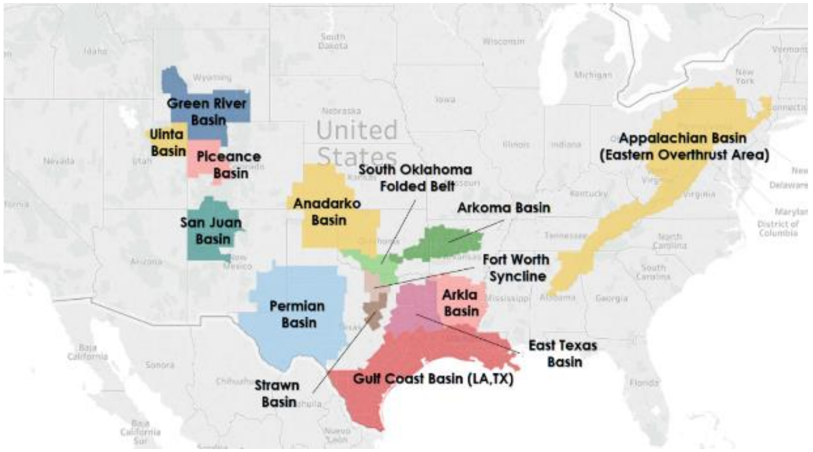
Outcomes

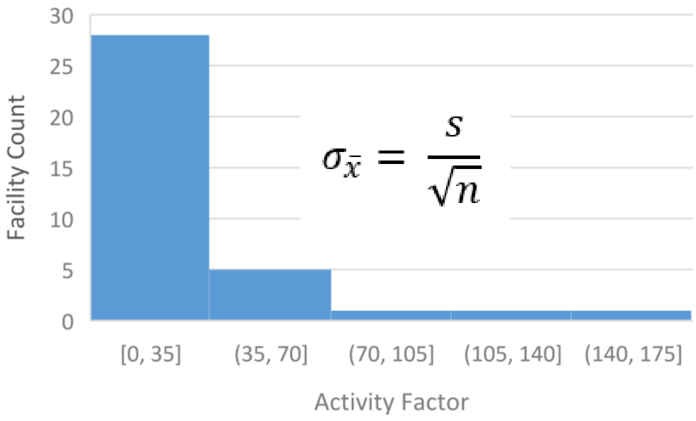
- Report and model publicly released. 2017 results released separately.
- https://netl.doe.gov/energy-analysis/details?id=3198
- https://netl.doe.gov/energy-analysis/details?id=35d27478-88a0-4ef4-ab51-2e1bbcf5332e

Upstream Modeling Approach

Processed-based Modeling	Regionalization	Characterization of Variability



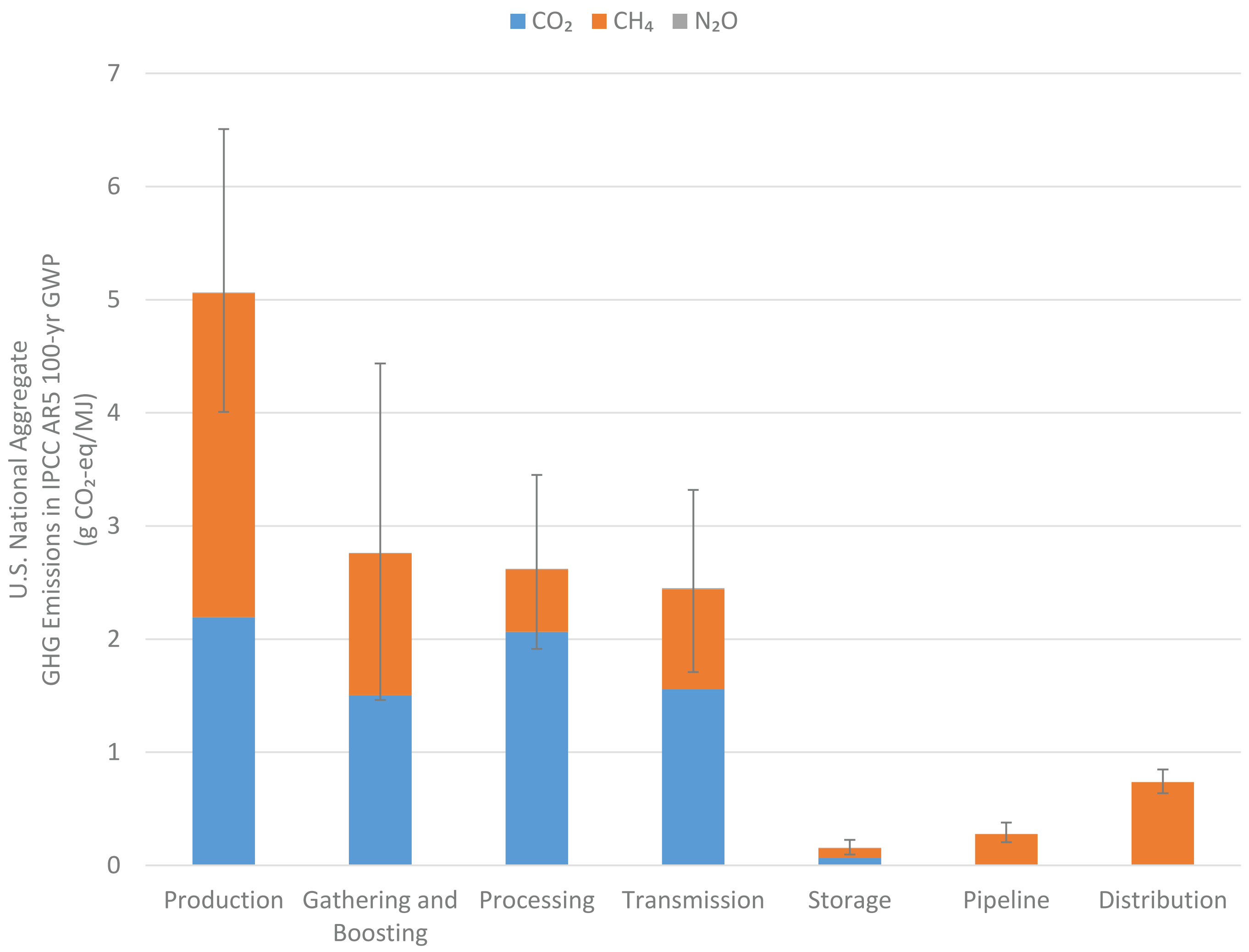




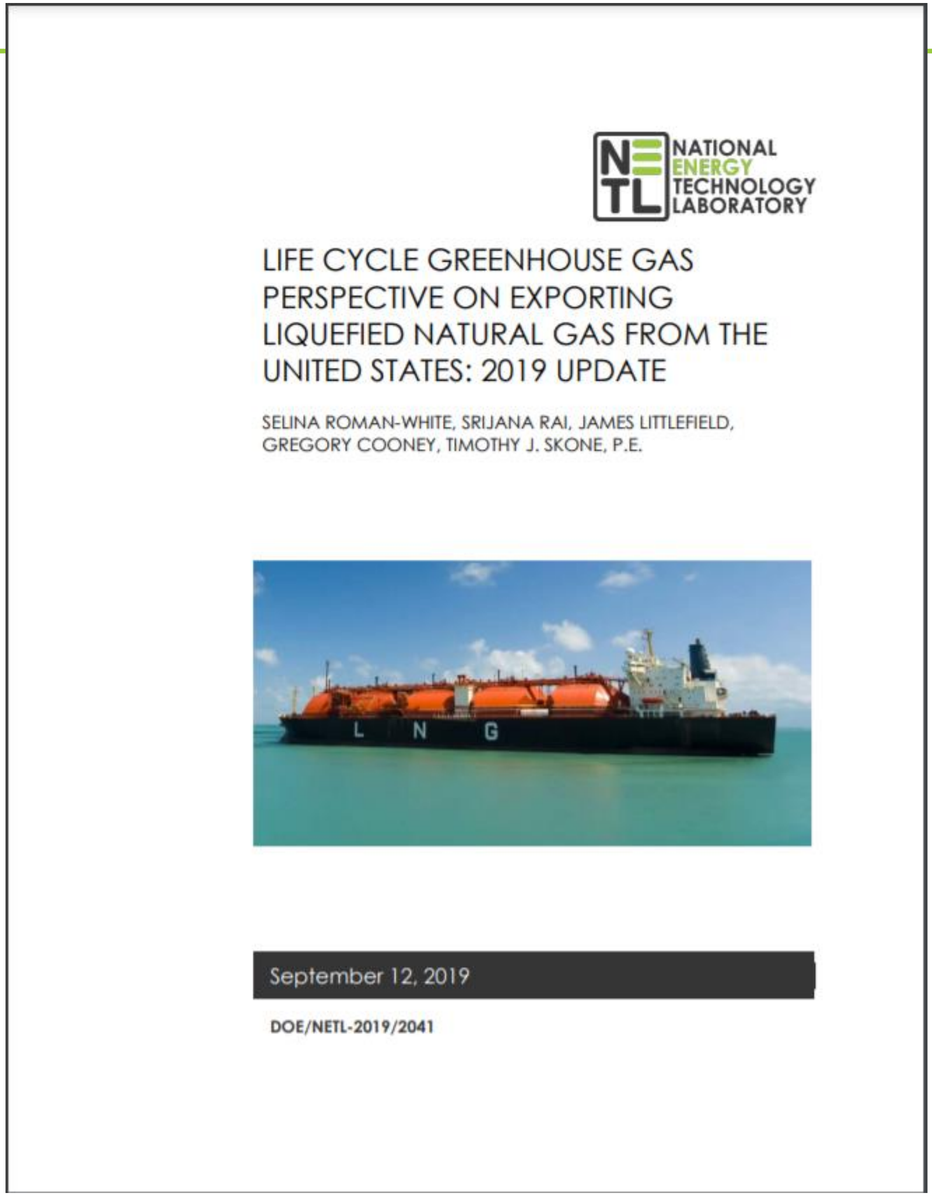
$$\sigma_{\bar{x}} = \frac{s}{\sqrt{n}}$$

NETL's modeling approach allows identification of specific emission sources, key contributors to life cycle emissions, and component-level uncertainty.

Results: Stage Contributions



- Due to combustion for energy and flaring, production through transmission are sources of CH_4 and CO_2 emissions
- Storage, pipeline and distribution have fewer sources of combustion emissions, so their GHG emissions are mostly CH_4
- Error bars represent 95% confidence interval of sample means
- CO_2e in 100-yr GWP
  - Mean **14.1 g CO_2e/MJ**
  - 95% CI of 10.0 to 19.2 g CO_2e/MJ
- CO_2e in 20-yr GWP
  - Mean **23.5 g CO_2e/MJ**
  - 95% CI of 16.7 to 32.2 g CO_2e/MJ



NATIONAL ENERGY TECHNOLOGY LABORATORY

LIFE CYCLE GREENHOUSE GAS PERSPECTIVE ON EXPORTING LIQUEFIED NATURAL GAS FROM THE UNITED STATES: 2019 UPDATE

SELINA ROMAN-WHITE, SRIJANA RAI, JAMES LITTLEFIELD, GREGORY COONEY, TIMOTHY J. SKONE, P.E.

September 12, 2019

DOE/NETL-2019/2041

LNG Life Cycle Model

Life Cycle GHG Analysis of LNG Exports

Scope Overview

- Objective: Determine if exporting U.S. LNG to European and Asian markets for power production is environmentally beneficial compared to in-country coal production and use for power production.

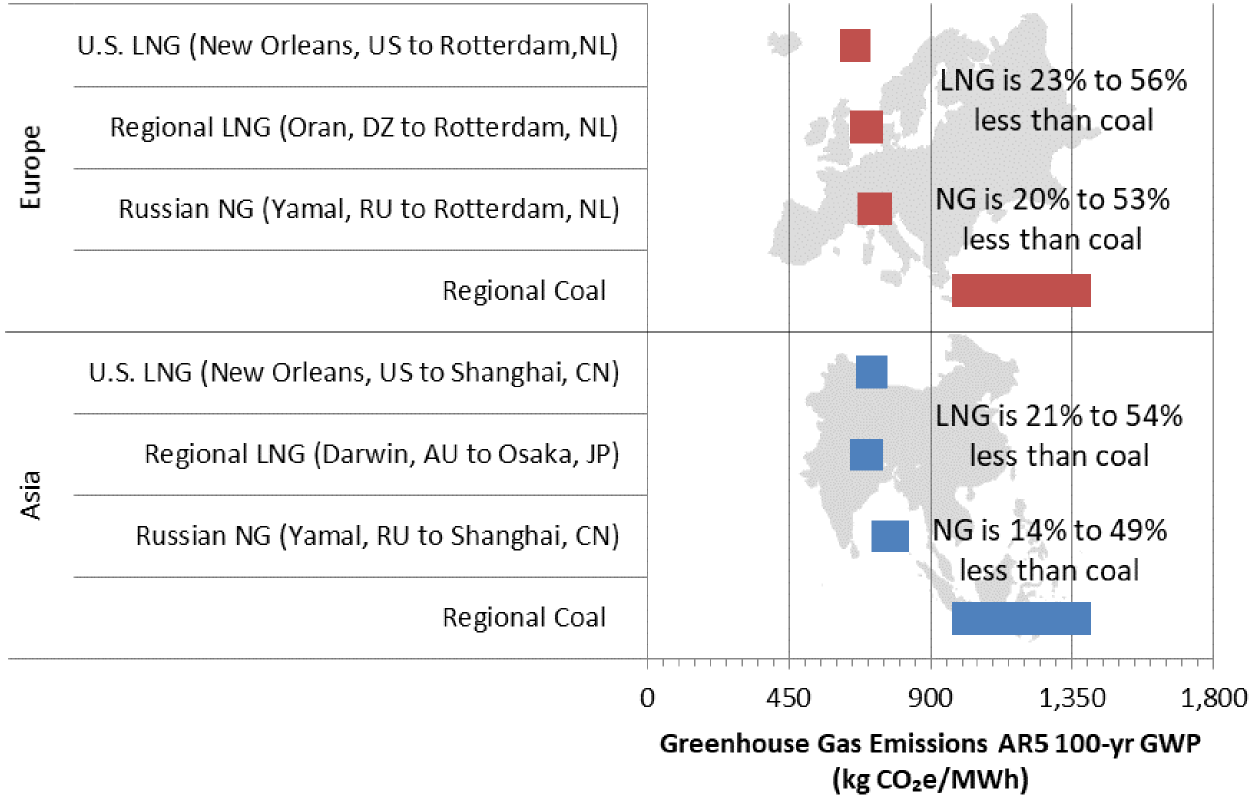
Highlights

- 2014 report update, key changes include:
  - Revised data for liquefaction, ocean transport, and regasification
  - Updated upstream data using NETL's 2019 natural gas LCA
  - Changed IPCC GHG impact assessment from AR4 to AR5
- U.S. LNG scenarios have lower life cycle GWP than in-country coal options.
- Mitigation of supply chain methane emissions is an effective strategy for making U.S. LNG competitive from a climate impact perspective

Outcomes

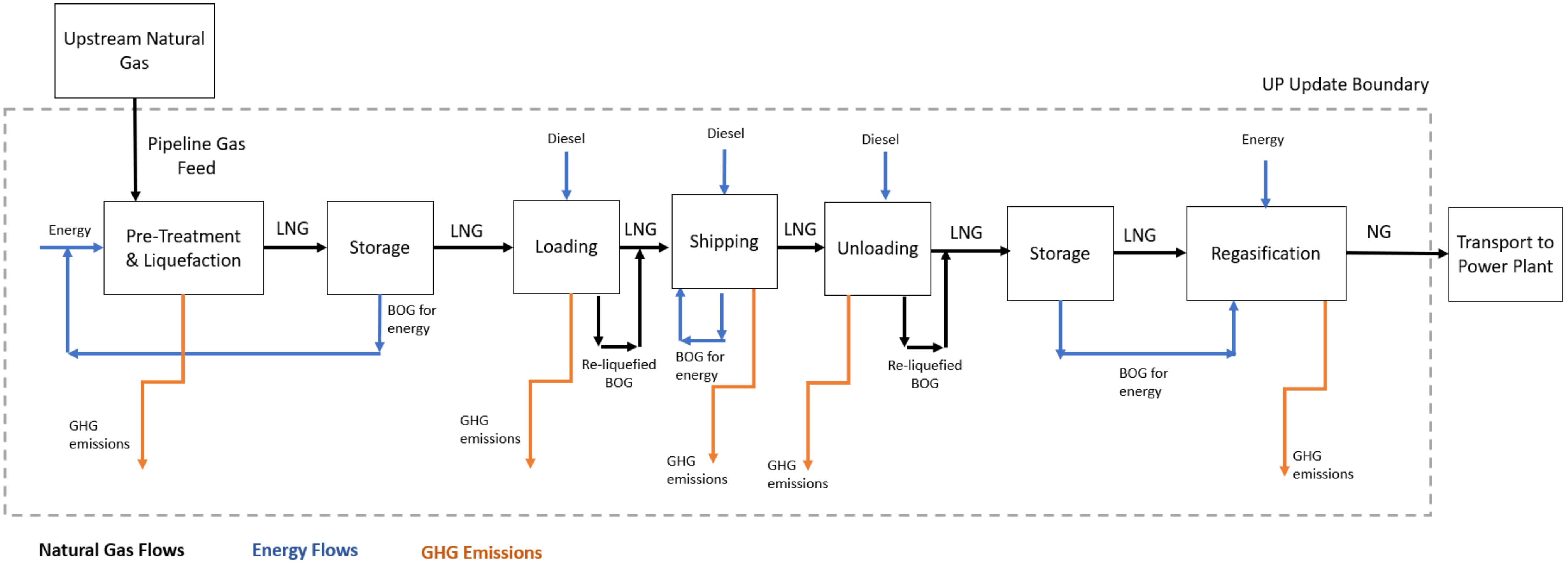
- Report is publicly available at: https://www.energy.gov/sites/prod/files/2019/09/f66/2019%20NETL%20LCA-GHG%20Report.pdf

100-yr GWP Comparison of Coal and Natural Gas Power in Europe and Asia (Exhibit 6-6, NETL LNG LCA, 2019)

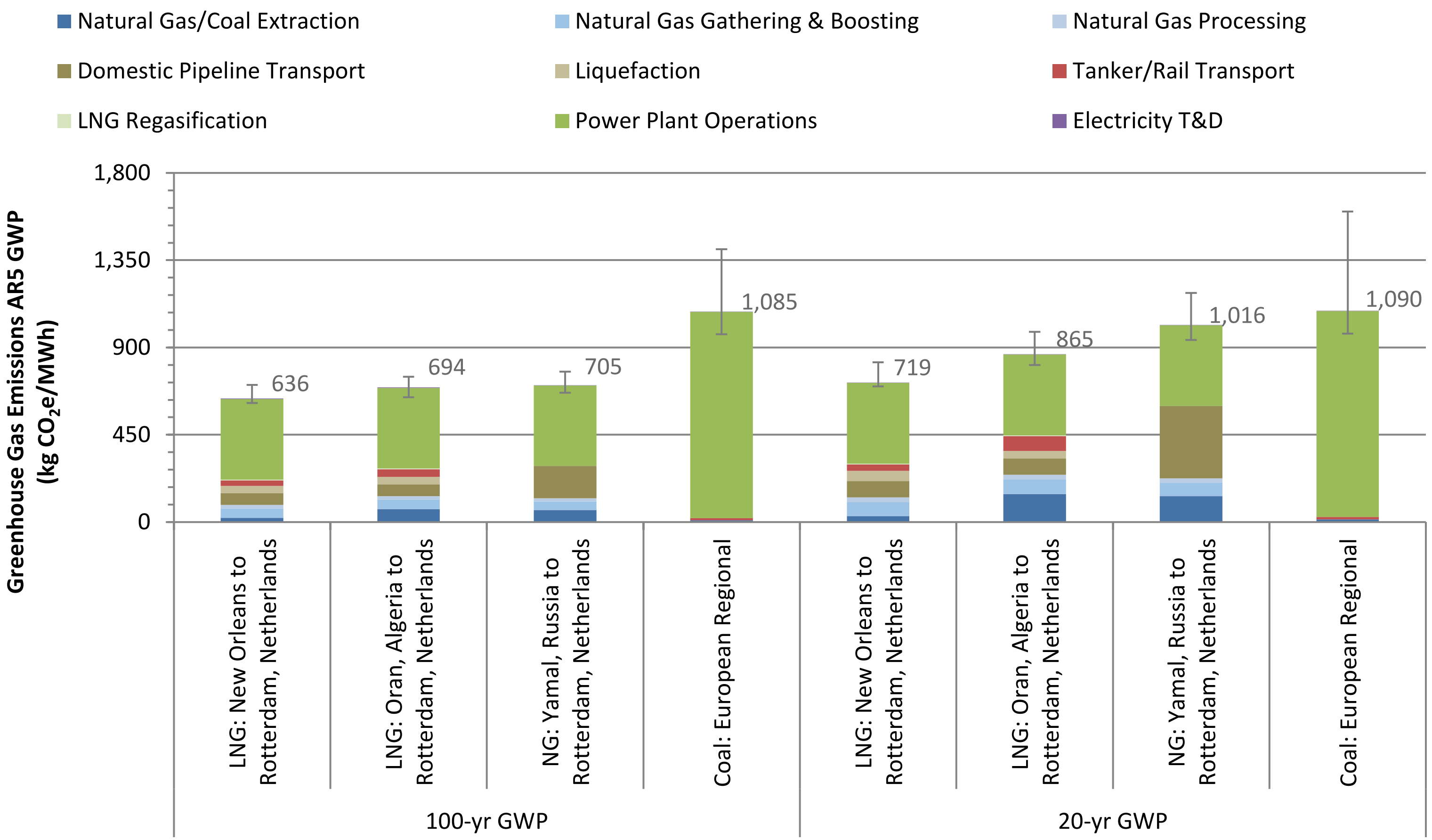


Process Flow Diagram

- This work modeled natural gas from extraction through electricity distribution
- This simplified flow diagram focuses on the LNG portion of the supply chain

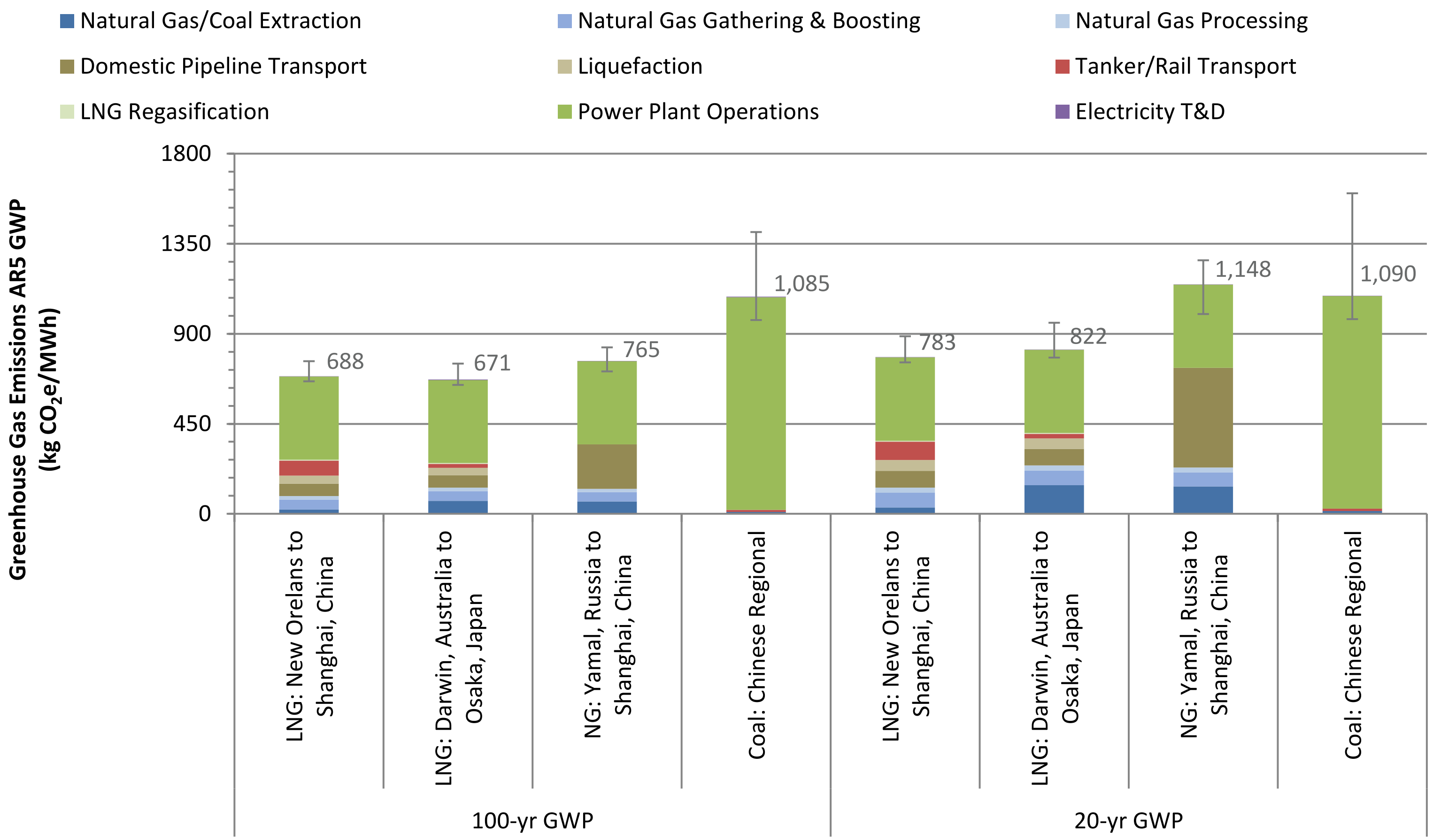


Life Cycle Results – LNG to Europe



- On a 100-yr and 20-yr GWP basis, US LNG has a lower GHG intensity than regional coal
- Combustion emissions at the power plant are the largest contributor to GHG intensity
- Variability in the supply chain and model uncertainty lead to overlapping error bars between natural gas and regional coal on a 20-yr GWP for some scenarios

Life Cycle Results – LNG to Asia

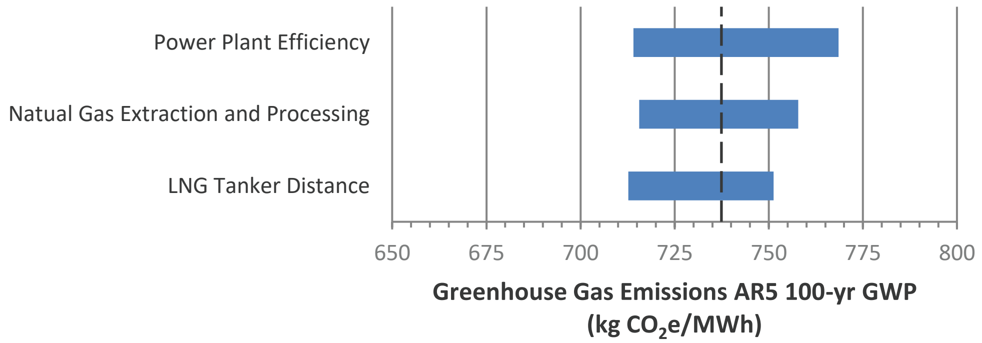


- Contribution from ocean transport increases due to the longer shipping distance between the US and Asia
- For Russian pipeline gas, the long transmission distance paired with the methane leakage rate is amplified on a 20-yr GWP basis
- US LNG still has a lower GHG intensity than regional coal on both a 100-yr and 20-yr GWP basis

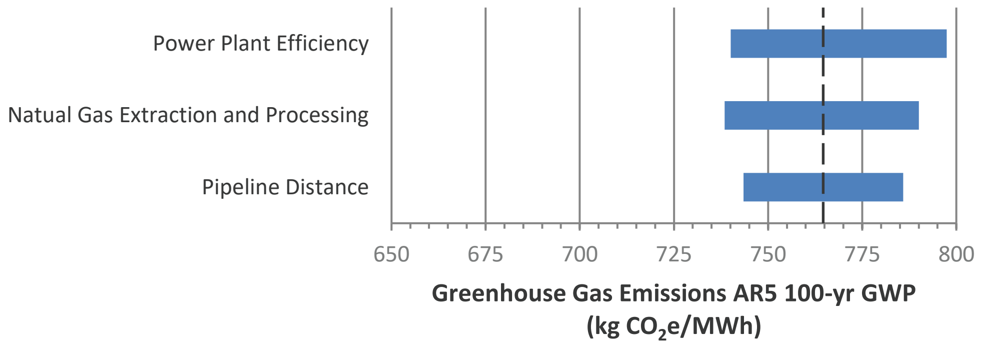
Sensitivity Analysis

NATIONAL ENERGY TECHNOLOGY LABORATORY

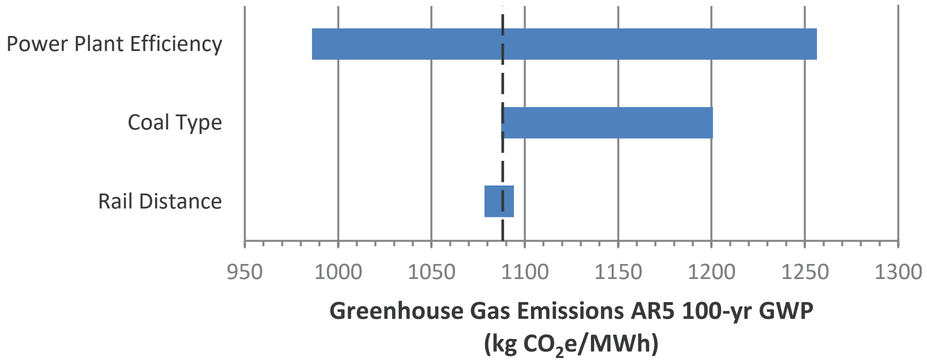
U.S. LNG to Shanghai



Russia Pipeline to Shanghai



Regional Coal



- These tornado plots demonstrate model sensitivity for different parameters/stages
- Sensitivity to power plant efficiency is common across all scenarios
- The upstream natural gas supply chain is a significant contributor to overall GHG intensity, whereas the coal supply chain GHG intensity is almost entirely due to power plant emissions
- Thus, natural gas supply chains are more sensitive to the GHG intensity of extraction and processing
- Transport distance is a bigger sensitivity for the natural gas supply chains, but this is likely because regional coal was modeled

Summary of Study Findings

- U.S. LNG used for power generation in European and Asian destinations has a lower GHG intensity than regional coal used for power generation (100-yr and 20-yr GWP)
- Upstream emission intensity, transport distance, and power plant efficiency are key sources of model sensitivity
- Data availability drives study limitations. Upstream profiles were adopted from U.S.-based models, and power plant efficiencies in destination countries were adapted from work based on U.S. power plants

Key (LCA) Challenges – Lessons Learned

Key (LCA) Challenges – Lessons Learned

1. "Fit for Purpose" LCA Model

2. Market Complexity of Global LNG Trade

3. Data Representativeness and Completeness (Quality)

"Fit for Purpose" LCA Modeling

- LCA must be designed to match the purpose for conducting the LCA

- DOE LNG LCA work question is, "What baseload energy production using imported fuels or domestic resources to produce electricity using coal or natural gas provides the lowest life cycle greenhouse gas emissions?"

- For another work/user, the parameters and the unit processes in the model will need to be adjusted based on the purpose/ objective of the work

Market Complexity of Global LNG Trade

NATIONAL ENERGY TECHNOLOGY LABORATORY

- Consequential effects should be excluded from the study
- Due to market complexity, it is impractical to align one action with a direct consequence
- Due to global trade nature of the market, a purchaser's decision cannot be directly associated with reduction (or displacement) of another energy fuel from being utilized somewhere else

Data Representativeness and Completeness

- The level of data precision and accuracy varies both within "a" value chain and comparatively across different value chains
- It is important to evaluate completeness and uncertainty in data
- Uncertainty is driven by both variability in natural systems as well as how the underlying data was collected
- Study results must also be tested through sensitivity analysis to determine what would change the interpretation of the results

Contact Information

Timothy J. Skone, P.E.
Senior Environmental Engineer
U.S. Department of Energy (US DOE)
National Energy Technology Laboratory (NETL)
Research & Innovation Center (RIC)
Strategic Systems Analysis & Engineering (SSAE) Directorate

(412) 386-4495 • *timothy.skone@netl.doe.gov*

LCA Life Cycle Analysis
energy sustainability

netl.doe.gov/LCA *LCA@netl.doe.gov* *@NETL_News*