Overview of LCA at NETL

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U.S. DEPARTMENT OF ENERGY | National Energy Technology Laboratory

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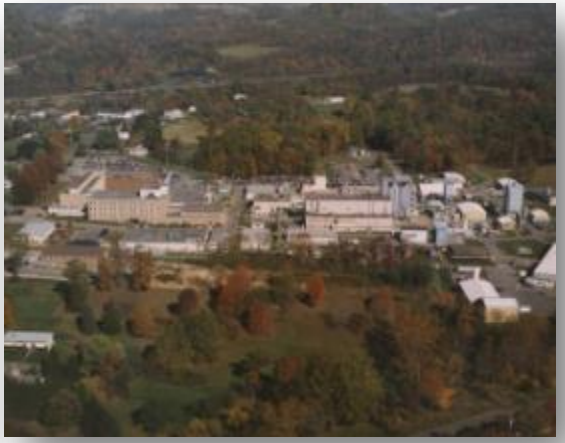


West Virginia

Overview of Energy Life Cycle Analysis at NETL

(The Agenda)

- **Purpose of LCA at NETL**
- **NETL Modeling Approach**
- **Recently Published LCA Work**
- **How to Access NETL's LCA Work**

Purpose of Life Cycle Analysis at NETL

1. **Produce Energy System LCAs**
   - Inform and defend the Technology Programs
   - Baseline different energy system technologies
   - Understand technology strengths and weaknesses when viewed from a life cycle perspective
   - Identify opportunities for R&D innovation (through depth and transparency of analysis)

2. **Improve LCA methods**
   - Expand inventory
   - Characterize uncertainty and variability
   - Build flexible and dynamic models
   - Keep data collection and modeling current with state-of-the-art LCA

3. **Enhance interpretation and comparability of inventory results without losing depth and transparency**
   - Stochastic simulation of life cycle inventory
   - Tools to explore uncertainty and variability

Research, Model, Document…Repeat

- **Life Cycle Inventory (LCI) data is developed from a wide range of sources from primary to secondary data**
  - The type of data used depends on the "use" of the data within the analysis being conducted
- **All data and calculations are documented in NETL's standardized unit process spreadsheet and documentation formats for quality assurance review**
- **Unit processes are imported into the GaBi Life Cycle Assessment Software (PE International)**
- **Unit processes are assembled (modeled) to represent the scope of the LCA of interest**
- **Results are evaluated, significant data contributions are improved, and finally study results are documented**

2014 LCA Work

- LCIA & Inventory Expansion
- OpenLCA Transition
- LNG Export GHG Analysis
- NG Leakage and Data Improvement
- U.S. Power Fleet Characterization
- Alternative Fuels
- Petroleum Updates
- Rare Earth Extraction
- Time Series GHG Modeling and Impacts

Work can be accessed at:
www.netl.doe.gov/lca

Evaluation of LCIA Methods

- **Reviewed TRACI, ReCiPe, Impact 2002+ and EDIP**
  - NETL will use TRACI 2.1 with some modifications, may use ReCiPe as a second method
- **Modifications and Additions**
  - Modify Human Health Particulates
    - Actual impacts vary by release height and population density
    - Factors are available from EPA
  - Scale Water Use by Geography
    - Location of withdrawal/use is as important as quantity
    - NETL can increase internal capabilities with training by outside SMEs
  - Remove Resource Depletion
    - Category doesn't account for new oil/gas resources
  - Expand GWP Inventory
    - Ozone precursors
    - Black carbon, sulfur and nitrate aerosols
  - Add Cumulative Energy Demand Metric
    - Captures total energy use in system
    - Develop factors for new resources like tight oil and tar sands
    - At most 5% different from ReCiPe fossil depletion factors
  - Include Significant Toxic Emissions
    - Report list of emissions and results separately due to high uncertainty

TRACI is the only method with data specific to the U.S.

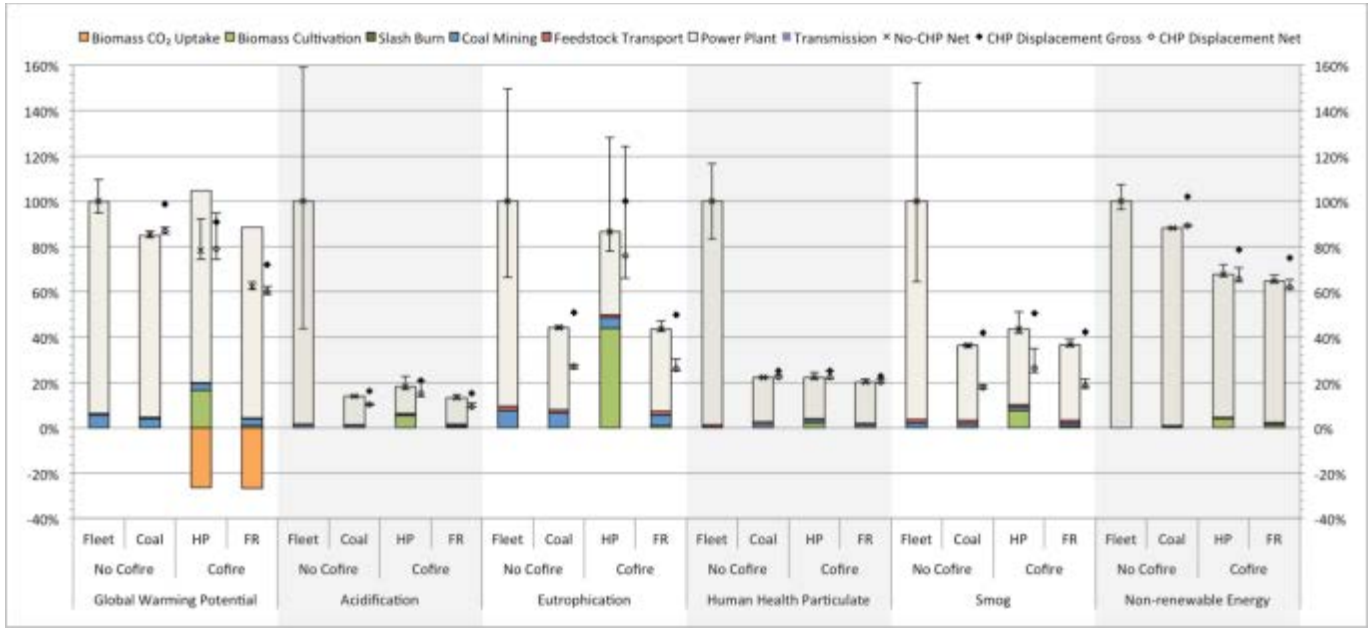
In use by many U.S.-based institutions and agencies

Expansion of Emission Species in Inventory

- **NETL processes historically have included GHGs, criteria pollutants, and a few heavy metals to air and water**
- **Expansion of inventory allows for broader & more accurate impact assessment**
- **Areas of work in 2014 include:**
  - Petroleum extraction, refining, & combustion
  - Natural gas flaring & venting processes
  - Coal extraction

PM →
PM2.5
Black carbon
Organic carbon

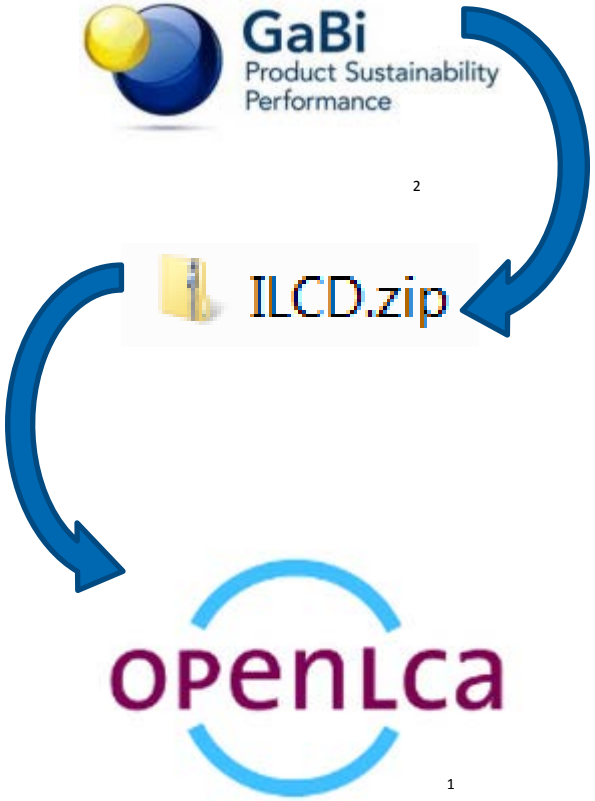
VOC →
Ethane
Benzene
Hexane
Formaldehyde



Conversion from GaBi to openLCA

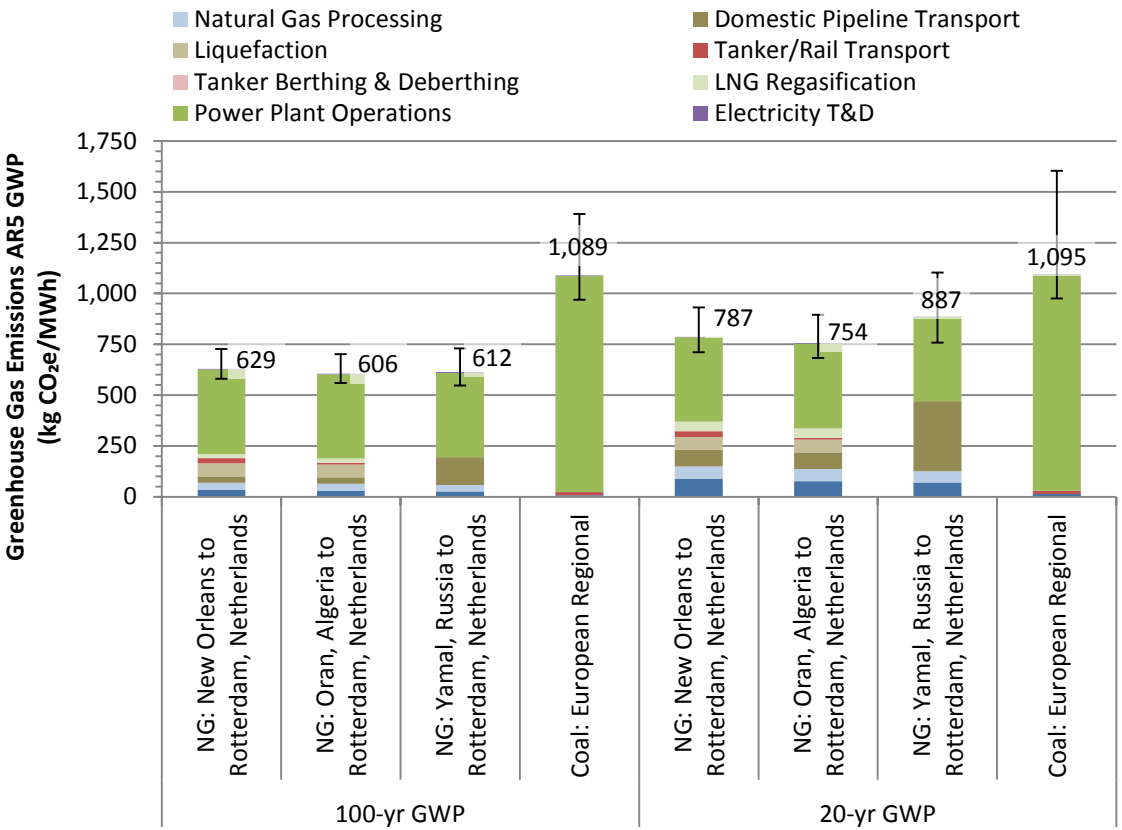
- **Updating existing GaBi based LCA models for full compatibility in the open-source openLCA software with the goal of full transparency in unit process and complete model development.**

- **Moving towards the adoption of a global modeling and naming convention to facilitate more universal applicability of individual unit processes in distinct project models.**



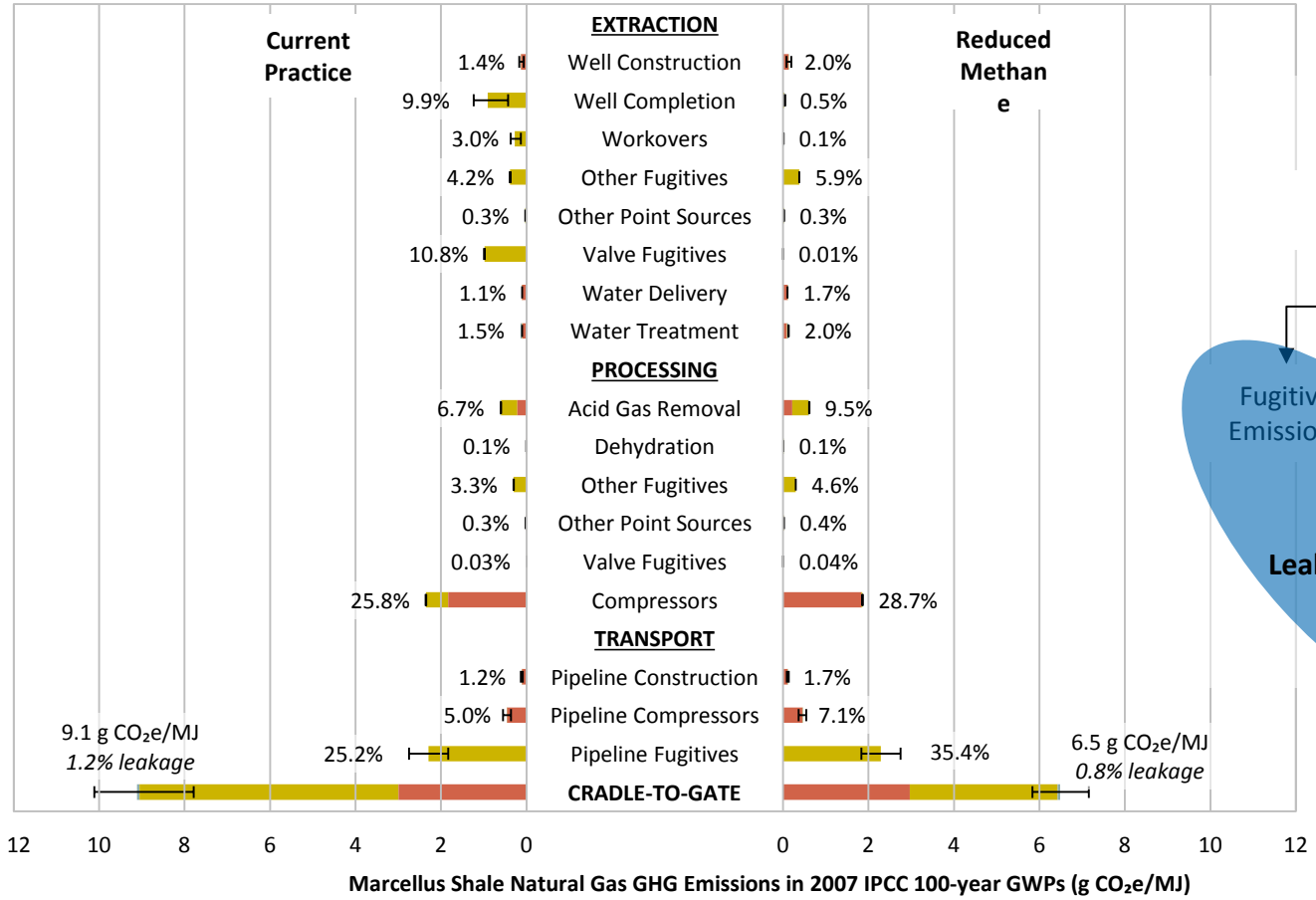
[1] openLCA (2014). *openLCA Logo.* GreenDelta. Retrieved April 21, 2014, from http://www.openlca.org/
[2] GaBi Software (2014). *GaBi Software Logo*. PE International. Retrieved April 21, 2014, from http://www.gabi-software.com/america/index/

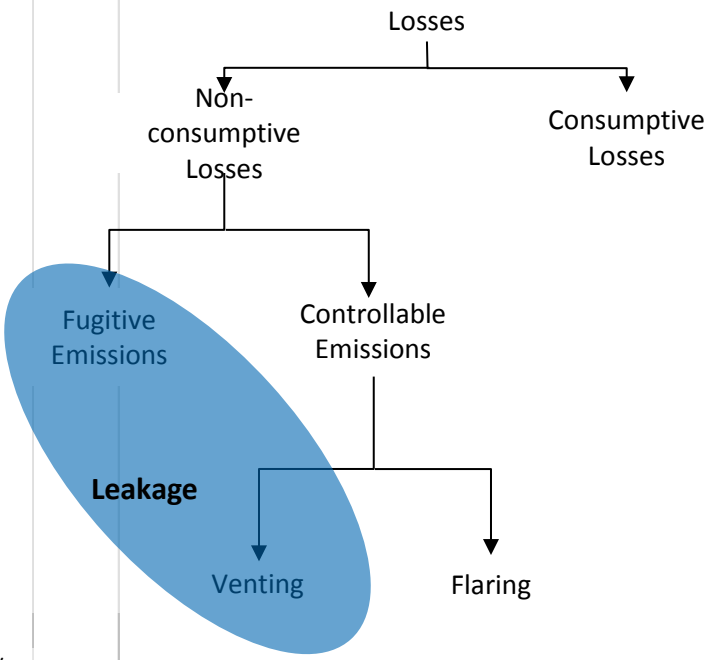
Evaluation of GHGs from U.S. LNG Exporting



- Use of U.S. LNG exports for power production in Europe and Asia will not increase life cycle GHG emissions when compared to regional coal scenarios
- Reducing upstream methane leakage is a near term opportunity for reducing life cycle GHG emissions from natural gas systems

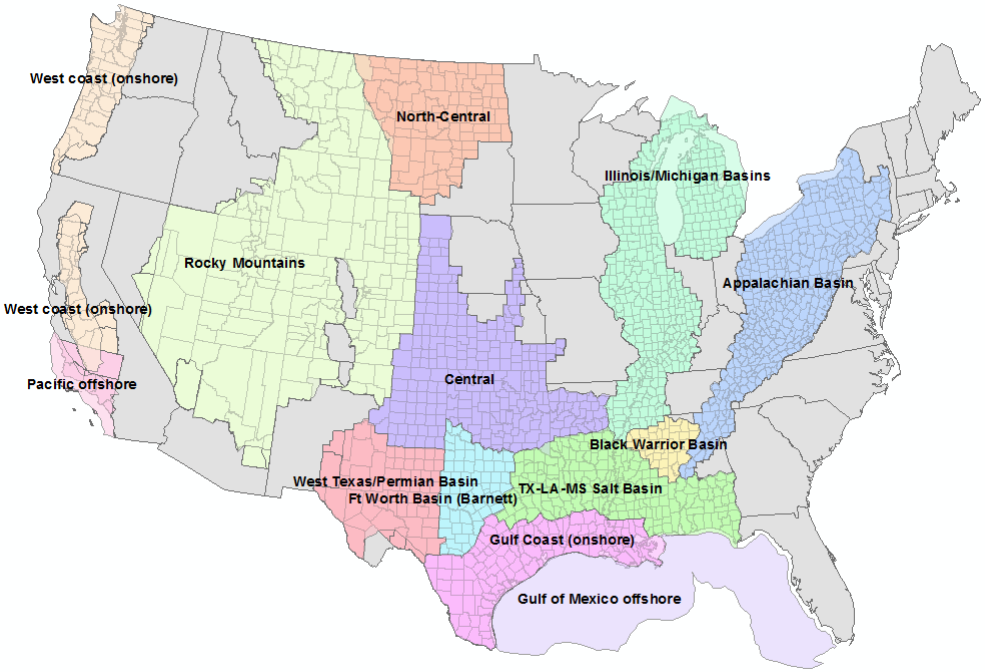
Analysis of Methane Leakage from Natural Gas Sector

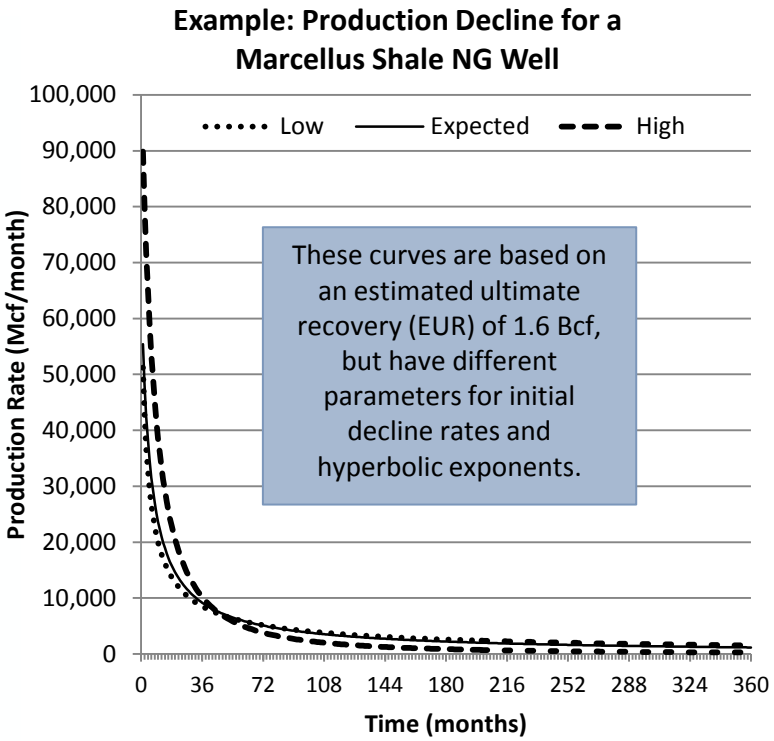




- Bottom-up model shows contributions of fugitive and controllable emissions, as well as NG use for processing and transmission
- Useful when comparing NG to other energy sources
- Stakeholders: DOE Office of Fossil Energy and Office of Energy Policy and Systems Analysis

Improve Underlying Natural Gas Data

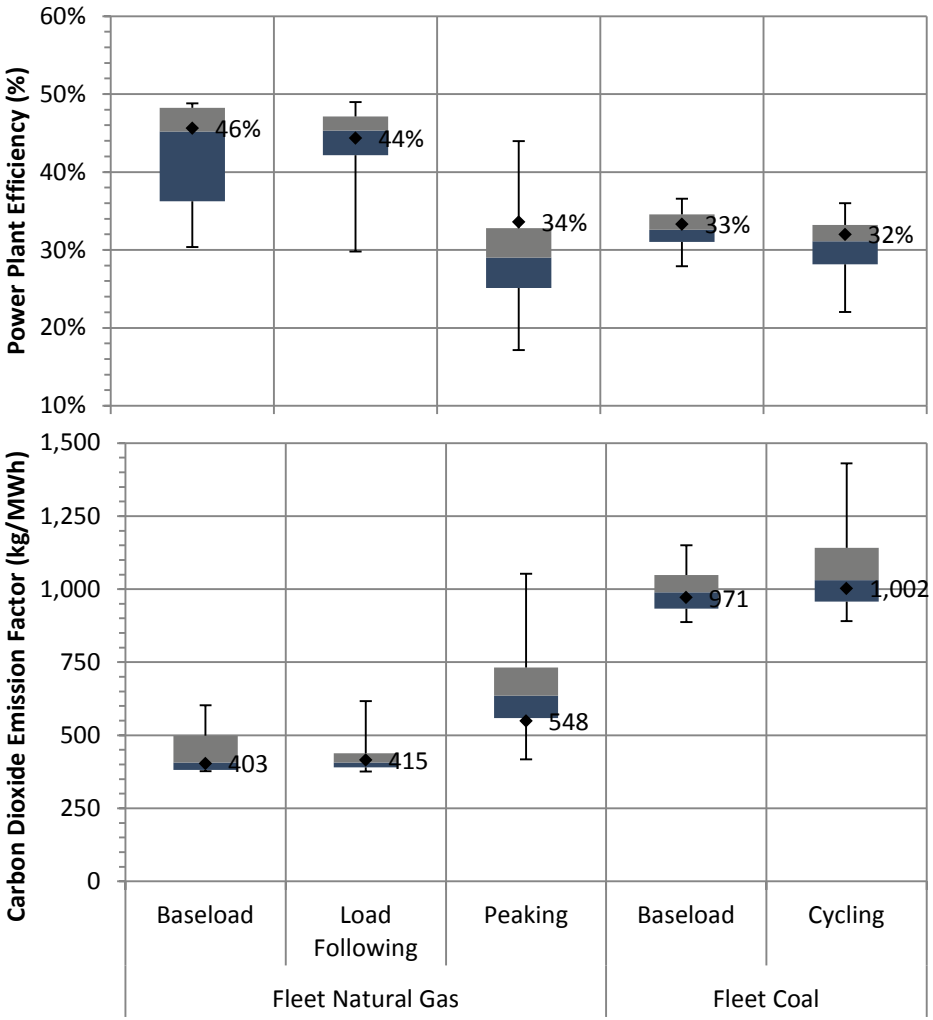




- Regional variation in fugitive emissions and natural gas compositions are being added as another modeling dimension
- Static emission factors for completion and workovers of shale and tight gas wells are being replaced with potential emissions that follow region-specific production curves
- Potential emissions from liquids unloading are now a function of well pressure, tubing diameter, hours per episode, and lift technology

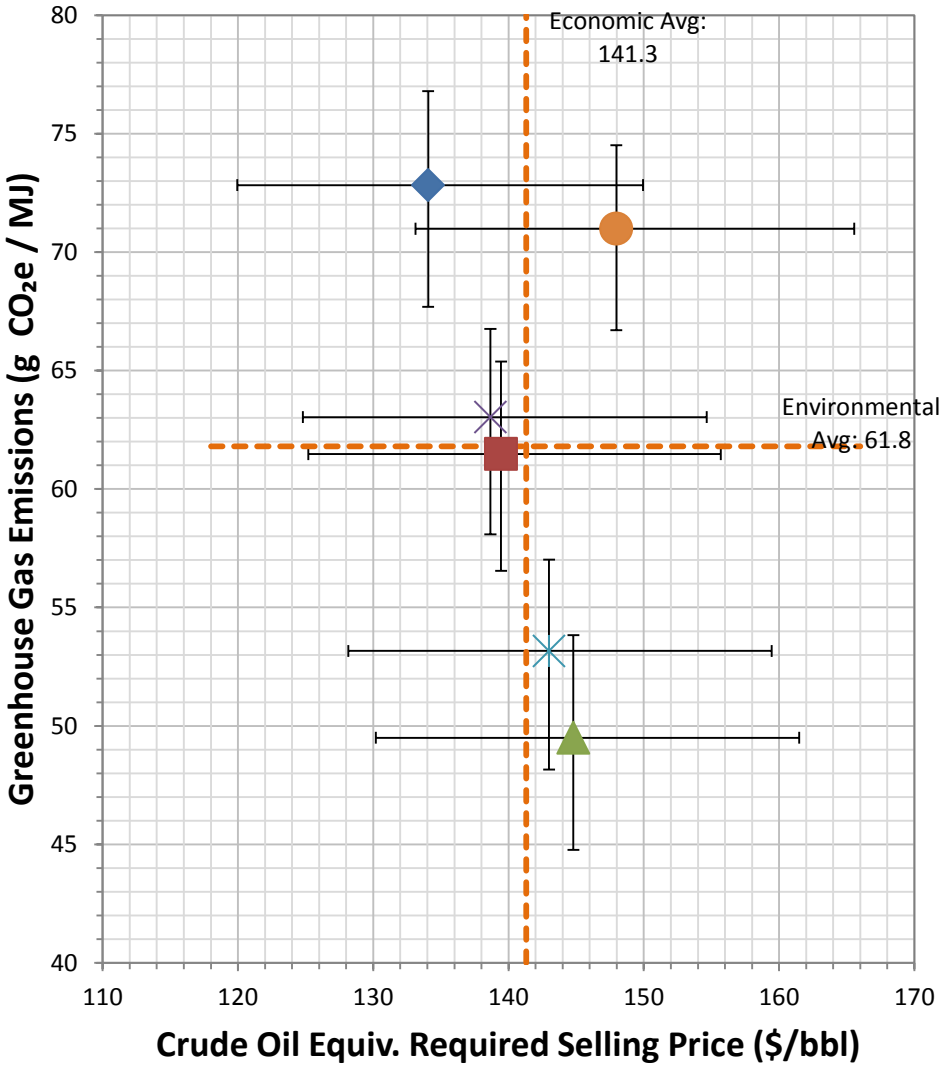
Characterization of U.S. Fleet Power Plant (Coal & Gas) Performance and Emissions

- **Generate emission profiles for expected baseload, load following, and peaking U.S. natural gas power plants and expected baseload and cycling U.S. coal power plants**
  - Subcategorized by NERC Region
- **Performance and emissions data (NO_x, SO_2, CO_2, CH_4, and N_2O) derived from the EPA eGRID 2010 data, ninth edition (Version 1)**
- **Various filters applied to isolate baseload plants for the corresponding fuel**
- **Capacity factor filter applied to the raw dataset in order to discern between fleet type (i.e. baseload or cycling)**



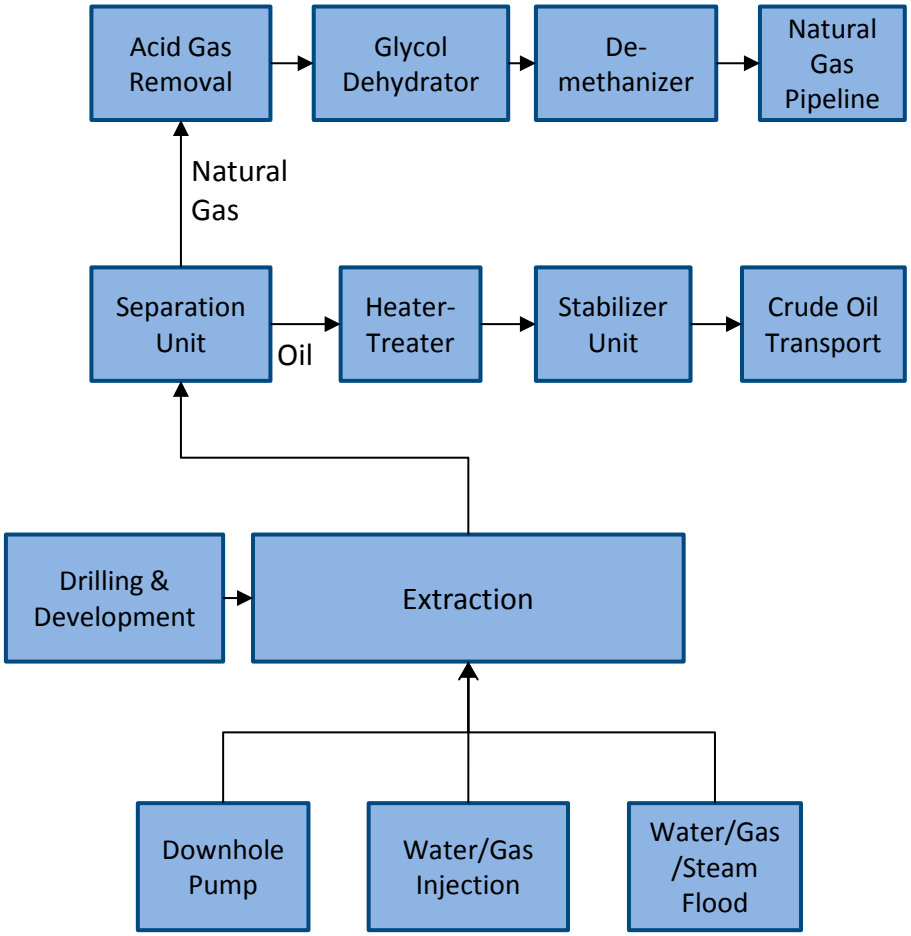
Modeling the Uncertainty of Fischer-Tropsch Jet Fuel GHG Emissions and Req'd Selling Price

- Defense Logistics Agency (DLA) funding via Connecticut Center for Adv. Technology
- Demonstrate liquid fuel production from coal that meets the Energy Independence and Security Act (EISA) of 2007, Section 526 requirements
- Utilize detailed process modeling to evaluate different gasifier configurations (TRIG and EFG) as well as different amounts and pre-processing steps for biomass
- Create a tool that gives the user access to key parameters that affect the LC GHG emissions and RSP and perform uncertainty analysis



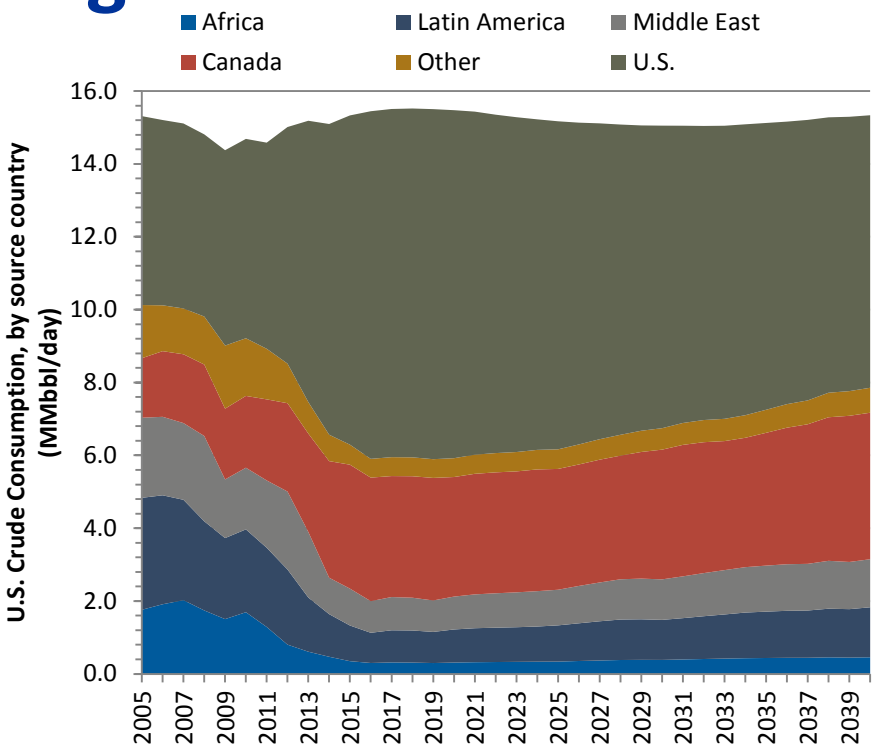
Improvements to NETL Petroleum Baseline – Translation of Crude Extraction Processes

- **Oil Production Greenhouse Gas Emissions Estimator (OPGEE)**
  - Created by Stanford University Dept. of Energy Resources Engr. (Adam Brandt)
  - Based on bottom-up engineering calculations to capture variability in crude extraction emissions
- **Create modular unit processes based on the stages in OPGEE**
  - Seven main stages: (1) Exploration, (2) Drilling and Development, (3) Production and Extraction, (4) Separation and Surface Processing, (5) Maintenance and Workovers, (6) Waste Treatment and Disposal, (7) Crude Product Transport
  - Augment with NETL CO_2 EOR work
  - Addition of non-GHG emissions to provide a more complete inventory



Developing the Approach for a New Petroleum Baseline; Evaluating Out to 2040

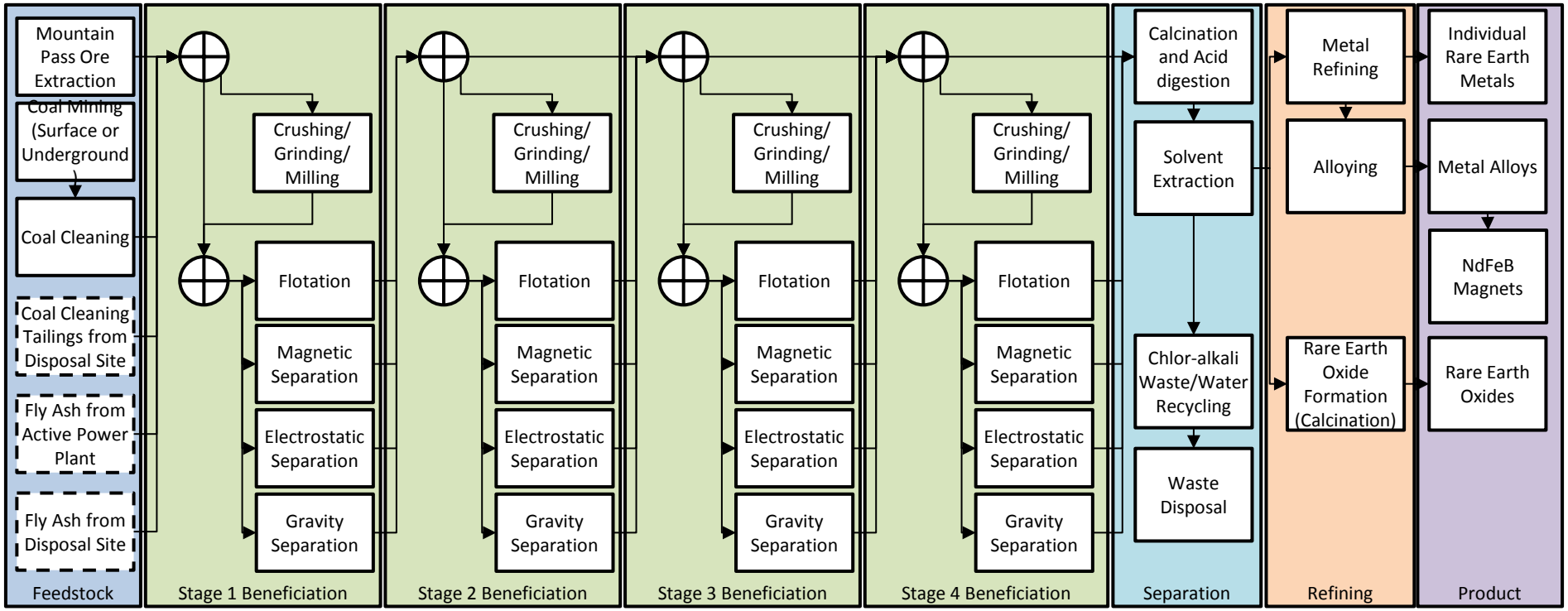
- **Significant changes since 2008 baseline:**
  - Known changes to crude oil mix (source, extraction method, and quality)
  - Transition to ultra low sulfur diesel, increasing refinery hydrogen demand
- **Utilize publicly available and peer-reviewed tools to inform the life cycle impacts of extraction 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)**
- **Working through extraction and transport; next step - refining**



- 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

[1] EIA. (2013). *AEO 2014 Interactive Table Viewer.* US Department of Energy Retrieved January 2, 2014, from http://www.eia.gov/oiaf/aeo/tablebrowser/
[2] EIA. (2013). *Petroleum & Other Liquids Data.* US Department of Energy Retrieved January 2, 2014, from http://www.eia.gov/petroleum/data.cfm
[3] Canadian Association of Petroleum Producers. (2013). *Crude Oil Forecast, Markets & Transportation.* (2013-0013). Alberta, Canada: CAPP

LCA of Rare Earth Elements from Coal and Coal By-Products

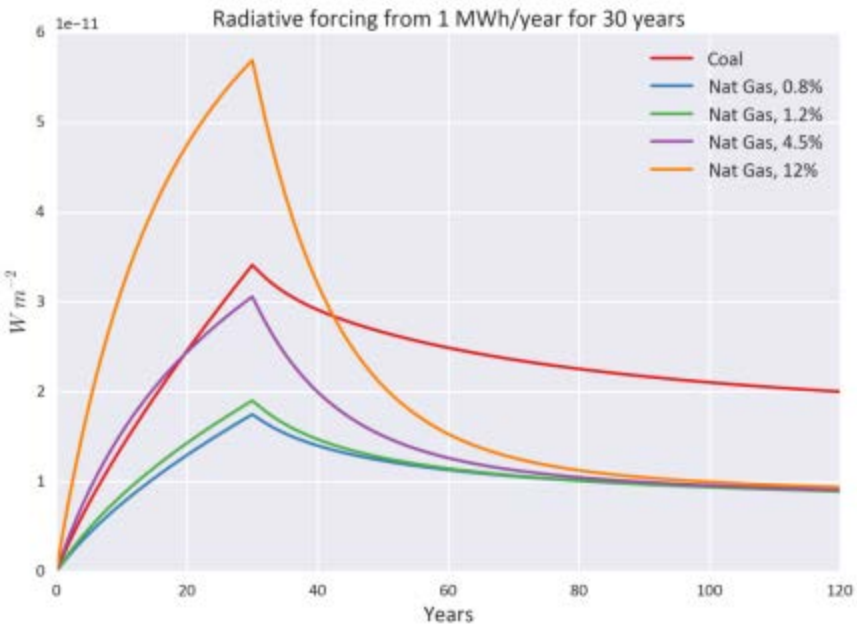


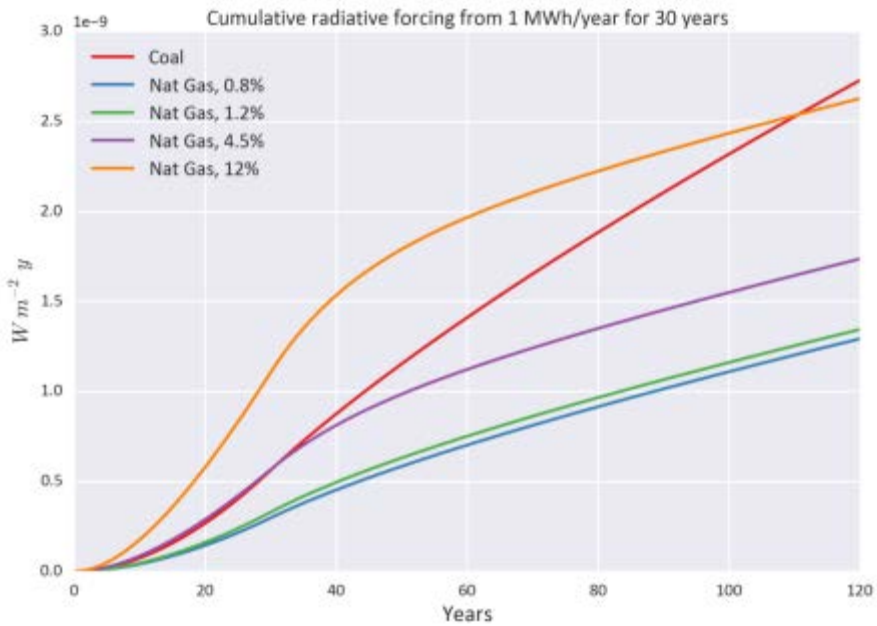
- Performed life cycle analysis for rare earths from domestic rare earth ore and coal processing wastes and power plant ash
- Focus is on flexibility for coal/ash processing since these feedstocks are not currently used in rare earth production
- Includes impacts through magnet production

Alternative Metrics: Time Series GHG Emissions

- **Exploration of climate impacts beyond GWP**
- **Timing issues affect biomass, systems with emissions over long periods of time**
- **Possible to see how systems evolve over time & the difference between forcing and cumulative forcing results**

Comparison of coal power & natural gas with different leakage rates





0.8% = NSPS; 1.2% = Expected; 4.5% = 20 yr GWP breakeven; 12% = 100 yr GWP breakeven

Upcoming Work

- **LCA of coal exports from the U.S.**
- **Continued inventory expansion**
- **Regionalization of bottom-up natural gas model**

Contact Us

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LCA Life Cycle Analysis

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