

# Establishing a Life Cycle Power Baseline for the U.S.



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U.S. DEPARTMENT OF  
ENERGY

# The utility of baselines

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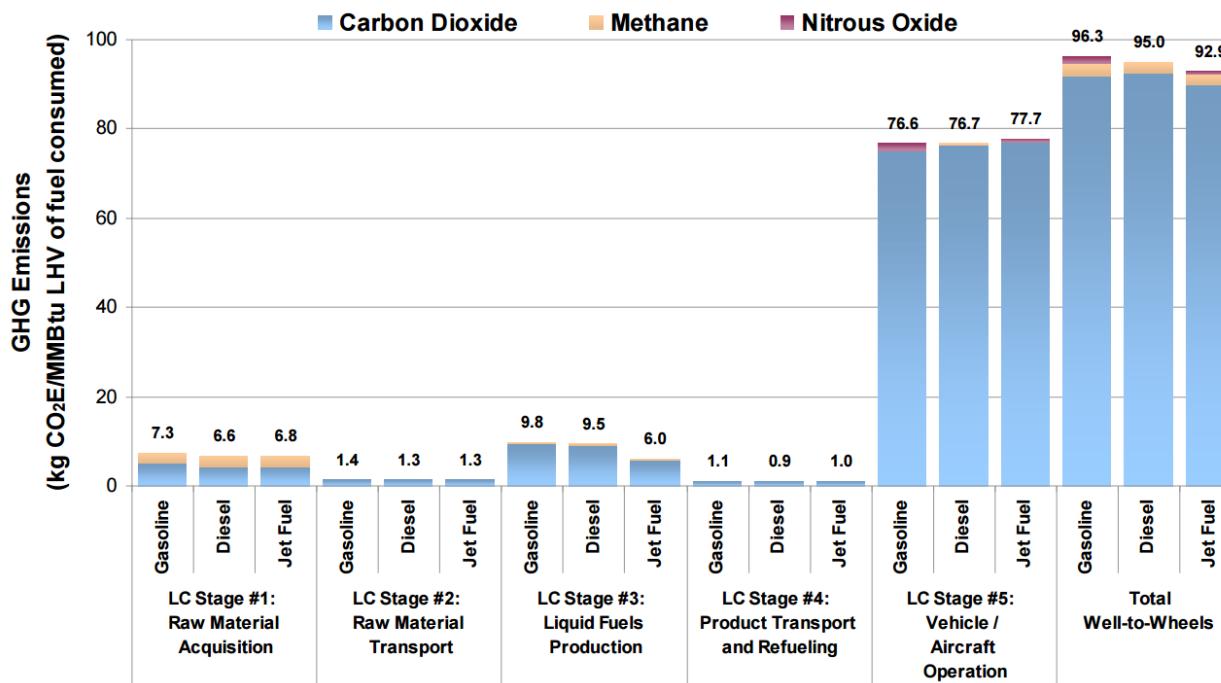
- **NETL's petroleum baseline has been useful**
  - Standardized plug-in to many of our processes
  - Benchmark that allows quantification of improvements
  - Tool for analyzing effect of changing crude mixes
- **A power baseline would also be useful**
  - Plug-in to NETL's 400+ unit processes
  - Resource for other LCA practitioners
  - Tool for analyzing grid scenarios

# As a reminder, NREL Petroleum Baseline



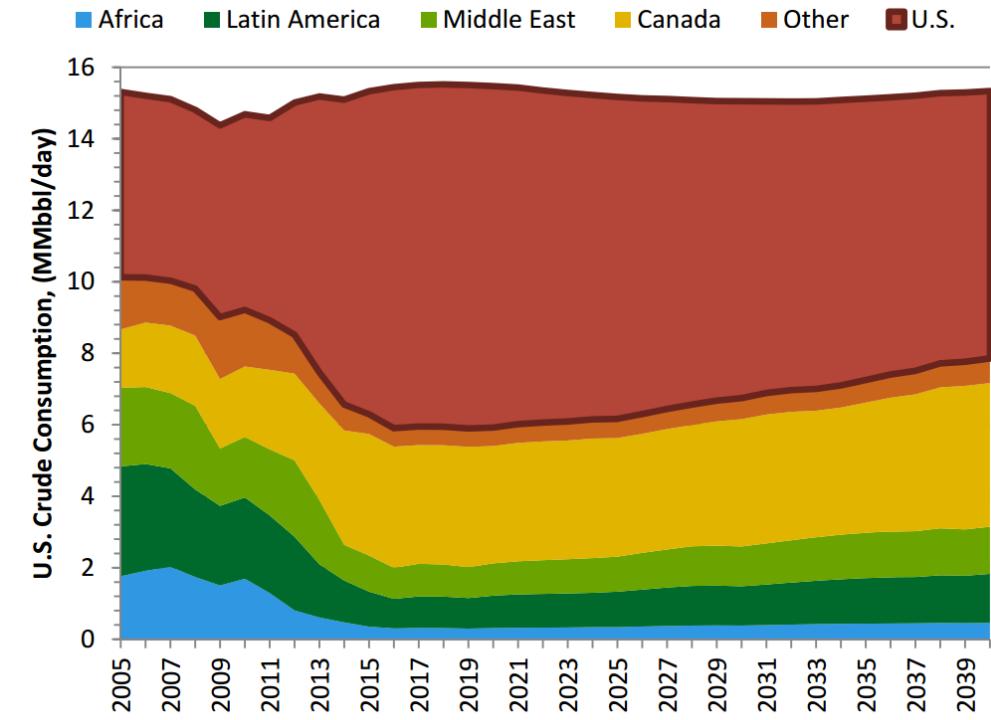
## Original (2008)

- Represents 2005 production
- Demonstrated the value of LCA
- Key decision point for EISA/526/RFS2



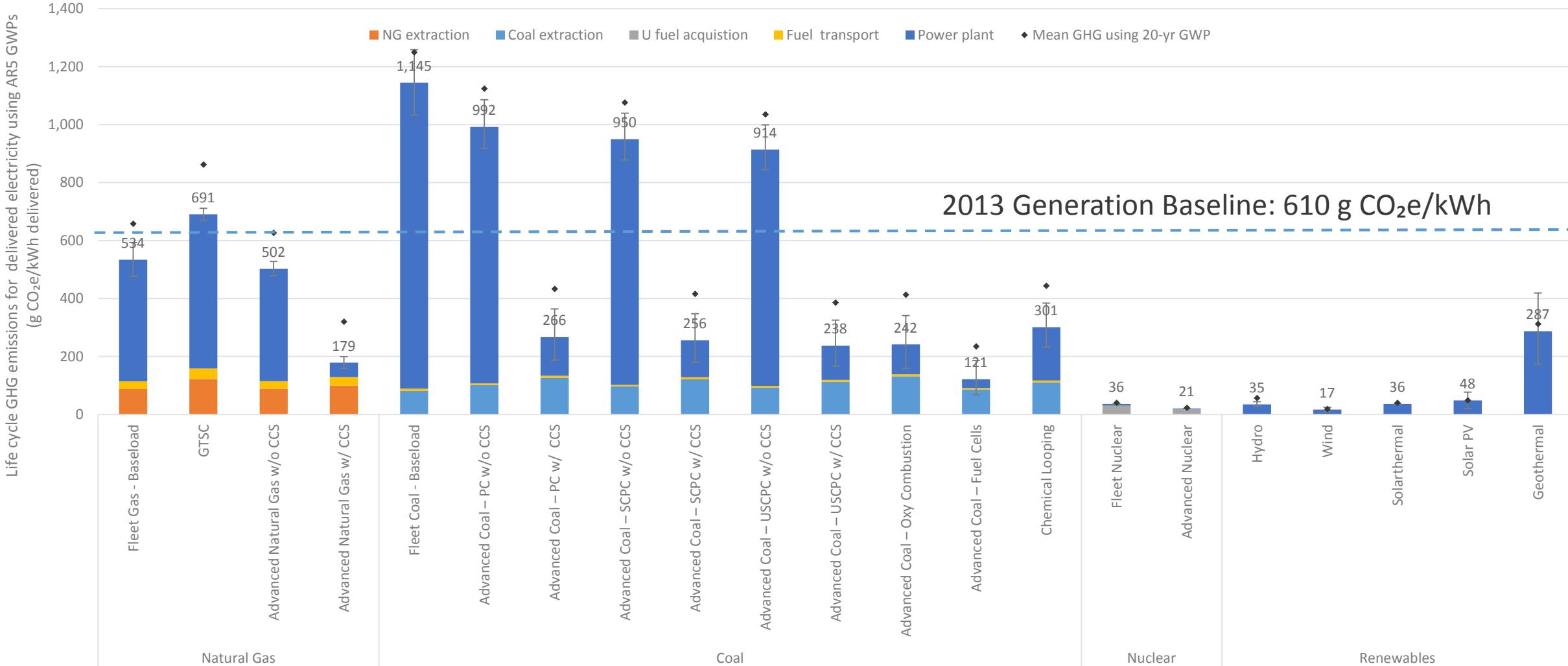
## Updated (2016)

- Represents 2014 production
- Accounts for known changes to crude mix
- Accounts for refining requirements for low sulfur diesel



# Current Capabilities: GHGs

We've already characterized the life cycles of most power technologies



# Current Capabilities: Other Inventory Items

Category (Units)	Emission species	Power Technology							
		Fleet Coal	Fleet Natural Gas	Existing Nuclear	Existing Hydro	Petroleum	Onshore Wind	Geothermal	Solar Thermal
Non-GHG Emission to Air (kg/MWh)	Pb								
	Hg								
	NH <sub>3</sub>								
	CO								
	NOX								
	SO <sub>2</sub>								
	VOC								
	PM								
Water Use (L/MWh)	Withdrawal								
	Consumption								
Water Quality (kg/MWh)	Arsenic (+V)								
	Lead (+II)								
	Manganese (+II)								
	Nickel (+II)								
	Zinc (+II)								
	Ammonium/ammonia								
	Phosphorus								

- Full inventory shows that no single technology is favorable across all metrics
- Power Baseline will use TRACI (with modifications)

# Baseline requirements

*A single, point value has limited use*

- Consistent across multiple boundaries
- Flexible to allow for multiple uses
- Transparent for trust and updating



<http://www.swisstool.co.uk/st/Swiss-Army-Knife-Range/>

# Functional unit for a power baseline?

*The when and where of generation and consumption should be considered*



- $1 \text{ kWh}$  of electricity delivered
  - Widespread use as an input to any life cycle model
  - Underspecified
- $1 \text{ kWh}$  baseload  $\neq 1 \text{ kWh}$  intermittent
  - Baseload and intermittent power are driven by different priorities (reliability vs. renewability)
  - Unless coupled with backup power,  $1 \text{ kWh}$  of wind power cannot provide same service as  $1 \text{ kWh}$  of baseload power (coal, nuclear, or natural gas)

# Power Baseline Goals

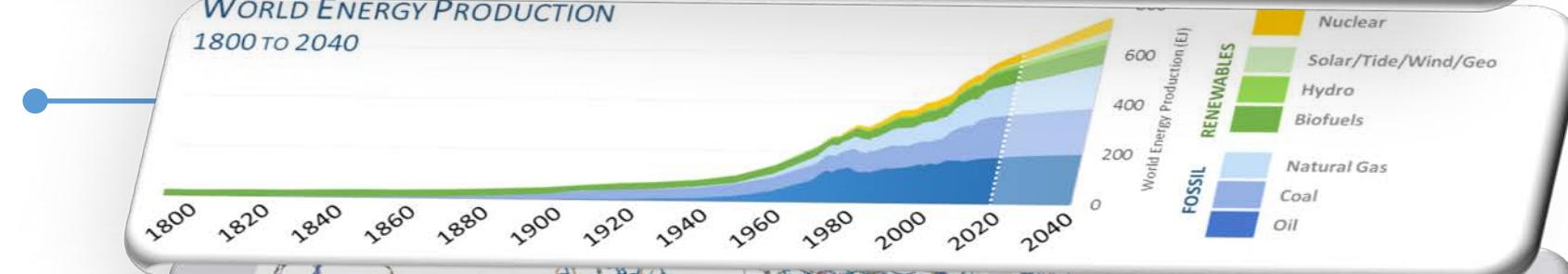
Impact Assessment



Supply Chain



Temporal Scope



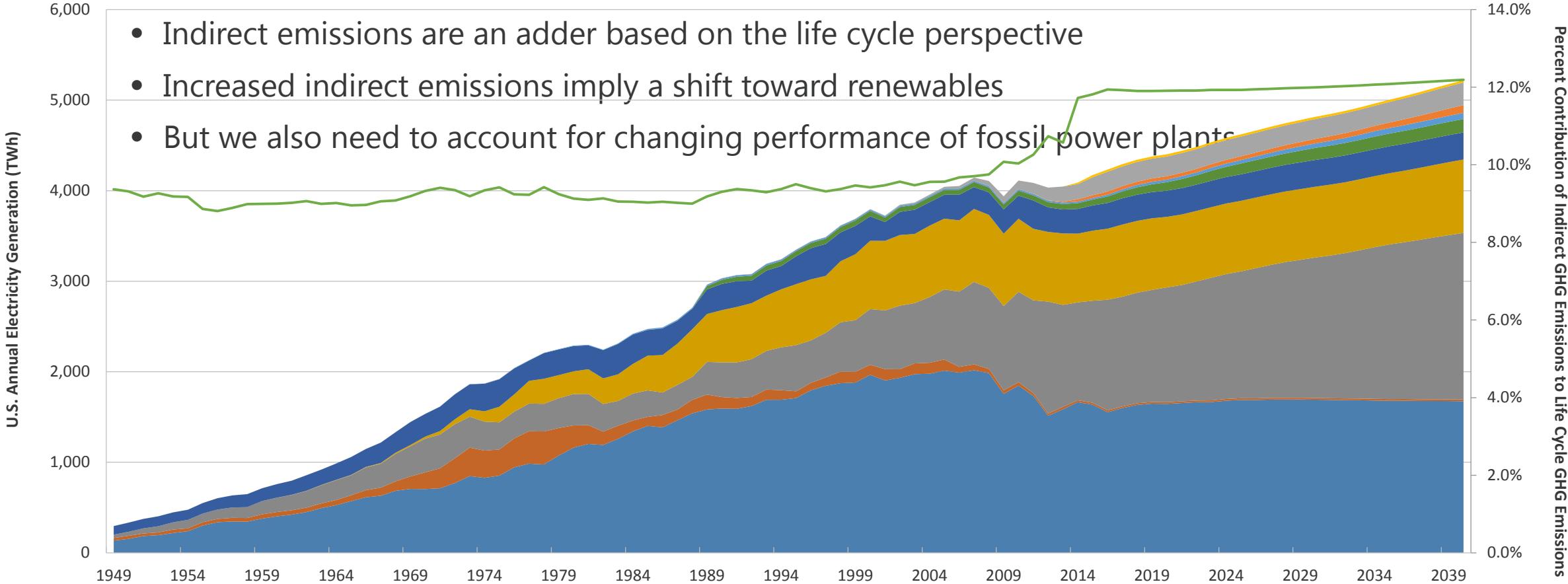
Geographic Scope



# Forecasting accounts for changing technology mixes



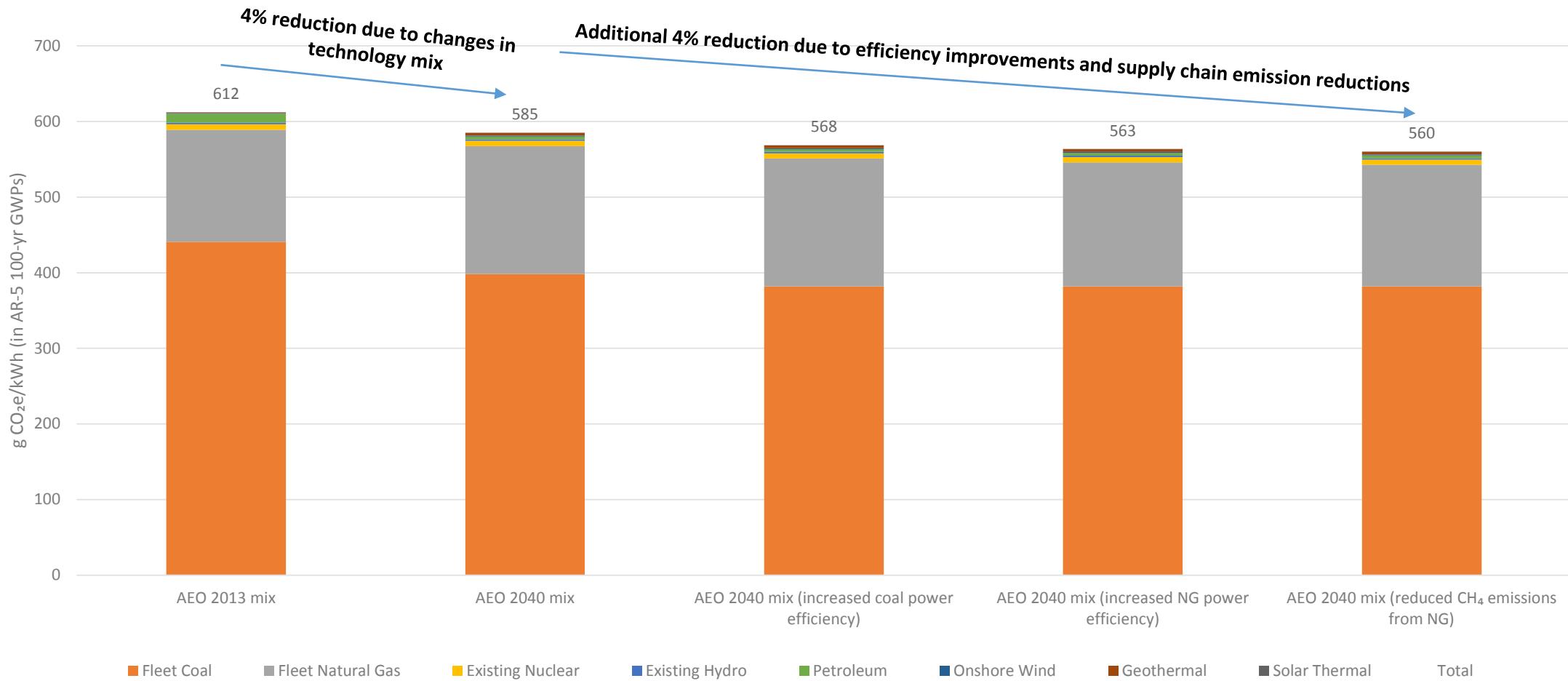
Coal Petroleum Natural Gas Nuclear Hydro Biomass Geothermal Solar Wind Other Indirect Share



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# Technology performance over time also matters

*The performance of a power pathway, not just its contribution to total generation, changes with time*

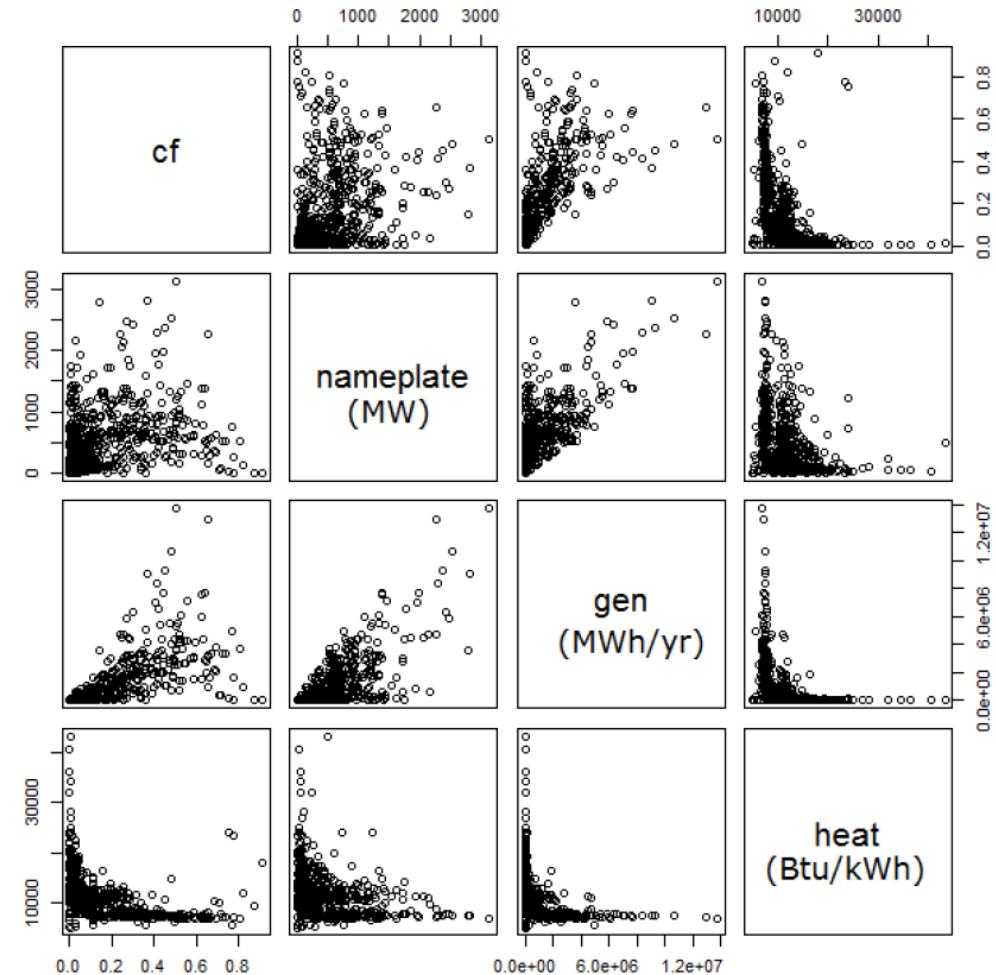


# Using performance factors to discern fleet trends

*We would like to discern time series trends from existing fleet data*

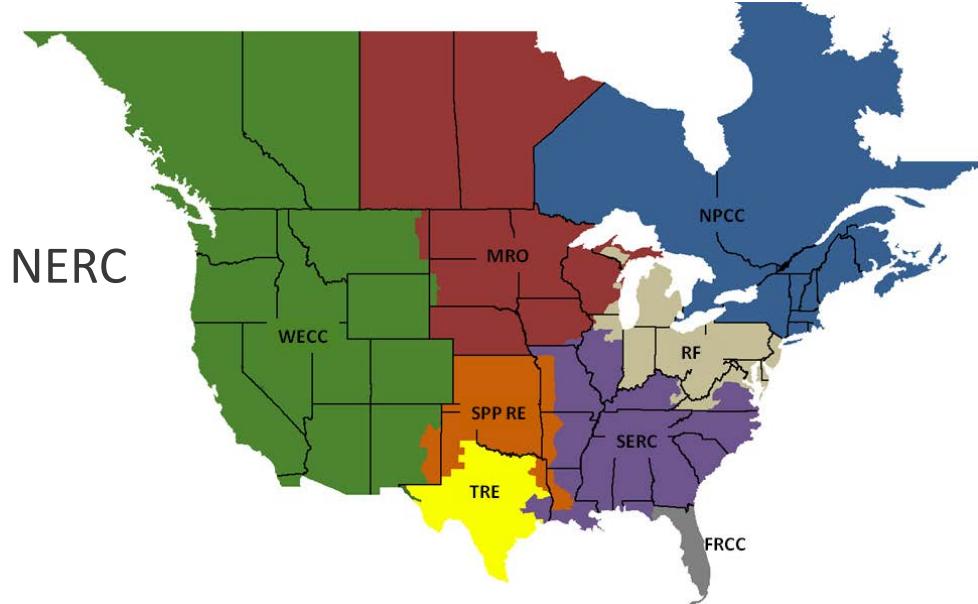
- Capacity factor characterizes a plant based on how often it is being run during the year in order to meet demand
- Nameplate capacity is the designed full-load sustained output (MW)
- Generation is a function of capacity factor and nameplate capacity
- Heat rate implies efficiency and vintage
  - 100 percent efficiency = 3,412 Btu/kWh
  - Efficiency of power plants have improved over time

No strong correlations between heat rate and other variables, making it difficult to forecast future performance based on plant age or other parameters



# Geographic boundary resolution

*Level of detail/aggregation must account for grid characteristics*

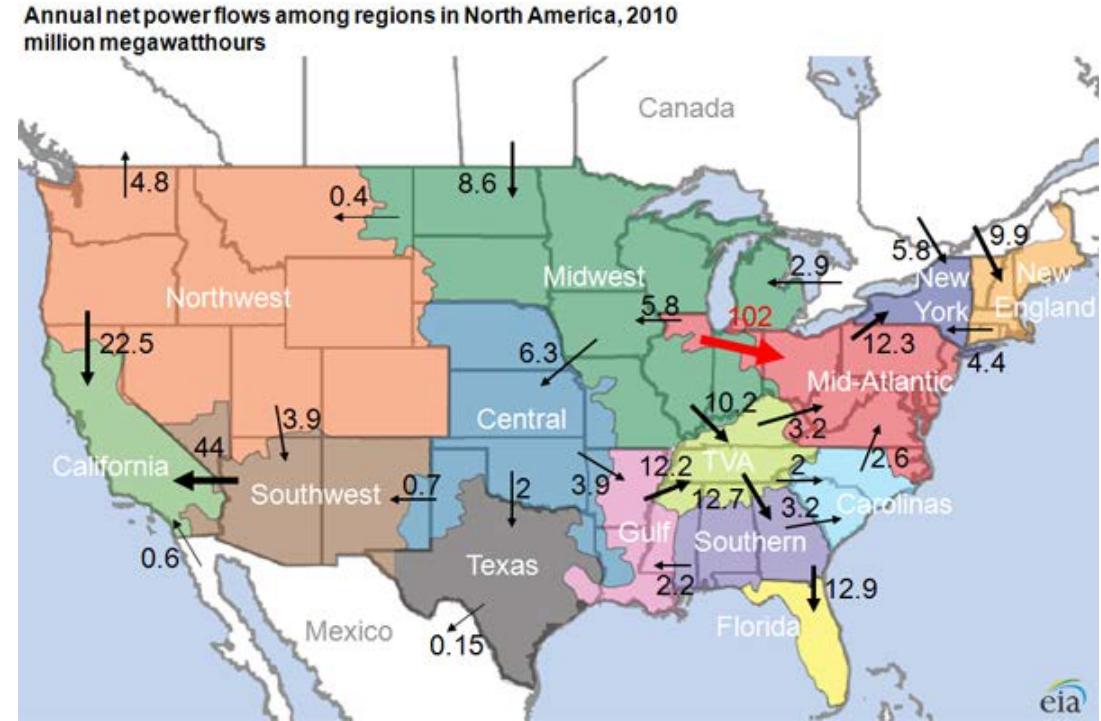


## Regions

- State profiles would be too narrow because interconnected grids envelop large regions, not single states
- Regionalization (NERC or ISO/RTO) is practical

## Imports/Exports

- Exchanges between grid regions allow us to track electricity import/exports
- Marginal production a key reason why a region's consumption does not match its generation
- Life cycle GHG emissions for 2013 U.S. consumption and generation are 604 and 612 g CO<sub>2</sub>e/kWh, respectively



# Data requirements

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- ✓ Performance and inventory data for >95% of annual generation
- ❑ Collaborative framework that facilitates completion of inventory and performance data for small, growing technologies
- ❑ Clear expectations on level of detail
  - Data collection and development must be resilient tradeoffs between low-level specificity and top-level accuracy
  - Supply chains need to be “average” (especially for key components like coal and natural gas)

# Summary

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- Ideally, a baseline should go beyond calculating a single value for certain conditions and provide complete inventories with temporal and geographic variability
- We have the data and modeling capability for generating current year GHG results for the U.S. grid
- More data and analysis are necessary for characterization of a comprehensive inventory with temporal and regional resolution
- We need community participation to fill data gaps

# Contact Information



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