

# 26<sup>th</sup> World Gas Conference

1 – 5 June 2015, Paris, France



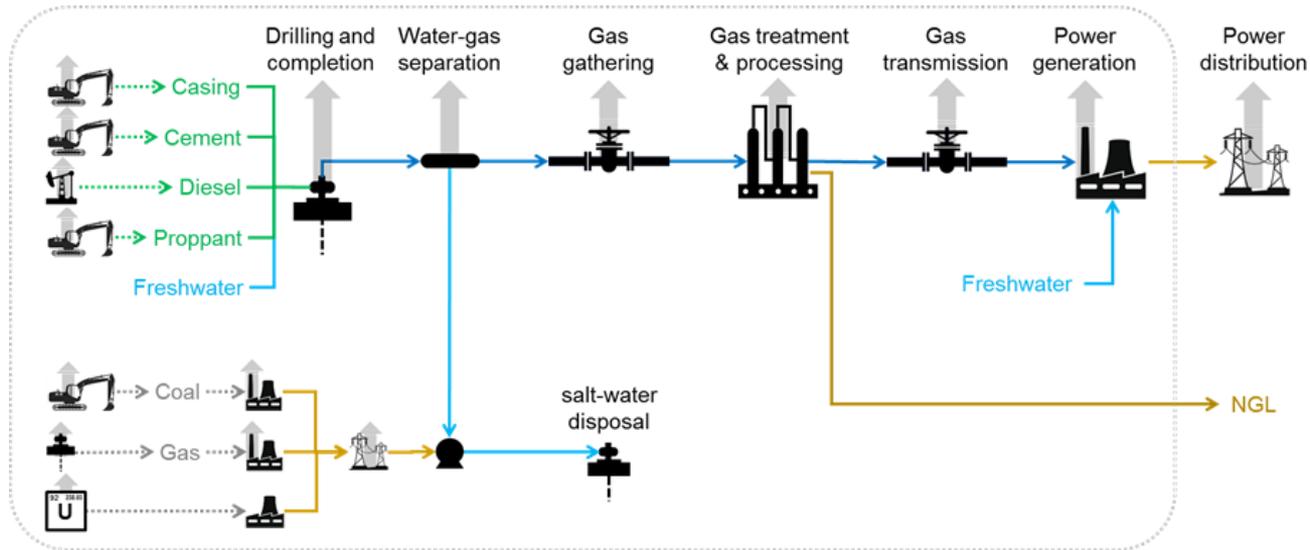
## ENVIRONMENTAL LIFE CYCLE ASSESSMENT OF NORTH AMERICAN SHALE GASES

Ian Laurenzi  
ExxonMobil Research and Engineering



# Life Cycle Assessment

- Objective: Assess impacts associated with power generated from shale gas (“well to wire”)
  - Greenhouse Gas Emissions, kg CO<sub>2</sub>eq/MJe (IPCC AR5 GWP, 100-year)
  - Freshwater consumption, L H<sub>2</sub>O/MJe



- Impacts of power generation must be assessed on a common basis (MJ of electricity)

# Data Sources

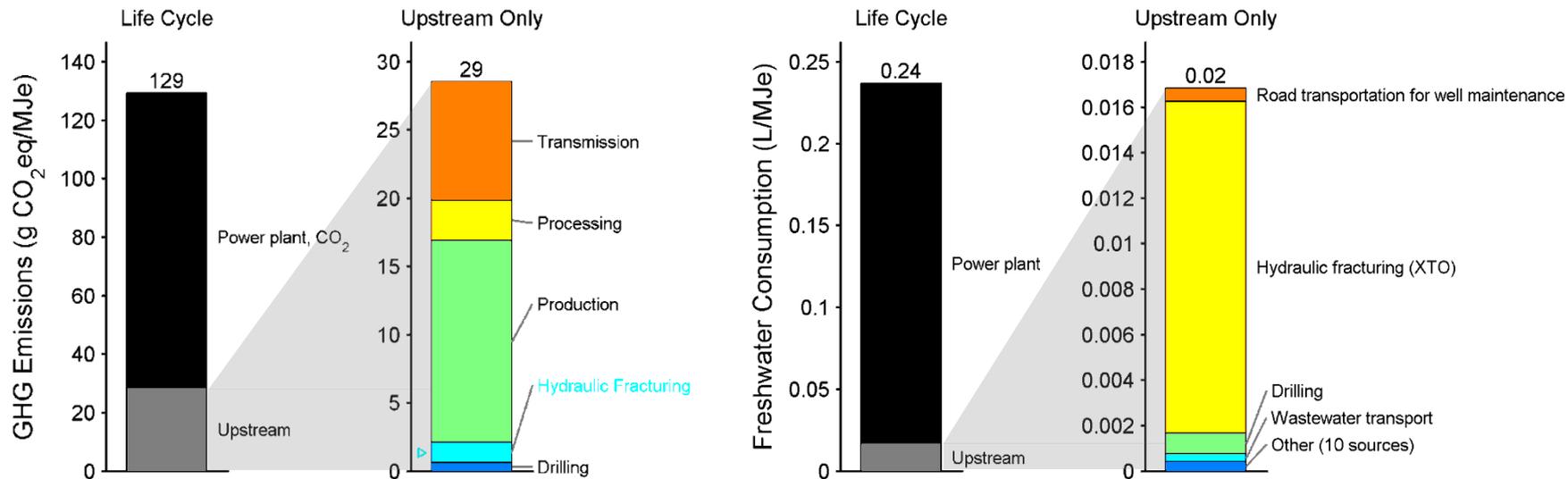
- Shale Gas
  - We used internal data from XTO Energy (an ExxonMobil affiliate) to assess impacts of upstream operations (e.g. hydraulic fracturing)
  - U.S. EPA estimates of fugitive emissions\* were utilized when ExxonMobil data were not available (e.g. chemical injection pumps)
  - EPA estimates have been validated by the findings of the University of Texas/EDF study of fugitive emissions from oil and gas
  - Power plant efficiency: 50.2% (HHV basis)
- Coal:
  - We employ the results of the LCA of coal power published by the U.S. Department of Energy (National Energy Technology Laboratory)†
  - Power plant efficiency: 36.8% (HHV basis)

\* Source: U.S. Environmental Protection Agency (EPA-600/R-96-080a)

† Source: U.S. Department of Energy (DOE/NETL-2012/1566)

# Life Cycle Impacts – Marcellus

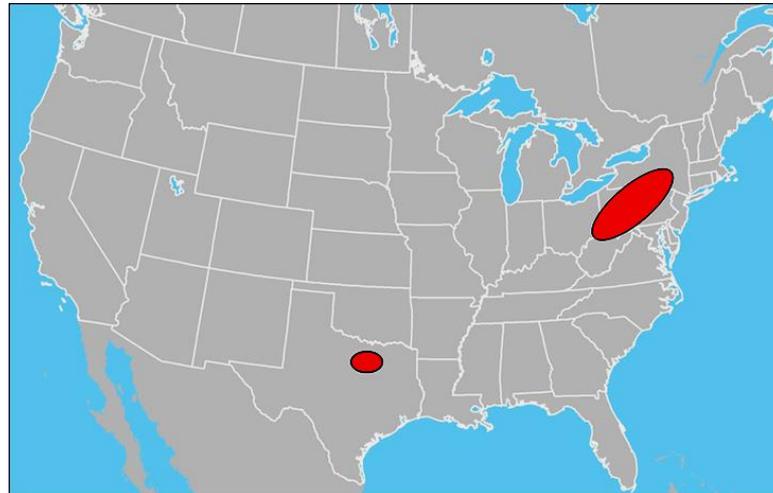
- Marcellus shale gas has half the GHG emissions, water consumption of coal
  - Coal power\*: 288 g CO<sub>2</sub>eq/MJ<sub>e</sub> power generated, 0.47 L/MJ<sub>e</sub> power generated
- Hydraulic fracturing emissions are minor compared with other sources
  - 0.66% of life cycle GHG, 6.3% of life cycle freshwater



\* Source: U.S. Department of Energy (DOE/NETL-2012/1566)

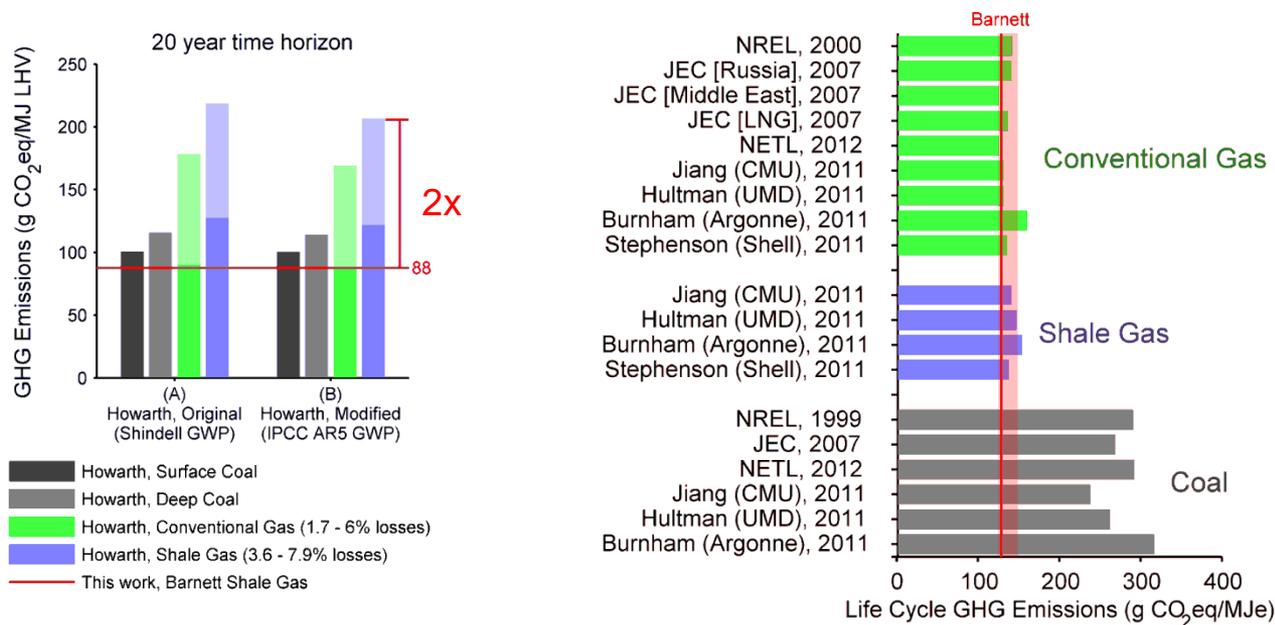
# Life Cycle Impacts – North American Shale Gases

	Barnett		Marcellus		Coal
	Rich	Lean	Rich	Lean	
GHG Emissions (g CO <sub>2</sub> eq/MJ <sub>e</sub> )	130	134	129	128	288
Fraction of Gross Methane Emitted	1.7%	1.6%	1.5%	1.4%	
Freshwater Consumption (L/MJ <sub>e</sub> )	0.24	0.24	0.24	0.24	0.47



# Comparison with other studies

- Our findings are consistent with the rest of the peer-reviewed literature
- One study overstates GHG emissions by **2x** for a 20-year horizon
  - Normalizes GHG emissions with respect to fuel LHV
  - Does not account for efficiencies of coal and gas power plants



# Summary

- Life Cycle Environmental Impacts
  - GHG emissions associated with power from shale gas are half those of coal power
  - Shale gas consumes half as much freshwater as coal
  - No significant difference between GHG from shale gas and conventional gas
- More than 98% of extracted methane is used as fuel
  - 87% at power plant (largest source of GHG emissions)
  - ~11% at engines & turbines that drive compression (2nd largest source)
- Life Cycle Freshwater Consumption
  - More than 90% occurs at the power plant (closed loop cooling)
  - Hydraulic fracturing constitutes 6 - 8% of life cycle water consumption
- Key Factors Influencing the Environmental Footprint
  - Power plant efficiency
  - Ultimate recovery (Bcf/well)