Hydraulic Fracturing of Unconventional Petroleum Reservoirs: Benefits and Risks

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Brief Review

- **Hydraulic Fracturing**
  - Routine Procedure Since Late 1940s
  - >1 Million Fracked Wells in U.S.

- **Horizontal Drilling**
  - Selective Use Since 1970s
  - Possible Owing To Downhole Drilling Motors

- **“Unconventional” Petroleum Reservoirs**
  - Shale (Barnett, Marcellus, Eagle Ford)
  - Mixed Lithology (Bakken, Niobrara)
  - Commercial Since Early 2000s By HD + HF

Sept 2017
Unconventional Reservoirs in the U.S. Lower 48

Source: U.S. Environmental Protection Agency, 2016
Benefits of “Unconventional” Development

- Energy Independence for North America
  - If Necessary
Liquids (Oil) Production and Consumption United States and Canada

Source: U.S. Energy Information Administration
Natural Gas Production and Consumption
United States

Source: U.S. Energy Information Administration
Benefits of “Unconventional” Development

- Energy Independence and Security
- Oil and Natural Gas Price Stability - Maybe
  - U.S. Production as a Price Governor since it is a Short-term Component of Global Supply
WTI Spot Oil Price at Cushing, OK

Source: U.S. Energy Information Administration

Sept 2017
Natural Gas Spot Price at Henry Hub

Source: U.S. Energy Information Administration
Benefits of “Unconventional” Development

- Energy Independence and Security
- Oil and Natural Gas Price Stability - Maybe
- Global and U.S. Economic Development
  - Global Benefit to Consumers of $7 Billion per Day in Lower Energy Cost (IHS Markit Estimate)
  - Most Evident at Regional Level
State of Wisconsin Involvement

Current Usage of Frac Sand
- One Ton of Sand per Lateral Foot of Borehole
- 50% of Frac Sand Comes from Wisconsin
- Some Sensitivity to Oil Price, but Usage Generally Rising

Wisconsin Statistics
- About 70 Active Sand Mines, 60 Processing Plants and 4 Railroad Loading Sites
- 70% of Output Shipped to Oil and Gas Industry
- 840 Direct Jobs Reported at 27 Locations in 2014
- Direct Value of $455 Million in 2015 for Property Tax Assessment (vs $66 Million as Raw Land)
- $150 Million of Added Plant/Equipment Value
- 34,000 Acres Devoted to Sand Mining vs 14.5 Million to Agriculture (0.2% ratio)

Source: Wisconsin Department of Natural Resources, June 2016
Benefits of “Unconventional” Development

- Energy Independence and Security
- Oil and Natural Gas Price Stability - Maybe
- U.S. Domestic Economic Development
- Greenhouse Gas Mitigation
  - Natural Gas, Not Coal, for Electric Power
U.S. Carbon Dioxide Emissions

Source: U.S. Energy Information Administration
Risks of “Unconventional” Development

- Fracking into Potable Groundwater
  - Fluid Injected at Depth Migrates through Fracture Network to Shallow Freshwater Aquifers
  - Five-year Study by U.S. Environmental Protection Agency Published in Dec 2016
    - Original Research + Review of 1200 Sources
    - No Confirmed Cases of Deep-to-Shallow Contamination Through Fracture Networks (but EPA notes that its study may have data gaps)

Reference: www.epa.gov/hfstudy
Risks of “Unconventional” Development

- Fracking into Potable Groundwater
- Overuse of Local Potable Water
  - Several Million Gallons of Water Are Used to Frac a Typical Horizontal Well
  - How To Mitigate?
    - Use Brackish Aquifers, Not Fresh Water
    - Recycle Water
    - Frac with Foam or CO2
Management of Hydraulic Fracturing Wastewater from Marcellus Shale in Pennsylvania 2009 - 2014

Data from the Pennsylvania Department of Environmental Protection (2015).

Other
Includes road spreading, landfill, and other disposal practices.

Reuse in Oil and Gas Activities
Includes non-hydraulic fracturing oil and gas activities.

Centralized Waste Treatment
Wastewater is treated and either discharged to surface waters or reused in other hydraulic fracturing operations.

Publicly-Owned Treatment Works
Wastewater is treated and discharged to surface waters.

Underground Injection
Wastewater is injected into Class II wells.

On-site Reuse in Hydraulic Fracturing
Risks of “Unconventional” Development

- Fracking into Potable Groundwater
- Overuse of Local Potable Water
- Poor Management of Drill Sites
  - Mitigate By
    - Lined Impoundment Pits
    - Drill Pad Liners
    - Multiple Wells per Drill Pad
    - Proper Cementing of Surface Casing
    - Logistics Management
Risks of “Unconventional” Development

- Fracking into Potable Groundwater
- Overuse of Local Potable Water
- Poor Management of Drill Sites
- Methane Emissions from Surface Facilities
  - General Issue for Oil and Gas Operations
  - Economic and Environmental Incentives to Minimize
Risks of “Unconventional” Development

- Fracking into Potable Groundwater
- Overuse of Potable Local Water
- Poor Management of Drill Sites
- Methane Emissions from Surface Facilities
- Induced Seismicity from Water Disposal
  - Phenomenon Known Since 1960s
Fluid Injection vs Earthquake Frequency
Rocky Mt Arsenal, Denver, Colorado


Sept 2017
Fluid Injection vs Earthquake Frequency
Central and Western Oklahoma

From Langenbruch and Zoback, 2016, Science Advances, Vol 2
Risks of “Unconventional” Development

- Fracking into Potable Groundwater
- Overuse of Potable Local Water
- Poor Management of Drill Sites
- Methane Emissions from Surface Facilities
- Induced Seismicity from Water Disposal
  - Phenomenon Known Since 1960s
  - Mitigate by Disposal Well Placement and Management of Injected Water Volumes
  - Currently the Most Significant Risk in Unconventional Oil and Gas Development