Land-Use, Resource Use in Utica Shale...Now and in the Future (a.k.a., The Resource Curse): Data and Sentiment

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**EROEI & Peak Oil**

**Energy Return on Investment (EROI):**

\[
\text{EROI} = \frac{E_{\text{net}}}{E_{\text{self}} + E_{\text{purchased}}}
\]

**Energy Surplus:**

\[
\text{Energy Surplus} = E_{\text{net}} - [E_{\text{self}} + E_{\text{purchased}}]
\]

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**Graphs:**

1. **Cumulative Energy Production vs. Time:**
   - Shows the cumulative energy production over time, with phases of construction, operational lifetime, and decommissioning.
   - Energy generation increases over time, with a peak and eventual decline.

2. **Energy Economics Diagram:**
   - Illustrates the flow of energy from direct and indirect sources, including the calculation of EROI.
   - The diagram shows how energy is purchased, self-generated, and the net energy to the rest of the economy.

3. **Oil Reserves and Production History:**
   - Demonstrates the historical production and future projections of oil reserves.
   - Highlights the peak production and the predicted decline in future oil discoveries.
Global Connections

• Build-out of pipelines is not geared towards “energy independence” but rather “energy arbitrage”
Regional Connections

• Nationally
  – 34K pipelines (range <1-302 miles); avg 6 miles in length
  • 195,989 miles total (49% increase proposed or being built)

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<td>123</td>
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Regional Connections

• 22,127 miles of Midwest pipeline proposals (105 unique segments; range 1-1,056 miles) averaging 211 miles in length

• In Ohio
  – 37 of these segments pass through Ohio (range 3.5-317 miles); averaging 118 miles in length
  – 4,380 miles total or 1/5\(^{th}\) of the proposed pipeline length
    • This would amount to 22,298 acres of disturbance
      – 4,460 acres of forest, 8,000 acres of crops, 5,400 acres of hay/pasture, and 1,780 acres of grasslands
        » Forest would loss 9.5 MT Carbon (6.2-15.9 MT) or 3.3 million Ohioans worth of CO\(_2\)
      – Potential ecosystem services, watershed resilience, water/air quality issues rise in parallel.
The MarkWest Proposals

- 63 unique pipeline segments – average length of 19 miles; range of 2.2-113 miles
- 1,197 miles of pipelines or 0.08 miles of pipeline per mi²
The MarkWest Proposals

• Nearly 10,200 polygons
  – Average 3.3 acres of disturbance per segment; high of 2.6 mi$^2$; total of 53 mi$^2$
  – 1,676 forested segments; 12.4 ac. Average and a total of 32.5 mi$^2$ of forest removal for this proposal
    • 13.1 mi$^2$ of agriculture; 5.3 mi$^2$ of developed; 33 acres of wetlands; 236 acres of open water traversed; 580 acres of grassland
  – Forest displacement would remove 580,545 tons of Carbon (426-1,095K)
    • This is equivalent to 30.3 MT of CO$_2$ (22.2-57.1 MT CO$_2$)
    • Amounts to the emissions of 1.69 million Ohioans (1.24-3.18 million Ohioans)
Secondary & Tertiary Facilities

• 1,948 miles of new pipelines
  – 16 mi^2 of disturbance associated with these two projects
    • 2.1K acres of forest, 3.8K acres of crops, 2.5K acres of hay/pasture, and 819 acres of grassland
  – For every 22 miles of pipeline proposed we see at least 1 facility needed
    • Fractionator, Regulator Station, Compressor Station, Processing Plant, Delivery Point, etc
What We’ve Learned from Bradford County, PA

- 306 unique pipeline segments – average length of 3.5 miles ± 4.6 miles; range of 0.26-47.64 miles
  - 1,070 miles of pipelines or 0.93 miles of pipeline per mi²
What We’ve Learned from Hoover Grant

- Spring 2014 – 511 mi\(^2\) across Columbiana, Carroll, and Stark (30*30 cm resolution)
What We’ve Learned from Mt. Union/Hoover Grant

• 122 Well Pads – Averaging 3.3 acres ± 0.36; range between 1.4 and 3.9 acres

• Limits of Disturbance (LOD) – we define this as pad plus disturbed area; 6.92 acres ± 1.76; range of 3.62-15.05
  • 11,324 acres; 5,751-45,629 acres
  • Land-Use - 2,265 ac. forest; 4,076 ac. crops; 2,717 ac. pasture; 906 ac. grassland
What We’ve Learned from Hoover Grant

- 630 miles of new pipelines – average width of 42 feet ± 14.1 feet; 2,148 acres of disturbance
- Total footprint excluding roads and retention ponds – 3,399 acres with the ratio of pipelines to well pads being 5.29:1
What We’ve Learned from Hoover Grant

• We have documented 210 unique buried pipelines totaling 13.3 miles (avg. 333 feet; 25-3,566 feet)
• 412 pipelines averaging 5.2 acres of disturbance and totaling 2,148 acres (0.2-86.8 acres)

Future Landscape Projections

• 11 County Core Utica Region – 20-30% of landscape will have been altered by shale gas activity
• 23 County Expanded Utica Region – 10-15% of landscape
What We’ve Learned from Hoover Grant
Resource Utilization - Water

- As laterals get longer (i.e., 50-55 feet per lateral per quarter) water, sand, and chemical needs expand in parallel
Resource Utilization - Water

- Average Ohio lateral requiring 6.2-7.0 MG
  - WV 6.9-7.6 MG per lateral
- Trend is increasing by 405-411K Per Quarter Per Year
  - WV 450K Per Quarter Per Year

Future Watershed Ramifications

- Watershed resilience
- MWCD freshwater pricing regimes
- Agricultural needs
- Wildlife Costs
Future Watershed Ramifications: The MWCD Case Study

• Residential Demands & Watershed Resilience
  – Industry has used 4.8-7.7% of the Muskingum River Watershed’s “available water”
  – Roughly 11-18% of annual residential water demands

• One Year From Now
  – 10.8% of “available water”
  – 25% of residential water demands
    • 5% more than the critical threshold identified by researchers for any one industry
Future Watershed Ramifications: The MWCD Case Study

- **Residential Demands & Watershed Resilience**
  - Industry has used 4.8-7.7% of the Muskingum River Watershed’s “available water”
  - Roughly 11-18% of annual residential water demands

- **One Year From Now**
  - 10.8% of “available water”
  - 25% of residential water demands

“adopting a precautionary principle setting 20% of the natural runoff in a region as the upper limit of human consumptive use, where “natural runoff” is defined as the sum of the observed runoff plus the human consumptive use that has reduced runoff below the value it had in the absence of such use. This precautionary limitation in effect defines an environmental flow requirement...Accordingly, human consumptive use that does not leave at least 80% of the natural runoff in a region available for reuse is deemed to pose a serious risk to the health of ecosystems served by the runoff...This limit of 20% on consumptive use is provisional, as is the case for any application of the precautionary principle, but it should be noted that more than 20% of a natural runoff may be withdrawn, so long as the resulting consumptive use remains below 20% of the natural flow.”

**Green Water and Global Food Security**

- Despite a decline in growth rates by almost half (since the early 1990s) and a rise in the global human population from 5.3 billion to 7.5 billion in 2025, with more than 1 billion added to the number in 2025 (Rice et al., 2012), the climate is expected to strain the available natural resources and to increase the risk of food shortages in some parts of the world. The availability of water, particularly in the arid regions of the world, is critical for food production and will be exacerbated by climate change. Therefore, it is important to understand the relationship between water availability and food production to develop sustainable strategies for food security. (Pimentel, 2009)
Production

- As laterals get longer (i.e., 50-55 feet per lateral per quarter) water, sand, and chemical needs expand in parallel
  - Total Production Increasing But Per Well Production Decreasing
Production

Eastern Ohio Utica Shale Oil & Gas Production

**Total Oil Production (Bbl)**

- 0 - 11,904
- 11,905 - 31,932
- 31,933 - 60,996
- 60,997 - 129,005

**Total Gas Production (MCF)**

- 0 - 288,640
- 288,641 - 758,927
- 758,928 - 1,641,991
- 1,641,992 - 3,181,013
Production

• As laterals get longer (i.e., 50-55 feet per lateral per quarter) water, sand, and chemical needs expand in parallel
  – Total Production Increasing But Per Well Production Decreasing

• 1st to 2nd Year Declines of 84% on a per day basis
  – Followed by 27% declines for oil and 10% for gas
  • Freshwater usage is increasing by 3.6 gallons of water per gallon of oil

• 2011 Vs Present
  – Oil – 2011 declines by 2.63 BPD Vs Present 21-48 BPD
  – Nat Gas – 2011 declines by 118 MCF Vs Present 125-251 MCF (Note: 2011 wells 3,158)
## Carroll County Production

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<th>Rest of State (409)</th>
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<td>91,193</td>
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<td>Oil (Barrels)</td>
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<td>Gas (MCF)</td>
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<td>Total</td>
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<td>Brine (Barrels)</td>
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<td>Total</td>
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### Maps

- [Map of Carroll County, OH Utica Shale Hydrocarbon & Brine Production](#)
- [Map of Brine Per Day (Barrels)](#)
- [Map of Nat Gas Per Day (MCF)](#)
- [Map of Oil Per Day (Barrels)](#)
- [Map of Days of Production](#)
Production

• Total Production Increasing But Per Well Production Decreasing
  • Red Queen Hypothesis
    – Oil Production = 349%
    – Gas = 171%
    – Brine = 278%
    – Permitting = 589%
  • Producing roughly 88% of drilled/drilling wells

• Tax Revenue Potential
  – 0.5-0.8% = 35 years to $4.6 billion proposed for 2020
  – 1-4% = 21 years....
  – 5-7% = 11 years
• 11-25% required to generate 2020 tax revenue
Where waste is going & Ohio’s Uniqueness

- Ohio at unique point in the middle of the Shale Drilling Venn Diagram
  - Plus Proximity to Pennsylvania and West Virginia
Where waste is going & Ohio’s Uniqueness

- Class II Injection Wells
  - Significantly varies by area and ownership
  - 117 Million Gallons Per Well; +5.4 Million Gallons Per Well
Where waste is going & Ohio’s Uniqueness

- Drill Cuttings and Southeast Ohio
  - Very little data to work with but for Columbiana-Carroll-Harrison SWD and Barb Walton
  - 28,098 Tons Per Facility; +15,319 Tons Per Facility
  - Drill Cuttings averaging 600-720 tons per lateral; + 4.7-5.2 tons per lateral per quarter
What the data says

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<td>Drill Cuttings (Tons)</td>
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<td>Landfill Drilling Muds (Tons Per Facility)</td>
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<td>OH**</td>
<td>6.2-7.0 MGs</td>
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<td>% of Residential Demand</td>
<td>11-18%</td>
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<td>% of “Available Water”</td>
<td>5-8% (11% w/in 1 year)</td>
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<td>Gallons Water Per Gallon Oil</td>
<td>16-38</td>
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<td>WV</td>
<td>6.9 MGs</td>
<td>450K</td>
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| Silica Sand (Tons)                            | 4,303     | 86                   |
| Injection Waste (Gallons Per Quarter)         | 117 MGs   | 5.4 MGs              |
| Total                                         |           |                      |
| Midwest Pipeline Proposals (Miles)            | 22,127    |                      |
| Disturbance (mi²)                             | 118       |                      |
| Forest (acres)                                | 17,132    |                      |
| Crops (acres)                                 | 30,730    |                      |
| Hay/Pasture (acres)                           | 20,742    |                      |
| Grasslands                                    | 6,837     |                      |

* Encana/Marathon Oil proposing 23-25 MGs laterals in Michigan
** 7-9% returns to surface as brine waste; OH wells producing 1.1-1.3 units of oil per unit of oil
# MWCD selling “excess” water to industry for $4.25 per 1,000 gallons; $00.10-00.12 per gallon of injection waste disposed; $3.50 per ton of drilling mud disposed in landfills
Organic Farming-Shale Gas Nexus

• 19,662 Organic Farms in the US and Canada (703 in Ohio (3.6% of Total))
  – 25 in Utica Core (<1 mile)
  – 103 Within Utica Intermediate (1-3 miles)
  – 195 Within Extended Periphery (3-5 miles)
    – 36 within 1 Mile of Injection Wells
    – 96 within 3 Miles of Injection Wells

• Nationally
  – 455 in Shale Gas Core (< 2.5 Miles)
  – 752 in Shale Gas Intermediate (2.5-5 miles)
  – 2,140 in Shale Gas Periphery (5-20 miles) or 11% of North American Organic Farms
Organic Farming-Shale Gas Nexus

- 19,662 Organic Farms in the US and Canada
- Nationally
  - 2,912 Organic Farms in the US Shale Gas Plays (15%)
  - 6,179 Organic Farms in the US Shale Gas Basins (31%)
  - California, 1,334; Colorado 297; Illinois 286; Indiana 334; Iowa 239; Michigan 504; Missouri 118; New York 834; Ohio 510; Pennsylvania 449; Texas 394; Wisconsin 271
Regional Conclusions

• Build-out of Shale Infrastructure & Resource Utilization:
  – Increases likelihood that “energy independence” was just cover for arbitrage and global export
  – Proposal/Permitting trend dwarfs current inventory and production
  – Increases likelihood of many small environmental/health events many of which will go undocumented
    • Increased environmental/health risk connectivity (Ex. Bradford County)
  – Further fragments landscape and dwarfs land-use/land-cover (LULC) associated with well pads
  – The potential loss of ecosystem services and watershed resilience is nontrivial
    • 1.7 Million Ohioans worth of CO₂ emissions (1.3-3.3 million)
    • Muskingum Watershed rapidly approaching “available water” tipping point with industry requiring more water and sand
      – Mining in northern Great Lakes has hit inflection point
  – Jobs and Economic Boost Ephemeral Vs Landscape Change and Watershed Resilience are permanent
Macro Conclusions

- **Leverage** – Resolute Energy, American Eagle Energy, Quicksilver Resources

- **Shareholder Returns**
  - 15 publicly traded Ohio firms have experienced a -4.33% decline in share price since DFP and -1.53% annually
  - Credit ratings plummeting and access to credit nonexistent

- **Geopolitics – Sheikhs Vs Shale**
  - “Geopolitics, Shale Gas, and Pipelines”

- **Water Scarcity/Security**

- **Resource Utilization** (i.e. sand mining)
Conclusions

• A couple Shameless Plugs
  – Our "US Organic Farms and Oil & Gas Activity" and "Ohio Shale Gas Viewer", and "Fracking Waste Transport & Disposal Network"