Let’s dive into the social sciences to explore some “wicked problems”
Finding the “sweet spot” for hydraulic fracturing public policy in Oklahoma

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Larry Sanders, Ph.D.
Dave Shideler, Ph.D.

County Officers and Deputies Association
Norman, OK
September 11, 2014
9:00 - 10:30 and 10:45 - 12:15
Sweet spot?

- Aiming for the middle is rarely a successful strategy in hydraulic fracturing
- For public policy, as well, “aiming for the middle” may not be a successful strategy...
Geology key points
Geology key points

**Hydraulic Fracking**
Other names:
Hydrofracking
Fracking or Fracing
A technique to release difficult-to-access oil and gas
Developed in the 1940’s as a way to stimulate the release of oil and gas from rock formations and wells that were no longer productive.

**Horizontal Drilling**
Drilling process used to create a non-vertical well.
Hydraulic Fracturing

Hydraulic fracturing, or “fracing,” involves the injection of more than a million gallons of water, sand and chemicals at high pressure down and across into horizontally drilled wells as far as 10,000 feet below the surface. The pressurized mixture causes the rock layer, in this case the Marcellus Shale, to crack. These fissures are held open by the sand particles so that natural gas from the shale can flow up the well.
Community impacts: Transportation & utilities
Hydraulic fracturing can involve thousands of truck trips
Alfalfa County Oil & Gas Production

Woods County Oil & Gas Production

Alfalfa County HWY Expenditures

Woods County HWY Expenditures

Oil & Gas Production (2000-2011)
County Road Expenditures (1998-2013)
Oil & Gas Production (2000-2011)
County Road Expenditures (1998-2013)
Where are we?

Oklahoma seismicity rate is still accelerating. Science will not provide any absolutes about single quakes. It is extremely difficult to claim the set of earthquakes in OK is natural.
Policy Options

Do nothing: USGS probability analysis of data suggests a significant earthquake is likely

Shut down everything: No evidence that is required and will have significant side effects to economy

Shut down existing high volume wells and limit injection rates: could determine if quake rate slows within a year

Monitor injection wells with Corp. Commission oversight
Mud and waste key points

Illegal dumping of drilling mud
Is this a road in your county?
Issue: Water used in process, produced water, and waste

- 2-8 million gallons water/well; Typically 4 wells per pad
- 20,000 – 400,000 gallons chemicals/well
- Produced water varies; often 100,000s of thousands of gallons/well
- Open pit storage (mud/water); injection wells (water); filtration/recycling*

Adapted from http://www2.epa.gov/hfstudy
Drilling mud additives may include:

- Bentonite clay (lubricator/sealer/viscosity)
- Barium sulfate (weight)
- Lime (corrosion)
- Soda ash (Na$_2$CO$_3$ – water conditioner)
- Lignite (viscosity control)
- Loss circulation material (sealer)
- Ground peanut shells, mica, cellophane, walnut shells, calcium carbonate, plant fibers, cottonseed hulls
**Water and oil base drilling mud**

**Water base mud** (uses water as solvent)

Salinization of soils
- Excess salts: Reduces the ability of the plant to uptake water
- Remedy: Leach out with natural rainfall and time

Sodic soils
- Excess Na: Poor drainage, poor structure, little growth
- Remedy: Gypsum and water

**Oil base mud** (uses diesel as a solvent)

TPH toxicity to plants
- Not a long term risk
- “Bio-Treatment”

Salinization and sodicity
- Not as much of a risk as for water base mud
Community and housing key points
Phases of community attitudes

Why do we care?
Financing responses to NGE impacts

Engaging community stakeholders

Community Issues and Alternatives

Affecting local goods and services

Impacting sociology
Paradox of plenty

Resource curse theory (paradox of plenty) suggests over-reliance of natural resource base eventually harms local economy. Research supports this claim: Study of 391 rural Rocky Mt. counties 1975-85 indicates boom economies may have been worse off in long run (Jacobsen & Parker)

![Bar chart showing average annual % change in employment, wage/salary income, median household income, and poverty rate.]

Community impacts: Sociological impacts

What about intangibles?
Legal key points

Oil and gas activities in Oklahoma are regulated

- Mineral interests have right to explore and produce the minerals
- State law and regulations administered through OCC
- Federal law and regulations pertain water and air quality issues; EPA
Economics points: Big and small

Key question: Do benefits outweigh the costs?
Answer: It depends... We may not know yet.
Environmental issues and options
90-Day Provisional-Temporary Permits
Oil, Gas & Mining Use (1992-2014)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Permits</th>
<th>Total Amount Permitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>710</td>
<td>3,211</td>
</tr>
<tr>
<td>1993</td>
<td>789</td>
<td>2,764</td>
</tr>
<tr>
<td>1994</td>
<td>1,312</td>
<td>3,868</td>
</tr>
<tr>
<td>1995</td>
<td>1,043</td>
<td>3,492</td>
</tr>
<tr>
<td>1996</td>
<td>1,259</td>
<td>3,243</td>
</tr>
<tr>
<td>1997</td>
<td>1,227</td>
<td>2,532</td>
</tr>
<tr>
<td>1998</td>
<td>904</td>
<td>1,956</td>
</tr>
<tr>
<td>1999</td>
<td>640</td>
<td>2,652</td>
</tr>
<tr>
<td>2000</td>
<td>1,019</td>
<td>2,914</td>
</tr>
<tr>
<td>2001</td>
<td>982</td>
<td>2,270</td>
</tr>
<tr>
<td>2002</td>
<td>703</td>
<td>3,233</td>
</tr>
<tr>
<td>2003</td>
<td>1,206</td>
<td>5,253</td>
</tr>
<tr>
<td>2004</td>
<td>1,449</td>
<td>5,472</td>
</tr>
<tr>
<td>2005</td>
<td>1,628</td>
<td>3,547</td>
</tr>
<tr>
<td>2006</td>
<td>1,794</td>
<td>4,229</td>
</tr>
<tr>
<td>2007</td>
<td>1,792</td>
<td>7,957</td>
</tr>
<tr>
<td>2008</td>
<td>1,993</td>
<td>6,486</td>
</tr>
<tr>
<td>2009</td>
<td>875</td>
<td>9,320</td>
</tr>
<tr>
<td>2010</td>
<td>1,286</td>
<td>15,659</td>
</tr>
<tr>
<td>2011</td>
<td>1,891</td>
<td>23,541</td>
</tr>
<tr>
<td>2012</td>
<td>2,270</td>
<td>27,291</td>
</tr>
<tr>
<td>2013</td>
<td>2,043</td>
<td>17,480</td>
</tr>
<tr>
<td>2014</td>
<td>1,100</td>
<td></td>
</tr>
</tbody>
</table>

OWRB, 2014, thanks to Tracy Scopel
Conclusions

• Much uncertainty about natural gas extraction issues remains, such as earthquakes, environmental impacts
• All stakeholders have numerous options for action
• Informed dialog among stakeholders at every level is critical
• Some awareness of short term impacts; long term impacts less certain

• More research is needed
• Industry ability/desire to fracture is outpacing research
• Education and transparency are important
Discussion
Thank you!
2014 OSU Hydraulic Fracturing Education Team

Shannon Ferrell
Todd Halihan
Gina Peek
Chad Penn
Larry Sanders
Dave Shideler
Appendix

What we are currently doing
  charting/mapping
  comparative analysis for key counties
## Payne County, OK

<table>
<thead>
<tr>
<th>Year</th>
<th>Bldg permits/units/cost</th>
<th>Oil (% change in prod. 2000-2011)</th>
<th>Gas (% change in prod. 2000-2011)</th>
<th>County road expenditures</th>
<th>Crime rates</th>
<th>Earthquakes</th>
<th>Economic indicator (retail sales per cap.)</th>
<th>employment rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>14/37/ $1.9 mil</td>
<td></td>
<td></td>
<td>$2.6 mil.</td>
<td></td>
<td></td>
<td></td>
<td>3.0-3.9</td>
</tr>
<tr>
<td>2011</td>
<td>101/291/ $29.9 mil.</td>
<td></td>
<td></td>
<td>$3.7 mil.</td>
<td></td>
<td></td>
<td></td>
<td>5.0-5.9</td>
</tr>
<tr>
<td>% change</td>
<td>720%/790%/1570%</td>
<td>-15%</td>
<td>255%</td>
<td>142%</td>
<td></td>
<td></td>
<td></td>
<td>167%</td>
</tr>
</tbody>
</table>

http://www.census.gov/construction/bps/
“From my back porch in every direction I see oil derricks and wind generators dotting the horizon. These industries bring in billions of dollars to our state’s revenue, but at what cost to our state’s infrastructure?

I feel the most important issue facing my community … is the deterioration of roads, bridges, dams, levees, transit, and water/wastewater systems. Just travel any road in my area, you will encounter giant potholes, sinking culverts, damaged bridges and basically untravel-able roads, all because these roads are being destroyed by the giant rigs, endless trails of salt water tankers, and relentless over-weight traffic of the oil field industry.

There are miles and miles of water pipe lying in the ditches to provide water to the fracking rigs. They are draining our reservoirs, and the waste because of leaks is ridiculous.

Yes, the oil industry is bringing billions of dollars to the state, but who is going to be responsible for repairing the infrastructure they destroy or deplete?

Anonymous Oklahoma farmer, 2014
Technology and policy implications

- Hydraulic fracturing technology evolves
  - OK: 1.5 b.-5 b.
  - US: 1.3 t,-2.4 t.
- Fracturing process underground yields oil, gas, salt water, waste (complex with geology, hydrology, technical procedures)

Public policy (support/restrict)

Hydraulic fracturing process above ground issues:
- Opportunity cost of water
- Disposal of fracturing water; salt water
- Air pollution (Methane)
- Vehicle, equipment, and pipeline transport to/from well sites
- Boom-bust issues
- Earthquakes
Water Planning Regions, Oklahoma Comprehensive State Water Plan 2012 & potential major deficits through 2060

Note: Groundwater provides 75-87% of irrigation water supply

OWRB, 2011
Public financing for infrastructure: Focus on roads/bridges

A blend of local (community & county), state & federal funds, as well as bonds sold in private sector

State transportation department non-appropriated
- Vehicle fuel taxes, state revenue, Fed Hwy Trust Fund, state bonds
- County responsibility
- 70% of roads, 59% of bridges
- County Hwy Fund (state fuel taxes, vehicle registration fees, state oil/gas production tax; fed funds; county sales tax varies)
- Payne County (25% bridges structurally deficient; 7 bridges “obsolete”)
Funding for County Roads/Bridges in 2013

**Revenue**

- State sources allocated $347.8 million to counties by formula (population, land area, road miles)*
  - Gross Production tax $76 mil.
  - County Bridge & Road Improvement Fund (CBRIF) by formula (above plus terrain/traffic volume)
  - County local option sales tax revenue provided $34 million
  - Tribal funds where applicable

**Expenditures**

- County highway fund: $351.7 million
- Other accounts vary
- Payne County Hwy Fund
  - Expenditures $3.7 mil
  - Hwy Fund revenue ($4.8 mil.)

See Tax Commission annual report
2014 changes in OK oil/gas production tax

Prior to change

- Prior to change (price-based rates)
- 7% if greater than $2.10/mcf; oil $17/bbl or greater
- 4% if greater than $1.75/mcf and less than $2.10; oil $14-$17
- 1% if less than $1.75; oil less than $14
- 1% for first 4 years of horizontal well production
- Several rebates/exemptions (first 6% of the 7%)

New law (HB 2562)

- 2% first 3 years
- 7% after 3 years
- 1% first 2 yrs for horizontal wells
- Exemption incentives extended to 2020 for secondary, tertiary, reestablished production, production enhancement
- 50% of collections to Gen. Rev. Fund, 25% County Hwy Fund, 25% to counties for schools
- Tax Commission estimates impacts revenue neutral in 2016
Oil/Gas improving competitiveness across sectors with significant energy inputs.
Oil/gas exports

United States Balance of Trade

United States Current Account to GDP
The answer depends on where you ask the question

<table>
<thead>
<tr>
<th>Gas Shale Basin</th>
<th>States</th>
<th>Rock Column Thickness b/w Play and Treatable Water, ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnett</td>
<td>TX</td>
<td>5,300 – 7,300</td>
</tr>
<tr>
<td>Fayetteville</td>
<td>AR</td>
<td>500 – 6,500</td>
</tr>
<tr>
<td>Haynseville</td>
<td>LA, TX</td>
<td>10,100 – 13,100</td>
</tr>
<tr>
<td>Marcellus</td>
<td>NY, PA, OH, VA, WV</td>
<td>2,125 – 7,650</td>
</tr>
<tr>
<td>Woodford</td>
<td>OK, TX</td>
<td>5,600 – 10,600</td>
</tr>
<tr>
<td>Antrim</td>
<td>MI</td>
<td>300 – 1,900</td>
</tr>
<tr>
<td>New Albany</td>
<td>IL, IN, KY</td>
<td>100 – 1,600</td>
</tr>
</tbody>
</table>
### Federal regulations

<table>
<thead>
<tr>
<th>Legislation/Regulation</th>
<th>Agency</th>
<th>Purpose</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe Drinking Water Act</td>
<td>EPA</td>
<td>Regulates waste injection wells under Underground Injection Control (UIC)</td>
<td>Hydraulic fracturing is generally exempted from UIC regulation</td>
</tr>
<tr>
<td>Spill Prevention Control and Countermeasures (Clean Water Act)</td>
<td>EPA</td>
<td>Requirements for well sites to prevent spills and/or contain them</td>
<td></td>
</tr>
<tr>
<td>Clean Air Act</td>
<td>EPA</td>
<td>Sets air pollution limits for oil/gas production</td>
<td></td>
</tr>
</tbody>
</table>
## Oklahoma regulations

<table>
<thead>
<tr>
<th>Legislation/Regulation</th>
<th>Implementing Agency</th>
<th>Purpose</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seismic Exploration</td>
<td>OK Corporation Commission</td>
<td>Regulate oil/gas exploration</td>
<td>Gives mineral interest owner right to permit seismic exploration; limits liability to unreasonable surface damage and damage from explosives</td>
</tr>
<tr>
<td>Regulation Act</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Damage Act</td>
<td>District Court</td>
<td>Defines procedure for determining damages from the production of oil and gas</td>
<td>Stipulates process for negotiating land lease; gives parties opportunity to determine damages by jury trial</td>
</tr>
<tr>
<td>Fracturing Fluid Disclosure Requirement</td>
<td><a href="http://www.fracfocus.org">www.fracfocus.org</a></td>
<td>Disclose fluids used in drilling new fractured wells</td>
<td>Disclosure is required within 60 days of well completion [OK Code sec 165: 10-3-10(b)]</td>
</tr>
<tr>
<td>Well Construction</td>
<td>OK Corporation Commission</td>
<td>Provides standards for casing, cementing and surface requirements</td>
<td></td>
</tr>
<tr>
<td>Regulations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulations for</td>
<td>OCC</td>
<td>Numerous regulations in place for the management and disposal of wastes</td>
<td>Regs cover commercial disposal pits, “soil farming,” and land application</td>
</tr>
<tr>
<td>Exploration and Production (E&amp;P) Waste</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Surface water pollution prevention

• Stormwater management
  – Not required for wellsite itself, BUT
  – Required for runoff in contact with industrial materials or pollutants on site
  – Usually handled by general permit/BMPs

• SPCC requirements for wellsites
State regulation of E&P waste

• RCRA exemption gives states option to regulate wastes
• Numerous OCC regulations for management and disposal of wastes
  – Commercial disposal pits
  – “Soil farming”
  – Land application of wastes
# Air quality issues

<table>
<thead>
<tr>
<th>Onshore Exploration Source Type</th>
<th>Specific Emission Sources</th>
<th>Potential Pollutants(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling Rigs</td>
<td>Diesel engines to run electricity generators</td>
<td>SO(<em>2), NO(<em>x), VOC, PM(</em>{10}), PM(</em>{2.5}), CO</td>
</tr>
<tr>
<td></td>
<td>Drill mud degassing (open pits or storage tanks)</td>
<td>VOC</td>
</tr>
<tr>
<td>Gas Well Completion</td>
<td>Emissions from flaring from the gas well completion phase</td>
<td>CO, NO(_x), VOC</td>
</tr>
<tr>
<td></td>
<td>Emissions from venting from the gas well completion phase</td>
<td>VOC</td>
</tr>
<tr>
<td>Oil Well Completion</td>
<td>Emissions from flaring from the oil well completion phase</td>
<td>CO, NO(_x), VOC, SO(_2)</td>
</tr>
<tr>
<td></td>
<td>Emissions from venting from the oil well completion phase</td>
<td>VOC</td>
</tr>
<tr>
<td>Gas Well Pneumatic Devices</td>
<td>Fugitive emissions from pneumatic devices used during gas well exploration and production</td>
<td>VOC</td>
</tr>
<tr>
<td>Oil Well Pneumatic Devices</td>
<td>Fugitive emissions from pneumatic devices used during oil well exploration and production</td>
<td>VOC</td>
</tr>
</tbody>
</table>
Oklahoma Natural Gas Prices & Active Rigs

Sources: Baker Hughes & U.S. Energy Information Administration

Oklahoma Oil Prices & Active Rigs

Sources: Baker Hughes & U.S. Energy Information Administration
Natural resource curse (a.k.a., Dutch Disease)

Community impacts: Community costs

infrastructure systems and services
bridges
water supply
law enforcement
utilities
waste water treatment
medical
education

who will pay for these?
who will capture tax revenues?
Alternatives: Community

Financing responses to NGE impacts
- Ad valorem tax (at time of sale)
- Severance tax (at time of removal)
- Resource revenue trust funds
- Voluntary mitigation funds
- Revenue-sharing between governmental levels/units

Engaging community stakeholders
- Education efforts for community leaders
- Public deliberation forums
- Community social events engaging current & new residents

Housing
- Community-built housing
- Developer-built housing
- Facilitation of private housing development
- Streamline housing approval / permit process
- Voucher / subsidy programs for low- or fixed-income residents

Sociological impacts
- Crime prevention through community engagement programs
- On-site drug abuse prevention programs
- Public-private partnerships to address sexual abuse / disease
- Community programs for supportive youth environments
- Domestic violence support / therapy programs
What about “remaining reserves”?

- **Demonstrated**
- **Inferred**

**KNOWN**

- **Hypothetical**
- **Speculative**

**UNKNOWN**

- **Undiscoverable**
- **Irretrievable**

**ECONOMIC**

- Economic (generally defined by market and government)

**SUBECONOMIC**

- Technological/Geological Feasibility (generally defined by research/development)

Monitor injection wells with Corp. Commission oversight,
Limited research findings

- Few underground problems
- Some air pollution
- Some surface water contamination
- Some land damage
- Increase in earthquakes (injection wells)...
- Accelerated risk of quakes

Community impacts

- Weak net economic benefit
  - more beneficial short run
  - less beneficial long run
- More competition for fresh water
- Reduced quality of life in adjacent rural areas
- Increased pressure on public infrastructure
- Increased incidence of crime
Limited research findings

- National impact
  - Improved competitiveness
  - Less energy import dependence
  - Relatively lower fuel costs
  - Contributed to economic recovery (shortened recession)
  - Expansion of industries with significant energy input

- Some issues with severance tax

- Technology very net beneficial for oil/gas industry

More research is needed