ECONOMIC IMPACTS OF THE PENNSYLVANIA MARCELLUS

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OUTLINE OF TALK

- What is the nature of shale energy production?
- What is the shale energy supply chain?
- What are the economic impacts?
- What are environmental impacts & costs?
- What are costs & benefits of shale energy?
- What are the observable economic impacts of shale energy development?
- Implications & strategies for economic development
I. NATURE OF SHALE ENERGY PRODUCTION
PA MARCELLUS DRILLING & PRODUCTION

- Intensive drilling
  - Increased from 97 wells in late 2009 to 405 in late 2010
- Production increased
  - 152 mmcf per day in late 2009
  - Over 2 bcf per day in late 2010
- In three years PA becomes an exporter of natural gas
- Industry is getting very proficient at drilling
- Production is increasing faster than anticipated
THE PRODUCTION DECLINE CURVE

- Why is drilling so intensive?
- The steep production decline curve
- First example to right
  - Year 1: 511.9 mmcf
  - Year 2: 257 mmcf
  - Year 10: 88 mmcf
  - Year 30: 32 mmcf
- To keep increasing output, need to keep drilling – treadmill effect
- Multi-stage fracturing is increasing well productivity
- More gas with fewer wells

![Marcellus Production Decline Curves](image)

**Marcellus Production Decline Curves**

- Horizontal pre 2008 EUR = 2.8 bcf
- Stimulated Horizontal 2010 EUR = 4 bcf
2. THE SHALE ENERGY SUPPLY CHAIN
LEASING ACTIVITY

- Goal is to obtain access to prospective properties for exploration
- Must define land and mineral rights & ownership
- People & businesses involved in leasing
  - Land men
  - Clerks & legal assistants
  - Real estate brokers
  - Lawyers
EXPLORATION ACTIVITIES

- Objective is to locate and define oil and gas deposits
- Exploration activities
  - Very advanced technology
  - Seismic survey crews
- Affected businesses
  - Local hotels
  - Restaurants
  - Coffee shops
  - Convenience stores
SITE PREPARATION

- Clearing land and building roads
- Providing access to water and utilities
- 5,000 tons of aggregate per well
- Businesses involved
  - Excavation equipment manufacturers
  - Contractors and dealers
  - Painters and haulers
  - Mulch and fertilizer suppliers
  - Safety equipment manufacturers and suppliers
  - Electrical equipment supplies & contractors
  - Surveying equipment suppliers and contractors
  - Surveying engineering companies
  - Aerial mapping services
WELL CONSTRUCTION

- Starts with a well “spudded” when the bit hits the ground
- Drilling to total depth may take anywhere from 2-4 weeks
- Businesses involved:
  - Crane manufacturers and leasing companies
  - Drill bit manufacturers
  - Steel manufacturers
  - Cement and concrete companies
  - Chemical manufacturers
  - Safety equipment companies
- Many companies contract out drilling operations
- 125 tons of concrete per well
WELL STIMULATION

- Hydraulic fracturing

Businesses involved:
- Hydraulic fracturing contractors
- Trucking companies
- Diesel fuel companies
- Water management companies

Water and material intensive
- 25 rail cars of sand
- Millions of gallons of water
MIDSTREAM DEVELOPMENT

- Construction of compressor stations
- Lower pressure gathering lines
- High pressure steel pipelines
- Businesses involved:
  - Pipeline construction companies
  - Heavy equipment contractors
  - Steel pipe producers
  - Value and compressor manufacturers
NATURAL GAS PROCESSING

- Strip out valuable liquids
- Some products
  - Propane, butane, ethane, etc.
  - Valuable feed stocks for petrochemical production
- Businesses
  - Pipe fitters
  - Steel pipe manufacturers
  - Equipment producers
  - Contractors
EXPANSION OF DOWNSTREAM INDUSTRIES

- Abundant, low cost shale energy attracts additional industry
- Possible sectors:
  - Petro-chemical manufacturing
  - Fertilizer production
  - Metal and glass industries
  - Electric power generation
  - CNG use in transportation
- These industries have their own supply chains and would generate additional economic impacts
3. ECONOMIC IMPACTS
WHAT IS ECONOMIC IMPACT ANALYSIS?

- Quantitative model of the inter-industry transactions between economic sectors
- Developed by Wassily Leontief who won Nobel Award for this in 1973
- Provides an estimate for how spending in one sector affects
  - Other sectors of the economy and
  - Household disposable income
- Widely used for many types of projects, from sports stadiums, wind turbines to coal mines
Increase in spending

Stimulate supply chain sales

Increase in income and employment

Induced increase in consumer spending

Feedback
PENN STATE STUDIES ON MARCELLUS

- Collected accounting data on what drilling companies spent and where they spent their dollars
- Conducted two subsequent surveys of Marcellus industry spending
- Estimated impacts of this spending on Pennsylvania economy
  - Jobs
  - Valued added
  - Tax Revenues
## Pennsylvania Marcellus Spending in Millions of Current Dollars

<table>
<thead>
<tr>
<th>Category</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Spending</td>
<td>3,224.6</td>
<td>5,283.9</td>
<td>11,477.1</td>
</tr>
<tr>
<td>Lease &amp; Bonus</td>
<td>1,837.7</td>
<td>2,172.4</td>
<td>2,068.5</td>
</tr>
<tr>
<td>Exploration</td>
<td>121.9</td>
<td>117.1</td>
<td>208.4</td>
</tr>
<tr>
<td>Upstream: Drilling &amp; Completion</td>
<td>857.8</td>
<td>2,151.0</td>
<td>7,377.0</td>
</tr>
<tr>
<td>Midstream: Pipeline &amp; Processing</td>
<td>329.4</td>
<td>698.6</td>
<td>1,303.9</td>
</tr>
<tr>
<td>Royalties</td>
<td>22.2</td>
<td>53.4</td>
<td>346.0</td>
</tr>
<tr>
<td>Other</td>
<td>55.5</td>
<td>91.4</td>
<td>173.3</td>
</tr>
</tbody>
</table>
COMPOSITION OF FIRST ROUND OF SUPPLY CHAIN SPENDING

- Construction 30%
- Oil & Gas Support 26%
- Wholesale Trade 16%
- Oil & Gas Drilling 12%
- Services 7%
- Retail Trade 3%
- Transportation 2%
- Stone & Quarrying 2%
- Manufacturing, Utilities, Agriculture 2%
## JOBS & VALUE ADDED (MILLIONS) 2010

<table>
<thead>
<tr>
<th>Sector</th>
<th>Jobs</th>
<th>Value Added</th>
<th>Sector</th>
<th>Jobs</th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, etc</td>
<td>780</td>
<td>22.2</td>
<td>Real estate &amp; rental</td>
<td>5,360</td>
<td>1,192.30</td>
</tr>
<tr>
<td>Mining</td>
<td>14,886</td>
<td>1,411.00</td>
<td>Scientific &amp; tech services</td>
<td>11,042</td>
<td>1,058.10</td>
</tr>
<tr>
<td>Utilities</td>
<td>478</td>
<td>194</td>
<td>Management of companies</td>
<td>1,318</td>
<td>195.2</td>
</tr>
<tr>
<td>Construction</td>
<td>23,730</td>
<td>1,431.80</td>
<td>Administrative &amp; waste services</td>
<td>6,387</td>
<td>268.2</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>2,936</td>
<td>370.7</td>
<td>Educational services</td>
<td>3,405</td>
<td>152.1</td>
</tr>
<tr>
<td>Wholesale Trade</td>
<td>9,974</td>
<td>1,338.80</td>
<td>Health &amp; social services</td>
<td>12,815</td>
<td>736.1</td>
</tr>
<tr>
<td>Retail trade</td>
<td>16,581</td>
<td>839.3</td>
<td>Entertainment &amp; recreation</td>
<td>2,641</td>
<td>91.6</td>
</tr>
<tr>
<td>Transportation</td>
<td>4,864</td>
<td>354</td>
<td>Hotel &amp; food services</td>
<td>7,767</td>
<td>229.9</td>
</tr>
<tr>
<td>Information</td>
<td>1,729</td>
<td>274.6</td>
<td>Other services</td>
<td>6,634</td>
<td>254.5</td>
</tr>
<tr>
<td>Finance &amp; Insurance</td>
<td>4,986</td>
<td>664.7</td>
<td>Government &amp; Misc.</td>
<td>1,577</td>
<td>81.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>139,889</td>
<td>11,160.80</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. ENVIRONMENTAL IMPACTS
ENVIRONMENTAL IMPACTS

- Unavoidable impacts
  - Clearing of land for well pads and pipelines
  - Local congestion, noise, dust in rural communities
  - Emissions during drilling

- Environmental hazards
  - Stray gas – failures in casing & contamination of water
  - Containment pond breaches
  - Spills from petroleum liquids handling
  - Well blow-outs & resulting spills

- Environmental risk – perceptions
  - There have been problems
  - What is there proper context?
  - Can these problems result in widespread contamination?
Environmental Violations per Hundred Wells Drilled in Pennsylvania Marcellus, 2008-2010

- Administrative: 42.0%
- Erosion: 16.4%
- Water: 15.2%
- Cement and Casing: 9.2%
- Blowouts and Venting: 7.1%
- Other Spills: 3.4%
- Serious Violations: 2.6%
- All Violations: 0.4%

- Serious Violations:
  - Administrative: 2.6%
  - Erosion: 0.7%
  - Water: 0.4%
  - Cement and Casing: 0.3%
  - Blowouts and Venting: 0.2%
  - Other Spills: 0.1%

- All Violations:
  - Administrative: 42.0%
  - Erosion: 16.4%
  - Water: 15.2%
  - Cement and Casing: 9.2%
  - Blowouts and Venting: 7.1%
5. BENEFIT COST ANALYSIS
ECONOMIC BENEFITS & ENVIRONMENTAL COSTS

- **Benefits**
  - Gains in real output, jobs, and tax revenues
  - Environmental – avoided emissions from coal

- **Costs**
  - Air emissions from shale energy production
  - Water pollution
  - Forest disruption
  - Noise, traffic externalities, etc.

- **What level of benefits are necessary to accept environmental risks?**
### BENEFITS & COSTS IN DOLLARS PER WELL

<table>
<thead>
<tr>
<th>Economic &amp; Environmental Benefits</th>
<th>Environmental costs:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic value added</td>
<td>Air impacts from upstream life-cycle emissions</td>
<td>2,796</td>
</tr>
<tr>
<td>Avoided air pollution</td>
<td>Air impacts from diesel use during hydraulic fracturing</td>
<td>7,245</td>
</tr>
<tr>
<td>Avoided community health impacts from coal</td>
<td>Water pollution using household values</td>
<td>193</td>
</tr>
<tr>
<td>Subtotal</td>
<td>Forest disruption</td>
<td>3,943</td>
</tr>
<tr>
<td>Total Benefits</td>
<td>Total Costs</td>
<td>14,178</td>
</tr>
</tbody>
</table>
6. SHALE ENERGY, JOBS, AND TAX REVENUES
UNEMPLOYMENT RATE DIFFERENCES FROM STATE AVERAGE, 2007-2011

Percentage point

Greene 215 Wells
Washington 363 Wells
Susquehanna 227 Wells
Tioga 481 Wells
Lycoming 261 Wells
Bradford 691 Wells
CUMULATIVE DRILLING & UNEMPLOYMENT BY COUNTY 2011

Average Monthly Difference from Pennsylvania’s State Monthly Unemployment Rate 2011

- Marcellus Wells Drilled Since 1/1/2008
- 1.6 or more percentage points above the unemployment rate
- 0 to 1.5 percentage points above the unemployment rate
- 0.01 to -1.5 percentage points below the unemployment rate
- -1.6 or more percentage points below the unemployment rate

Wells: The Pennsylvania Department of Environmental Protection
Unemployment: The U.S. Bureau of Labor Statistics
7. ECONOMIC DEVELOPMENT STRATEGIES
STRATEGIES FOR DEVELOPMENT

- Based upon cost-benefit analysis, environmental risks are acceptable
  - Tough but flexible regulation is required
  - Determine the facts and encourage technological innovation
- Infrastructure development is important
  - Shale energy companies may be well positioned to contribute
  - Innovation again is key
- Work force development will be important
- Must realize competition between shale plays – taxation
- Identify and nurture market opportunities for shale energy products
THANK YOU !!!