Natural Gas – A National Treasure
NECPUC Symposium
5/21/2012
Who is Southwestern Energy?

US Lower 48 Gas Production Sorted by 1Q12 (MMcf/d)

SWN is 8th overall as of 1Q12

Source: Public company reports, Southwestern Energy
United States Shale Gas Plays

United States Shale Gas Plays

Stacked Appalachian Plays

- Marcellus
- Utica
- Devonian (OH shale)

Shale Gas Plays
Basins

November 2008

0 150 300 600 Miles

EIA
Energy Information Administration
Office of Oil and Gas

www.eia.doe.gov
The Current Gas Issue

Demand Compared to 914 Production
Rolling Yearly Average

- 12 Mo Demand
- Lwr 45 12 Mo 914 Prod
May 18, 2012

**Commentary**
The combined horizontal gas rig count for the six major plays decreased by 2 to 242. The Haynesville and Fayetteville lost a rig each, while the Marcellus, Barnett, Eagle Ford and Pinedale/ Jonah remained flat WoW.

(Based on data from Baker Hughes, Smith Bits, PIRA, Pl/Dwight & HPDI)
• SWN currently producing **2 BCF per day** gross

• SWN reached **2 TCF** – 7.5 years from 1st production in early May 2012
• SWN holds approx. 925,000 net acres in the Fayetteville Shale play (approx 1,400 sq. miles).

• Mississippian-age shale, geological equivalent of the Barnett Shale in north Texas.

• SWN discovered the Fayetteville Shale and has first mover advantage – average acreage cost of $253 per acre with a 15% royalty and average working interest of 74%.

• We plan to drill approximately 425-435 operated wells in 2012.

Notes: Rates are AOGC Form 13 and Form 3 test rates.

Forward-Looking Statement
New Brunswick, Canada Project

- SWN currently holds exploration licenses to over 2.5 million acres within the Maritimes Basin
- Principal targets are the conventional and unconventional sandstone and shale reservoirs of the Horton Group (Frederick Brook Shale)
- Oil and gas production from fields along southern flank:
  - McCully – reserves 190 bcfg
  - Stoney Creek – cum 800,000 bo, 30 bcfg
- 3-year initial exploration license to complete work program
  - $47MM total work commitment with options for multiple 5-year extension leases
  - $14.2MM invested in 2011; $13.2MM investment planned for 2012

Forward-Looking Statement
What Makes a Project Unconventional?

Mid Bakken  Eagle Ford  Niobrara  Lwr. Smackover

Modified from Nelson, 2009, AAPG Bull
"Brown Dense" is the largest source rock system in the US

Conventional: 3.4 billion BO & 38 TCFG onshore.

Source rock estimated to have generated 2.5 Trillion BOE (onshore and offshore)

Kerogen Type: I & IIS: Oil-prone kerogen (algal, amorphous, bacteria), sulfur-rich

TOC: 0.06 – 8.42% (up to 60%)

TOC Avg.: 0.58% (not corrected for Ro)

Laminated carbonate & kerogen (mm scale), in core and thin section below
Eclipse - Brown Dense Thin Section
Interlaminated carbonate source rock with microporosity

Talley #B-1 (9190'), offset to Location #2: phi = 11.3%, perm = 0.154 md, 100x.

- **microporosity**
- **porous channels created by dissolution from organic acids**
- **kerogen-rich layers with pervasive microporosity**
- **expulsion fractures enhanced by dissolution of carbonate and clay**
- **blue haze = microporosity**
Regulatory Considerations

Surface Considerations

Air Emissions

Surface Impact

Water Supply
Water Handling
Water Reuse & Disposal
Regulatory Considerations

Subsurface Considerations

Protecting Underground Water Resources

Frac Fluid Disclosure
Well Integrity is the Key

1. Evaluate Stratigraphic Confinement
2. Well Construction Standards
3. Evaluate Mechanical Integrity of Well
4. Monitor Frac Job & Producing Well
1. Evaluating Stratigraphic Confinement

Virtually all fresh water wells are less than 500 feet deep in the Fayetteville Shale area.

Thousands of feet of rock separates the Fayetteville Shale from shallow, freshwater zones.

Cross sectional view
The largest recorded seismic event generates the same amount of energy as would be released when dropping a gallon of milk from chest high to the floor.
2. WELL CONSTRUCTION STANDARDS

- CONDUCTOR PIPE
- SURFACE CASING
- PRODUCTION CASING
- CEMENT

FRESH WATER AQUIFER ZONE

SHALLOW PRODUCING ZONE

TARGET PRODUCING ZONE
3. Evaluating Mechanical Integrity of Well

- **Internal Mechanical Integrity**
  - Verify appropriateness of proposed casing program (e.g., size, grade, minimum internal yield pressure, etc.)
  - Test casing string to ensure it can withstand maximum stimulation pressure

- **External Mechanical Integrity**
  - Verify quality of cement
  - Identify top of cement
  - Test cement job (FIT, CBL, etc.) when operations indicate inadequate coverage
FRESH WATER AQUIFER ZONE

SHALLOW PRODUCING ZONE

CONDUCTOR PIPE

SURFACE CASING

PRODUCTION CASING

GOOD MECHANICAL INTEGRITY

TARGET PRODUCING ZONE
CEMENT CHANNELING

PRESSURE BUILDS UP

CONDUCTOR PIPE

SURFACE CASING

PRODUCTION CASING

FRESH WATER AQUIFER ZONE

SHALLOW PRODUCING ZONE

TARGET PRODUCING ZONE

CASING

CEMENT

FORMATION

SWN

Southwestern Energy®

TARGET PRODUCING ZONE

SHALLOW PRODUCING ZONE

FRESH WATER AQUIFER ZONE
LEAK THROUGH CASING

CONDUCTOR PIPE
SURFACE CASING
PRODUCTION CASING

PRESSURE BUILDS UP

FRESH WATER AQUIFER ZONE
SHALLOW PRODUCING ZONE
TARGET PRODUCING ZONE

CASING
FORMATION

Southwestern Energy®
INSUFFICIENT CEMENT COVERAGE

CONDUCTOR PIPE

SURFACE CASING

PRODUCTION CASING

PRESSURE BUILDS UP

FRESH WATER AQUIFER ZONE

SHALLOW PRODUCING ZONE

TARGET PRODUCING ZONE
Surface Considerations

Air Emissions

- Drilling Operations
- Completion/Fracturing Operations
- Storage Tanks
- Compressor Stations
- Site Construction
Regulating Air Emissions

Emission Type
- $\text{NO}_x$
- $\text{SO}_2$
- CO
- $\text{CH}_4$
- VOCs (incl. BTEX)

Reduction Technology
- Catalytic reduction
- Ultra-low sulfur diesel fuel
- LNG and CNG fuels
- Oxidation catalysts
- Green completions, vapor recovery units, low bleed/no bleed pneumatic devices, plunger lift systems, leak detection

Emission Levels
- EPA
- Industry
- State regulators
- Research groups
Water Issues

Water Supply
Water Handling
Water Reuse & Disposal
Water Supply

Location, Volume & Timing of Withdrawals

Cumulative Impact Assessment

Alternative Sources of Supply
Volume and Rate of Withdrawals
Fayetteville Shale

Statewide:
11,500 million gallons/day

SWN Operations:
10 million gallons/day (600 Wells/year)

Arkansas Water Uses

Percent of Statewide Water Consumption (not all categories included)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Consumption (gallons/day)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWN Operations</td>
<td>9</td>
<td>.09%</td>
</tr>
<tr>
<td>City of Little Rock</td>
<td>65</td>
<td>.5%</td>
</tr>
<tr>
<td>Duck Hunting Clubs</td>
<td>270</td>
<td>2.3%</td>
</tr>
<tr>
<td>Power Plants</td>
<td>2,000</td>
<td>17%</td>
</tr>
<tr>
<td>Irrigation</td>
<td>8,300</td>
<td>72%</td>
</tr>
</tbody>
</table>

Total Statewide Consumption: 11,500 million gallons per day

Water Handling

Trucks vs. Pipeline
- Truck Traffic
- Road Damage

Impoundments vs. Tanks
- Closed-Loop Drilling Systems
- Recycling Logistics
- Air Emissions

Tracking Wastewater
- Characterize Wastewater
- Record Volumes Produced
- Verify Volumes Delivered
Water Recycling & Reuse
- Reduces fresh water demand
- Reduces impact on roads and related infrastructure
- Reduces amount of wastewater requiring disposal

Water Treatment Facilities
- Flowback & produced water chemistry
- Capacity & Capability limitations (NORM, DBPs, heavy metals)
- Central vs. drill site facilities

Water Disposal Wells
- Geological & hydrological limitations
- NIMBY concerns
- Induced seismicity considerations
Recycled Flowback Water

Frac fluid pumped down wellbore during stimulation job.

Approximately 20-40% of frac fluids return to the surface as "flowback water."

Additives mixed with fresh and recycled water to make up "frac fluid."

Supply

25% Recycled Water
17% Public Fresh Water Sources
58% Private & SWN Fresh Water Sources

Handling

Well

~10% Recycled
~90% Disposal Wells

Reuse & Disposal

100% Recycled

Treated Water
NPDES Permitted Discharge

Recycled Flowback Water

Flowback Water

Produced Water

Treatment Facilities Private/Public

Waste Disposal

Fresh Water Sources
Surface Municipal, Streams, Rivers
Surface Water, Shallow Ground Water
Surface Municipal, Streams, Rivers

Supply

Handling

Reuse & Disposal

Water Cycle for Hydraulic Fracturing Operations

Waste Disposal

NPDES Permitted Discharge

Reused & Disposal

Recycled Flowback Water

Flowback Water

Produced Water

Treatment Facilities Private/Public

Waste Disposal

NPDES Permitted Discharge

Water Cycle for Hydraulic Fracturing Operations

Waste Disposal

NPDES Permitted Discharge

Recycled Flowback Water

Flowback Water

Produced Water

Treatment Facilities Private/Public

Waste Disposal

NPDES Permitted Discharge
Surface Considerations

Surface Impact

Drilling Locations
- Pit construction
- Erosion and sedimentation
- Chemical storage

Infrastructure
- Compressors
- Pipelines
- Roads
- Water treatment facilities

Truck Traffic & Road Damage
### Top Positives

<table>
<thead>
<tr>
<th>Issues</th>
<th>Overall</th>
<th>Johnson</th>
<th>Wise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Availability of good jobs</td>
<td>0.36</td>
<td>0.28</td>
<td>0.45</td>
</tr>
<tr>
<td>2 Med. and health care services</td>
<td>0.13</td>
<td>0</td>
<td>0.27</td>
</tr>
<tr>
<td>3 Quality of local schools</td>
<td>0.10</td>
<td>0.03</td>
<td>0.17</td>
</tr>
<tr>
<td>4 Fire protection services</td>
<td>0.10</td>
<td>0.04</td>
<td>0.16</td>
</tr>
<tr>
<td>5 Local police protection</td>
<td>0.06</td>
<td>0.03</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Getting worse: -1  
Staying the same: 0  
Getting better: 1

Source: Gene L. Theodori, Sam Houston State University
Surface Considerations
Perception Change due to Shale Drilling

Top Negatives

<table>
<thead>
<tr>
<th>Issues</th>
<th>Overall</th>
<th>Johnson</th>
<th>Wise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased truck traffic</td>
<td>-0.73</td>
<td>-0.72</td>
<td>-0.73</td>
</tr>
<tr>
<td>Amount of freshwater used</td>
<td>-0.56</td>
<td>-0.53</td>
<td>-0.59</td>
</tr>
<tr>
<td>High tax rates</td>
<td>-0.43</td>
<td>-0.35</td>
<td>-0.51</td>
</tr>
<tr>
<td>Noise pollution</td>
<td>-0.41</td>
<td>-0.40</td>
<td>-0.43</td>
</tr>
<tr>
<td>Water pollution</td>
<td>-0.39</td>
<td>-0.26</td>
<td>-0.53</td>
</tr>
</tbody>
</table>

Getting worse: -1  
Staying the same: 0  
Getting better: 1
No Pad Drilling
Surface Considerations

Pad Drilling

• Reduce surface footprint by over 80%
• Reduce truck traffic up to 65%
• Optimize installation of infrastructure
Fulfilling the Promise of Natural Gas

Straight talk/open dialogue
Debate the real issues
Regulation without the politics
The Promise of this National Treasure

PUC’s + Power Generators + Natural Gas Industry = Better Environment
Less Expensive Energy
Energy Security
May 18, 2012

**U.S. Drilling Rigs**

<table>
<thead>
<tr>
<th>Rig Types</th>
<th>Change</th>
<th>This Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>+2</td>
<td>600</td>
</tr>
<tr>
<td>Oil</td>
<td>+10</td>
<td>1,382</td>
</tr>
<tr>
<td>Misc.</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>+12</td>
<td>1,986</td>
</tr>
</tbody>
</table>

**Natural Gas Rigs**

<table>
<thead>
<tr>
<th>Rig Types</th>
<th>Change</th>
<th>This Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal</td>
<td>-1</td>
<td>451</td>
</tr>
<tr>
<td>Vertical</td>
<td>+1</td>
<td>80</td>
</tr>
<tr>
<td>Directional</td>
<td>+2</td>
<td>69</td>
</tr>
</tbody>
</table>

**Oil Rigs**

<table>
<thead>
<tr>
<th>Rig Types</th>
<th>Change</th>
<th>This Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal</td>
<td>-6</td>
<td>809</td>
</tr>
<tr>
<td>Vertical</td>
<td>+5</td>
<td>449</td>
</tr>
<tr>
<td>Directional</td>
<td>-1</td>
<td>124</td>
</tr>
</tbody>
</table>

**Commentary**

Total US drilling rig count increased by 12 rigs to 1,986. This increase was driven by oil rig additions. In the oil category, the directional (+11) and vertical (+5) classes offset a 6 rig loss in the horizontal class. In the gas category, small gains in the directional (+2) and vertical (+1) class made up for a single rig loss in the horizontal class.

The Canadian rig count gained a total of 3 rigs. A 6 rig increase in the oil category, offset a 3 rig loss in the gas category.

(Based on data from Baker Hughes & Smith Bits)
Intensity Creates Visibility

1,275 trucks

1st Well

550 trucks

Incremental Wells

675 trucks

Comeback Well

Note: Graphs includes water activity through 60 days after first sale.

Forward-Looking Statement
Characteristics of a Shale Play

- High present day TOC, Kerogen Content, Type, & Richness
  - RockEval, TOC, S1/S2, S2/S3, HI, OI, NOC, PI, FIT, NGSL

- Thermal Maturity >1.3% Ro (Gas Window)
  - Vitrinite Reflectance, Tmax, TAI, FIT, Resistivity

- Observed/Measured Porosity usually >4% and Perm
  - Cores, D-N logs, SEM, Epifluorescence,

- Brittle Rock – Silica/Carbonate content >40%
  - Dipole sonic (Poissons Ratio & Youngs Modulus)

- Sufficient Thickness and quality for Gas In Place
  - Isopach maps: 50-400’ gross thickness

- Mudlog Gas Shows prevalent throughout AOI
  - C1-C5

- Free Gas vs. Absorbed Gas
  - Micropores vs. Van de Waal effects of hydrocarbon gases on atomic carbon

Source: Ray Ambrose - Devon Energy, Robert Hartman - Weatherford Laboratories, Mery Diaz-Campus, I. Yucel Akkutlu and Carl H. Sondergeld - University of Oklahoma
Regulatory Considerations

Surface Considerations

- Air Emissions
- Surface Impact
- Water Supply
- Water Handling
- Water Reuse & Disposal