Allegheny County

A Challenged Natural Gas Super-giant

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Allegheny County, Pennsylvania, sits atop vast reserves of natural gas, enough to qualify it as a super giant gas field. But various factors, including high population density, have conspired to place most of these reserves off limits to full development. Allegheny and two adjoining counties, Washington and Greene, are situated within the "core of the core" of the recently named Appalachian Mega Giant Gas Field. Each county has recoverable natural gas reserves likely exceeding them at or near the highest county natural gas reserve base in the nation.

As the second-most populous county in the state and home to Pittsburgh, Allegheny County presents unique challenges to full development of the resources. By a quirk of nature, these three counties lie atop some of the best shale reservoir rock in the world in the Marcellus, Utica and the lesser-known Upper Devonian Barnett/Genshaw Shale. Estimates of total technically recoverable reserves exceed 150 trillion cubic feet equivalent (Tcf) for Allegheny County alone equivalent to 1.881 of liquid or 6.361 of gas. This is nearly five times the minimum required for classification as a super-giant gas field (30 Tcf) and enough natural gas to provide all of America's needs for more than five years. At today's currently depressed market prices, the value of this resource exceeds $400 billion, and the value of potential royalties payments to landowners in the county is more than $60 billion.

Of the three counties, Allegheny County provides the greatest challenges to development of the resources due mainly to the urban/suburban nature of the majority of the county. Residences, office buildings, political issues, regulatory restrictions, topography and splintered subsurface rights all contribute to prevent full development of the resources. To date, only the peripheral, semi-rural margins of the county have seen any shale gas development at all. These obstacles are likely to preclude development across large portions of the county; and only 4% of the entire county's acreage appears to have viable drilling locations available.

The size of the prize
The Marcellus Shale is the most prolific natural gas resource in the world, and Allegheny County is situated in the heart of some of the best productive areas of the "Southwest Core Area" of the resource. The productive portion of this black, organic-rich shale is about 80 feet in thickness and found at drilling depths ranging from 3,500 feet along its western boundary with Beaver County deepening to more than 7,000 feet in the south. The hydrocarbons that would be produced in the county vary corresponding generally to depth, with liquids rich wet gas in the shallowest areas in the west that would feed the yet-to-be-built Shell ethane cracker plant, and trending to dry gas in the southeast.

Based on production results from existing wells completed by top-tier companies surrounding and within Allegheny County, it is estimated that the Marcellus has 34 Tcf of technically recoverable reserves. Significant liquids and ethane contribute to the large conventional equivalent numbers in the wet gas areas.
Allegheny County

Marcellus wells
(permited & drilled)

Why is that big hole in the middle of all the wells?
Allegheny County

Marcellus wells (permitted & drilled)

Allegheny County- Home to the 2nd largest population in Pennsylvania
Allegheny County

Allegheny County review

- Resources/Size
  - Burket/Geneseo
  - Marcellus
  - Utica
- Challenges to Development
  - Regulatory Offsets
    - Homes/Businesses
    - Streams
  - Topography
- Where can we drill?

Marcellus wells
(permited & drilled)
Allegheny County, Pennsylvania

Home to THE largest natural gas reserves in the world

Home to 2nd largest population in the state

Can the two coexist and what is the future of gas development in the county?
Allegheny County

Some background on the county

- 2nd most populous county in Pennsylvania (behind Philadelphia)
- Population of 1,231,225 (2014)
Allegheny County is home to 127 municipalities including:

- Cities
- Boroughs
- Townships
Reservoirs... & the size of the prize
Allegheny County – The Size of the Prize

<table>
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<tr>
<th>No.</th>
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<th>Recoverable Reserve Tcf</th>
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<td>Russia</td>
<td>95</td>
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<tr>
<td>8</td>
<td>Hugoton</td>
<td>USA (TX-OK-KS)</td>
<td>81</td>
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<tr>
<td>9</td>
<td>Groningen</td>
<td>Netherlands</td>
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<td>15</td>
<td>Kish</td>
<td>Iran</td>
<td>45</td>
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</tbody>
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Giant: >3 TCF  
Super-Giant: >30 TCF  
Mega-Giant: >300 TCF  

Appalachian Mega-Giant likely has >2,000 TCF (recoverable reserves) making it easily the largest natural gas field in the world.

Marcellus & Burket (Upper Devonian) Gas-in-Place nearly equals the sum of the remaining 14 largest gas fields in the world (does not include the Utica Shale GIP)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Field Name</th>
<th>Country</th>
<th>Size (Km)</th>
<th>In-Place Reserves (TCF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Marcellus/Burket (Upper Dev)</td>
<td>United States</td>
<td>148,000</td>
<td>3,698</td>
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<tr>
<td>2</td>
<td>South Pars/North</td>
<td>Iran &amp; Qatar</td>
<td>35,000</td>
<td>1,800</td>
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<tr>
<td>3</td>
<td>Urengoy</td>
<td>Russia</td>
<td>6,300</td>
<td>353</td>
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<tr>
<td>4</td>
<td>Yamburg</td>
<td>Russia</td>
<td>3,900</td>
<td>289</td>
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<td>5</td>
<td>Hassi R’Mel</td>
<td>Algeria</td>
<td>3,500</td>
<td>110</td>
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<td>6</td>
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<td>Russia</td>
<td>3,100</td>
<td>130</td>
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<td>7</td>
<td>Galnysh</td>
<td>Turkmenistan</td>
<td>2,800</td>
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<td>8</td>
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<td>Russia</td>
<td>2,700</td>
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<td>9</td>
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<td>United States</td>
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<td>Mevezh'ye</td>
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<td>1,900</td>
<td>83</td>
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<td>North Pars</td>
<td>Iran</td>
<td>1,400</td>
<td>59</td>
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<td>1,300</td>
<td>67</td>
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Allegheny County - Resources Shale Plays

Three resource shale reservoirs in Allegheny County

- Burket/Geneseo - Depth: 5,300 - >7,000’
- Marcellus - Depth: 5,500 - >7,000’
- Utica - Depth: 10,000 - >14,000’
Allegheny County - Marcellus Shale

Southwest Core Area

Marcellus wells
(permited & drilled)
Allegheny County - Marcellus Shale Drilling Depth
Allegheny County - Marcellus Shale Hydrocarbon Zonation
Allegheny County - Marcellus Shale Geology

Wang siliceous organic facies isopach
Allegheny County - Marcellus Shale Gas-in-Place

Gas-in-place* BCFe/square mile

- Ranges from 90 to >150 BCFe
- Average of 130 BCFe
Allegheny County - Marcellus Shale Recoverable Reserves

Recoverable reserves assigned using BCFe/1,000’ of lateral basis

Sources:
- Proprietary EURs
- Corporate Reporting

<table>
<thead>
<tr>
<th>Company</th>
<th>Avg EUR/1,000’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>2.62 (max &gt;3.6)</td>
</tr>
<tr>
<td>Consol</td>
<td>1.95</td>
</tr>
<tr>
<td>EQT</td>
<td>2.1</td>
</tr>
<tr>
<td>Rice</td>
<td>2.16</td>
</tr>
</tbody>
</table>

Calculations:
- 750’ spacing = 17.22 acres/1,000’
- Average EUR/1,000’ = 2.1 BCF
- Average EUR/acre = 122 MMCF

Total Marcellus recoverable reserves for Allegheny County: 58.2 TCFe
Fun with numbers:

Range Southwest Core:

- **GIP:**
  - ~130 BCF/section = 203 MMCF/acre

- **EUR:**
  - 2.6 BCF/1,000’ = 152 MMCF/acre
    - (Range spacing is 1,000’)

**This implies a 56% recovery factor**
Allegheny County – Burket/Geneseo Shale
Allegheny County – Burket/Geneseo Shale

High daily production rates from wells on-trend with Allegheny County.
Burket / Marcellus Fracture Interaction/Enhancement ??

Data indicate:

- Most Burket wells in SW Core area – drilled as stacked lateral between deeper Marcellus wells
- Staggered pattern between Marcellus wells at half spacing
- Likely done as zipper fracs with Marcellus wells from same pad
Burket / Marcellus Fracture Interaction/Enhancement

Consol NV39F
Outperforming Consol type curve*
- Predicted: 5.8 BCFe
- Actual: 9.0 BCFe

Consol reports “great impact” on underlying Marcellus
- 2 Marcellus offsets tested 10.0 & 9.0 MMCF/d

*Consol 3Q, 2014 Company Presentation

Consol 3Q, 2014 Company Presentation
Burket / Marcellus Fracture Interaction/Enhancement ??
Allegheny County – Burket/Geneseo Shale

Recoverable reserves assigned using BCFe/1,000’ of lateral basis

Sources:
- Proprietary EURs
- Corporate Reporting

**Company** | **Avg EUR/1,000’**
--- | ---
Consol | 1.5

Calculations:
- 750’ spacing = 17.22 acres/1,000’
- Average EUR/1,000’ = 1.5 BCF
- Average EUR/acre = 87 MMCF

**Total Burket/Geneseo recoverable reserves for Allegheny County: 42 TCFe**
Allegheny County – Utica Shale

TOC is key production metric

Allegheny County is situated in the heart of the best reservoir based on TOC

Point Pleasant Average TOC*

*McClain MS Thesis 2013 WVU
Allegheny County – Utica Shale

- No wells drilled yet in Allegheny County
- Outstanding flow rates surrounding Allegheny County

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<td>2.8</td>
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<tr>
<td>EQT</td>
<td>2.6 – 6.0 (Scotts Run)</td>
</tr>
<tr>
<td>Rice</td>
<td>2.33</td>
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Calculations:
- 1,000’ spacing = 22.97 acres/1,000’
- Average EUR/1,000’ = 2.5 BCF
- Average EUR/acre = 108.9 MMCF

Total Utica recoverable reserves for Allegheny County: 51.9 TCF
Allegheny County – Burket/Geneseo Shale

Total technically recoverable reserves (TCFe)

Burket/Geneseo  41.5
Marcellus       58.1
Utica          51.9

Total Allegheny County

151.6 TCFe

*Range 2016 08 23
Sun Trust Zagorski
Allegheny County – The Size of the Prize

Allegheny County alone

Would rank above all but 2 of the world’s largest conventional gas fields for recoverable reserves

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Table Sources: Global Natural Gas Reserves - A Heuristic Viewpoint
Raphael Sandrea, 2006
Size refers to ultimate recoverable reserves expressed in trillion cubic feet


Zagorski, Wrightstone & Bowman
Allegheny County

Drilling Access Issues
Allegheny County – Challenges to Development

• Regulatory restrictions
  • Set backs from habitable buildings or businesses
  • Set backs from streams

• Topography

• Legal
  • Force pooling
    • Marcellus/Burket
      • No force pooling in Pennsylvania for Marcellus/Burket
      • Multiple small tracts required to be under lease
      • Areas with old drilling leading splintered ownership
    • Utica
      • Force pooling is available in Pennsylvania for Utica
  • Pipeline availability
  • Splintered O&G rights
  • Community & environmental activism opposition
Allegheny County – Challenges to Development

Set backs.... The waters have been muddied

Act 13 passed in 2012
• Established Impact Fee
• 500’ set backs from homes/businesses
• 300’ set backs from streams

Anti-drilling environmental activists sued to overturn the law

State Supreme Court in December 2013 ruled portions of the Act 13 restricting local zoning was unconstitutional including:
• Cannot preempt local zoning rules
• Must allow municipalities to restrict drilling in certain zoning

Anti-drilling activists want:
• Set backs of 2,000’ or greater (de facto drilling ban)
• Drilling limited to areas zoned for industrial use

Thanks to Robert Johnson of ADKL for summary
Allegheny County – Challenges to Development

500’ Set backs from all habitable dwellings and business buildings

Shape file from county showing all homes and offices
Allegheny County – Challenges to Development

500’ buffer around all buildings

ID possible sites for drilling pads using shape file buffer map
Allegheny County – Challenges to Development

GIS layer 2 years out of date

Lots of construction in that time
Allegheny County – Challenges to Development

County layer had issues w/ non-homes showing up... like cell phone towers
Allegheny County – Challenges to Development

County layer had issues w/ non-homes showing up... park pavilions
Allegheny County – Challenges to Development

County layer had issues with non-homes showing up... park pavillions
Allegheny County – Challenges to Development

County layer had issues w/ non-homes showing up... park pavilions
Allegheny County – Challenges to Development

300’ setback from a “blueline stream or wetland”

Blueline stream

Intermittent waterway
Topographic restrictions on construction of pads and roads

Estimated maximum 15% slope for construction of a 400 x 400’ pad
Allegheny County – Challenges to Development

Digital elevation model used to ID areas w/ >15% slope

Many thanks to intern Justin Skaggs for the GIS work on this.

Layer: Slope small 23
Allegheny County – Challenges to Development

Drillable areas
Allegheny County – Challenges to Development

Drillable areas

Semi-rural
North Fayette Township

Fairly accessible with opportunities
Allegheny County – Challenges to Development

SW Allegheny County
North Fayette Township

Drillable areas

Peripheral, semi-rural areas provide moderate to good opportunities

• Fairly accessible
• Good # of possible sites
Allegheny County – Challenges to Development

Legal issues:

**Marcellus & Burket/Geneseo:**
- No force pooling
- Required to lease every royalty owner under each lateral
- Likely 100’s of agreements needed for each pad

**Utica:**
- Force pooling in effect
- Easing likelihood of minor holdouts preventing drilling
Allegheny County – Challenges to Development

Drillable areas
Heavily populated areas through the central part of Allegheny County:
- isolated “legal” suburban drill pads
- County parks
- Golf courses

Legal sites for vertical wellbore

N. Allegheny County
McCandless Township

Allegheny
Allegheny County – Challenges to Development

Drillable areas

Heavily populated areas through the central part of Allegheny County:
Allegheny County – Challenges to Development

Drillable areas
Heavily populated areas through the central part of Allegheny County:
- Golf courses
Allegheny County – Challenges to Development

Oakmont has hosted more combined PGA & USGA championships than any other course in the US
Allegheny County – Challenges to Development

Drillable areas

- Densely populated core of county 0 – 2% of area has possible locations
- Peripheral semi-rural areas have increasing availability for pads
Historic drilling

- Old drilling dating back to late 1800’s
- Lots of unlocated shallow vertical wells
- Nightmare of severed oil & gas rights likely
Allegheny County – Long history of drilling

Pittsburgh’s First Natural Gas Boom. Source: “Harper’s Weekly, Nov. 7, 1885, 744-45


Allegheny County – County owned parks

- Nine (9) parks
- Total 12,000 acres
Allegheny County – County owned parks

Deer Lakes Park

- 1,180 acres
- Only County park to be leased
- Range negotiated contract in May 2014
- Wells drilled from pad on adjoining private lands
Allegheny County

Range Resources
- Upfront payment of $4.7 million
- Donated $3.0 million to park improvement fund
- 18% royalty has earned $503,000 since March 2015

- 24 new benches
- Cleaned up lake waters
- Added bathrooms
- Upgraded pavilions
- Trail improvements
Allegheny County – County owned parks

Remaining Parks

Most of other parks are not likely targets for drilling
- Old field development
- No legal sites, too close to homes/businesses
Who is drilling and where....
Allegheny County – Who is drilling?

- Consol
- Pittsburgh Int. Airport
- Range
- Chevron
- Range
- Consol
- Pittsburgh Int. Airport
- EQT
Allegheny County – Pittsburgh International Airport drilling

CONSOL Pittsburgh International Airport

- 9,200 acres
- 6 planned pads
- At least 45 Marcellus wells planned
- 2/2013: Agreement signed
- $45 million up-front payment
- 1st production from 6 wells on Pad #2
- Per enplaned passenger rate has dropped 12.2%
Allegheny County

Great potential but significant challenges to develop the resources.

Questions??