Production and Water Use in Pennsylvania’s Organic Shales*

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Search and Discovery Article #20486 (2020)**
Posted July 27, 2020

*Adapted from oral presentation given at 2019 AAPG Eastern Section Meeting, Columbus, Ohio, October 12-16, 2019

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Abstract

Thousands of shale gas and oil wells have been drilled in Pennsylvania since 2004. In addition to the Marcellus Formation, other organic-rich shales are being targeted, including the Upper Devonian Geneseo and Burket shales and the Upper Ordovician Utica Shale. Water is used to hydraulically fracture these wells, with a portion of these treatment waters flowing back after stimulation. Formation water is also generated after the well has been turned into production. Shale wells produce hydrocarbons in 35 of Pennsylvania’s 67 counties. Most of the production comes from the two ‘sweet spots’ in the Marcellus play in southwest and northeast Pennsylvania.

This study looks at production and water use in shale wells from 2010 through 2018. Producing formation information is from the Pennsylvania Geological Survey’s Exploration and Development Well Information Network (EDWIN). Treatment water volumes are as reported by operators on well completion reports. Production and wastewater data are from PA DEP’s database. Information from these sources was compiled for almost 6800 wells that reported production between 2010 and 2018. Different regions were compared to identify patterns of fresh and recycled water use.

More than 75% of the state’s hydrocarbon production comes from the two ‘sweet spots’ of the Marcellus play: Greene and Washington counties in the southwest and Bradford, Lycoming, and Susquehanna counties in the northeast. More than half of the natural gas production comes from the northeastern ‘sweet spot’ where county-wide average daily gas production per well ranges from 1808 to 3243 MCF/day. County-wide average daily gas production per well in the southwestern ‘sweet spot’ ranges from 1571 to 2088 MCF/day. The two counties with the highest average daily production per well, Wyoming (4889 MCF/day) and Sullivan (3944 MCF/day), are adjacent to the northeast’s ‘sweet spot.’ Ninety percent of the liquids production (oil plus condensate) comes from Washington County. All the liquids production comes from the western part of the state, but not necessarily from the ‘sweet spot.’ Liquids production is also significant in Butler and Mercer counties.
The most shale wells have been drilled in Washington County. This county has also used the most hydraulic fracture treatment water and produced the most oil and condensate. Susquehanna County has used the second-largest amount of treatment water and has the highest natural gas production. Most (80 to 95%) of the wastewater from these wells is recycled and reused in other wells.
Production and water use in Pennsylvania’s organic shales

Katherine Schmid, P.G.

2019 AAPG

Eastern Section Meeting
Introduction

• Since 2004, multiple organic shales have been targeted across Pennsylvania by drillers

• This study examines well production and water use in these shale wells
Outline

• Wells drilled in these organic shales
• Hydrocarbon production from the shales
• Amount of water used to fracture the shales
Data Sources

• Well specific production data has been compiled from PA DEP’s Oil & Gas Production/Waste Reports (OGRE) Website
• Interpreted producing formation data are from DCNR’s EDWIN database
• Amounts of water used to fracture wells are from the well completion reports scanned into EDWIN
Organic Shale Extents with Wells

- Utica Shale
- Marcellus Shale
- Rhinestreet Shale

Rhinestreet Wells
Organic Shale Extents with Wells

- Utica Shale
- Marcellus Shale
- Rhinestreet Shale

Legend:
- Blue: Utica Shale
- Pink: Marcellus Shale
- Yellow: Rhinestreet Wells
- Green: Genesee/Burket Wells
Organic Shale Extents with Wells

- Utica Shale
- Marcellus Shale
- Rhinestreet Shale

- Utica Wells
- Rhinestreet Wells
- Geneseo/Burket Wells
- Marcellus Wells
- Utica Wells
Marcellus Sweet Spots

- Geneseo/Burket Wells
- Rhinestreet Wells
- Utica Wells
- Marcellus Wells

• Rhinestreet Wells
• Geneseo/Burket Wells
• Marcellus Wells
• Utica Wells
Number of shale wells in each county
Now to focus on Hydrocarbon Production...
Hydrocarbon production per well in the different shales

![Bar Chart]

- **Rhinestreet**
  - Natural gas production per well: Very low
  - Oil production per well: Very low
  - Condensate production per well: High

- **Geneseo/Burket**
  - Natural gas production per well: Mid-range
  - Oil production per well: Low
  - Condensate production per well: Low

- **Marcellus**
  - Natural gas production per well: High
  - Oil production per well: Low
  - Condensate production per well: Mid-range

- **Utica/Point Pleasant**
  - Natural gas production per well: Low
  - Oil production per well: High
  - Condensate production per well: Low

**Note:** The BCF (Boiler Conversion Factor) is used to convert volumes of natural gas to a standard volume at a given temperature and pressure.
Rhinestreet Shale Extents with Upper Devonian Wells
Upper Devonian Oil Production
July 2010 - Dec 2018

Total oil production (bbls)
- 0 – 500
- 500 – 5,000

Rhinestreet Shale
Upper Devonian Condensate Production 2010-2018

Total condensate production (bbls)
- 0 – 500
- 500 – 5,000
- 5,000 – 20,000
- 20,000 – 50,000
- 50,000 – 100,000
- 100,000 – 150,000

Rhinestreet Shale
Upper Devonian Natural Gas Production 2010 - 2018

Total gas production (BCF)

- 0 – 0.5
- 0.5 – 2.5
- 2.5 – 5.0
- 5.0 – 7.5

Rhinestreet Shale
Marcellus Shale Extents with Marcellus Wells
Marcellus condensate Production
2010 - 2018

Total condensate production (bbls):
- 0 – 500
- 500 – 5,000
- 5,000 – 20,000
- 20,000 – 50,000
- 50,000 – 100,000
- 100,000 – 150,000
- 150,000 – 200,000
Marcellus Natural Gas Production
2010 - 2018

Total gas production (BCF)
- 0 – 0.5
- 0.5 – 2.5
- 2.5 – 5.0
- 5.0 – 7.5
- 7.5 – 10.0
- 10.0 – 15.0
- 15.0 – 22.0

Marcellus Shale
Utica Condensate Production

Total condensate production (bbls)
- 0 – 500
- 500 – 5,000
- 5,000 – 20,000
- 20,000 – 50,000

Utica Shale
Utica Natural Gas Production

Total gas production (BCF)
- 0 – 0.5
- 0.5 – 2.5
- 2.5 – 5.0
- 5.0 – 7.5
- 7.5 – 10.0
- 10.0 – 15.0
- 15.0 – 22.0

Utica Shale
Water used to Frac Upper Devonian Wells

Total frac water (Mgal)
- 0.0 – 2.5
- 2.5 – 6.5
- 6.5 – 10.0
- 10.0 – 12.5
- 12.5 – 15.0
- 15.0 – 25.0

Rhinestreet Shale
### Water and recycled water used to Frac Upper Devonian Wells

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Water and recycled water used to Frac Marcellus Wells

Total frac water (Mgal)
- 0.0 – 2.5
- 2.5 – 6.5
- 6.5 – 10.0
- 10.0 – 12.5
- 12.5 – 15.0
- 15.0 – 25.0
- 25.0 – 35.0

Total recycled water (Mgal)
- 0.0 – 2.5
- 2.5 – 6.5
- 6.5 – 10.0
- 10.0 – 12.5
- 12.5 – 15.0
- 15.0 – 35.0
- 25.0 – 35.0
Water and recycled water used to Frac Marcellus Wells

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Recycling Facility
Water used to Frac Utica Wells

Total frac water (Mgal)
- 0.0 – 2.5
- 2.5 – 6.5
- 6.5 – 10.0
- 10.0 – 12.5
- 12.5 – 15.0
- 15.0 – 25.0

Utica Shale
Water and recycled water used to Frac Utica Wells

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Annual gas production vs water use

- Annual gas production (MMCF)
- Annual water used to frac shale wells (barrels)
- Annual recycled water used to frac shale wells (barrels)
- Wastewater recycled (barrels)

Graph shows the annual gas production and water use from 2010 to 2018.
Conclusions

• More than 75% of the state’s hydrocarbon production comes from the two ‘sweet spots’ of the Marcellus shale play
  • Over half the natural gas production comes from the northeastern ‘sweet spot’
  • 90% of the liquids production comes from Washington County in the southwestern ‘sweet spot’
• Most of the waste water from these wells is recycled and reused in other wells
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