### Nuclear and Natural Gas

New York State Energy Resources - II

<table>
<thead>
<tr>
<th>Year</th>
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<th>Hydroelectric</th>
<th>Natural Gas</th>
<th>Nuclear</th>
<th>Other</th>
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Nuclear - Benefits and Environmental Tradeoffs

Benefits:
- Carbon neutral (except for construction – concrete)
- High capacity factor
- Low fuel transportation costs

Environmental Tradeoffs:
- Long term storage of waste
- Mining and milling (but compare with coal)
- NIMBY but legitimate concerns

Economic impacts
- Cost of construction is prohibitive for most investors
- Price of electricity marginally competitive with dirty coal
There are 6 licensed commercial nuclear reactors in New York. Half of the reactors are of the boiling water type (BWR), including the pair at Nine Mile Point and the lone reactor at the James A. Fitzpatrick power plant. Together, these total 2,468 (MW(e)) capacity. The other three reactors, Indian Point 1 and 2 and the Ginna unit, are pressurized light water reactors (PWR) total 2,600 MW(e) capacity.

**Permanently Shutdown Commercial Reactors:** The Indian Point Nuclear Plant originally had three reactors. Indian Point 1 (PWR, capacity 615 megawatts thermal) was permanently shut down on October 31, 1974. The Shoreham Nuclear Plant (one BWR, 2,436 megawatts thermal capacity) was shut down on June 28, 1989, and decommissioning has been completed.

**Nuclear Power Generation in New York, 1965 through 2005**

**Million kilowatthours**

- Sources: Energy Information Administration, Form EIA-906, Power Plant Report, and predecessor forms.
<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Unit Number</th>
<th>Net Capacity MW</th>
<th>Net Generation Thousand Kwh</th>
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</table>

1. Plant Ownership, Nine Mile Point, Unit 1: Nine Mile Point Nuclear Station, LLC; Unit 2: Nine Mile Point Nuclear Station, LLC, (82%), and Long Island Power Authority (18%).
Natural Gas - Benefits and Environmental Tradeoffs

Benefits:
- Lowest carbon footprint of any fossil fuel
- Flexible energy source – electricity, heating, transportation
- US resources are considerable
- Landowners benefit through leases, royalty payments
- Technology is well-established

Environmental Tradeoffs:
- Pipelines require monitoring and maintenance
- LNG poses serious explosion risks
- New ‘shale gas’ reservoirs pose technical challenges, water management problems, possible aquifer and surface water risks

Economic impacts
- ‘Boom and bust’ scenarios
- Reduction in land values post-development
- Local infrastructure (roads, etc.) impacts
Natural Gas Supply and Demand – Present and Future

Expansion of Shale Gas Development in the United States

Regional Distribution – Current and future development
Madison and Chenango County - Ongoing development
Future Marcellus and Utica Shale development?

Shale Wells – Horizontal Drilling and Hydrofracturing Processes
Drilling Fluids – Demands on water supply
Fracture Fluid – What is in it? Where does it go?
Flowback Water – Management and Disposal
Produced Water – Management and Disposal

Environmental Impacts and Existing Regulations
Water demand and potential supply impacts
Regulations in NY, Delaware and Susquehanna
Threats to water quality during well development
Pre and post-development water quality parameters
Disposal of drilling/fracture/flowback/production fluids
Gas seepage - domestic wells and houses
Ground disturbance
Why so much interest in natural gas development in the eastern United States - the Appalachian Basin?
Figure 4. Wellhead price of natural gas since the mid-1970s to January 2009. [Source U.S. Energy Information Administration, 2009.]
A Chenango resource finally gets tapped

Norse Energy Inc.

"We were here before anybody and we are the only ones left with an interest."

Dennis Holcomb

TheHolcomb play the past year in October, Norse Energy created a stir among its neighbors and developers as it announced plans to build a large natural gas pipeline in Chenango County. The company says the pipeline would be used to transport gas from Marcellus and Utica shale formations in southern New York to eastern Pennsylvania and west Virginia.

"Our Energy is the leader of natural gas exploration and development in this area," said John, the company's chief executive officer. "We are excited to bring this new infrastructure to the region and create jobs for local workers."
What is ‘natural gas’?

‘Hydrocarbons’ are C-H compounds with C-H and C-C bonds.

Breaking of these bonds by oxidation (combustion) releases heat energy

Most common petroleum and gas hydrocarbons are alkanes, with the general formula - \( \text{C}_n\text{H}_{2n+2} \)

Natural gas has the lowest carbon footprint of any fossil fuel – and is made up mostly of methane -

- \( \text{CH}_4 \), with some ethane – \( \text{C}_2\text{H}_6 \), propane - \( \text{C}_3\text{H}_8 \) and butane - \( \text{C}_4\text{H}_{10} \)

‘Heavier’ alkanes - pentane, hexane, heptane, octane, etc - are liquid at surface temperatures and pressures

Liquid petroleum is a mixture of \( \text{C}_5 \) to \( \text{C}_{30} \) alkanes, plus aromatics (e.g. benzene) and alkenes

Methane is also produced by a variety of biological processes at the earth’s surface

methane from surface biological systems is rarely accompanied by ethane, propane or butane

methane from biological systems can be distinguished from natural gas (petroleum system) methane using carbon and hydrogen stable isotope ‘fingerprinting’

Petroleum system natural gas is usually associated with minor liquid hydrocarbons (wet gas with condensate)

Dry gas systems are most common in sedimentary rocks that have been heated above 140ºC

Brine (formation water) is produced from most natural gas wells and must be safely disposed of
This map depicts the distribution of gas and oil fields in New York State in 1980. Virtually all of the historical development has been in the western part of the state. No oil has been recovered from wells east of the Finger Lakes region, but there is considerable potential for natural gas.

All of the oil and gas in New York is found in Paleozoic sedimentary rocks which were deposited from 520 to 300 million years ago. Most of these rocks were laid down in a sedimentary basin – the Appalachian Basin – that stretched across eastern North America from Nova Scotia to Alabama.
Summary of Natural Gas Production in NYS

The most common unit of measure for natural gas is the MCF

1 MCF = 1000 cubic feet of gas at surface temperature and pressure. This is approximately equal to 1,000,000 BTU

1 Therm = 100,000 BTU  ---  1 MCF is approximately 1000 Therm

A typical residence in the NE US consumes ~75 MCF for domestic heating in one year

In 2008:

NYS consumed 1,190,341,000 MCF of natural gas
NYS produced 50,320,077 MCF of natural gas  =  4.2% of consumption

7790 natural gas wells in NY had production reported

the top 100 producing wells accounted for 70% of the state’s production

76 of the top 100 wells produced gas from the Trenton-Black River reservoir system

other producing formations in the top 100 – Theresa (5 wells); **Oneida (5); Herkimer (4)**
Rock strata in central New York dip gently to the southwest. This cross-section exaggerates the dip and shows the sedimentary units and their ages. The oldest rocks in New York are the 1.1 billion year old metamorphic and igneous rocks of the Adirondacks. These ancient rocks contain no oil or gas, but host ore deposits for metals such as iron, titanium, lead and zinc, and minerals such as talc, wollastonite and garnet.

The red pattern indicates rock units that may serve as reservoir beds in central and western New York.
Most gas wells in Madison County tap reservoirs in the **Oswego/Oneida/Herkimer sandstones**. The Utica Shale may be source bed for the gas. Minor fold structures in the sandstone help to trap the gas in commercial quantities. Wells in the Town of Smyrna are developed in a minor fold structure where the sandstone is unusually thick. The overlying Ilion Shale forms a seal on the reservoir sandstone. Wells are typically 2500-4000’ deep.

Deeper wells (greater than 10,000 feet) in the eastern Finger Lakes region have encountered large reservoirs in the Trenton-Black River Group trend. Trenton-Black River discoveries are related to deep fault structures and have proven difficult to locate, but very profitable when exploited.

Schematic model of the Bradley Brook Natural Gas Field
Drilling of a gas well requires construction of a drilling pad and access roads, and moving in and out of heavy equipment. Development of the well may involve installation of casing and cement sheath, and treatment of the producing formation to increase gas flow into the well. The above-ground equipment is not visually obtrusive; pipelines, valves and compressor facilities pose some safety risk. Properly designed and maintained wells do not offer significant environmental hazard.
Horizontal Well in Herkimer Sandstone
Town of Lebanon, Madison County

- Marcellus
- Onondaga
- Helderberg
- Oriskany
- Camillus
- Syracuse
- Vernon
- Lockport
- Willowvale
- Herkimer SS
Herkimer Sandstone Potential

Potential Herkimer Sandstone fairway
Marcellus and Utica Shale Development:

Development of high-yield wells that are economic requires horizontal drilling and hydrofracturing.

Hydrofracturing has been used for decades to increase gas, oil or water flows from tight formations. The process involves isolation of the target formation after the well is drilled, placement of downhole equipment, high-pressure pumping of fracture fluid, and subsequent flowback and well-cleanout.

Horizontal drilling has also been used widely, and is currently used in Madison and Chenango Counties for Herkimer Sandstone well development.

Horizontal drilling and hydrofracturing has been used in coalbed methane wells in Wyoming and other states, and has been implicated as a source of groundwater contamination.

Horizontal drilling and hydrofracturing of shale wells in NYS is currently not permitted. The NYS DEC will issue GEIS guidelines for permitting of shale wells within the next few weeks.
Utica Shale high probability fairway

Subsurface Utica Shale at reasonable reservoir depths.
Marcellus Shale Gas Potential

Subsurface Marcellus Shale at reasonable reservoir depths.

Marcellus Shale high probability fairway
Natural gas production in Chenango County is almost entirely from the Oswego Sandstone-Herkimer Sandstone-Oneida Conglomerate interval.

While there has been much speculation about the potential for natural gas development from the Marcellus Shale, the most likely areas for development are where the Marcellus is at depths great enough (>1500 feet) to assure reasonable formation pressure and reservoir integrity.

The map on the left shows areas in southern Madison and Chenango County where the Marcellus Shale unit lies at depths great enough (red color contours) for likely development. Areas with green contours have Marcellus Shale at depths less than 1500 feet.

The Utica Shale, another potential shale gas target, underlies all of Madison and Chenango County. The Utica Shale potential may exceed that of the Marcellus in Chenango County.
September 16, 2009
Marcellus regulations delayed

DEC plans release for end of month

By Tom Wilber
twilber@gannett.com
A much-anticipated draft of new regulations for drilling into the Marcellus Shale will not be released by Tuesday as expected, but DEC officials said it will come before the end of the month.
The amended state regulations follow a review of the industry that began in the summer of 2007 to address concerns over drilling's impact on water and the environment. The regulatory update must be complete before full-scale natural gas development can proceed in the Southern Tier.
Originally, the review was expected by the beginning of summer. The time frame was extended in the face of persistent public concern over how the drilling, and a process called hydro-fracturing, will affect water supplies and the landscape.
Officials moved the anticipated release date of the regulatory update to the end of summer, which is Tuesday.
The delays have come because of the vast scope of the issue and the intensity of public interest it has generated, said Lori Severino, a spokeswoman for the agency. Last year, thousands of Southern Tier residents attended public meetings held to debate the future of drilling in the Marcellus area, and it's economic and environmental fallout.
The shale formation is one of the largest natural gas reserves in the country, extending from the Southern Tier throughout Pennsylvania, and parts of Ohio and West Virginia. "It's a very thorough review and a unique situation," Severino said. "There is a lot of staff involved, and they want to make sure it is as complete as possible before it goes to the public for comment."
The DEC will extend the standard comment period of 30 days, although no decision has been made about the exact time frame, Severino said.
Roughly 200 tanker trucks deliver water for the fracturing process. A pumper truck injects a mix of sand, water and chemicals into the well. Natural gas flows out of well. Recovered water is stored in open pits, then taken to a treatment plant. Storage tanks. Natural gas is trucked to a pipeline for delivery.
Figure 6. A hydraulic fracturing stimulation in 2007 on a Marcellus Shale gas well showing the amount of equipment involved.
Figure 7. Example of a gel used in hydrofracturing to carry proppant into a fracture. Photograph by Daniel Soeder, USGS.
**New York**

**Permits:** New York does not require permits for groundwater withdrawals used for private purposes. A permit is required to install or expand a public water supply, although exemptions exist for some municipal and county systems.

**Registration:** Facilities planning to withdraw an average of 100,000 gallons of water per day in a consecutive 30-day period must register with the New York Department of Conservation.

**Reporting:** Facilities that withdraw more than an average of two million gallons per day in a consecutive 30-day period must report to the state any new or increased operating capacity, as well as the average monthly and annual rates of discharge or return flow.
Water withdrawals:

Current practices involve transport of fracture water to drill site in tanker trucks. A Marcellus Shale well requires 2-5 million gallons of water.

Water may be pumped from surface sources – reservoirs, rivers – or (more rarely) from groundwater sources.

Water withdrawals are regulated, but regulations are ‘patchy’ and may be inadequate.

Magnitudes and sources of water withdrawals should be part of the well permitting process.
Much of the active development of Marcellus Shale gas is within the Susquehanna River Basin.
The Department of Environmental Conservation is responsible for regulating the development and production of oil and gas resources in New York State. Natural gas exploration and production companies, and mineral rights owners, are interested in developing a potentially significant gas resource in the Marcellus Shale through the use of horizontal drilling and a hydraulic fracturing technique known as “slick water fracturing.” This technique requires large volumes of water. The Department has identified the action of well permit issuance when high-volume hydraulic fracturing is proposed as one which requires further review under the State Environmental Quality Review Act (“SEQRA”).

Aspects of high-volume hydraulic fracturing identified in this Final Scope for further review include the potential impacts of (1) water withdrawals, (2) transportation of water to the site, (3) the use of additives in the water to enhance the hydraulic fracturing process, (4) space and facilities required at the well site to ensure proper handling of water and additives, (5) removal of spent fracturing fluid from the well site and its ultimate disposition and (6) potential impacts at well sites where multiple wells will be drilled during a three-year period. Noise, visual and air quality considerations are noted, along with the potential for cumulative and community impacts. The well permitting process is described, and regulatory coordination with other jurisdictional agencies and local governments is also discussed.
Flowback and production water:

A typical horizontal Marcellus Shale well requires 1-3 million gallons of treatment water.

Following hydrofracturing, the treatment water becomes ‘flowback’ and is pumped (or forced back by gas pressure) to the surface.

The flowback water volume is typically about ½ of the treatment volume as the shale ‘wicks up’ some of the treatment water, by design, during hydrofracturing.

Flowback water contains residual chemicals (a long list, mostly innocuous, some toxic), salt from the saline brine in the shale, some well cutting materials (shale) and drilling mud.

Flowback water is temporarily held in plastic-lined holding ponds, and then trucked away for disposal at appropriate water treatment plants.

Natural gas wells also produce saline brine water during normal production. This is stored in above ground tanks and trucked away for disposal. In some states, production brine is used for dust control on gravel roads, and for de-icing in winter.
Disposal of Treatment Flowback and Production Water in New York State

**State Pollutant Discharge Elimination System (SPDES)**
New York State has a state program which has been approved by the United States Environmental Protection Agency for the control of wastewater and stormwater discharges in accordance with the Clean Water Act. Under New York State law the program is known as the State Pollutant Discharge Elimination System (SPDES) and is broader in scope than that required by the Clean Water Act in that it controls point source discharges to groundwaters as well as surface waters. (from the NYSDEC website)

**USEPA Underground Injection Control (UIC) Permit**
A Class IID Underground Injection Control permit must be obtained from the Region II Office of the USEPA before operating any well for brine disposal. EPA staff review proposed operations with respect to protection of groundwater aquifers. Parameters reviewed by the EPA may include well construction and plugging plans, proposed injection rate and pressure, injectate composition, and proposed injectate and groundwater monitoring plans.

Note: There are currently no UIC wells permitted for treatment water disposal in New York.