New York's Natural Gas and Oil Resource Endowment:

Past, Present and Potential

NYSERDA

New York State
Energy Research and
Development Authority

NOTICE

This report was prepared by Advanced Resources International of Arlington, Virginia in the course of performing work contracted for and sponsored by the New York State Energy Research and Development Authority (hereafter "NYSERDA"). The opinions expressed in this report do not necessarily reflect those of NYSERDA or the State of New York, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it. Further, NYSERDA, the State of New York, and the contractor make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods, or other information contained, described, disclosed, or referred to in this report. NYSERDA, the State of New York, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

ACKNOWLEDGEMENTS

This report would not have been possible without the assistance of key individuals and organizations involved with the natural gas and oil industry in New York. Special thanks to the New York Department of Environmental Conservation, Division of Mineral Resources, Bradley Field, Director, for reviewing the draft report and for providing current State data on natural gas storage, and natural gas and oil leasing, exploration and production. Thanks also to the New York State Museum Reservoir Characterization Group, particularly Richard Nyahay and Langhorne Smith, for providing miscellaneous illustrations and data pertaining to the Trenton-Black River play in New York State, as well as selected historical images, historical data, maps and access to ESOGIS. The Independent Oil and Gas Association of New York shared ideas and helpful suggestions at the outset of this project.

PHOTO CREDITS

Unless otherwise noted below, all photographs of natural gas and oil operations in the State of New York are provided courtesy of the New York Department of Environmental Conservation, Division of Mineral Resources.

Cover:	Seneca County Drill rig, Seneca County, New York, courtesy of John Martin, NYSERDA
Page 3:	Richburg Oil Field, courtesy of Richburg-Wirt Historical Society Museum, Richburg, NY. Available at www.usgennet.org/usa/ny/county/allegany.
Page 7:	Shooting an oil well, courtesy of Richburg-Wirt Historical Society Museum, Richburg, NY. Available at www.usgennet.org/usa/ny/county/allegany.
Page 8:	Barcelona lighthouse, courtesy of Richard Nyahay, New York State Museum
Page 9:	Plaque for Richburg discovery well, courtesy of Ron Taylor, Allegany County, NY; Local History and Genealogy Website. Available at www.usgennet.org/usa/ny/county/allegany.
	Job Moses #1, courtesy of Richard Nyahay, New York State Museum
Page 10:	Modern New York Oil Field, courtesy of J. Walchli, Nathan Petroleum Corporation
	Richburg Oil Field circa 1890's, courtesy of Richburg-Wirt Historical Society Museum, Richburg, NY. Available at www.usgennet.org/usa/ny/county/allegany.
Page 23:	Union Springs Formation outcrop, courtesy of Charles Ver Straeten, New York State Museum
Page 25:	Utica Shale outcrop, courtesy of John Martin, NYSERDA
Page 27:	Medina gas well, courtesy of Stripper Well Consortium and Lenape Resources
Page 29:	Geologists, courtesy of Advanced Resources International
	Oil field, courtesy of J. Walchli, Nathan Petroleum Corporation
Page 31:	3-D seismic image, courtesy of Talisman Energy
Page 35:	Gazebo and pumpjack, courtesy of J. Walchli, Nathan Petroleum Corporation
Page 38:	Oswego Lighthouse, courtesy of NYS DED, D. McGee

CAPTURING THE BENEFITS FROM NEW YORK'S NATURAL GAS AND OIL RESOURCE ENDOWMENT

New York has a long history of oil and natural gas development and production. For more than 140 years, New York's oil and gas industry has been driven by foresight, leaps in technology development, perseverance and improved understanding of the State's hydrocarbon resource potential.

A Rich History

Vision, ingenuity and persistence have been applied to the development of New York's oil and natural gas since the early years and continue to be applied today. In fact, the State of New York is the place of many firsts:

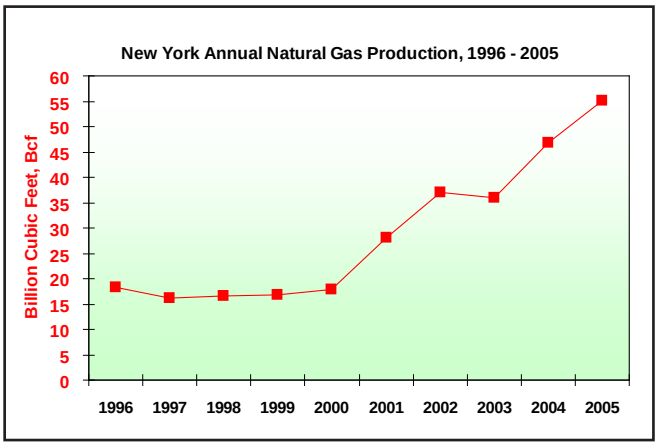
- The first commercial natural gas well, dating back to 1821, was drilled near Fredonia. The first commercial natural gas company was established shortly thereafter.
- In 1830, in the hamlet of Barcelona on Lake Erie, not far from Fredonia, the Barcelona lighthouse became the world's first navigational beacon lighted by natural gas.
- In 1870, a company in Bloomfield bored pine logs and banded them together with iron, creating the industry's first natural gas pipeline, stretching 25 miles to Rochester.
- The New York State Geological Survey, established in 1836, was the first state geological survey and served as an early model for many other state surveys, as well as the United States Geological Survey.

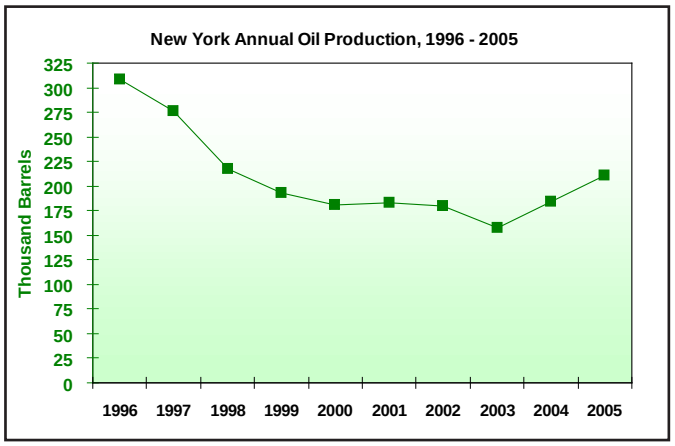
Commercial oil and gas development and production in New York dates back to well before the beginning of the 20th century. New York's first oil well was drilled in Allegany County in 1863, just four years after the famous Drake well in Pennsylvania. New York's oil production reached its peak of 7.3 million barrels of oil in 1882. Natural gas production reached its peak of 55 billion cubic feet in 2005. To date, an estimated 75,000 oil and gas wells have been drilled in New York.

An Exciting Present

Despite being one of the most mature natural gas and oil producing areas in the world, New York's future hydrocarbon potential remains bright:

- New York produced 55 billion cubic feet (Bcf) of natural gas in 2005; an 18 percent increase over 2004, exceeding the previous record from 1937. New York's current gas production represents a nearly three-fold increase since the mid 1990s. Natural gas was produced in 21 counties in New York in 2005.





- Annual crude oil production in New York State, although not reaching record production like natural gas, has recently reached levels not seen since the mid-1990s. In 2005, New York produced more than 211,000 barrels, up 15 percent over 2004. Oil is produced in Cattaraugus, Chautauqua, Allegany, Erie, and Steuben Counties.

- The pace of oil and gas drilling in 2005 was four times that of the late 1990s. Drilling in the State is at a 20-year high. More than 8,700 wells were producing oil and natural gas in New York in 2005.

Natural gas and oil production from New York already makes far-reaching contributions to the regional economy, especially in western New York and the Southern Tier — generating jobs, tax revenues, and other benefits to New York citizens.

- According to the U.S. Department of Labor, New York's oil and gas industry directly employs nearly 4,500 people in the areas of exploration and production, pipeline transportation, and refining and gas processing, with 10 times more employed in the wholesale and retail trade of petroleum fuels and the distribution of natural gas.

- In 2005, approximately $53 million was paid to primarily rural landowners in the form of royalties on oil and gas production, an increase of 27 percent over 2004.

- Local taxes, collected annually on the State's oil and gas production are estimated to be $13 million, a nearly 10-fold increase over annual tax receipts a decade ago. Since 1996, local governments have collected more than $44 million in tax revenues from natural gas and oil production, mainly in western New York and the Southern Tier.

- Since 1985, New York has received nearly $30 million in revenues from natural gas leases on State lands, of which $26 million were received since 1998. During 2006, natural gas lease sales on State lands produced more than $9 million in apparent high bids, more than all previous lease sales combined.

- Annual royalty payments to the State from production on State lands have grown by two orders of magnitude since 2002, due to increased production and rising prices for natural gas. New York received royalty revenue of more than $3 million in both 2005 and 2006.

Promising Future Potential

Prospects for boosting these contributions through increased resource recovery are promising. New York contains significant additional hydrocarbon resource potential that, increasingly, can be produced economically with new technologies. Moreover, the continuation of historically high prices for oil and natural gas will likely drive additional exploration and development and the pursuit of more challenging resources, resulting in further benefits to the State of New York.

Most of the natural gas reservoirs generating renewed interest in New York are challenging; these include "tight" gas sands, gas shales and deep reservoirs. In 2005, six new natural gas fields were discovered in the deep Trenton-Black River formation, four fields in Steuben County, and two fields in Chemung County. Also contributing to the resurgence of natural gas in New York were discoveries in the Oneida-Oswego and Theresa Sandstone reservoirs, and new gas shale discoveries. Despite being one of the most mature hydrocarbon producing areas in the world, substantial resource opportunity remains for New York in new formations, deeper geologic horizons, and in the untapped areas of old fields.

While oil and natural gas opportunities in New York remain bright, interest is growing regarding other subsurface resources in the State, such as geothermal energy, compressed air energy storage in geologic settings, and CO2 sequestration in geologic formations to address concerns around climate change. The links between these rest on a basic understanding of the State's geology and evolving applications of technologies and practices originally associated with oil and gas exploration and production.

The Challenges Ahead

The current pace and scale of natural gas development in New York presents challenges for all stakeholders: private landowners, exploration and production companies, State and local government, and the public, to protect the environment and support the infrastructure and resources of local communities. Consequently, New York State government has the obligation to manage natural resources, protect environmental quality and improve public health while facilitating the flow of benefits from environmentally-sound natural gas and oil development. To accomplish this mandate, the State of New York requires that development proceed with protection of the environment and the public interest as the primary focus.

In New York today, the resurgence of natural gas and oil development is facilitated by proactive state agencies that ensure environmentally responsible development and protect the interests of all stakeholders, and by exploration and production companies that engage the community and are responsive to public concerns.

Benefiting from New York's Hydrocarbon Endowment

The future benefits from New York's hydrocarbon resource endowment are promising, but New York's successful realization of these benefits will require continued vigilance and action from both the government and the private sector in key areas:

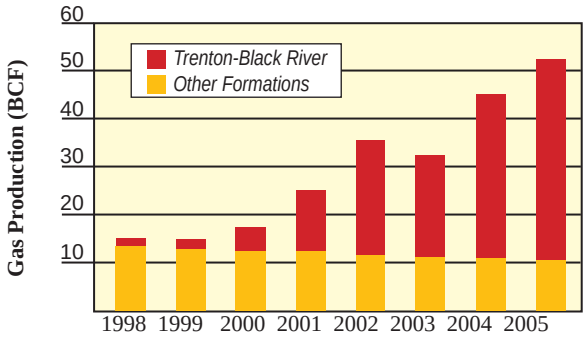
- Environmental Stewardship
  State government must continue its strong and responsive regulatory programs to ensure effective protection of the environment and the public interest, incorporating cost-effective regulatory strategies and focused public education and outreach, along with expeditious permitting. Developers must focus on superior environmental performance, effectively addressing landowner and public concerns.

- Technology Progress
  Advanced technologies and state-of-the-art practices, applicable to the unique characteristics of New York's natural gas and oil resources, must be developed and applied to extend the lives of existing wells and to economically find and produce new drilling prospects. This will require continued public-private partnerships in research, development, and demonstration of new technologies, as well as continued work to better understand the unique characteristics of New York's remaining gas and oil resources.

- Access to High-quality Data
  Potential developers and investors in the oil and gas sector in New York will require access to high-quality data about the State's resources and production, coupled with effective data analysis and data management. Both government and industry must work collaboratively to ensure that all stakeholders have access to high quality data.

Natural Gas Production from the Trenton-Black River Formations

The "hottest" action in New York is in the deep Trenton-Black River play, which now dominates New York's natural gas production. In 2005, the Trenton-Black River produced 44 billion cubic feet (Bcf), accounting for almost 80 percent of the State's total gas production. Total Trenton-Black River production since 1998 is more than 154 Bcf from 71 producing wells.



Pursuing the Trenton-Black River hydrothermal dolomite play is a high-tech, high risk enterprise that requires state-of-the-art technology. Geologic understanding of this play has been aided by a recent multi-state study published by the Trenton-Black River Appalachian Basin Exploration Consortium, an example of a new spirit of public-private partnership in the State.

- Access to Resources
  State policies and programs must continue to:
  - support access to resources on public and private lands in an environmentally sound manner,
  - resolve mineral rights conflicts,
  - address unique access issues in urbanized areas, and
  - ensure that certain public lands such as State Preserves are permanently off-limits to natural gas and oil development.

Collaborative approaches and state-wide perspectives will be needed to tackle these key areas and accelerate recovery of natural gas and oil in New York. All stakeholders have an interest in the responsible recovery of these resources, not only to help meet the State's energy needs, but also to stimulate economic growth and other benefits. Collaborative public-private strategies will be valuable in leveraging technology to its fullest potential in the region.

While many agencies, organizations, and individuals are interested in oil and gas development, the New York State Department of Environmental Conservation (DEC), particularly its Division of Mineral Resources, plays the lead role in working cooperatively with all stakeholders to achieve its mission of ensuring the environmentally sound, economic development of New York's non-renewable energy and mineral resources for the benefit of current and future generations.

Lower map shows all wells penetrating the Trenton Formation or deeper zones. Upper map shows current Trenton-Black River gas fields in red and all oil and gas wells shown in grey. Maps courtesy of New York State Museum and NY Division of Mineral Resources.

Gas is flared during a test of a newly-drilled Trenton-Black River. During the past decade, annual tax receipts and royalty payments to landowners from natural gas and oil development have increased by ten-fold during the past decade.

Consistent with the theme of New York firsts, the New York State Energy Research and Development Authority (NYSERDA), the first state-chartered public benefit corporation dedicated to state-focused energy research and development and public education, plans to continue its important role inhelping New York address the energy and environmental challenges it faces. NYSERDA's support for hydrocarbon exploration and production dates back to its inception in 1975. NYSERDA recognizes the need to continue its work to facilitate the use of innovation and technology to solve some of New York's most difficult energy and environmental problems in ways that improve the State's economy. This will include diversifying and increasing state energy supplies from indigenous resources, including oil and natural gas, and in providing unbiased information to decision-makers, investors, and end-users on the performance and environmental impacts of energy technologies and systems in New York.

Moreover, the continued willingness of the private sector to engage with local communities to address their concerns, along with expanded cooperation with NYSERDA and other State programs will be critical to success. Some future opportunities could require concerted efforts by many industry and government entities. Pursuit of these key strategies will help ensure the energy and environmental future for the State of New York.

NEW YORK'S OIL AND NATURAL GAS HISTORY – A LONG STORY, BUT NOT THE FINAL CHAPTER

Vision, ingenuity and persistence have been applied to the development of New York's oil and natural gas since the early years, and continue to be applied today. This resourcefulness and hard work has sustained the New York natural gas and oil industry for many decades. New York's future hydro-carbon potential remains bright, despite the State being one of the most mature oil and gas producing areas in the world. Building upon the long history of natural gas and oil production in New York, this report describes the recent resurgence of natural gas and oil exploration and development activity, and the benefits resulting from a reinvigorated industry. It describes how government policy and programs have facilitated this renewed activity, while ensuring that all stakeholder interests and the natural environment are appropriately protected. Most important, this report describes the diverse natural gas and oil resource potential that still remains in New York and the continued actions needed to fully develop the State's hydrocarbon resource potential. Following is an overview of some highlights of New York's rich oil and gas history.[1] To learn more about this history, additional sources are provided in the End Notes.[2]

"Shooting" an oil well with nitroglycerine to stimulate production.

Plaque commemorating the discovery well for Richburg Oil Field.

Natural Gas has Fueled Local Economic Development in New York for 186 Years

Natural gas seeps in Ontario County, New York were first reported in 1669 by the French explorer, M. de La Salle, and a French missionary, M. de Galinee, who were shown the springs by local Native Americans. William Hart, a local gunsmith, drilled the first commercial natural gas well in the United States in 1821 in Fredonia, Chautauqua County. The Hart well was first dug to a depth of 27 feet in the shale that outcropped in the area. A 1.5 inch diameter borehole was then drilled to a depth of 70 feet. Hart built a simple gas meter and piped the natural gas to an innkeeper on the stagecoach route from Buffalo to Cleveland.

Shallow natural gas wells were soon drilled throughout the Chautauqua County shale belt. This natural gas was transported to businesses and street lights in Fredonia at the cost of $1.50 a year for each light, approximately $22.00 today. Street lights fueled by this natural gas frequently attracted travelers, often causing them to make a significant detour to see this new "wonder." The first Lake Erie lighthouse illuminated by natural gas was built in 1828 at Barcelona.

Birth of New York's Commercial Natural Gas Industry

The original Hart gas well produced until 1858 and supplied enough natural gas for a grist mill and for lighting in four shops. By the 1880s, natural gas was being piped to towns for lighting and heat, and to supply energy for the drilling of oil wells. Natural gas production from sandstone reservoirs in the Medina Formation was discovered in 1883 in Erie County. Medina production was discovered in Chautauqua County in 1886. By the early years of the twentieth century, Medina production was established in Cattaraugus, Genesee and Ontario Counties. Gas in commercial quantities was first produced from the Trenton limestone in Oswego County in 1889 and in Onondaga County in 1896. By the close of the nineteenth century, natural gas companies were developing longer intrastate pipelines and municipal natural gas distribution systems. The first gas storage facility in the United States was developed in 1916 in the depleted Zoar gas field south of Buffalo.

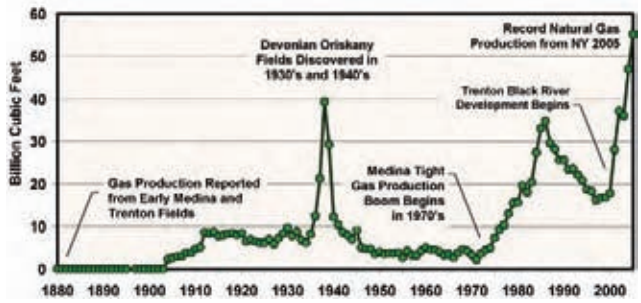
Despite New Gas Discoveries, Demand Outpaced Supply

By the late 1920s, declining production in New York's shallow gas wells prompted gas companies to drill for deeper gas reservoirs in Allegany, Schuyler, and Steuben Counties. The first commercial gas production from the Oriskany sandstone was established in 1930 in Schuyler County. By the 1940s, deeper gas discoveries could no longer keep pace with the decline in shallow gas supplies. Rapid depletion and over-drilling of deep gas pools prompted gas companies in western New York to sign long-term contracts to import gas from out of state.

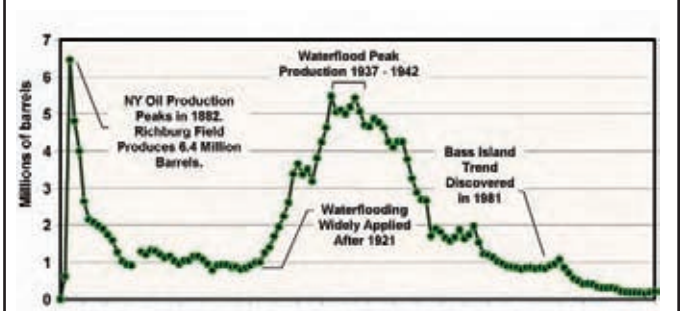
Advances in Exploration and Production Technologies Opened New Gas Plays

Onondaga reef fields were discovered by seismic prospecting in the late 1960s. Seven reef fields have been discovered to date in southern New York. Today, the Onondaga reef fields and many Oriskany fields are largely depleted and are being converted to gas storage fields. Hydraulic fracturing was widely applied in the 1970s and 1980s to develop low permeability reservoirs ("tight" gas sands) in the Medina Group. The rapid development of New York's current Trenton-Black River gas play is made possible by technological advances in three-dimensional (3-D) seismic imaging, horizontal drilling, and well completion.[4]

New York Natural Gas Production (1880 - 2005)



New York Crude Oil Production (1880 - 2005)



First Commercial Oil Development in New York

Oil "springs" and natural gas seeps in western New York were long known to the local Native Americans who used the oil for a variety of purposes. In 1627, a French missionary Fr. de la Roche d'Allion, provided the earliest description of oil obtained from a spring now believed to be Seneca Oil Spring in Cuba Township, Allegany County. Col. Bradford H. Alden obtained the first lease for oil exploration in the state of New York from the Seneca Nation on December 15, 1859. Oil exploration in New York commenced a mere three months after the completion of William Drake's oil discovery well at Titusville, Pennsylvania, the world's first commercial oil well. Col. Alden drilled three dry holes by 1861; eventually, oil was produced in non-commercial quantities.

The first commercial oil well is credited to Job Moses and his Hall Farm Petroleum Company. The discovery well was located in Carrollton Township, Cattaraugus County. The Moses No. 1 well was completed in November 1865 to a depth of 1,165 feet and a cost of more than $7,000, a huge expense for the time. Initial production was seven barrels per day. The first three Moses wells were marginal producers at best, but were later proved to be on the edge of what became the Bradford oil field and New York's "oil belt."

Job Moses #1 Well, Cattaraugus Co., 1865

Crude Oil Refining in New York State

New York's earliest crude oil refineries were established in Olean in 1861 to produce lamp oil. Initially, the crude oil was purchased in Venango County, Pennsylvania and shipped by rail to Olean. The first crude oil pipeline in New York was completed in 1875, to deliver oil from New York oil fields to the Pennsylvania Railroad terminal in Olean. By 1877, oil refining had become a major industry in New York State. Buffalo had six refineries, New York City had forty-three, and Brooklyn had seven. Olean remained an important refining center, hosting the world's largest refinery at one point. By 1948, the total number of refineries in New York State had dwindled to six, located in Brooklyn, Buffalo, Olean, Staten Island, Tonawanda and Wellsville, with total refining capacity of 90,000 barrels of crude oil per day. Today, no petroleum refineries remain in New York State. All of New York's crude oil is trucked to refineries in Pennsylvania and West Virginia, with most going to the American Refining Group refinery in Bradford, Pennsylvania. New York crude oil is used in the manufacture of a range of products including motor vehicle fuel, home heating oil, lubricating oil, and other specialty lubricants.

Enhanced Recovery, New Discoveries, Rising Prices

New York's annual oil production peaked at approximately 7.3 million barrels in 1882. By 1914, 60 million barrels of oil had been produced in New York, but oil production from most oil wells had declined to under a barrel per day per well. The first water flood in New York was demonstrated in Allegany Field in 1911, but intentional waterfloods of oil fields were not widely applied until the 1920s. As waterflood techniques improved, New York's annual oil production increased to a second peak in 1942 of more than 5.4 million barrels.

New York's oil production entered a prolonged period of decline after 1942, as oil and gas exploration companies became more interested in other prospective areas. Following the discovery in 1981 of the Bass Island Trend in Chautauqua County, seismic techniques were used to explore for narrow, fault-controlled reservoirs in the Akron Dolomite. Rising crude oil prices since 2002 have spurred the first increases in drilling and production in the State in 20 years. This increased activity halted the long-term production decline. New York's oil industry remains small and local, generally relying on low cost production methods. In 2005, the annual oil production of the average New York oil well was 76 barrels.

New York's "stranded oil" resources -- the oil remaining in a reservoir after traditional primary and secondary recovery operations -- are thought to be substantial. Throughout the United States, stranded oil generally represents about two-thirds of the original oil resource in place. For New York's old oil fields, stranded oil may be much as 80 percent of the more than the estimated one billion barrels of original oil in place. Approximately 255 million barrels of New York's stranded oil resources are estimated to be the maximum amount recoverable by future primary and enhanced recovery techniques.[5] The future of New York's oil industry lies in finding ways to economically recover a portion of the State's stranded oil resources through innovative approaches to enhanced recovery tailored to New York's geology and operational history.

Barcelona Lighthouse, Lake Erie - first lighthouse to be illuminated by natural gas.

Richburg Oil Field Circa,1890's

Modern New York Oil Field

REDISCOVERING THE MOST MATURE HYDROCARBON REGION IN THE WORLD

New York's natural gas and oil production have increased significantly during the past decade. New York produced 55 billion cubic feet (Bcf) of natural gas in 2005; representing an 18 percent increase over 2004 and exceeding the previous record gas production in 1938. New York's current annual gas production represents a nearly three-fold increase since the mid-1990s. Natural gas was produced in 21 counties in the New York in 2005. Most of the State's natural gas production comes from the deep Trenton-Black River formation in five counties that accounts for about 80 percent (44 Bcf) of total production. Cutting-edge seismic imaging, horizontal drilling, and multi-lateral completion technologies are needed to successfully explore for and develop deep Trenton-Black River wells. Such technologies are now profitable to apply in New York State given the attractivenatural gas prices that have prevailed in recent years.

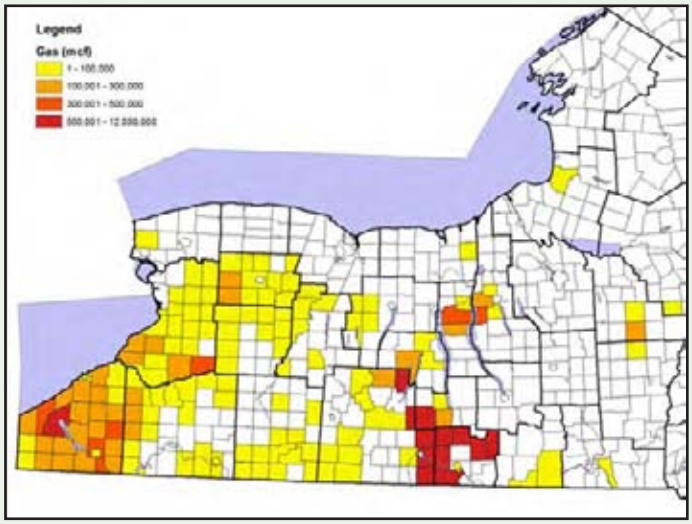


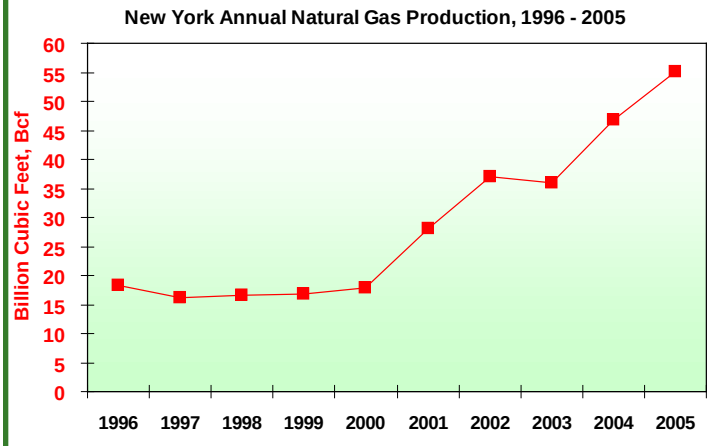
Photo: The high-deliverability Stagecoach facility is the easternmost underground natural gas storage facility in the United States. The field uses horizontal wells to increase gas flow. The Stagecoach facility has a maximum withdrawal capacity of 500 MMcf/day to meet peak gas needs in the eastern United States. Map: Annual Natural Gas Production by Town, 2005, courtesy of NY Division of Mineral Resources.

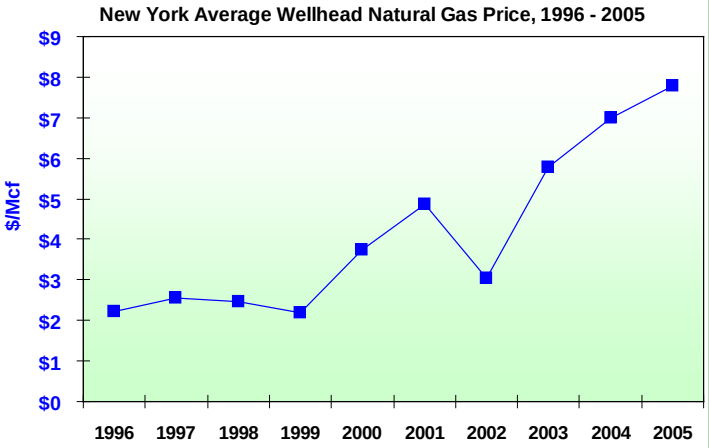
Annual crude oil production in New York State, although not reaching record production like natural gas, has reached levels not seen since the mid-1990s. In 2005, New York produced more than 211,000 barrels (nearly 580 barrels per day), up 15 percent over 2004 production. Oil is produced in Cattaraugus, Chautauqua, Allegany, Erie, and Steuben Counties. High crude oil prices have stimulated the drilling of new oil wells in old fields.

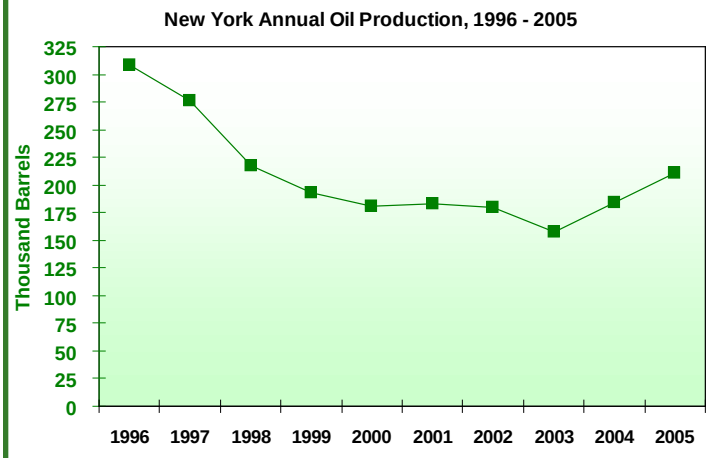
The pace of oil and gas well drilling in 2005 was four times that of the late 1990s. Drilling permits in the State are at a 20-year high.

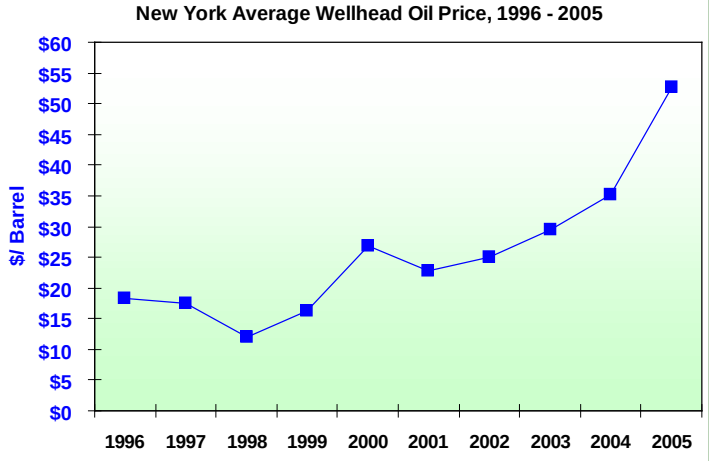
In 2006, 352 gas well permits were issued; nearly double the 180 permits issued in 2005. At least 183 new gas wells were completed in 2006, a substantial increase from the 104 gas well completions in 2005. Similarly, 186 oil well permits were issued in 2006, slightly less than the number of oil well permits issued in 2005, but nearly four times the number in 2004. Oil well completions surged to 166 new oil wells in 2006, up from 95 oil well completions in 2005. More than 8,700 wells were producing oil and natural gas in New York in 2005, with about twice as many producing gas wells as oil wells.[7]

New York Production is Responding to Higher Natural Gas and Crude Oil Prices









What is a Mcf, MMcf, Bcf or Tcf?

Natural gas is sold in units of thousand cubic feet, (Mcf, using the Roman numeral for one thousand). Units of a million cubic feet (MMcf), billion cubic feet (Bcf), or trillion cubic feet (Tcf) are used to measure larger quantities. The United States currently consumes about 22 Tcf annually. A Tcf is enough natural gas to:

- Heat 15 million homes for one year
- Generate 100 billion kilowatt-hours of electricity
- Fuel 12 million natural-gas-fired vehicles for one year

How much is a bbl?

A barrel (bbl) of crude oil or natural gas liquids is equal to 42 U.S. gallons.

The United States currently consumes about 20 million barrels (MMbl) of oil per day, or 7.3 billion barrels (Bbbl) per year.

Bbl = barrel

New York's Natural Gas Resources Have Easy Access to Interstate Pipelines, Gas Storage Facilities and High-Value Markets

Natural gas producers in New York are generally not far from an interstate gas pipeline. Moreover, New York natural gas supplies are close to the large East Coast market. This proximity gives New York a competitive advantage compared to other gas producing regions such as the Rocky Mountain West. This advantage is generally translated into higher prices for their production.

New York's natural gas production is also close to a significant concentration of underground natural gas storage facilities, which play a critical role in balancing natural gas supply and demand in the region and the nation. New York has twenty-five underground natural gas storage facilities, mostly in the western and central regions of the State. Twenty-four storage facilities are located in depleted natural gas fields and one storage facility is a solution-mined salt cavern. An additional three facilities store liquefied petroleum gas. A total of 808 storage wells have the capability to deliver up to 1.9 Bcf of natural gas per day. Seven new gas storage wells were completed in 2006. Access to ample gas storage capacity allows New York's natural gas production to increasingly serve the Northeast power generation and home heating markets, in addition to its traditional industrial consumers.

New York Citizens Benefit from the State's Oil and Gas Production

New York State consumed more than 1,000 Bcf of natural gas and 250 million barrels of petroleum fuel in 2005. Although New York consumes far more natural gas and oil than it produces; the State's 2005 natural gas production of over 55 Bcf was nevertheless enough to supply 800,000 homes for a year and meet about five percent of the State's natural gas demand. The total market value of New York's 2005 oil and natural gas production was about $440 million, representing a nearly ten-fold increase in market value compared to ten years ago.

Job Creation. New York's natural gas and oil production not only makes important contributions to the region's domestic energy portfolio; it also creates significant positive benefits to the New York State economy, especially in upstate rural and agricultural areas. One benefit is job creation. According to the U.S. Department of Labor, New York's oil and gas industry directly employs nearly 4,500 people in the areas of exploration and production, pipeline transportation of natural gas and petroleum, and refining and natural gas processing. Total petroleum industry employment in the State is more than 50,000 people, largely in the wholesale and retail trade of petroleum fuel and the distribution of natural gas.[8]

Northeast Natural Gas Interstate Pipelines

Snapshot of Oil and Natural Gas Activity in New York State

Activity	Natural Gas	Oil
2005 Annual Production	55,176 MMcf	211,292 bbl
2005 Active Wells	5,957 wells	2,767 wells
2006 Well Permits Issued	352 permits	186 permits
2006 Wells Completed (reported as of 4/23/07)	183 wells	176 wells

Royalty Payments and Tax Receipts. Landowners and local communities reap economic benefits from oil and gas development in the State in the form of royalty payments to landowners and taxes paid to local governments. Landowners typically receive royalties of 1/8 (12.5 percent) of the value of production from an oil or gas well on their land. Some landowners in the prolific Trenton-Black River natural gas production trend collect royalties of $100,000 or more per year. In 2005, approximately $53 million was paid to primarily rural landowners in the form of royalties on oil and gas production, an increase of 27 percent over 2004.

Local governments in New York assess annual taxes on oil and gas production on a unit of production value determined by the State Division of Equalization and Assessment. For 2005, the Division of Mineral Resources estimates the total amount of local taxes collected for the State's oil and gas production at approximately $13 million. This represents a nearly ten-fold increase over annual tax receipts a decade ago. Since 1996, local governments have collected more than $44 million in tax revenues from oil and gas production, primarily in western New York and the Southern Tier.

The Economic Benefit of Natural Gas Development in New York Increased drilling and oil and gas production in New York correspond to increased investment in the State. The economic impact of this investment and the resulting oil and gas production is most significant when evaluated at the local level. The dramatic increase in New York production over the past several years has been primarily due to deep natural gas discoveries in the central New York Finger Lakes region and the Southern Tier.

The largest operator of Trenton-Black River wells in New York is Fortuna Energy Inc. In 2006, Fortuna Energy drilled or participated in a total of 17 horizontal and 5 vertical Trenton Black River wells. According to an economic impact study recently completed by Fortuna Energy, the company directly spent $72.3 million in the region in 2005, with the largest outlay being $43.6 million in royalty payments to more than 1,000 landowners. The company spent $20.2 million for goods and services from local suppliers. Fortuna Energy has concluded that the impact on gross regional economic output from their direct spending includes:

- $50.6 million in direct spending stimulus
- $4.9 million of indirect impacts arising from business to business spending
- $10.8 million of output gains induced by increased household incomes

In addition, Fortuna Energy estimates that its operations generate the equivalent of 700 jobs in the region and more than $8 million in additional tax revenues. [13]

Center for Energy Technology at Jamestown Community College

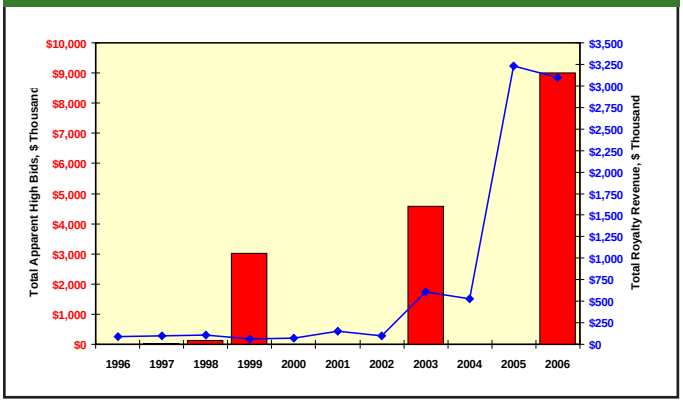
*Local communities can benefit from the employment opportunities created by New York's reinvigorated oil and natural gas industry only to the extent that there are enough qualified workers to fill the jobs. To meet the growing demand for skilled employees, NYSERDA, in partnership with the Jamestown Community College and the Independent Oil and Gas Association of New York (IOGA-NY), is helping to launch the Center for Energy Technology at Jamestown Community College to train and develop a capable regional workforce equipped for the modern New York oil and gas industry. The Center for Energy Technology will offer job trai*ning, public outreach, job placement, and other *vocational programs developed in coordination with IOGA-NY and other organizations.*

The Economic Benefit of Natural Gas Exploration and Development in New York – A Single Well Example Of the 55.2 Bcf of natural gas produced in New York in 2005, 44 Bcf was produced by just 71 Trenton-Black River gas wells. This example illustrates the substantial local economic impact of a prolific Trenton-Black River producing well. [14]

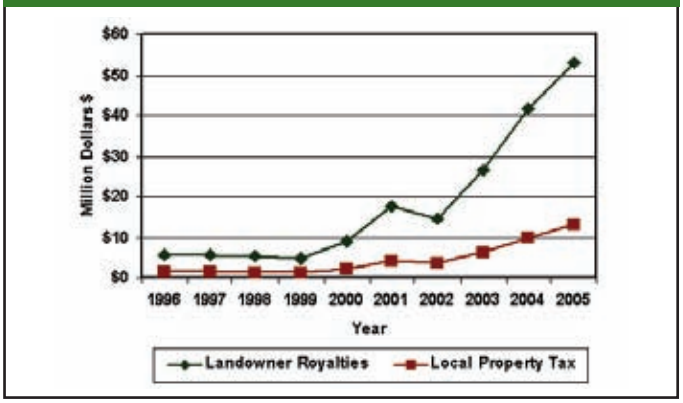
State Land Leasing Revenues The success of Trenton-Black River and other natural gas development on private lands, which led to renewed interest in the resource potential and development opportunities on State-owned lands. Leasing of New York State lands provides revenue from four sources:

- Bonus bids placed at State lease sales to acquire leases
- Delay rental payments to the State to hold non-producing leases
- Royalty payments to the State equal to a share of the market value of natural gas or oil produced from the lease, typically 12.5 percent
- Storage lease fees.

New York State Land Leasing Revenues 1996 - 2006[15]



Landowner Royalties and Local Government Taxes



Total state land leasing revenues have increased dramatically since 1998. New York has received a total of $29.5 million in lease revenues from all sources since 1985, of which $26.1 million was received after 1998. The State lease sales during 2006 produced more than $9.0 million in apparent high bids on 19,300 acres, nearly double the $4.6 million received in apparent high bids from the previous lease sale in 2003.

Annual royalty payments to the State have increased by two orders of magnitude since 2002, due to growing Trenton-Black River production and rising natural gas prices. New York received royalty revenue of more than $3 million in 2005, and again in 2006.

"Scores of rural 'upstaters' ride high natural gas prices all the way to the bank..."

Despite a long history of oil and gas production, New York State is experiencing a new surge in development which provides economic benefits to diverse public and private stakeholders. The hydrocarbon resource potential that remains in New York suggests that these economic benefits can continue for years to come. Oil and gas development in New York continues to play an important role in the economic development of the State, especially in rural upstate communities.

"...Retirees and farmers in the Southern Tier of New York—the area between the Finger Lakes and Pennsylvania—are cashing royalty checks of $5,000 a month or more, courtesy of a gusher of new natural gas wells drilled in the area... Some struggling to make ends meet as dairy farmers are the beneficiaries of a natural gas boom in New York... The boom has created numerous jobs in addition to infusing cash into a struggling part of the State..."

New York Post, February 4, 2007

Year	Gas Mcf	Estimated Homes Heated	$/Mcf	Wellhead Value	Landowner Royalty	Local Assessed Value
2002	631,138	9,147	$3.03	$1,912,348	$239,044	$2,294,347
2003	1,647,301	23,874	$5.00	$8,236,505	$1,029,563	$1,922,796
2004	584,818	8,476	$6.98	$4,082,030	$510,254	$1,729,968
2005	241,462	3,499	$7.78	$1,878,574	$234,822	$637,460
Total	**3,104,719**			**$16,109,457**	**$2,013,682**	

Drilling a Deep Natural Gas Well in New York

Collecting Seismic Data. Geophysicists, geologists, and engineers search for underground reservoirs of oil and natural gas, using both surface and subsurface techniques. In exploring for oil and natural gas, prospectors may drill several unsuccessful wells for each successful one. Technologies like seismic imaging have increased the likelihood that exploratory wells will be successful.[9]

Access Road to Drill Site. If exploration efforts indicate the possible existence of a hydrocarbon prospect, some land disturbance will be necessary to drill a well. The actual drilling of the well is just a temporary activity, similar to a construction project, requiring some movement of equipment on site. A site of about one to four acres may need to be cleared. This may require the use of existing roads or the construction of new roads on a landowner's property to get to the drilling site.[10]

Drilling a Deep Trenton Black River Well. Trenton-Black River natural gas prospects in New York can be accessed successfully through vertical or horizontal drilling. Drilling to typical 10,000 ft. depths generally takes from two to eight weeks, depending on many factors. After the conductor, surface and intermediate steel casing strings are cemented, the well is drilled to the target depth and production casing is cemented in place. The drill rig may be utilized to complete the well or the operator may choose to bring in a smaller rig to test and complete the well if it appears capable of producing an economic volume of natural gas. Wells may have water, sand or other materials injected into the reservoir to fracture the rock and thus improve the flow of gas from the reservoir to the well bore.[11]

Producing Gas Well Site. If the well is capable of economic production and all well drilling and testing are complete, the drilling site is reclaimed, generally within 45 to 60 days, with a smaller active area reserved for production equipment. Production equipment can include wellhead-valve assemblies, meters, tanks and gas gathering lines. Special equipment may be required to treat the gas to remove any water or impurities. An access road to the site is maintained.[12]

Reclaimed Drilling Site. If no commercial gas production is established, no production site is built, and the well site is reclaimed. The wellbore is plugged with cement; a combination of steel casing and cement plugs protect potable water aquifers. All surface structures and equipment are removed and the site is completely reclaimed. Landowners may request special conditions for site reclamation.

THE FUTURE – NEW YORK'S REMAINING NATURAL GAS AND OIL RESOURCE POTENTIAL

New York is part of the Appalachian Basin, the largest, oldest, and most extensively drilled oil and natural gas producing basin in the United States. More than 75,000 wells have been drilled in New York alone and more than 8,700 oil and gas wells were reported active in 2005. These facts might suggest that New York's potential for future production is dim, if it were not also for the fact that after more than a century of oil and gas development, New York produced a record volume of natural gas in 2005. The hydrocarbon resource potential of both New York and the Appalachian Basin is far from depleted.

New York's Natural Gas and Oil Resource Potential

As of year-end 2005, New York's proved natural gas reserves were 349 Bcf, up from 324 Bcf of proved reserves at year-end 2004.[16] Proved reserves are replenished through exploration for and development of the State's estimated remaining resource base. Recent estimates of New York's remaining technically recoverable natural gas resources range from 6.2 to 7.1 trillion cubic feet (Tcf).[17, 18]

Undiscovered Natural Gas Resources A recent assessment of Trenton-Black River resources by an industry-government-academic consortium estimates a mean of 4.4 Tcf of undiscovered gas resources in the hydrothermal dolomite reservoirs of the Appalachian Basin. New York's share of this resource base is estimated to be 1.5 Tcf.[19] A previous assessment by the United States Geological Survey (USGS) of undiscovered conventional natural gas resources in the Appalachian Basin provides a mean estimate of 0.77 Tcf for New York, of which approximately 80 percent is contained in the Trenton-Black River hydrothermal dolomite play.

The Challenges of Estimating New York's Remaining Natural Gas Resources

Accurate and timely assessments of potential oil and gas resources are essential to ensure that public policy is based on sound information. The United States Geological Survey (USGS) conducts periodic national assessments of the potential undiscovered oil and gas resources of the United States. These oil and gas resources have not been discovered; rather, they represent a pool of ***potential*** *oil and gas resources which operators must find through exploration. The USGS assessments draw upon input from local industry experts, the latest oil and gas production information, and the most up-to-date geological and geophysical data available. The USGS National Assessment presents potential recoverable oil and gas resources as a range of estimated values, ranging from resources with a low probability of occurrence to a high probability of occurrence, as well as an estimated mean value.*

Oil and natural gas resource estimates evolve over time in response to production that has already occurred, advances in geologic knowledge, new exploration and recovery technology, and the economic conditions and public policies under which exploration and production are expected to occur. Resource assessments typically assume that oil and natural gas is "technically recoverable" using current technology or incremental foreseeable improvements on that technology. Throughout the history of oil and natural gas production in New York, technological leaps have helped industry to pursue resources previously thought to be unproductive, creating large and unexpected additions to estimated resources.

Unconventional Natural Gas Resources. The USGS estimates that unconventional reservoirs such as low permeability "tight" gas sandstones and fractured shale and siltstone reservoirs are the greatest source of undiscovered natural gas resources remaining in New York, potentially containing more than 5.4 Tcf of technically recoverable natural gas. Many of New York's unconventional gas reservoirs produce at low rates, but have long-producing lives. With modern drilling and production technologies and improving market conditions, New York's unconventional gas resources are increasingly attractive targets for exploration and for further development within established fields.

Remaining Oil Resources. New York State is currently estimated to have producible crude oil reserves of 1.2 million barrels. Some geoscientists believe that New York's oil potential remains "under-explored." An extensive 1980's geological study of the State's resource-base estimated original oil-in-place to be 1,118 million barrels. Cumulative oil production through 2005 has totaled approximately 245 million barrels, which would represent an estimated oil recovery rate of approximately 22 percent of original oil-in-place. Primary production can usually recover a maximum of 30 percent of oil-in-place with another 10 percent to 15 percent possible from enhanced oil recovery methods. Assuming a 40 percent to 45 percent maximum recovery factor, New York's total recoverable oil resources are estimated to range from 447 to 503 million barrels. If approximately 245 million barrels have already been produced in the State, the remaining recoverable crude oil potential ranges from approximately 200 million barrels to 250 million barrels.

Improved market conditions since 2004 have renewed interest in New York's remaining oil potential. Drilling permits and new oil well completions have increased significantly. Modern geologic concepts are currently being applied to study the oil-producing sandstone reservoirs of New York's Upper Devonian age Canadaway Group in an effort to identify potential untapped reservoir sandstones.

Also attracting exploration interest are hydrothermal dolomite reservoirs in the shallow Trenton-Black River formation in western New York, representing a possible extension of Trenton-Black River trends that produce oil in southwestern Ontario and Southern Michigan.

Several Natural Gas Plays are Attracting New Interest in New York

The natural gas reservoirs generating renewed interest in New York are in challenging geologic formations – including tight gas sands, gas shales and deep reservoirs. In 2005, six new Trenton-Black River fields were discovered, four in Steuben County, and two in Chemung County in south-central New York. Recent discoveries in the Oneida-Oswego and Theresa sandstone plays, as well as various gas shale discoveries, also contributed to the resurgence of gas production in New York. Several specific plays of interest are profiled in the following pages.

Definitions

Proved Reserves - *Proved reserves are demonstrated with reasonable certainty, based on geologic and engineering evidence, to be economically recoverable from known, accessible reservoirs.*

Probable or Inferred Reserves – *(also called "Reserves Growth") are assumed to be recoverable with additional development in discovered fields. Additional development includes drilling infill wells on tighter well spacing, testing new reservoir zones in established fields, and extending the field boundaries of discovered fields through drilling of extension wells.*

Undiscovered Conventional Resources – *are postulated to exist outside of known oil and/ or gas fields based on geologic information and theory. Conventional resources are contained in discrete accumulations by conventional hydrocarbon trapping mechanisms. Reservoir fluids (natural gas, oil and water) are generally segregated in the reservoir with water downdip from oil and gas. Although, oil and gas can be extracted using traditional exploration and development practices, conventional resources can still present significant technical challenges. The Trenton-Black River Formation and Oriskany Sandstone are important conventional resources in New York.*

Unconventional Resources - *Unconventional gas resources may occur as hydrocarbon accumulations over a broad geographic area, in which the accumulation does not appear to be controlled by conventional trapping mechanisms. Segregation of reservoir fluids may not be evident or may be atypical, such as gas occurring downdip from water. Unconventional resources may occur in reservoirs with low porosity and permeability and low flow rates, often requiring the presence of natural and induced fractures for economic production. Undiscovered unconventional oil and gas resources are found in reservoirs whose geologic characteristics generally require special technology or a unique approach for economic development. Successful development practices for unconventional resources have included horizontal drilling, hydraulic fracturing, multiple-zone completions, and reservoir desorption. Much of New York's current natural gas production and remaining undiscovered resource potential consists of unconventional resources such as low permeability or "tight" sandstone reservoirs and shale gas. Tight sandstones of the Medina Group comprise a major developed unconventional natural gas resource in New York. The State's extensive shale formations are estimated to contain a significant volume of undiscovered unconventional gas resources.*

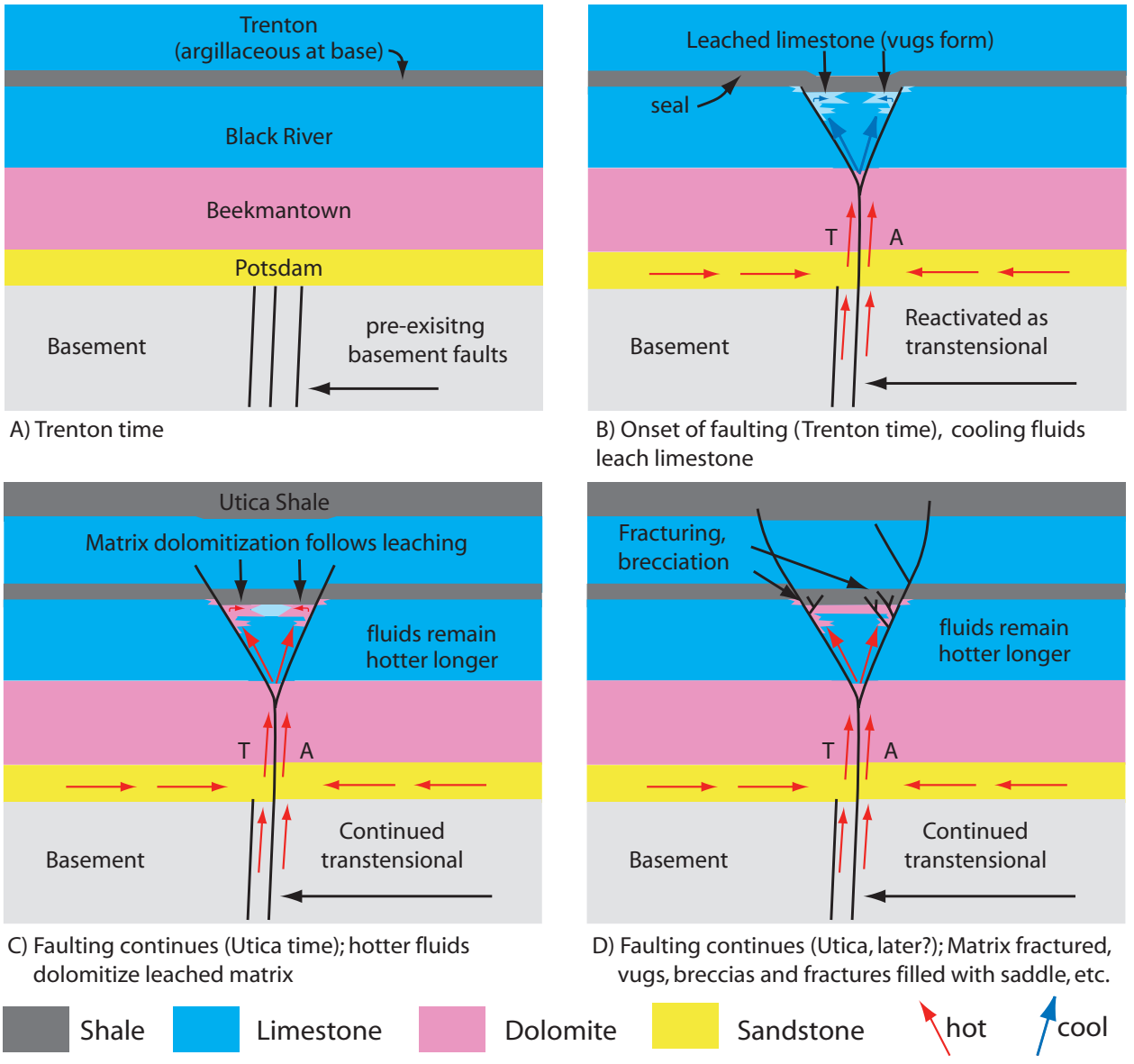
Geologic Play - *A geologic play is a set of known or postulated natural gas or oil accumulations sharing similar geologic, geographic and temporal properties such as hydrocarbon source, migration pathway and timing of hydrocarbon migration, trapping mechanism, and hydrocarbon type. The geologic play is the unit of assessment for estimating undiscovered oil and natural gas resources. In fact, the most recent U.S. Geological Survey resource assessments refer to geologic plays as "Assessment Units." The geologic play that is generating the greatest renewed interest in New York is the Trenton-Black River formation hydrothermal dolomite play.*

New York State Stratigraphic Column; Showing Oil and Gas Producing Formations

PERIOD (AGE)		GROUP	FORMATION	LITHOLOGY	THICKNESS (feet)	PRODUCTION
PENNSYLVANIAN		Pottsville	Olean	Sandstone	75-100	
MISSISSIPPIAN		Pocono	Knapp	Sandstone	5-100	
DEVONIAN	UPPER	Conewango	Riceville	Shale, Sandstone	70	
		Conneaut	Chadakoin	Shale, Sandstone	700	
		Canadaway	Undifferentiated	Shale, Sandstone	1100-1400	Oil, Gas
			Perrysburg-Dunkirk	Shale, Sandstone		Oil, Gas
				Shale		
		West Falls	Java	Shale, Sandstone	365-125	
			Nunda	Shale, Sandstone		Oil, Gas
			Rhinestreet	Shale		
		Sonyea	Middlesex	Shale	0-400	Gas
		Genesee	Genesee	Shale	0-450	Gas
	?		Tully	Limestone	0-50	Gas
	MIDDLE	Hamilton	Moscow	Shale	200-600	
			Ludlowville	Shale		
			Skaneateles	Shale		
			Marcellus	Shale		Gas
			Onondaga	Limestone	30-235	Gas, Oil
	LOWER	Tristates	Oriskany	Sandstone	0-40	Gas
		Helderberg	Manlius	Limestone	0-10	
			Rondout	Dolomite		
SILURIAN	UPPER		Akron	Dolomite	0-15	Gas
		Salina	Camillus	Shale, Gypsum	450-1850	
			Syracuse	Dolomite, Shale, Salt		
			Vernon	Shale		
		Lockport	Lockport	Dolomite	150-250	Gas
	LOWER	Clinton	Rochester Herkimer	Shale, Sandstone	125	Gas
			Irondequioit	Limestone		
			Sodus	Shale	75	Gas
			Reynales	Limestone		
			Thorold	Sandstone		
		Medina	Grimsby	Shale, Sandstone	75-150	Gas
			Whirlpool	Sandstone	0-25	Gas
ORDOVICIAN	UPPER		Queenston	Shale	1100-1500	Gas
			Oswego	Sandstone		Gas
			Lorraine	Shale		
			Utica	Shale	900-1000	
	MIDDLE	Trenton-Black River	Trenton	Limestone	425-625	Gas
			Black River	Limestone, Dolomite	225-550	Gas
	LOWER	Beekmantown Group	Tribes Hill-Chuctanunda	Limestone	0-550	Gas
CAMBRIAN	UPPER		Little Falls	Dolomite	0-350	
			Galway "Theresa"	Dolomite, Sandstone	575-1350	Gas
			Potsdam	Sandstone, Dolomite	75-500	Gas
PRECAMBRIAN				Gneiss, marble, quartzite		

Modified from 2002 NYSERDA Report, Fractured Gas Shale Potential in New York, prepared by TICORA Geosciences, Inc.

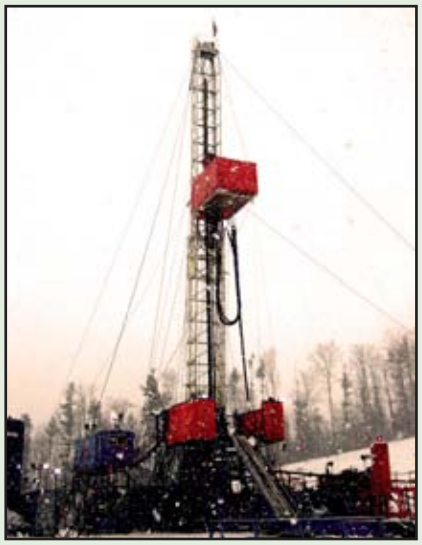
Fault-Related Hydrothermal Alteration Model for Black River Group Dolomite



Current evidence suggests that the limestone of the Black River Group and the overlying Trenton Limestone were hydrothermally altered to dolomite by high-pressure, high-temperature fluids moving up active faults during middle to late Ordovician time. This early dolomitization, which enhanced reservoir properties, was followed by further fracturing from later tectonic activity. A successful hydrothermal dolomite exploration model for the Trenton-Black River, based largely on New York, has found that the best reservoirs are in structures developed in association with basement faults, where subsequent faulting does not extend much into the overlying Utica Shale.

Courtesy of New York State Museum, from Geologic Playbook of Trenton-Black River Exploration in the Appalachian Basin.

New York Trenton-Black River Production



- New York is estimated to contain approximately 35 percent of the resources attributed to the Trenton-Black River hydrothermal dolomite play in the Appalachian Basin.
- 98 deep Trenton-Black River tests have been drilled in the State since 1985. Only 8 Trenton-Black River wells were drilled between 1985 and 1998, but Trenton-Black River exploration and field development drilling has increased steadily since 1998. 73 Trenton-Black River wells were drilled in New York in 2004 and 2005.
- Notable Trenton-Black River discoveries in 2006 include the Stoscheck #1 well, Van Etten Township, Chemung County, which was placed on production at a rate of 22 MMcf per day. A second discovery well, the Hartman BJ #1 in Caton Township, Steuben County produced at an initial rate of 12 MMcf per day.
- Since the play was discovered in 1986, attention has focused on developing an exploration model for the play, improving the effectiveness of seismic imaging, and developing efficient drilling and well-completion techniques.
- Fortuna Energy Inc., with New York headquarters in Horseheads, is the largest Trenton-Black River producer in the State. In 2005, Fortuna Energy produced more than 41 Bcf from 50 wells. Chesapeake Energy Corporation, a relatively recent entrant to New York through their 2005 acquisition of Columbia Natural Resources, is also targeting the Trenton-Black River play.
- Most Trenton-Black River production is from Steuben and Chemung Counties, but current activity also includes exploration efforts in Cayuga, Cortland, Schuyler, Tioga and Tompkins Counties.
- Successful Trenton-Black River wells have been drilled using both vertical and horizontal drilling techniques, though recent Trenton-Black River wells are frequently drilled horizontally. A combination of vertical and horizontal drilling may be used. From the vertical hole at about 9,500 to 10,000 feet deep, the well bore is gradually turned 90 degrees and the well continues to be drilled horizontally for another 3,000 feet. This technique has been found to generally increase well productivity and decrease the chance of a dry hole.

Trenton-Black River Hydrothermal Dolomite

In New York and Ontario, the Ordovician age Trenton and Black River Formations produce natural gas from fractured limestone reservoirs and from limestone reservoirs that were altered to more porous and permeable dolomite by hot, mineral-laden fluids. Dolomite is a crystalline sedimentary rock that is formed by the chemical alteration of limestone (calcium carbonate.) Dolomite often makes an excellent reservoir rock for oil and natural gas. Deep Trenton-Black River "hydrothermal dolomite" reservoirs now dominate New York's natural gas production.

Pursuing the Trenton-Black River hydrothermal dolomite play is a high-tech, high-risk enterprise that requires accurate interpretation of 2-D and 3-D seismic imaging data, drilling of deviated or horizontal wells in some areas, and integration of seismic, well logs and geologic and geochemical data into a sophisticated exploration and development model. Deep Trenton-Black River wells may be drilled vertically and then steered horizontally to total depths in the range of 10,000 to more than 12,000 feet.

Recent Trenton-Black River exploration and development drilling in New York may use 2-D seismic for exploration drilling and 3-D seismic for development drilling.

Seismic data has proved to be so effective for mapping Trenton-Black River hydrothermal dolomite reservoirs that recent Trenton-Black River production spacing units are based on bounding faults defined by seismic data. The play continues to generate substantial interest in New York because the potential rewards are great. Individual wells have produced as much as 6 Bcf in a single year; the best well in the play to date has produced 15 Bcf in four years. [20, 21]

Industry's geologic understanding of this play has been aided by a recent multi-state study by the Trenton-Black River Appalachian Basin Exploration Consortium, which has developed and published an integrated stratigraphic, structural and chemical model for the Trenton-Black River hydrothermal dolomite reservoirs in New York.

Shale Gas

Organic-rich black shale formations are found throughout the stratigraphic section in New York. Some are thick and widespread, correlating with shale formations elsewhere in the Appalachian Basin, while some are thin and limited in extent. During the nineteenth century, hundreds of shallow establishment of Lakeshore Field. Naples and Dansville Fields were discovered in the 1880 and 1881. Despite this early history, the shale gas potential of New York remains largely untested. Since 1900, fewer than 100 wells have been purposely drilled to test the potential of New York's Devonian and Silurian-age shale formations, and no wells have tested the Ordovician-age Utica Shale. Several research wells were drilled by NYSERDA and the U.S. Department of Energy in the 1980s, establishing a number of one-well gas fields, some of which are still producing. Until recently, low production rates from shallow shale gas wells limited commercial interest in shale gas.

The recent economic success of other U.S. shale gas plays like the Barnett and Fayetteville shales has renewed industry interest in New York's shale formations. A potential Devonian shale gas resource-in-place of more than 400 Tcf, plus recent advances in shale development concepts and drilling and completion technology, have made New York's fractured shale gas potential more economically attractive. [22] The recompletion potential of New York shale formations currently "behind pipe" in thousands of wells drilled for deeper objectives could potentially allow the economic development of shale reserves that might not otherwise support the drilling of a new well.

Every shale gas play is unique and New York shales are no exception. Exploration strategies should focus on locating areas with high gas content that also have sufficient permeability for economic production. Organic-rich shales, which have a relatively high content of total organic carbon, typically have the best gas-in-place and the most natural fractures. Natural fractures in shale reservoirs are generally supplemented with induced hydraulic fractures so that wells can produce at economic rates.

Horizontal drilling has been applied successfully in other shale gas plays and horizontal drilling could become economically attractive for New York shale formations as drilling and well completion techniques continue to improve, and as the optimal reservoir characteristics of New York shale formations are better understood. [23]

Union Springs Formation, Marcellus Shale, US Rte. 20 near Cherry Valley, NY

Devonian Age Shale

Devonian age formations extend across 22,500 square miles of south-central New York. The organic-rich, gas-bearing shale formations occur in the Middle and Upper Devonian, from the top of the Onondaga Limestone through the Perrysburg Formation of the Canadaway Group. Thickness ranges from less than 100 feet for the Pipe Creek and Genesee Shales to more than 1,200 feet for the Rhinestreet shale. Measured total organic carbon (TOC) values for Upper Devonian black shales range from less than 0.4 percent to as much as 7 percent by weight. The average TOC content of the Rhinestreet shale is 3 percent.

The Rathbone Field, discovered in 1931 in Steuben County, is the only successful Upper Devonian shale gas field since the establishment of Lakeshore field in the late 1800s. Thirty-one wells were drilled in Rathbone Field targeting the Rhinestreet Shale, of which twenty-four wells were producers with initial flow rates ranging up to 2,000 Mcfd.

Marcellus Shale Formation

Much of the renewed interest in New York's Devonian shale gas potential is focused on the Middle Devonian Hamilton Group, the oldest strata of the Devonian gas shale sequence. The Marcellus Shale is the target black shale formation of the Hamilton Group, ranging in thickness from 25 feet in southwestern New York to 180 feet in central New York.[24]

Naples Field, discovered in 1880, produced 32 million cubic feet (MMcf) from the Marcellus Shale. Nearly all of the New York shale gas discoveries after Naples Field were in the Marcellus Shale/ Lower Hamilton Group. A joint NYSERDA and U.S. Department of Energy research program of the 1980s established five productive gas fields in the Marcellus Shale, four of which are still producing.

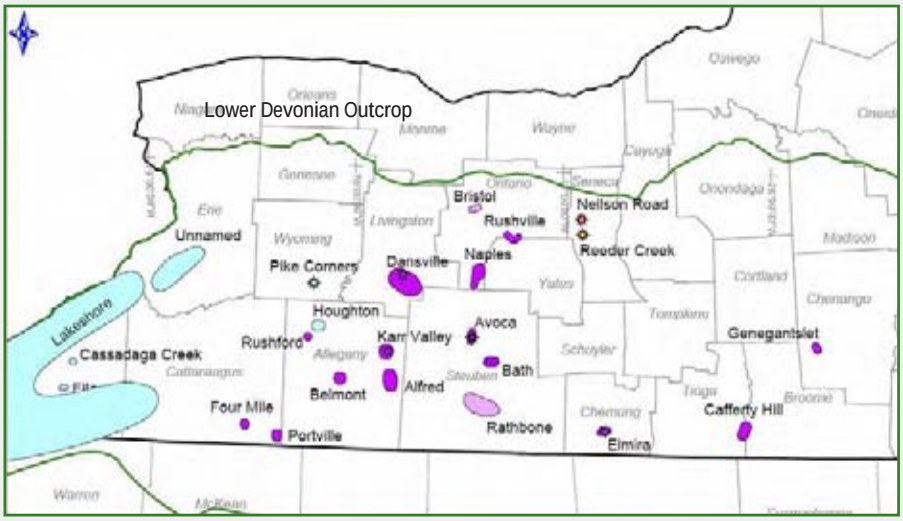
The Genegantslet Field, discovered in 1964 in Chenango County, produced gas from the Marcellus in three wells including the Decker #2 well, which had an initial flow rate of 1,650 Mcfd.

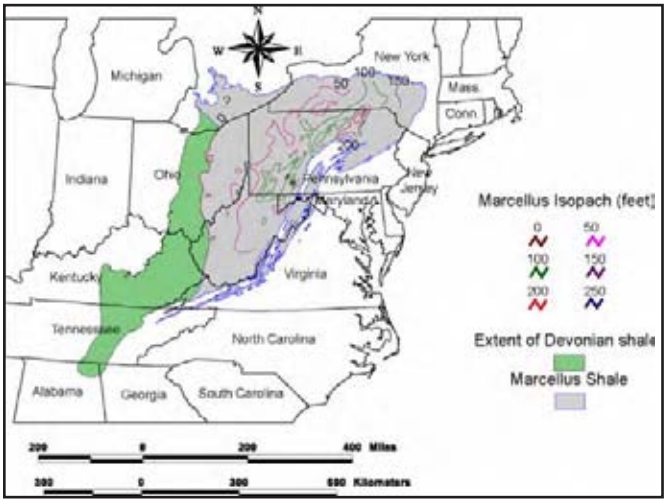
NYSERDA is currently sponsoring research on the Marcellus Shale, providing geochemical and geological analyses of prospective Marcellus zones and identifying the most promising modern well completion techniques. Preliminary results show a wide range in the reservoir quality of the Marcellus Shale. For example, total organic content ranges from 0.3 percent to 11 percent. Work is ongoing to develop a comprehensive understanding of the geologic controls on economic gas production from the Marcellus Shale.

New York Devonian Shale Production

- New York contains approximately 15 percent of the Devonian shale natural gas resources in the Appalachian Basin.
- 100 Shale gas wells have been drilled in NY since 1900; 60 wells have been drilled since 1965.
- 98% targeted Devonian shale; 2% targeted Silurian shale.
- Most New York shale wells currently produce for home or small commercial use.
- Since 1980, most shale R&D activity has targeted the deeper Marcellus Shale.
- Current activity includes testing the Upper Devonian in western New York and western Pennsylvania.

New York Producing Shale Fields





Silurian Age Shale

Lower Silurian Clinton Group shales of potential interest for gas production include the Sodus Shale and the Rochester Shale.[25] Both are primarily gray shales; no data are available on the organic carbon content. Two one-well gas fields produced from Silurian shales. Reeder Creek Field in Seneca County was completed in the Rochester Shale in 1989 and has since been abandoned, and Meridian Exploration discovered the Neilson Road Pool in 1990, which produced 84 MMcf.

Utica Shale

The Ordovician-age Utica Shale is an organic-rich and thermally-mature black to grey-black shale that overlies the Trenton Limestone. The Utica Shale outcrops along the west and south-southeast sides of the Adirondack Mountains but is deeply buried across most of the State. The Utica Shale is considered to be the source rock for lower Devonian through Cambrian oil and gas production. Across much of the State, the Utica Shale is approximately 300 feet thick, thinning to the west and north. Estimated total organic carbon content ranges from 1.5 to 3.0 percent in eastern New York and from 2 to 15 percent in northern New York, Ontario and Quebec.[26]

Significant gas shows have been encountered while drilling through the Utica Shale. NYSERDA is funding detailed geological studies of Utica Shale reservoir properties and resource potential to develop an exploration model that would promote production testing using modern completion technology.

Medina Group 'Tight Gas'

The Lower Silurian age Medina Group sandstones comprise the dominant tight gas sandstone play in western and southwestern New York. The Medina tight gas is trapped in low porosity, low permeability sandstone reservoirs, which require hydraulic fracturing to produce gas at economic rates.[28] Hydraulic fracturing is the practice of pumping fluids into the formation at high pressure to crack the rock so that natural gas can flow more easily to the well bore. Low permeability sandstone reservoirs of the Medina Group were extensively explored in the 1980s as a result of the Federal Energy Regulatory Commission Tight Gas Sand designation. Production from the Medina tight peaked in the mid-1980s. In 2005, the Medina produced more than 8.5 Bcf from 5,223 active wells, contributing 15 percent of New York's total annual gas production and accounting for 76 percent of New York's total non-Trenton-Black River production of 11.2 Bcf.[29]

Despite being a mature play, the Medina tight gas sandstones are estimated to have substantial remaining undiscovered resource potential. The USGS recently estimated more than 4 Tcf of undiscovered Medina resources in New York. Operator interest in the Medina remains strong in response to sustained high gas prices, and relatively low drilling costs, and low drilling risk.

A successful Medina production strategy includes the application of cost-effective new technologies and practices to optimize individual well performance and total field production.

New technologies and operating practices aimed at improving marginal well performance have been developed. Not only does the Medina continue to provide infill drilling and well recompletion opportunities, but the formation has remaining potential for field extension and occasional wildcat drilling. Typical Medina wells in New York recover 80 to 100 MMcf of reserves; seventy Medina wells were drilled in 2005.[30]

New Technology Solutions Help Maintain Well Production and Optimize Performance of Tight Gas Fields

A NYSERDA-funded research project found that a persistent and widespread production problem in New York's Medina wells is the accumulation of produced water in the well bore, which reduces the gas flow rate to below economic levels and may kill gas production altogether. Regular removal of the accumulated water increases average gas production. Conventional water removal techniques such as swabbing and beam pumps are too costly for many of New York's tight gas wells and wells may be prematurely abandoned.

A cost-effective water removal technology has been developed with support of the Stripper Well Consortium and NYSERDA. The Gas-Operated Automatic Lift (GOAL) PetroPump is designed to freely operate within the well casing. The pump rises when gas pressure builds up below the piston, carrying accumulated water to the surface where the water is discharged and the accumulated gas is produced. The pump then descends back downhole as wellhead pressure declines.

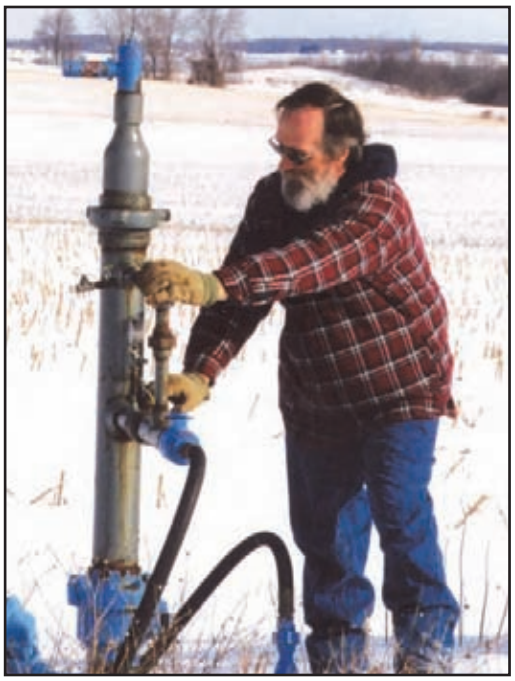
Lenape Resources, one of the larger independent producers in New York State, installed the PetroPump in a 3,200-foot Medina completion that produced about 1,100 Mcf/year and required periodic soaping and swabbing to remove brine. Production after tool installation averaged 3,416 Mcf/year and payout was achieved in eight months. Several other subsequent installations by Lenape Resources resulted in similar increases in production.[27]

New Frontiers in Deep Gas

The Appalachian Basin has been called the "most drilled and least explored" basin in the world. The Appalachian Basin overall is mature in terms of shallow production (at depths less than 5,000 to 6,000 feet), but deeper gas formations offer a new exploration frontier.

What is "deep gas" in New York? Deep gas can be thought of as gas produced from reservoirs located at significant physical depths of 7,500 to 10,000 feet or more below the surface. But "deep gas" in New York can also be thought of as under-explored sedimentary formations in the lowermost portion of New York's stratigraphic section, regardless of physical depth. Such formations are Middle to Late Ordovician to Cambrian in age and include the Trenton, Black River, Theresa and Potsdam. In the Finger Lakes area and Southern Tier, Middle and Lower Ordovician and older formations are quite deep. To the north and west, the Middle Ordovician age and older formations, including the Trenton, the Black River and formations below, are found at much shallower depths.

By either measure, New York has untapped "deep" exploration potential. Of more than 33,000 wells currently in the New York well database, fewer than 600 wells were drilled deeper than 5,000 feet. Only 655 wells in New York's current database were drilled to the Trenton Formation or deeper. (This total may not include recent Trenton-Black River wells, which are confidential.) Fewer than 110 wells have penetrated the entire sedimentary section.[31]



Tending a Medina Gas Well.

Upper Cambrian Theresa Sandstone Play

The Theresa Sandstone play (Galway Formation) consists of Upper Cambrian age sandstone reservoirs that lie at or near the Knox Unconformity. The Theresa Sandstone in New York is equivalent to the active Rose Run Sandstone play in Ohio, and underlies most of western New York at depths ranging from 3,000 to 13,000 feet. The thickness of the formation increases to the south to more than 260 feet; the porosity of the Theresa Sandstone ranges from 6 to 12 percent. Theresa wells are drilled vertically to depths ranging from 5,000 to 7,000 feet.

Although the Upper Cambrian Theresa Sandstone has produced gas from a few small fields in western New York since 1990, the Theresa has not been widely explored. Recent discoveries in the Theresa (notably Ardent Resources' Bockhahn Field in 2004 in Erie County), in addition to many gas shows in the Theresa, have prompted renewed interest in understanding the rock properties and regional distribution of Theresa Sandstone reservoirs. Three wildcat wells were drilled for Theresa objectives in 2004. The Theresa produced more than 430 MMcf from six wells in 2005.

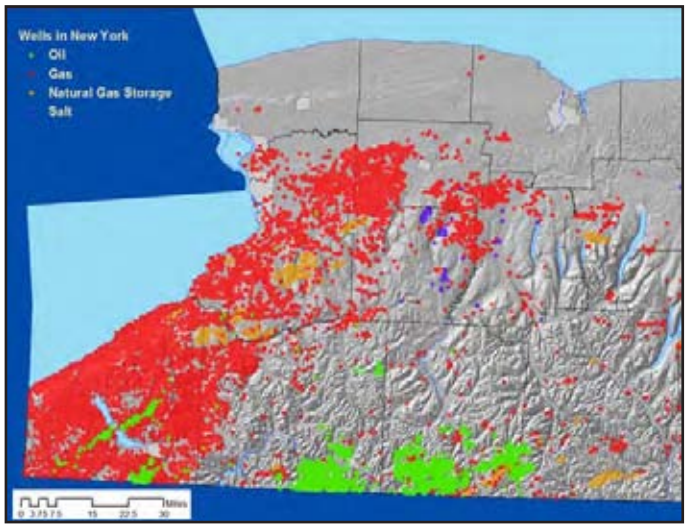
Ardent Resources is updating older studies of the Cambrian-Ordovician stratigraphy in New York using new well log data from wells that have penetrated the Trenton-Black River and deeper formations. Seismic data acquired for Trenton Black River exploration could potentially be used to refine exploration prospects for the Theresa Sandstone. [32, 33]

Extracting More of New York's Crude Oil Potential

New York has produced approximately 245 million barrels of oil since 1880. Today, all of the State's oil production is characterized as stripper well production. New York's stranded oil resources, remaining after traditional primary and secondary oil recovery, are unknown, but are thought to be as much as 255 million barrels.

As the average wellhead price of oil has more than doubled since 2003, New York has seen a surge of interest in the State's remaining oil potential. Annual production of more than 211,000 barrels for 2005 represents a nearly 15 percent increase over 2004 production of 184,000 barrels.

The majority of oil production in New York is from Upper Devonian sandstone reservoirs of the Canadaway Group. Oil is also produced from naturally fractured Bass Island Dolomite and Middle Devonian Onondaga Limestone. The sandstones in the upper part of the Canadaway and the Conneaut Groups in New York correlate to the Bradford sandstones in Pennsylvania. New York's Conewango Group correlates to the Venango sandstones in Pennsylvania. Only recently have modern analytical techniques and concepts been applied to New York's Upper Devonian reservoir sandstones. The goal of current research by the University of Buffalo, funded in part by NYSERDA, is to develop modern models for the Upper Devonian sandstones in western New York State that relate the productive oil fields to sandstone deposition, faulting, folds and basement structure. Such work could result in effective exploration strategies for overlooked or by-passed oil reservoirs, leading to new approaches for extracting the substantial "stranded" oil resources in New York's old producing fields. [36]



Map of Southern Tier and Western New York showing oil producing areas (green) and natural gas producing areas (red). Courtesy of the NY Division of Mineral Resources.

What is a Stripper Well?

Stripper wells (also called marginal wells) are defined as oil wells that produce less than 10 barrels (bbl) of oil per day, or gas wells that produces less than 60 thousand cubic feet (Mcf) of natural gas per day. In 2005, 401,072 stripper oil wells in the United States produced a total of 321 million barrels, which was 17 percent of domestic oil production. That same year 288,898 stripper gas wells produced more than 1.76 Tcf, representing 9 percent of domestic production. The average marginal gas well in the United States produces 16.7 Mcf per day and the average marginal oil well in the U.S. produces 2.2 barrels per day.[34]

All oil production in New York is stripper well production. The average New York oil well produces 0.21 barrels per day, or approximately 76 barrels per year. Average stripper gas production from non-Trenton Black River gas wells in New York is approximately 4.8 Mcf per day, or approximately 1.75 MMcf per year.[35]

CO_2-Enhanced Oil and Natural Gas Recovery and CO_2 Storage

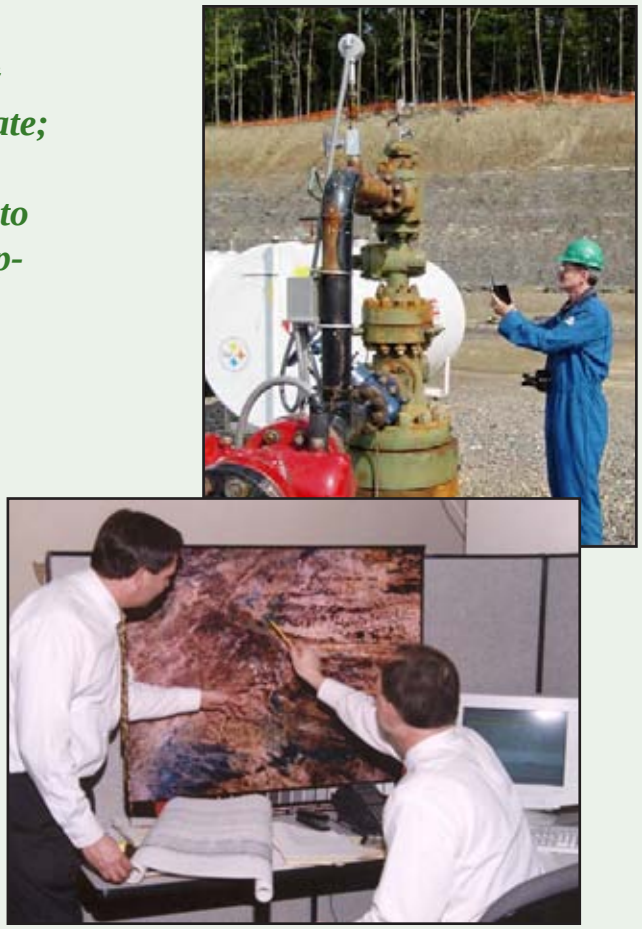
From 50 to 80 percent of oil-in-place and from 20 to 30 percent of natural gas-in-place typically remains trapped in New York's depleted oil and gas fields, not recoverable by traditional primary and secondary recovery techniques. CO_2 flooding is the fastest growing form of enhanced oil recovery (EOR) in the United States, producing an estimated 237,000 barrels per day in 2006. One of the most attractive features of CO_2 injection for EOR is that the CO_2 can be from industrial facilities that may otherwise vent the CO_2 to the atmosphere, contributing to global warming.

CO_2-EOR is most effective if reservoir depth and pressure are great enough to inject CO_2 at sufficient pressure to achieve miscibility with oil contacted in the reservoir. There has been little CO_2-EOR attempted in Appalachian Basin oil fields, and none in New York oil fields. Most New York oil fields have insufficient depth and reservoir pressure for miscible CO_2 floods. Some deeper oil reservoirs might be candidates for less-efficient but still potentially viable immiscible CO_2 floods, and as candidates to permanently store, industrial sourced CO_2.

In addition, CO_2-enhanced gas recovery (EGR), while still in the conceptual stage, is thought to be a likely result of injection of CO_2 into a depleted gas reservoir for the ultimate purpose of sequestering the CO_2. New York's deeper sandstone reservoirs may have potential for substantial CO_2 storage plus incremental gas recovery. CO_2-EGR has yet to be adequately tested. New York's organic-rich shales may also provide an attractive CO_2 sequestration opportunity because the CO_2 can be absorbed onto the shale. CO_2 storage in organic-rich shales is still in the conceptual stage.

PREREQUISITES FOR CAPTURING THE BENEFITS FROM NEW YORK'S NATURAL GAS AND OIL RESOURCES

Natural gas and oil development makes a significant contribution to New York's economy, especially upstate; generating jobs, tax and royalty revenue to state and local government, and royalties and other revenues to landowners and local businesses.Natural gas development in particular provides an economic stimulus to rural communities in New York.



The current pace and scale of development in New York can create challenges for the relationships between all stakeholders: private landowners, exploration and production companies, State and local government, and the general public. Consequently, State government has the obligation to manage natural resources and protect environmental quality and improve public health while facilitating the benefits that flow from environmentally sound natural gas and oil development. To do this, the State must ensure that hydrocarbon development proceeds with protection of the environment and the public interest as its primary focus.

The recent growth in gas and oil exploration and development activity in New York has been facilitated both by proactive state agencies that ensure environmentally responsible development and protect the interests of all stakeholders, and by operators that remain responsive to public concerns.

Continued success in capturing the benefits of New York's hydrocarbon resource endowment will require concerted action from both government and the private sector in several areas:

- Environmental stewardship. State government must support strong and responsive regulatory programs to ensure effective protection of the environment and the public interest, incorporating cost-effective regulatory strategies and public education and outreach, along with expeditious permitting. Developers need to continue to focus on superior environmental performance, effectively addressing landowner and public concerns.

- Technology progress. Advanced technologies and state-of-the-art practices, applicable to the unique characteristics of New York's resource endowment, must be developed, demonstrated and applied to extend the lives of existing wells and to economically find and produce new prospects. This will require continued public-private partnerships in research, development, and demonstration of new technologies and development approaches.

- Access to high-quality data. Potential developers and investors in the oil and gas sector in New York will require access to high-quality data about the State's resources and production, coupled with effective data analysis and data management capabilities. Both government and industry must work collaboratively to ensure that all stakeholders have access to high quality data.

- Access to resources. State policies and programs must continue to support access to resources on public and private lands in an environmentally sound manner, to resolve mineral rights conflicts, to address unique access issues in urbanized areas, and to keep certain designated areas, such as in some State Parks and Preserves, permanently off-limits to development. Developers need to continue to respect the interests of the landowners.

Statewide perspectives and public/private collaboration are fundamental to addressing these prerequisites. New York's long history of oil and gas development has allowed for substantial progress on each of these fronts, contributing, in part, to the recent resurgence of oil and gas development in the State.

Environmental Stewardship

New York has strong and mature regulatory programs for oil and gas exploration and development that are effective at protecting the environment and public safety. The Division of Mineral Resources in the Department of Environmental Conservation (DEC) is responsible for ensuring the environmentally sound economic development of New York's non-renewable energy and mineral resources for the benefit of current and future generations.

Role of New York Oil and Gas Industry in Reducing Greenhouse Gas Emissions

The New York Advanced "Clean Coal" Power Plant Initiative (ACCPP) was established to identify sites for the potential development of one or more advanced "clean coal" power plants. Winning plant sites will act as host sites for the research, development, and deployment of CO2 capture and/or sequestration technologies. NYSERDA will coordinate and facilitate capture and/or sequestration RD&D projects at the project sites.

Many of the skills, technologies, and analytical approaches used for oil and natural gas exploration and development are directly applicable to underground injection of CO_2 for permanent storage. The expertise and infrastructure of New York's oil and natural gas industry could play an important role in identifying, evaluating, and implementing potential CO_2 storage (sequestration) projects in the State's geologic formations.

New York's Oil, Gas and Solution Mining Law 37 requires oil and gas producers to apply sound environmental principles and ensure that areas affected by minerals development are returned to a condition that allows productive use of the land. The Division of Minerals is responsible for regulating all oil, gas, underground storage or solution salt mining wells of any depth, and brine disposal, geothermal or stratigraphic wells deeper than 500 feet. The Division of Minerals reviews all well drilling and plugging permit applications and inspects drilling wells, production sites, and abandoned well sites. Minerals Division staff are all highly trained and well qualified for reviewing permits and inspecting drilling sites. Many are petroleum engineers, petroleum geologists or technicians.

Features of New York's oil and gas regulatory program include the following:

- To protect the land environment during and after oil and gas extraction, drilling permit requirements prevent oil spills and ground-water contamination, and require proper disposal of highly saline brines and other wastes. Land impacted by drilling operations must be properly reclaimed for productive use.

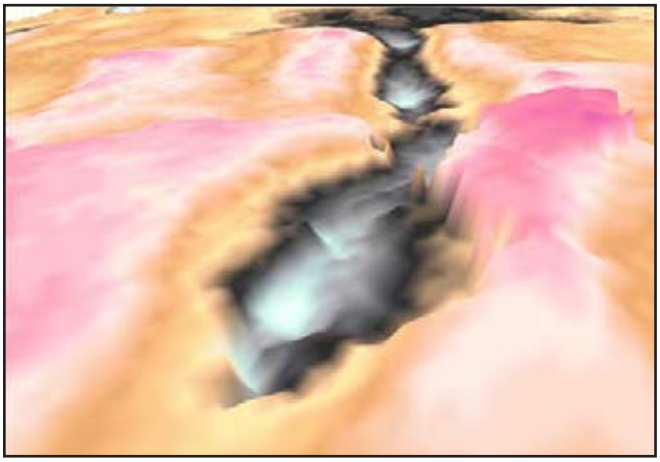
- To protect surface and groundwater, drilling permits require that well casing be cemented in place from the ground surface to at least seventy-five feet below the deepest freshwater aquifer penetrated by the well. In addition, all oil and gas-bearing zones in the well must be further isolated by production casing cemented in place across the hydrocarbon bearing zones. These measures prevent the flow of gas, oil or salt water between underground formations. Municipal and private water wells, reservoirs, and streams, lakes and ponds are protected with required drilling setbacks. Permits also require proper disposal of drilling waste and proper containment of drilling fluids.

DEC staff person inspects a producing gas well. A new rust-proof tank helps prevent leaks at the site.

- To protect public health and safety, and prevent waste during drilling, each permit includes conditions designed to prevent the escape of methane and dangerous gases from wells. Regulators monitor drilling sites for compliance with these conditions, and bring enforcement actions against violators.

- Site-specific permit conditions ensure that the environmental impact of resource extraction is mitigated to the greatest extent possible and that public safety is maintained. All well drilling permit applicants must submit an Environmental Assessment Form, which allows the DMN to evaluate the environmental impacts and determine whether special environmental protection and mitigation measures are required. For example, additional measures of protection are generally required for wells drilled in environmentally or technically sensitive areas, such as locations in the vicinity of primary or principal aquifers.

Ongoing efforts of New York's Division of Mineral Resources ensure that oil and gas operations in New York continue to be pursued with a high priority on environmental protection. This especially applies to environmentally sensitive areas such as the Finger Lakes region or areas where suburban expansion and oil and gas development overlap. Clear, simple and predictable regulations and policies provide substantial benefits to both developers and the public.



3-D Seismic Image

New York's Orphaned and Abandoned Wells

- To obtain a drilling permit, operators must provide financial security to guarantee well plugging and site reclamation. As of the end of 2006, $14.9 million in bonds and other security had been posted. In 2005, 150 wells were plugged in accordance with DEC requirements.

- The New York Oil and Gas Account was created to plug "orphaned" wells that predate the State's regulatory programs. These are abandoned wells for which no financially responsible party can be found. The Oil and Gas Account is funded by a $100 per well permit fee. More than 600 orphaned wells are on the DEC priority plugging list.

- In addition the DEC maintains an ongoing program to locate, identify, and assess previously abandoned and unreported wells.

DEC staff person locates an orphaned and abandoned well in Cattaraugus County

Innovation and Technology Progress

The successful application of cutting edge exploration and production technology to theTrenton-Black River hydrothermal dolomite play shows that recent technology advances can greatly enhance natural gas and oil recovery in the state and reduce environmental impacts. New York benefits from technology progress in four priority areas, described below:

Targeting High Productivity Reservoirs. Past perception of New York's declining natural gas potential was due in part to poor selection of sites and target formations for exploratory drilling. Advances in seismic imaging of the subsurface and integrated geologic and engineering models help to better identify targets for exploration and development in New York. Widely used throughout the world, 3-D seismic imaging can provide detailed information about fault distribution, reservoir continuity, subsurface structure and reservoir fluid movements. Increasingly, operators in New York are finding economic justification for acquiring 3-D seismic data to refine their stratigraphic objectives in complex reservoirs. Seismic data are increasingly used for mapping reservoirs and justifying proposed spacing units in permit applications. Seismic imaging has proved to be definitive for determining the structure of Trenton-Black River hydrothermal dolomite reservoirs, and Trenton-Black River production spacing units are now based on bounding faults defined by seismic data.

Improving Drilling and Well Completion. Advances in drilling and completion technologies are critical to reducing future well costs and making more resources economically producible. For example, the Stripper Well Consortium is funding research on the best fracture imaging best suited to the Appalachian Basin. Improved fracture imaging provides better calibration of fracture models and can be used to optimize hydraulic fracture treatments. Other key advances are continuing improvements in drilling horizontal wells and multi-lateral well completions, which have already proved valuable in Trenton-Black River development in New York. A recent technological development with potential for New York is the successful use of horizontal wells to develop shale gas plays, particularly the Barnett Shale in Texas and the Fayetteville Shale in Arkansas. The success of horizontal wells in other shale formations may stimulate renewed interest in testing New York's Devonian and Ordovician-age gas shales with horizontal wells.

Schlumberger directional drilling assembly photographed at Fortuna Energy's Drumm #1 well in Steuben County. A directional drilling assembly allows the driller to control the direction of the wellbore while a well is being drilled. This type of tool is used to drill horizontal or directional wells.

Extending Well Life. Given the large amount of stripper-well production in New York, extending the lives of low-productivity wells is an important objective of advanced natural gas and oil development technology. Production levels in many wells decline prematurely, often due to avoidable and repairable wellbore damage. Higher oil and natural gas prices alone are not enough to save wells — and entire fields — from premature abandonment.

The Pennsylvania State University, with support from NYSERDA and the U.S. Department of Energy, established the Stripper Well Consortium (SWC) to assist small and independent operators who own and operate marginal wells in New York and throughout the Appalachian Basin. The SWC is an industry-driven consortium focused on the development, demonstration, and deployment of new technologies needed to improve the production performance of stripper wells. Through the SWC, small operators who would otherwise have no staff or resources for research can leverage their resources to analyze the causes of premature production decline and develop effective remediation approaches. Such efforts can result in higher production volumes, longer well life, and, thus, greater production and resulting economic benefits.

Reducing Greenhouse Gas Emissions. Reducing greenhouse gas emissions has become an important priority for New York and the nation. Seven northeastern states, including New York, have formed the Regional Greenhouse Gas Initiative (RGGI) with the goal of reducing greenhouse gas emissions in the region. The oil and gas sector could play an important role in this initiative by assisting in the storage of greenhouse gases, particularly CO2, in geologic formations. Substantial research and development efforts are required to better understand the risks and opportunities for geologic storage of CO2 in New York, and NYSERDA has recently initiated several research efforts with this goal in mind.

Across the board — from exploration, to drilling and completion, to production, to environmental protection — advanced technologies can make all the difference in enabling increased oil and gas supplies from the hydrocarbon plays of New York. Smaller independent producers may lack the access to capital and expertise required to integrate advanced technologies into their operations. Renewed efforts to demonstrate to small independent producers the potential application of advanced technologies could pay substantial future dividends to industry, landowners, and consumers in the State.

Access to High-Quality Data

Access to high-quality data, including geologic, engineering, reservoir and production data, is invaluable to potential developers and other stakeholders. Good data enable the identification of new prospects, increase the likelihood of successful exploration and production, and assist state agencies in monitoring the progress of development and ensuring use of appropriate environmental safeguards.

New York has one of the best developed information management systems for oil and gas data in the Appalachian Basin and in the U.S. The Division of Mineral Resources has extensive oil and gas data on its website, including live database queries. In addition, the Minerals Division and the Resource Characterization Group of the New York State Museum have collaborated on the development and maintenance of the Empire State Oil and Gas Information System (ESOGIS), a comprehensive data source for oil and gas data in the state of New York. ESOGIS allows users to query and view data for all of New York's 33,000+ recorded wells, and provides online access to maps, papers and other information important to New York's oil and gas industry, potential investors, and the public. Currently, ESOGIS contains paper files for 26,000 wells, formation tops for 11,000 wells, raster images for 13,000 wells and complete digital log suites for 400 wells. [38]

NYSERDA Supports the Stripper Well Consortium

The Stripper Well Consortium (SWC), established in 2000, is focused on the development, demonstration and deployment of new technologies needed to improve the production performance of natural gas and petroleum stripper wells. The SWC receives base funding from the DOE, NYSERDA, and the Pennsylvania State university. The Pennsylvania State University is responsible for management of the SWC. Research is conducted in three broad areas: reservoir remediation, wellbore liquids removal and clean-up, and surface-system optimization.

NYSERDA co-funds technology development and demonstration projects independently and as a partner in the SWC. Recent projects focused on increasing the productivity and extending the economic life of New York's existing oil and gas wells include:

•Advanced Decline-Curve Modeling for Stripper Well Production Analysis. This project developed software designed for low-permeability gas wells, enabling operators to cost-effectively analyze under-performing wells.

•Improvements to the GOAL PetroPump, an affordable and effective automated casing swab-and-lift designed for stripper gas wells.

•Demonstration of "Hyrdroslotter" technology in New York to improve near wellbore permeability for wells that cannot be hydraulically fractured.

•Demonstration of a prototype of a new pump designed to reduce casing-head pressure and improve performance of stripper wells

Access to Resources

Obtaining access to explore and develop oil and natural gas resources can be a complex task, involving the interests of private land and royalty owners, sometimes ambiguous mineral rights, and competing land uses. Approximately 93 percent of the New York portion of the Appalachian Basin is private land. Less than one percent of total Appalachian Basin acreage in New York is federal land or split-estate land (where the federal government owns mineral rights while another entity, either private or state, owns the surface land). Federal lands in the basin are managed primarily by the U.S. Forest Service. Oil and gas resources underlying the 174,984 acres of Federal lands in New York are currently not open to oil and gas leasing, with the exception of two parcels in New York that are owned jointly by the State and the Federal government. [39]

State Land. New York State controls more than one million acres of land for parks, recreation, reforestation, and other uses. Some lands, such as state parks, have legal or constitutional use restrictions on leasing for oil and gas development. For example, Catskill State Park is excluded from oil and gas leasing. On other lands, multiple uses, including oil and gas development, may be allowed depending on specific circumstances. New York State leases State Reforestation Areas, Multiple Use Areas, Wildlife Management Areas, Department of Transportation rights-of-way, and other state agency and certain State University lands. New York's Environmental Conservation Law ("ECL") Article 23, Title 11 (§ 23-1101) authorizes the Department of Environmental Conservation to issue leases on behalf of the State for all state-owned lands for the purpose of oil and gas development, except for State park lands and other specifically prohibited lands. This program did not become active on a regular basis until the mid-1980s. Some tracts may be withdrawn from leasing to protect important habitat, wildlife, recreational, and scenic values.

There are four ways in which New York State receives revenue from leasing of state lands:

- The State receives bonus bid payments from the successful bidders on tracts offered at State lease sales. Competitive oil and gas lease sales were held in 1999, 2003 and 2006.
- In 2005, New York received annual delay rentals, typically $5 per-acre per-lease, for more than 31,754 acres under primary term.
- In 2005, the State received a 12.5 percent, or one-eighth royalty, on the gross production revenues from 20,856 acres under secondary term leases.
- The remaining 11,911 acres were leased for gas storage fields for which the State received an annual fee.

NYSERDA's Contribution to Oil and Gas R&D

NYSERDA conducts multifaceted energy and environmental research and development (R&D) remains unique as the only state-supported, industry-driven R&D program in the United States. NYSERDA works with New York's oil and gas industry to reduce the risk associated with identifying and developing new resources, and with using new technologies for exploration, drilling, and production.

NYSERDA's support for hydrocarbon exploration and production dates back to its inception in 1975. Early support included the Eastern Gas Shales Program, Trenton Limestone exploration, and the Auburn geothermal/natural gas well, which helped initiate the Trenton-Black River hydrothermal dolomite play. Recent NYSERDA projects and partnerships have led directly to greater industry investment in oil and gas resources in New York and increased production of natural gas. Examples include:

- *A joint venture between Ardent Resources and U.S. Energy Development Corporation drilled a Theresa Sandstone discovery well in Erie County using NYSERDA supported geologic data. As of year end 2005, cumulative production from the well exceeds 201 MMcf.*
- *NYSERDA funded studies of the Trenton Limestone potential in New York's Northern Tier to determine if the application of technology could create new oppor-tunities in the shallow fractured Trenton limestone. NYSERDA's study led directly to the leasing and drilling of three wells in Oswego County. Four more wells have been drilled in Wayne and Cayuga counties. Three of these wells resulted in natural gas discoveries.*
- *In response to expanding gas production from fractured shale formations throughout the United States, NYSERDA funded new studies of the natural gas production potential of New York's Devonian and Ordovician black shale formations, primarily focused on developing tools and approaches that industry can use to explore and develop reservoirs of this type in New York.*

As of year-end 2006, 64,521 acres of state land were leased for oil and gas development and natural gas storage.

Environmental protection measures in drilling permits stipulate the location of the drill site and access roads to minimize land surface disturbance. Environmental mitigation and land reclamation measures are required to minimize environmental impacts. As of year-end 2006, only 31 acres of the 40,000 state lands leased in the 1999 and 2003 lease sales have been disturbed by drilling and production activities.

The Chemung SRA #1 disturbed 1.5 acres out of a total of 195 acres leased. The use of native vegetation to reclaim the drill site made the producing well barely visible from the road.

Private Land. Most of the natural gas and oil development in New York State occurs on private land. The high percentage of private land ownership New York, often distributed in relatively small parcels, creates technical and operational challenges. Acquiring an acreage position large enough for drilling or for a 3-D seismic program can become expensive and time-consuming.

In 2005, new legislation was enacted that provides additional protections to landowners who lease their properties for oil and natural gas development. The new legislation simplifies the options for integrating landowner interests into oil and gas units and improves consumer protection measures. An oil or natural gas unit includes the landowners and mineral rights owners within a geographic area that corresponds to the reservoir area expected to be drained by a producing well.

Mineral rights owners within the surface boundaries of a proposed unit now have the option to participate in a well as a working interest owner, or to be integrated cost-free into the unit as a royalty interest owner. All individuals participating in oil and natural gas units must have notice of the significant legal import of their leases, and all lease contracts are required to contain an unconditional right of rescission within three business days.

Wells drilled to any formation but the Trenton-Black River, and some other formations, have standard rules for the spacing of wells, the size of oil and gas units, and the well-setbacks from lease boundaries. Well spacing rules for the Trenton-Black River vary by depth. The boundaries of Trenton-Black River units are based on the shape and area of the underlying reservoir as indicated by well data, seismic imaging or other suitable remote sensing technology, such as gravity and magnetic surveys.

Most natural gas and oil development in New York occurs on private land.

AN UPSTATE SUCCESS STORY— NATURAL GAS AND OIL IN NEW YORK

Oil and natural gas production currently makes a significant contribution to New York's economy, especially in western New York and the Southern Tier — generating royalties, jobs, tax revenues, and benefits to landowners and local communities, businesses, consumers, and state and local government. In the last decade, this contribution has grown significantly, made possible by new technology, improved understanding of New York's petroleum geology, and rising prices. For more than 140 years, New York's oil and gas industry has been driven by foresight, creative thinking, leaps in technology development, perseverance and improved understanding of the State's hydrocarbon resource potential. This continues to be true today.

Horses graze near drilling operations for the Gublo #1 well in Chemung County, which was drilled as a Trenton-Black River field extension well.

New York State government has played an active role in ensuring that natural gas and oil development proceed with high regard for the environment and the public interest. The dramatic growth in natural gas and oil exploration and development activity in New York has been facilitated, to a large extent, by proactive state agencies ensuring environmentally responsible development and protecting landowner rights. New York State policies, and the programs responsible for implementing them, continue to evolve for the benefit of all citizens:

- to ensure proper environmental stewardship
- to provide appropriate access to natural gas and oil resources on public and private land
- to enhance access to high-quality information on resource potential
- to enable investment and demonstration of new technology for meeting the unique challenges of New York's hydrocarbon resources.

Many believe that the current reinvigoration of natural gas and oil production in New York can continue, yielding substantial returns to the state economy and New York citizens, especially in upstate rural and agricultural areas. Significant additional natural gas and oil resource potential exists within the State. This potential, coupled with its proximity to existing pipeline and storage infrastructure and major population centers,positions New York to reap benefits from its hydrocarbon resource endowment for many years to come.

Drilling a Trenton Black River well at the edge of a suburban community.

Oswego Light, Lake Ontario

ENDNOTES AND SOURCES

[1]Main source for information on the history of the natural gas and oil industries in New York is Herrick, John, 1949, Empire Oil, the Story of Oil in New York State, Dodd, Mead & Company (out-of-print) , New York, 474 pp.

[2]The Pioneer Oil Museum of New York
P.O. Box 332, Bolivar, NY, 14715
Curator: Ray Payne
The museum is dedicated to preserving the oil heritage of southwestern New York and northwestern Pennsylvania. Items on display include antique engines, a model rig, a "dynamite" wagon, and similar items related to the local oilfields. Also on display are plaques, photographs, news articles, and video footage. The museum maintains a Web site with current and historical articles and photographs documenting New York's oil industry. http://www.usgennet.org/usa/ny/county/allegany/OIL-COUNTY/OIL-OIL-MORE%20OIL.htm

The American Oil and Gas Historical Society (AOGHS)
1201 15th Street NW, Suite 300,
Washington, DC, 20005
202-857-4785, bawells@aoghs.org
Executive Director: Bruce Wells
AOGHS is dedicated to preserving the history of United States oil and natural gas exploration and production. The Society provides advocacy and service for organizations that work to preserve that history. AOGHS publishes a newsletter. The Web site is a good source of articles, photos, and links to oil and natural gas history museums throughout the United States. www.aoghs.org.

Drake Well Museum
202 Museum Lane, Titusville, PA 16354. Phone: (814) 827-2797.
Director: Barbara Zolli; administered by the PA Historical and Museum Commission.
The Drake Well Museum collects, preserves, and interprets the founding of the oil industry in Pennsylvania for residents and visitors by educating audiences about the persons, places, and events important to the development of the petroleum industry and its growth into a global enterprise. www.drakewell.org/museum

[3] Historical natural gas production data compiled by Rich Nyahay, January 2007, New York State Museum, Reservoir Characterization Group.

[4]The discovery well for the current Trenton-Black River hydrothermal dolomite play was drilled in 1986 by Columbia Natural Resources. Several years following the discovery were devoted to studying the play and developing an exploration and development strategy. Drilling of development wells and additional exploration wells began in 1996. The success of the Trenton-Black River play in New York is due in part to the successful application of 3-D seismic imaging to the placement of development wells.

[5] Arthur Van Tyne, New York oil and gas industry consultant, Wellsville, NY personal communication to Advanced Resources International and John Martin, NYSERDA personal communication to Advanced Resources International. An extensive geological study of the State's resource base done in the 1980s, estimated original oil-in-place to be 1.118 billion barrels. Cumulative production through 2005 totaled approximately 245 million barrels, representing an estimated recovery rate of approximately 22%. Primary production can usually recover a maximum of 30% with another 15% possible from enhanced oil recovery methods. Assuming a 45% maximum recovery factor, total New York production from primary and enhanced methods may total 503 million barrels with approximately 245 million barrels already produced and 255 million barrels yet to be recovered.

[6] Historical crude oil production data compiled by Rich Nyahay, January 2007, New York State Museum, Reservoir Characterization Group.

[7] Current data on New York natural gas and oil drilling and production provided by the NY Department of Environmental Conservation Division of Mineral Resources.

[8] Table shows estimated oil and gas industry employment for New York State. The U.S. Census Bureau is the source for these data. Alternative estimate can be made using the United States Department of Commerce Bureau of Economic Analysis RIMS II multipliers for output, earnings and employment by state. The Final-Demand Employment Multiplier for the Oil and Gas Extraction Industry in New York is 4.3 jobs per $1 million change in final demand for oil and gas extraction in the State. The Direct-Effect Employment Multiplier is 4.38 jobs per direct job: (direct job+ indirect job + induced job)/(direct job). This means that each direct job is estimated to sustain 3.38 indirect plus induced jobs.

[9] http://www.naturalgas.org/naturalgas/exploration.asp

[10] http://www.dec.state.ny.us/website/DMR/brochure.pdf

[11] http://www.naturalgas.org/naturalgas/extraction.asp

[12] http://www.naturalgas.org/naturalgas/production.asp

Sector	Employment
Exploration and Production	784
Refining	1,951
Transportation	1,753
Wholesale	47,230
TOTAL	**51,718**

[13] Personal communication from Bradley Field, NYSDEC Division of Mineral Resources to Advanced Resources conveying selected results from unpublished economic impact study of Fortuna Energy operations in New York conducted by Pennsylvania State University.

[14] Single well example of the direct economic benefit to the State of a single prolific Trenton-Black River well from Bradley Field, NYSDEC Division of Mineral Resources.

[15] New York State Department of Environmental Conservation Division of Mineral Resources, Oil and Gas Leasing Report, 2005 and preliminary results of 2006 lease sales from Division of Mineral Resources.

[16] U.S. Energy Information Administration, Advance Summary: U.S. Crude Oil, Natural Gas and Natural Gas Liquids Reserves Report, 2005.

[17] Milici, R.C. and others, 2002, United States Geological Survey Assessment of Undiscovered Oil and Gas Resources of the Appalachian Basin.

[18] USGS resource assessments are fully-risked estimates ranging from a 95 percent chance of occurrence through a 5 percent chance of occurrence. Values shown here are the mean estimates. T-BR Consortium used USGS methodology and new T-BR data. Mean estimate shown. USGS allocates a percentage of the estimated Appalachian Basin undiscovered resources to individual states. Table reflects the percentage of estimated resources that are allocated to New York by individual assessment unit (geologic play).

Sources: USGS 2002 Assessment and Trenton-Black River Consortium 2006 Assessment	**Assessment Units (Geologic Age)**	**New York Undiscovered Natural Gas Resources, Bcf**
Conventional Resources	Oriskany Sandstone (Devonian)	74.7
	Black River Trenton Hydrothermal Dolomite - USGS 2002 (Ordovician)	633.8
	Black River Trenton Hydrothermal Dolomite (Trenton Black River Consortium, 2006)	**1524.0**
	Theresa Sandstone and Beekmantown (Cambrian/Ordovician)	42.2
	All Other Conventional Reservoirs (Silurian, Ordovician, Cambrian)	22.5
	Total New York Conventional *(total includes 2006 T-Br Assessment)*	***1673.4***
Unconventional Resources	Upper Devonian Tight Sandstones, Siltstones & Shale	1072.0
	Marcellus Shale (Middle Devonian)	96.3
	All Other Devonian Siltstone & Shale	194.0
	All Clinton-Medina Group (Silurian)	4041.6
	Total New York Unconventional	**5403.9**

[19] National Energy Technology Laboratory, 2006, Geologic Play Book of Trenton-Black River Exploration in the United States. This study applies the USGS assessment methodology for undiscovered oil and gas resources to the most current and complete Trenton-Black River play data available. The USGS allocates 34.5 percent of the total undiscovered resources in the Appalachian Basin hydrothermal dolomite play to New York.

[20] Soderblom #1 in the town of Big Flats, Chemung County produced 6.3 Bcf in 2005.

[21] Lovell #1 in Steuben County has cumulative production of 15.2 Bcf; producing rate is 9.7 MMcfd

[22] Milici, Robert, 2005, Assessment of Undiscovered Natural Gas Resources in Devonian Black Shales, Appalachian Basin, Eastern U.S.A, U.S. Geological Survey Open File Report 2005 – 1268.

[23] TICORA Geosciences and NYSERDA, 2002, Fractured Gas Shale Potential in New York. NYSERDA report available for download from Empire State Oil and Gas Information System (ESOGIS).

[24] Milici, Robert, 2005, Assessment of Undiscovered Natural Gas Resources in Devonian Black Shales, Appalachian Basin, Eastern U.S.A, U.S. Geological Survey Open File Report 2005 – 1268.

[25] TICORA Geosciences and NYSERDA, 2002, Fractured Gas Shale Potential in New York. NYSERDA report available for download from Empire State Oil and Gas Information System (ESOGIS).

[26] Hill, D.G., 2002, 181 Years Later – Why Isn't Shale A Major Source of Natural Gas Production in New York? TICORA Geosciences, Inc. Presentation to the Ontario – New York Oil and Natural Gas Conference, November 4 – 6, 2002.

[27] Stripper Well Consortium, Keeping the Home Wells Flowing. Helping Small Independent Oil and Gas Producers Develop New Technology Solutions, Summer 2005.

[28] Hydraulic fracturing is the practice of pumping liquids into the formation at high pressure to induce a crack into rock so that natural gas can flow more easily to the well bore.

[29] New York State Department of Environmental Conservation, Minerals Division, 2005 production data.

[30] New York State Department of Environmental Conservation, Minerals Division, 2005 production data.

[31] New York State Museum, ESOGIS, Empire State Oil and Gas Information System. Totals do not include confidential wells. Operators may hold wells confidential for up to two years. Deep Trenton-Black River wells drilled during 2005 and 2006 may not be represented in these totals.

[32] Copley, D. L. and L. Robert Heim, 2006, Preliminary Subsurface Correlations of the Theresa (Galway) Sandstone Formation in New York State: Implications for Exploration, presentation at the AAPG Eastern Section Meeting, October 8 – 10, 2006, Buffalo, NY.

[33] Copley, D. L., Ardent Resource, 2004, The Theresa Sandstone in New York State; the Next Big Play? presentation at the AAPG Eastern Section Meeting, October 3 – 15, 2004, Columbus, OH.

[34] Interstate Oil and Gas Compact Commission, 2006, Marginal Wells, Fuel for Economic Growth. Available from IOGCC website. www.iogcc.state.ok.us.

[35] New York State Department of Environmental Conservation, Division of Mineral Resources, 2005 New York State Oil, Gas and Mineral Resources Annual Report.

[36] Jacobi, R.D. and G.J. Smith, 2006, Depositional and Tectonic Models for Upper Devonian Sandstones in Western New York State, Guidebook and Field Trip, October 7, 2006, American Association of Petroleum Geologists, Eastern Section Meeting, Buffalo, NY.

[37] The New York State Department of Environmental Conservation is charged with implementing this law.

[38] http://www.nysm.nysed.gov/esogis/

[39] U.S. Departments of Interior, Agriculture and Energy, 2006, Scientific Inventory of Onshore Federal Lands' Oil and Gas Resources and the Extent and Nature of Restrictions or Impediments to Their Development, Phase II Cumulative Inventory, published November 2006, available from the U.S. Bureau of Land Management.

17 Columbia Circle
Albany, New York 12203-6399

Toll Free: 1 (866) NYSERDA
(518) 862-1090
Fax: (518) 862-1091
www.nyserda.org
info@nyserda.org