This primer contains a brief history of domestic natural gas uses and consumption. The influence of shale gas drilling is discussed with particular emphasis on Marcellus Shale. The paper is accompanied by case studies from business and government entities who have made successful transition to CNG from another fuel source.

Natural Gas: A Summary of the History, Uses, and Consumption with a Discussion on the Influence of Domestic Shale Drilling. This Primer is Accompanied by Case Studies

December 2011 - Updated April 2012

This research was prepared with support from the National Energy Technology Labs, URS, and Wilkes University's Institute for Energy & Environmental Research.

Natural Gas: History, Uses, and Consumption

Natural gas is a mixture of several hydrocarbon gases, containing seventy to ninety percent methane in most cases. Other common molecules include ethane, propane, butane, carbon dioxide, oxygen, nitrogen and hydrogen sulfide. Over millions of years, decayed plant and animal matter builds up in layers in the earth and becomes trapped by sand and silt that turns to rock. The organic matter, through a process of heat and pressure under this rock, then turns to coal, oil, or natural gas. Natural gas is considered 'dry' when it is almost purely methane, and 'wet' when there is a significant amount of other hydrocarbons.

The process for gas drilling begins with geologists locating the type of rock that will likely contain gas. Geologists then use seismic surveys (involving echoes and vibrations) to gain information about the rock. If the area seems like it will yield natural gas, drilling begins. Drilling can be performed on land (onshore) or in the ocean (offshore). Compared to onshore drilling, where there is ground on which to stabilize drilling machines, offshore drilling is much more complicated.

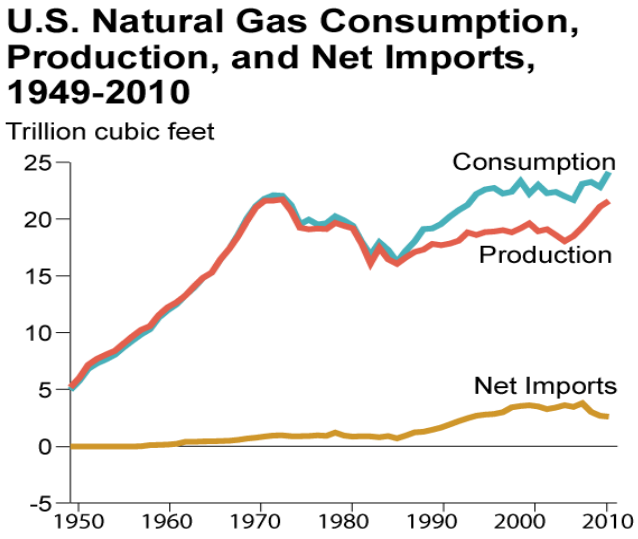
Historically for onshore drilling, the percussion method was used. This involved lowering a heavy metal drill bit into the earth over and over to create a hole. This method was largely abandoned, because it could not reach depths of more than 400 or 500 feet, on average.

For offshore drilling, the wells are deep beneath the surface of the ocean, and artificial platforms are constructed on the surface. The first offshore rig was built and used in 1869, but it was not until 1974 that drilling was done far out in the ocean in deep water—namely, in the Gulf of Mexico. The original rigs, like the one patented by T. F. Rowland in 1869, were designed to work solely in very shallow water. The rigs that are used today have a similar four-legged design to the earliest models, but are able to drill in very deep water.

Deep sea rigs have specific components that allow them to function efficiently. The two most important features are the subsea drilling template and blowout preventer. The subsea drilling template connects the drilling site to the platform at the surface of the water, and the blowout preventer is in place to prevent oil or gas from leaking into the water. Today, there are two main types of deep sea rigs—movable and unmovable. Moveable rigs are able to move from location to location and drill in multiple places, while unmovable rigs remain in one place only. Moveable rigs are less expensive and are used many times for exploratory purposes. There are also various other types of rigs, including drill ships and drilling barges. Once natural gas is extracted from onshore and offshore sites, it is transported to consumers by way of pipelines. Before it reaches the pipelines, however, it needs to be purified into the state it will be in when it enters homes and businesses. This requires the separation of various hydrocarbons and fluids from the pure natural gas to produce 'pipeline quality' dry gas. Restrictions are placed on the quality of natural gas that is allowed to enter pipelines. Natural gas is also sometimes stored in large underground areas because demand is higher in different seasons of the year. From the

large pipelines, the gas goes into smaller pipelines called mains, and then further into even smaller pipes called services that lead directly into homes and buildings to be heated. Natural gas can also be cooled to a very cold temperature and stored as a liquid. Turning the gas into a liquid allows for easier storage because it takes up less space. Then, when it needs to be distributed, it is returned to its original state and sent through pipelines.

Natural gas is among America's most heavily used sources of energy. In the mid to late 1800's, wood was the country's main energy source. As we moved into the 1900's, coal became increasingly popular and remained so throughout the 20th century. Also during this century, nuclear electric power became a new, popular energy source. The three major fossil fuels—petroleum, coal, and natural gas—have totaled to 87% of U.S. energy use is the past decade, and have been the nation's top fuels for well over one hundred years. U.S. natural gas consumption and production was mostly equal in 1986. Since then, we have seen an increase in the consumption of and the need for imported gas. Between 2006 and 2010, domestic natural gas production increased with the use of more efficient, cost effective drilling techniques.



Source: U.S. Energy Information Administration, *Annual Energy Review 2010*, Table 6.1 (October 2011).

Source: US Energy Information Administration

In 2010, natural gas accounted for approximately 25% of U.S. energy consumption. In 2009, the top states for natural gas consumption were Texas, California, Louisiana, New York, Florida, and Illinois. Natural gas is consumed in a number of ways. Most natural gas consumption occurs in the home, as a heat source for homes and water. More than half of all homes in the U.S. use natural gas as their main home heating source. Natural gas is also used by manufacturing industries it is considered a raw material as it serves as a hear source for various manufacturing processes. It is used to produce steel, glass, paper, clothing, brick, and electricity. Industry is the largest consumer of natural gas, accounting

for 43% of all U.S. natural gas consumption. The most common industrial uses of natural gas are in the pulp and paper, metals, chemicals, petroleum refining, stone, clay and glass, plastic, and food processing industries

In the 1800's, natural gas was mainly extracted from coal to be used locally. However, in the early 1900's natural gas began to be moved across state lines. This left states unable to accurately monitor natural gas sales. For almost 40 years, the federal government also failed in its attempts to regulate the industry. Finally, the Natural Gas Act of 1938 gave the Federal Power Commission (FPC) the ability to regulate natural gas prices from the pipeline to the consumer. In 1942, the FPC was also granted authority to oversee the construction of interstate pipelines. In 1954, the Supreme Court ruled in Phillips Petroleum v. Wisconsin that the FPC had authority over the gas producers who were selling to interstate pipelines. This meant that the FPC had the power to regulate prices from the wellhead to the pipeline.

The FPC struggled in the years after the Phillips Petroleum v. Wisconsin decision to take on the administrative responsibility of regulating natural gas producers. The FPC's decision to handle each natural gas producer individually was often considered to be the reason for natural gas shortages in the 1970's. The Natural Gas Policy Act of 1978 began to deregulate the natural gas industry and allow the supply and demand to equalize. In the early 1980s, price changes lowered demand significantly and surpluses were faced, but the issue eventually resolved. Barriers between interstate and intrastate natural gas markets were broken down and the price regulation was substituted with a price ceiling by 1985. The Natural Gas Wellhead Decontrol Act of 1989 enacted a plan that phased out all regulation by 1993. Such deregulation allows gas producers to sell directly to marketers, local distribution companies, and/or the end user.

In 2002, the U.S. produced about 22.5% of the world's natural gas. Historically, gas drilling was primarily conducted in southern states and in the Rocky Mountains. More recently, exploration has expanded to the Appalachian Mountains. Other drilling areas include Alaska, California, North Dakota, the Gulf of Mexico, and the Pacific Ocean. For years, geologists have been aware of certain areas that contain abundant sources of natural gas trapped beneath shale; however, the technology to drill through this shale was not yet available. In the past ten years, advances in such extraction have occurred and we are now able to drill into shale.

In particular, Marcellus Shale is of interest to the northeast region of the country because it lies under the Appalachian basin. Geological structures in these regions, such as shale basins, tend to yield high quantities of natural gas. It is estimated that shale basins in the United States have a potential to produce from 500-1,000 trillion cubic feet of natural gas. Marcellus Shale alone is expected to contribute 225-516 trillion cubic feet to the national total.

Marcellus Shale

The Marcellus Shale Formation is a black shale formation from the Devonian Age, lying under the Appalachian Basin that extends from New York to Tennessee. The shale sediment is a source of natural gas that has been extracted with the use of methods known as horizontal drilling and hydraulic fracturing. The majority of Marcellus Shale is found in West Virginia and Pennsylvania, where land is being leased to gas companies for drilling, although various forms of shale can be found across the country. These areas full of natural gas areas are called shale "plays"—or shale formations containing a large amount of natural gas which share similar geologic and geographic properties. Shale drilling is important to the US because 87% of our natural gas used is drilled domestically. Drilling in Marcellus Shale allowed the US to maintain this statistic because it was now able to support its own natural gas needs.

Source: US Energy Information Administration

Exploration of the Marcellus Shale Formation began nearly 200 years ago. The first natural gas well on the formation was drilled in 1821 in Fredonia, New York. However, the drilling technology at that time could not successfully collect a profitable amount of natural gas from the Marcellus Formation, due to the depth of the natural gas pockets. In addition, the formation was not thought to contain a large amount of recoverable natural gas. This changed in 2002, when the U.S. Geological Survey estimated that the formation held approximately 1.9 trillion cubic feet of recoverable natural gas. Advancements in technology throughout the beginning of the 2000s, especially honing the techniques of horizontal drilling

and hydraulic fracturing, brought more and more interest and exploration to the Marcellus Shale region. The first well was drilled in 2003 by Appalachia, LLC, in Washington County, Pennsylvania. Gas production from the well began in 2005. By the end of 2007, over 375 gas wells were permitted in the state of Pennsylvania. In 2009, the U.S. Department of Energy made a new estimate that the Marcellus Formation contained 262 trillion cubic feet of recoverable natural gas.

Changes came with the new exploration. Bradford County, Pennsylvania, is a rural area that has been greatly affected by the shale boom. From 2008 through 2010, 482 wells were drilled in the county. In 2010 alone, 355 of the 1,368 wells drilled in Pennsylvania were drilled in this county. Approximately 500 of the 1,100 gas drilling employees at the time of the survey were Pennsylvania residents. This is credited with lowering the county's unemployment rate. In a survey of 1,000 businesses in the county, one-third reported an increase in sales due to the drilling industry and only three percent reported a decrease. However, 90 percent of businesses said that the increase in business did not lead them to increase their staff. Other changes in Bradford County have not been positive. Crime rates have increased, rents have doubled in many areas, and workers moving into the area are taking up the available housing, causing a shortage.

How Natural Gas is Extracted from the Marcellus Shale in Pennsylvania

Conventional natural gas production involves finding gas reservoirs in sandstone and carbonate rock formations. In order to expand the possibilities of gas production, wells are now being drilled into low-permeability, tight sandstones, gas shale, and coal bed methane formations. This is known as "unconventional natural gas production." Most of the wells in the Marcellus Shale region are drilled using these unconventional methods.

Some of these new technologies include horizontal drilling, acidizing, and fracturing. Horizontal drilling is frequently used at the end of the well in order to increase the area accessible to the well. Instead of being exposed to only 50 feet of a formation, horizontal drilling increases that exposure by 2,000 to 6,000 feet. Injecting acid into a well can dissolve rock to allow access to more hydrocarbons. Rock can also be fractured by injecting high pressure fluids into the formation. Hydraulic fracturing uses a mixture of water, sand, and chemicals to create pores in hard shale rock. This destroys natural barriers in order to increase the flow of natural gas to the wellbore. These techniques were originally intended for oil wells, but are now being applied to gas wells.

When a company comes into Pennsylvania hoping to drill for natural gas it must find land to lease and then apply for permits to drill and later sell the natural gas. Hundreds of thousands of acres have already been leased in Pennsylvania for the purpose of natural gas drilling. However, only a small number of pipelines have already been set up to transport the gas away from the drilling sites. A network of major

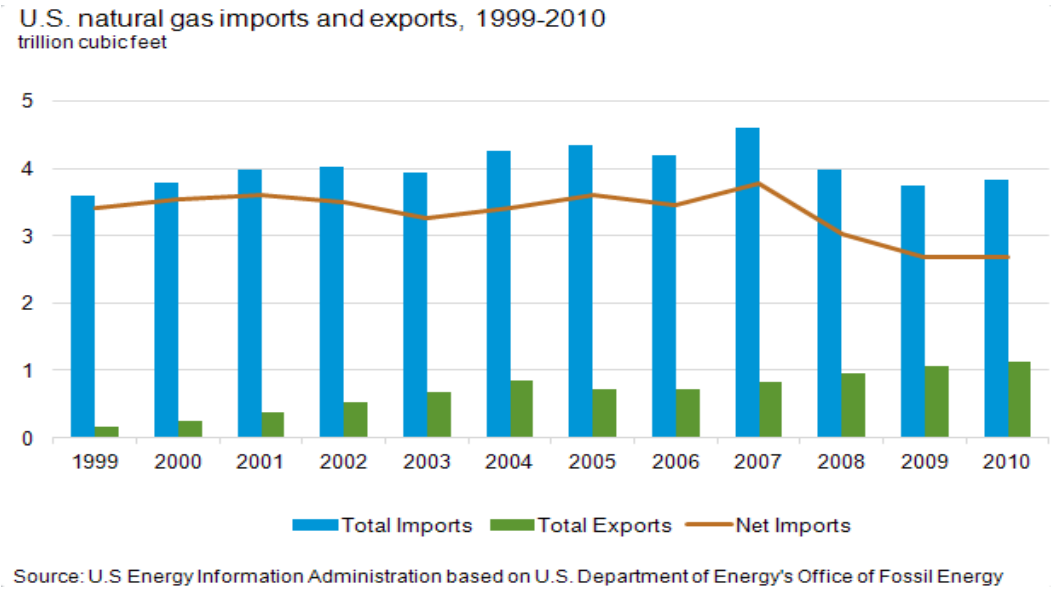
and minor pipelines is needed in order to transport the gas collected. This will require the construction of thousands of more miles of pipelines and wells.

The construction of a well involves several processes including drilling, casing and completion. Casing is a process that strengthens the well. There are many kinds of well casing, including conductor casing, surface casing, intermediate casing, liner string, and production casing. After the well is cased, it is evaluated and installed with proper equipment. The process of well completion involves preparing the well for natural gas production. The types of well completion include open-hole completion, conventional perforated completion, sand exclusion completion, permanent completion, multiple zone completion and drain hole completion. The wellhead is mounted at the opening of the well to manage the extraction of oil and natural gas and prevent blow outs. The three parts of a wellhead include the casing head, the tubing head, and the Christmas tree. The casing head and tubing head provide a seal between the casing and the surface. They also provide support for the casing throughout the well. The Christmas tree consists of branching tubes and valves that control the outflow of the well.

A well is abandoned if it is not producing enough to make a profit, but successful wells in Texas have been active for 20 to 40 years. Over time, the flow of hydrocarbons slows. New technologies have been introduced in order to facilitate the flow of hydrocarbons in well formations. These technologies increase the production of a well, but also decrease their lifespan.

Natural Gas Today

Natural gas is used throughout the U.S. and the world for, among other things, home heating, cooking, and public transport vehicles. Manufacturing and refining industries comprise 84 percent of industrial natural gas usage in the U.S., however, in 2010, the net import of natural gas declined by 3 percent. This occurred because of continued growth in the export of natural gas out of the U.S. Imports alone declined by 6 percent, even though domestic natural gas consumption grew in 2010. The drop in imports is due, in large part, to shale drilling. While shale gas is not currently being exported, companies are exploring the possibility. Several companies have even applied for permits to ship gas from the Marcellus shale.



One of the greatest logistical issues for companies that sell natural gas, either in the U.S. or abroad, is transportation. Natural gas is transported by interstate and intrastate pipelines to local distribution companies (LDCs) – also known as your natural gas utility company. LDCs are typically owned by investors or the local government. LDCs transport natural gas to their customers using a network of small diameter distribution pipes. Transportation and distribution costs make up approximately half of a natural gas customer's bill. The other half of the bill is comprised of the commodity cost, which is based on current and future prices on the New York Mercantile Exchange.

There are over two million miles of distribution pipes in the U.S. Natural gas fueling stations provide either compressed natural gas or liquefied natural gas, but compressed natural gas is more common. Compressed natural gas can be compressed by the station or brought in trucks. Liquefied natural gas (also known as LNG) is only provided by a few large U.S. companies. The process of liquefying natural gas is expensive and requires the gas to be kept at -260 degrees Fahrenheit during transport.

Today, there are over 6,300 producers of natural gas in the U.S. These producers range from huge corporations that have business all over the world, to one or two people who own a rig. The largest producers are termed 'majors'; there are 21 such majors in the U.S. The U.S. also has more than 530 natural gas processing plants, which produced about fifteen trillion cubic feet of natural gas in 2006, and about 160 pipeline companies, with 300,000 miles of pipeline across the country. There are 123 natural gas storage centers, and about 1,200 distribution companies. The natural gas industry has changed drastically since the 1980's. During this time, things were much simpler because there were limited options for gas delivery and extraction. Today, the industry is much more open to choice and competition. Well-head prices are not regulated, so they are based off of supply and demand. This makes the natural gas market similar to many other markets in our economy—the ability of supply to meet demand affects the prices at any given time. Currently, the demand for natural gas is on a steady

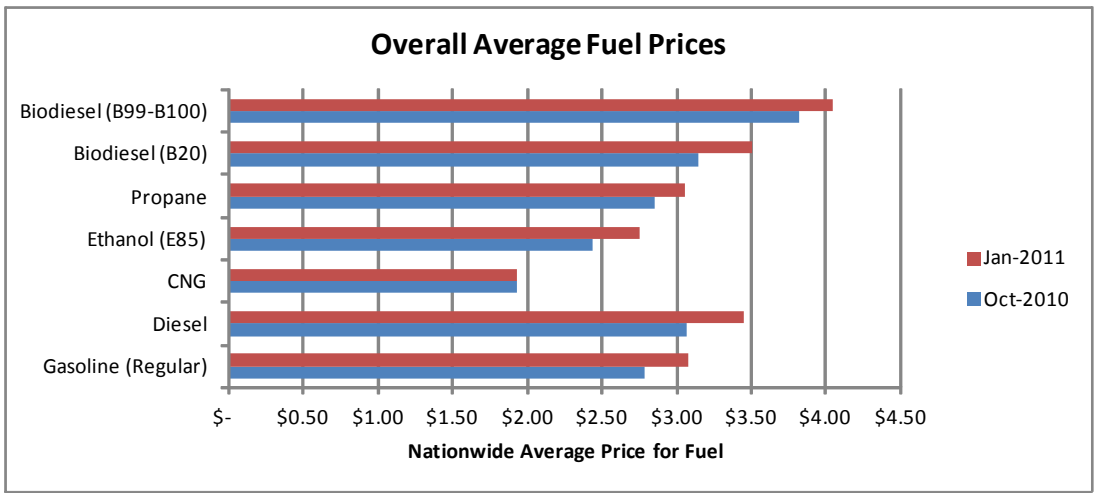
upward trajectory, although this demand is constantly affected by factors such as weather and the current economy. In terms of revenue, natural gas is a backbone to the American economy. In 2009, natural gas and oil together generated one trillion dollars, which was 7.7% of the US gross domestic product, and together provided 9.2 million jobs.

Just as in the past, the movement of natural gas from wells to households takes many steps. In each step, a different important role is played before the natural gas can move on in the chain. The entire process starts with exploration, which is how natural gas areas are found and how companies decide where to drill. The process of locating natural gas has drastically changed over the last twenty years with advances in technology. The next step is extraction. As discussed previously, extraction is the process of drilling and how natural gas is brought from underground to the surface. Next is production, which involves the purification of natural gas before it is put into pipelines for transportation. After production is transport, which involves the movement of natural gas through huge networks of pipelines that progressively get smaller until they enter into households. If all the natural gas is not used, it goes into storage underground until it is needed. Distribution speaks to the breaking down of major pipelines into smaller ones that distribute natural gas to individual customers, and finally marketing has the role of assisting in selling their product to the user.

Case Studies

Natural Gas in Transportation

With growing awareness of global warming and our carbon footprint, many companies and individuals are researching alternative fuel methods, like Compressed Natural Gas (CNG). CNG has a variety of uses, including fuel for both commercial and consumer vehicles. Private companies and government entities have begun to switch over their vehicles from gasoline to CNG. Benefits of doing so include lower fuel price, ample domestic supply and lower emissions. For instance, a standard school bus running on CNG will emit 70% less carbon monoxide than a diesel fuel powered bus. In addition, CNG is less expensive; diesel costs upwards of $3.50 per gallon in today's market, while CNG costs below $2.00 per gallon. The chart below illustrates that CNG is the cheapest fuel, while biodiesel (B99-B100) is the most expensive.



Source: Clean Cities Alternative Fuel Price Report

Another attractive feature of CNG is that 90% of it comes from domestic wells. This results in a more stable market and more stable prices. As detailed in the above chart, the prices of all other fuels rose between October 2010 and January 2011, while CNG held steady.

Conversely, CNG does present some drawbacks. For instance, compared with gasoline or diesel, a gallon of CNG gets lower mileage, which means more frequent fill-ups. The U.S. also offers far fewer CNG fueling stations than gasoline or diesel; of 910 CNG fueling stations nationwide, 49 are in Pennsylvania. By comparison, in 2008, the U.S. Census reported there were over 115,000 gasoline fueling stations nationwide. While home fueling units are available, they carry a significant upfront cost. Perhaps the most prohibitive aspect is the initial cost of a CNG vehicle; this is especially true for the only CNG vehicle available to American consumers, as explained in the following section.

Consumer Vehicles

The Honda Civic Natural Gas has a starting price of $26,155 and averages 38 miles per gallon (mpg) on the highway. The gas electric hybrid Civic starts at $24,050 and averages 44 mpg. The standard Civic starts at $15,805 and averages 39 mpg. While the federal government offers income tax credits to consumers who purchase alternative fuel vehicles, such credit does not always make up the difference. The current tax credit on vehicles up to 8,500 pounds is generally around $7,500.

Options for natural gas vehicles are less limited in other parts of the world. The table below highlights CNG vehicles available for consumer use in other countries. CNG-powered vehicles are most widely offered in Germany, where five types are available. France, Italy, Peru, Thailand, and the US all offer just one type of CNG-powered vehicle for individual consumer use.

Model	China	Czech Republic	France	Germany	India	Italy	Peru	Spain	Thailand	United States	Total:
Aveo CNG									X		1
Berlingo			X	X							2
Doblo 16V		X		X		X		X			4
C-MAX CNG				X							1
CK 1.3 L CNG	X										1
Civic GX										X	1
Accent					X						1
520	X						X				2
Lancer CNG					X						1
Astra Caravan CNG		X									1
Kangoo				X							1
Ocatavia CNG				X				X			2
Golf Variant		X									1
Total:	2	3	1	5	2	1	1	2	1	1	19

Source: CNG Now

Another option for consumers is to have a gasoline vehicle retrofitted to use CNG. This process can only be done by certified installers on new or nearly new vehicles. It is estimated to cost between $12,000 and $18,000 in addition to the price of the vehicle. Converted vehicles are eligible for the same tax credits as factory CNG vehicles.

Commercial Vehicles

Many U.S. companies have implemented the use of natural gas fleet vehicles. Such changes will save these companies money in the long term, and reduce their carbon footprint. Two examples of such companies include AT&T and Waste Management (WM).

As of August 25, 2011, AT&T had 3,000 CNG vehicles operating in its alternative-fuel vehicle (AFV) fleet. The release of AFVs is part of a ten-year plan, through which AT&T has committed to replace approximately 15,000 fleet vehicles with AFVs through 2018 with a budget of $565 million. By 2013, AT&T hopes to have purchased approximately 8,000 CNG vehicles at about $350 million. "As the economy rises and falls with fuel prices, we have a responsibility to look for smart ways to reduce our costs," said Jerome Webber, vice president, AT&T Global Fleet Operations. "Putting 4,000 alternative-fuel vehicles on the road – including 3,000 compressed natural gas vehicles – is a significant statement about the ability of fleet operators to not only reduce costs, but also to cut vehicle emissions. Every alternative fuel vehicle on the road brings us closer to energy independence, and that's good for our company *and* our country."

Houston-based Waste Management (WM) has also begun to make the switch to natural gas. On July 12, 2011, WM added to its fleet its 1,000th natural gas-powered truck. One third of the WM "clean fleet" is powered by liquefied natural gas (LNG). The fleet's LNG source is WM's Altamont Landfill, located in Livermore, CA. Since 2009, WM has produced as much as 13,000 gallons of LNG per day. The process is done through the decomposition of organic waste in the landfill. According to WM, in just one year, [WM's] 1,000 natural gas trucks will displace eight million gallons of petroleum and eliminate 45,100 metric tons of greenhouse gas emissions.

The federal government offers companies incentives for making such changes, like those offered to individual consumers. Companies that make the switch to natural gas vehicles are eligible for a tax credit of up to 80% of the vehicle's "incremental" cost. Companies that convert vehicles to natural gas are eligible for a tax credit of up to 80% of the conversion cost.

Municipal Vehicles

California

Some government entities have also begun to make the switch to natural gas. In Culver City, California in western Los Angeles, all municipal vehicles and 80% of the refuse trucks run on CNG; this includes all public works vehicles and heavy and light duty trucks. Culver City was one of the first municipalities to switch to CNG vehicles, when they began in 1998.

According to the Natural Gas Vehicles for America web site, "Early on the [Culver] city took the initiative to work with manufacturers to develop new engine/chassis specifications for a CNG-powered asphalt truck, sewer truck, and other vocational trucks, since none of these vehicles were available at the time. These applications have now been improved on and offered to other cities."

Culver City has been aided in their switch to natural gas vehicles by federal government grants. Over five years, Culver City has received $2.2 million, in part because of poor air quality in that region of California. The funding was received from Mobile Source Reduction Committee's Clean Transportation Funding Program and locally through The South Coast Air Quality Management District.

Colorado

Much like WM's efforts, the City of Grand Junction, Colorado, is working to produce natural gas for its governmental and transit fleet, but in a different way. Grand Junction hopes to use biomethane from its Persigo Wastewater Treatment Plant to produce Compressed Natural Gas (CNG). This project is the first of its kind in the nation. The city received four new CNG refuse trucks at the end of 2010. While the trucks cost $30,000 more than diesel refuse trucks, they are expected run longer and cost less to fuel. The city also completed a "slow fill" station for municipal vehicles.

Slow fill stations require the trucks to sit overnight to fuel up. Grand Junction hopes to add a "fast fill" station, with the help of some private partners, for use by the general public. The city has received over $1million in grants from state, federal, and private sources to help with this project. The breakdown is as follows:

New Energy Communities Program of the Governor's Energy Office - $288,000
Governor's Energy Office and the Colorado Department of Local Affairs - $300,000
Encana, a natural gas drilling company - $150,000 investment in the project.
US Department of Energy through the Energy Efficiency and Renewable Energy - $80,000
FASTER asset solutions for the CNG Fleet Maintenance Building - $240,000.

Florida

Pensacola, Florida is just beginning to make the change over to CNG – powered vehicles. In October 2011, Mayor Ashton Hayward announced a partnership between city-owned natural gas provider, Energy Services of Pensacola (ESP) and Emerald Coast Utility Authority (ECUA). The agreement includes the construction of three natural gas fueling stations and transitioning both ESP's and ECUA's fleets to CNG. The fueling stations will also be available to private fleets that switch over to CNG. The mayor sees this change not only saving the city money, but possibly "as a potential revenue stream for ESP." In the first year, 10-15 vehicles will be converted, while the company aims to convert all of its vehicles to CNG in eight years. When the change is complete, ECUA estimates saving $250,000 per year in maintenance costs and over $1million annually in fuel costs.

Missouri

Kansas City, Missouri began its transition to natural gas vehicles in 1996 with 12 vehicles. From 2001 to 2008, the city received over $3.4 million in grants, and in 2010, it received an additional $4.03 million grant from the American Recovery and Reinvestment Act. Such grants helped to grow its fleet of CNG-powered vehicles to over 250, with four fast-fill stations and one slow-fill station. Kansas City covers a large geographic area, so the fueling stations were just as critical as the vehicles. The city hopes to lease the stations to a CNG provider in order to allow it to focus efforts on growing its fleet. The city also hopes to provide CNG to citizens who want an alternative to gasoline-powered vehicles. It estimates that with just 8 percent of its fleet now converted to CNG, annual savings already add up to $3.3 million.

New York

Another municipality that has made the switch to natural gas is Smithtown, New York on Long Island. In 2007, the town purchased 22 new CNG-powered refuse trucks. According to Natural Gas Vehicles for America, Russell Barnett, Director of the Department of Environment and Waterways, estimated that in

2010, the incremental fleet cost for the CNG refuse trucks was $7.38 per household, while fuel savings were $10.72 per home per year, saving the community of more than 35,000 homes $3.34 per household.

Pennsylvania

Six years ago the Centre Area Transportation Authority (CATA) in Centre County, Pa., completed transitioning its entire bus fleet to CNG – a project it began in 1996. CATA considers itself a pioneer in showing other government entities how to make the switch to CNG. In an October 2011, an article in the Centre Daily Times, Hugh A. Mose, General Manager of CATA, pointed out the many environmental benefits of CNG along with the abundance of natural gas in Pennsylvania. He stressed, "It is important that, as a state, we recognize these environmental benefits as well as the economic ones, and foster the safe and responsible development of this important energy source."

The city of Williamsport, Pennsylvania is also beginning to make the switch to CNG vehicles. River Valley Transit (RVT), which provides public transportation for Williamsport, is building a CNG fueling station that is expected to be completed in May 2012. The Commonwealth of Pennsylvania awarded the RVT $400,000 to use toward the fueling station's construction. In November 2011, the U.S. Department of Transportation awarded the RVT an additional $3.5 million grant to use toward the fueling station, which will serve city vehicles, as well as Lycoming County first responders. The station will make it easier for those entities to switch their fleets to CNG. The RVT plans to switch over its 30 bus fleet vehicles, as well. Eventually, the station is expected to reduce greenhouse gas emissions by 504 tons each year. The RVT is also looking to work with companies that are extracting natural gas from Pennsylvania's Marcellus Shale.

Making the Switch to Natural Gas

While financial incentives and CNG vehicle options continue to grow for corporations and government entities, some major hurdles exist. Many of the municipalities and transit authorities that have made the switch to natural gas have had to build their own fueling stations. This process is neither fast nor cheap. There are only a handful of U.S. companies that actually build such fueling stations. Once a fueling station is built, a CNG supplier must be located; again, there are only a few companies that supply CNG.

Buying a dedicated CNG vehicle or having a gasoline/diesel vehicle converted can be challenging, as well. An internet search returned less than fifteen small companies in California, Texas, and Canada that build CNG vehicles. For conversion to CNG, only certified technicians can do so. An internet search showed that most of these technicians are in California and Texas. Training centers are located in California and West Virginia. The small number of training centers and technicians may mean added wait times and costs to vehicles going through the conversion process, and especially for fleets.

Upfront costs are impossible for most municipalities to cover on their own. Government grants and partnerships with natural gas companies are necessary to help to move projects along. Both options take time and effort. Most of the cases examined here required eight to fifteen-year plans. However, in most cases, the fuel and maintenance savings combined with lowered emissions were worth the effort.

Updated– April 2012

With the enactment of Act 13, the Natural Gas Energy Development Program was established. This program funds grants projects to eligible applicants (authorities, local governments, state authorities, transportation organizations, nonprofits, state universities or companies) in order to convert five or more fleet vehicles into eligible vehicles or buy eligible vehicles (compressed natural gas vehicles or liquefied natural gas vehicles) and to construct and utilize a natural gas fueling station in Pennsylvania or the utilization of an existing natural gas fueling station. The details are outline in Subchapter 27 of Act 13.

References Cited

Arthur, J. D., Bohm, B., & Layne, M. (2008). Hydraulic Fracturing Considerations for Natural Gas Wells of Marcellus Shale. ALL Consulting. Retrieved from http://www.dec.ny.gov/docs/materials_minerals_pdf/GWPCMarcellus.pdf

Bartlow, Andrew. (2011). How Long are Wells in Operation? The Institute for Energy and Environmental Research. Retrieved from http://energy.wilkes.edu/pages/162.asp

DTE Energy. (2011). Unconventional Gas Production. Retrieved on June 15, 2011 from http://www.dteenergy.com/dteEnergyCompany/aboutDTEEnergy/unconventional/main.html

Geology.com. (2011). Marcellus Shale- Appalachian Basin Natural Gas Play. Retrieved on May 23, 2011 from http://geology.com/articles/marcellus-shale.shtml

Maykuth, Andrew. (2010). Marcellus Shale Gas Development Fueling Bradford County Boom. The Philadelphia Inquirer, December 27, 2010 Monday CITY-C Edition. Retrieved using LexisNexis.

Natural Gas Supply Association. (2010). Natural Gas. Retrieved on June 6, 2011 from http://www.naturalgas.org/index.asp

The Philadelphia Inquirer http://articles.philly.com/2011-11-13/business/30394235_1_natural-gas-american-public-gas-association-shale-gas/2

Pacific Gas and Electric Company. (2003). Tell Me More About Natural Gas: Natural Gas Facts. Natural Gas Safety World. Retrieved on June 6, 2011 from http://www.pge.com/microsite/safety_esw_ngsw/ngsw/more/facts.html

Penn State University. (2011). Local Business Impacts of Marcellus Shale Development: The Experience in Bradford and Washington Counties, 2010. Marcellus Education Fact Sheet. Retreived from http://pubs.cas.psu.edu/freepubs/pdfs/ee0005.pdf
U.S. Department of Energy. (2009). Natural Gas Distribution. Retreived on June 7, 2011 from http://www.afdc.energy.gov/afdc/fuels/natural_gas_distribution.html

U.S. Energy Information Administration. (2010). U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves. Retrieved on June 6, 2011 from http://www.eia.gov/oil_gas/natural_gas/data_publications/crude_oil_natural_gas_reserves/cr.html

http://www.naturalgas.org/naturalgas/extraction_offshore.asp

http://www.api.org/aboutoilgas/

http://www.census.gov/newsroom/releases/archives/county_business_patterns/cb08-96.html

http://www.ngvc.org/pdfs/FAQs_Converting_to_NGVs.pdf

http://www.att.com/gen/press-room?pid=20826&cdvn=news&newsarticleid=32579

http://www.wm.com/about/press-room/pr2011/20110712_Waste_Management_Reaches_1000th_Natural_Gas_Truck.pdf

http://www.ngvc.org/forfleets/municipalities/index.html