Natural Gas Overview
Due to technological advancements in horizontal drilling and hydraulic fracturing, the United States has unlocked vast reserves of natural gas that were previously considered uneconomically recoverable. Since 2007, natural gas reserves in the United States have increased over 58%. According to the U.S. Energy Information Administration (EIA), natural gas production is expected to increase by 1.3% per year, with domestic production outpacing domestic consumption by 2019. The Interstate Natural Gas Association of America (INGAA) has estimated that North America will require over $200 billion in natural gas infrastructure investment over the next two decades to build out the transportation and storage networks required to bring these supplies to market.

Natural Gas Gathering and Processing
The hydrocarbons that come out of the ground are as varied and diverse as the people who use them. While methane is the primary component of the natural gas that flows to American homes, the composition of the natural gas at the wellhead varies dramatically depending on where and how it was extracted. Companies engaged in the gathering and processing of natural gas are the first entities to interact with the hydrocarbons after they are extracted. The gasses and liquids that come from the wellhead are gathered using a series of small diameter, low pressure lines that usually feed to a nearby processing plant. The processing plant will then remove impurities and separate the hydrocarbon components into useable natural gas (consisting primarily of methane) and mixed natural gas liquids (commonly referred to as y-grade NGLs, including ethane, propane, butane, and others). The y-grade NGLs are then sent to a fractionation plant to be separated into their various components, while the residue natural gas will either be sold directly to end-users such as utilities, sold to marketers who will send it to interstate pipelines for delivery to American cities, or placed into storage to be sold and used at a later date.

In the US, unconventional natural gas resources have been discovered all across the country. Some discoveries, such as the Marcellus in the Northeast and Utica in the Midwest, are located in communities where there had been very little gathering and processing infrastructure investment as natural gas had never before been produced there. For some communities, the entrance of these gathering and processing companies have reinvigorated economies that were devastated by the 2008 financial crisis. However, the proximity of these shale plays to major population centers also raises unique environmental concerns, delaying some projects. Even areas with existing gathering and processing infrastructure, such as the Eagle Ford and Barnett shale in Texas, have been undergoing dramatic expansions in order to keep up with production.
In Canada, the gathering and processing situation is a bit less complicated. As the development of unconventional gas projects has largely been in very remote regions, there has been less resistance to the build-out of gathering and processing systems. However, given that Canada is a very large and relatively sparsely populated country, the long distance transportation of these natural resources to smaller market centers poses an economic problem.

**Natural Gas Transportation**

The access to vast reserves of natural gas in shale plays throughout the country has fundamentally altered not only the energy outlook for North America, but the directional flow of its pipelines as well. Large diameter distribution pipelines, called mainlines, typically bring natural gas close to cities, where they connect with much smaller lines that flow directly to homes, businesses, and power generation facilities. With shale plays such as the Marcellus and Utica now producing significant amounts of natural gas near population centers in the Midwest and Northeast, a number of these mainlines that previously brought natural gas from the South and Midcontinent regions have been rendered obsolete. As such, many of these pipelines are being either reversed to bring natural gas to Midcontinent markets, or being repurposed to transport other types of hydrocarbons. Not only are energy companies spending billions of dollars to build out brand new infrastructure, but they are also finding creative ways to recycle and reuse existing pipelines to further strengthen North America’s energy delivery network.

Natural gas transportation in Canada is somewhat different. The heart of Canada’s energy industry is located in Calgary, Alberta, which has recently experienced low natural gas prices, in part due to the tremendous growth of production from the US, but also from the lack of demand within Canada itself. With such low prices, producers will typically leave product in the ground as it cannot be sold for more than production costs. The province’s Standing Committee on Resource Stewardship recently began an initiative to encourage the use of natural gas throughout the country and abroad. Part of this initiative involves examining possible exports to Asia where LNG prices are considerably higher. However, in order to reach the Canadian West Coast—the most likely location of export terminals—Alberta producers must traverse huge expanses of land and mountains through British Columbia. Not only will Canada require billions of dollars of investment in new-build pipelines to connect Alberta to the West Coast, but they will also have to win over the support of the First Nations community, which is a collection of various aboriginal peoples in Canada whose populations and lands lay directly in the line of some proposed pipelines. Overall, most pipeline projects are proceeding with support from all facets of Canada’s political spectrum, with benefits extending not only to the government, but to investors, citizens, and the First Nations community as well.
LNG Exports From the US
As domestic natural gas supply has grown, prices have dropped dramatically, in stark contrast to international markets, where natural gas prices have historically been linked to oil prices and remain high. There are a number of proposals to begin exporting natural gas to Asia and Europe. While pipelines are by far the most economic and reliable method of transporting natural gas, building a large diameter pipeline across the ocean is unfeasible. The second best method is to use marine transportation. By cooling and liquefying natural gas, energy companies drastically reduce the volume and pressure requirements of storage, allowing for the safe and economical marine transportation of natural gas. As of October 2013, only four non-free trade agreement LNG export licenses have been approved by the US government (three are located on the Gulf Coast with the final one located on the East Coast). There are 18 more applications pending at the Department of Energy. These LNG export facilities will allow energy companies to build interconnects to the existing natural gas infrastructure in the US and open up entirely new markets overseas.

Adding to a challenging international LNG landscape, US policy makers are more concerned with securing the country’s domestic energy supply before exporting its own natural resources. Furthermore, as there are currently only US export facilities on the Gulf and East Coasts, when exporting to Asia, shippers must deal with the Panama Canal, which adds sailing time and costs. Additionally, the Panama Canal authority is expected to charge an LNG tariff for every ship that passes through its waters, although this charge has still not been finalized. However, when leaving from western Canada, LNG exports are able to access a much more direct route to Asia. Overall, Australia actually has the most well developed and well established LNG export market among OECD nations, and is currently the fourth largest producer of LNG in the world. Other projects in East Africa are also promising, and are expected to provide competition to the US and Canada, given their large conventional gas reserves and proximity to shallow waters but face challenges in infrastructure, security, and investment.

Domestic Natural Gas Demand Growth
While the enormous supply of natural gas in the US may eventually lead to significant exports, many industries have already taken advantage of lower natural gas prices domestically. Coal to natural gas switching for power generation has gained considerable momentum. The EIA has noted that it expects the share of total energy generation from coal to decline from 42% in 2011 to 35% in 2020, with switching to natural gas projected to be a long-term trend. While coal is currently the largest source of power generation in the US, natural gas power plants are more economical to build, maintain, and operate. Additionally, President Obama’s recently announced climate change strategy includes utilizing the Environmental Protection Agency (EPA) to establish and enforce carbon pollution standards for coal power plants, further increasing the cost of operation and raising the likelihood of coal plant retirements. Industrial demand for natural gas has also grown considerably, with many international corporations moving their petrochemical, refining, and manufacturing operations to the United States to take advantage of cheap natural gas. Additionally, natural gas could be used as a transportation fuel. Many city bus systems now use compressed natural gas (CNG) as their primary fuel, and commercial trucking firms have also begun to convert their vehicles.
What Comes Out of the Ground
When natural gas is extracted from the ground, the product that comes to the surface (known as the natural gas stream) varies depending on what sort of life form, water, or lack of water existed in a particular region millions of years ago. Typically, 70%-90% of the natural gas stream is methane, which is the consumable form of natural gas. The remainder can be of varying percentages of hydrocarbons such as natural gas liquids (NGLs), carbon dioxide, nitrogen, and hydrogen sulfide. “Dry” natural gas is when the stream is almost pure methane whereas “wet” natural gas has more NGL content.

Producers are paid according to the prices of the various components of their natural gas stream. In recent years, natural gas producers have shifted their drilling portfolios to more wet gas plays, because at the current level of low natural gas (methane) prices and high NGL prices, certain natural gas plays are profitable to drill only with the addition of NGL revenues.

NGLs, collectively, include ethane, propane, butane, isobutane, and natural gasoline. Ethane is primarily used as a feedstock, or input, into petrochemical plants to make ethylene, which is used to make plastics (primarily plastic bags) and other chemical products (such as solvents and adhesives). Propane by itself can be used as a heating fuel or used as a feedstock to make propylene, which can be used in the manufacturing of textiles or plastics (such as headlights, eyeglasses, foam bedding, and water bottles). In general, ethane and propane make up the bulk of the NGL stream, ranging from 55%-85%. Butane, isobutane, and natural gasoline are used to produce motor gasoline. Butane is the primary component of lighter fluid and can be used as a feedstock to make butadiene, which is used in creating synthetic rubber.

NGL Transportation.
The collective mix of NGLs is first separated from the natural gas stream in a processing plant. Then they must be transported via a y-grade pipeline to a fractionation facility to be separated into usable purity components. Y-grade is simply another way to describe the collective mix of NGLs. Drilling areas such as the Bakken in North Dakota, Eagle Ford in South Texas, Marcellus/Utica in the US Northeast, and Montney and Duvernay in Alberta need NGL pipelines that move product to the major NGL hubs in Mont Belvieu (Texas), Edmonton (Alberta), Conway (Kansas), and Sarnia (Ontario). These hubs have a large amount of fractionation capacity and the necessary storage for mixed NGLs and separated NGLs.

(Source: Alerian, September 2013.)
NGL Fractionation and Storage
At the fractionation facility, the liquids are separated into their usable individual components of ethane, propane, butane, isobutane, and natural gasoline. Fractionation refers to the process of heating the individual NGLs to their different boiling points through a series of distillation towers. Coincidentally, this is the same way a still works to make alcohol. As the temperature of the NGL stream is increased, the lightest (lowest boiling point) NGL component “boils off” the top of the distillation tower. This component is then cooled to a liquid form and can be stored underground. The remaining stream is then sent to the next tower and the process is repeated for a different NGL component, until the entire NGL stream has been separated into its individual components.

Importance of Mont Belvieu, Texas
Mont Belvieu in Southeast Texas is the world’s largest fractionation hub. By the end of 2014, Mont Belvieu will have 1.7 million barrels of fractionation capacity, 50% more than what is available today. Mont Belvieu is a natural NGL hub. It is located close to the petrochemical crackers that take ethane and propane to make ethylene and propylene. Additionally, it sits over a naturally occurring expansive salt dome formation, which can hold large amounts of volume while keeping the product contained well (little to no seepage). And finally, it is close to export docks along the Gulf Coast, which have become more important as international liquified petroleum gas (LPG) demand has increased.

Transporting Individual NGL Components
After the NGL stream has been separated into its individual components, these components must be transported by pipeline, truck, rail, or barge to the appropriate end users. As the demand for these components, in particular ethane, has become more solidified, there is an increasing number of plans to build ethane pipelines along the Gulf Coast to reach petrochemical plants.

Resurgence in the US Petrochemical Industry
Prior to 2007, the US was experiencing declining natural gas production which resulted in increasing natural gas prices. However, the development of horizontal drilling in conjunction with fracking has revived the natural gas industry and dramatically changed the reserve profile for the future.

Natural-gas-based feedstocks such as ethane, propane, and butane are typically tied to natural gas prices because they are derived from natural gas. However, ethylene, propylene, and butadiene can also be derived from crude oil and the prices of these products have historically been tied to crude oil prices. The petrochemical industry (the primary consumer of these products) chooses to use feedstocks from either natural gas or crude, primarily based on price.

In the early 2000s, as the US was issuing permits for the construction of LNG import terminals to bring foreign sources of natural gas to the US, petrochemical companies began abandoning their US facilities and moving their operations overseas where crude-based feedstocks were cheaper.

However, in just a short decade, the US energy markets have dramatically changed. Both natural gas and NGL supplies are at historic highs, driving prices down. As a result, petrochemical companies have been in the process of moving their operations back to the US. Many of them have restarted previously idled plants, and several are expanding capacity or beginning new construction. Ethylene crackers, which convert ethane into ethylene, are expected to increase capacity by 37% by 2017. Ethylene crackers are very expensive to construct and require long-term planning. The commitment from the petrochemical industry to be in the US indicates that the need for NGL fractionation infrastructure is here to stay.

LPG Export Market
Propane, butane, and isobutane are traditionally gases, but when they become liquid through pressurization or chilling, they are referred to as liquefied petroleum gases (LPG) and are used for heating, cooking, and motor fuel blends. In addition, in liquefied form, they can be transported via ships overseas for similar uses. LPGs can be derived either from the natural gas stream via separated NGLs or as a byproduct of the crude oil refining process. With natural gas prices at historic lows and crude oil prices remaining high, LPGs from US natural gas have become the feedstock of choice from a competitive standpoint.
While the demand for motor gasoline and propane as a heating fuel has been on a slow and steady decline due to conservation and fuel efficiency efforts in the US, the opposite is occurring worldwide. Latin American countries such as Honduras, Chile, and Mexico and other countries like Japan, India, and Turkey are either still developing or lack a stable supply of energy, thus driving increased demand. In fact, demand has increased much more rapidly than the industry predicted; energy infrastructure companies have scrambled the past two years to draw plans to expand or build LPG export terminals and docks. Building adequate infrastructure to export LPGs will help reduce overall price volatility for LPGs domestically and internationally. In addition, the completion of the Panama Canal expansion in 2015 will allow for more competitive access to Asian LPG markets from the Gulf Coast.

**Bitumen**
The raw viscous bitumen produced from Canadian oil sands must be blended with certain NGLs, known as diluents, in order to flow smoothly through pipelines. This does complicate things, as the largest NGL hub is in Mont Belvieu, Texas, over 2,200 miles away. The closest NGL hub to Alberta, albeit not much closer than Texas, is in Sarnia, Ontario. Due to Sarnia's proximity to the liquids-rich Marcellus natural gas shale play, it could be expanded to address the issue of getting NGLs from the US to Alberta. Plans to expand and upgrade Sarnia's fractionation plants are currently in discussion.
Exporting Crude
In Canada, the situation is easier than in the US. Canada is second only to Russia in land mass, but has fewer people than California. Canada is incredibly resource-rich, but has few people to buy its resources domestically, so exports make a lot of sense. The US is Canada’s most natural customer, but other markets are quickly emerging, particularly in Asia.

In the US, the government limits crude exports. Industry analysts do not think export licenses will be granted anytime soon, but there has been more interest in the past 12 months than in the last 30 years. All current exports require a license from the Bureau of Industry and Security (part of the Department of Commerce), even if a company is simply moving condensate, or just going to Canada. The last license was issued 25 years ago. However, foreign crude can be exported as long as it’s not of US origin, or commingled with US origin resources. In other words, foreign crude refined in the US can be exported.

Crude Production Boom
There’s the potential for the US to have more crude than Gulf Coast refining capacity. In fact, demand for crude storage on the Gulf Coast has been on the rise. Light-sweet imports to the US have been falling since 2007, and crude production is at its highest level in two decades. Texas is still the number one oil producing state, but North Dakota has come up behind it fast as new technologies unlock the tight Bakken Shale formation.

(Source: US Energy Information Administration, September 2013.)
Cushing Bottleneck
Cushing, Oklahoma is the distribution hub for imported oil, West Texas oil, and refined products from the Gulf Coast to the rest of the country, as it is conveniently located in the center of the United States. However, in the past five years, imports have been falling and domestic production has taken off thanks to technological advances that made previously inaccessible oil sources suddenly economically viable. Now, crude from the Canadian oil sands and from the Bakken in North Dakota is needed at the Gulf Coast refineries.

Until 2012, there was only one pipeline that could take crude from the Midwest to Texas, and that was ExxonMobil’s Pegasus line that ran from Illinois to Nederland, Texas near the Gulf Coast. Even that pipeline originally moved oil north until it was converted in 2006 to take heavy Canadian oil south.

In 2012, Enterprise (EPD) and Enbridge (ENB) reversed the Seaway pipeline, so it now flows from Cushing to the Gulf. In early 2013, the pipeline was expanded, providing it with 2.5 times its original capacity. A further expansion to Seaway is expected to be in service in the first quarter of 2014. TransCanada also has a newbuild project to Nederland, Texas that is expected to be in service during the fourth quarter of 2015.

Bringing More Crude to Cushing
With the increased takeaway capacity, more pipelines are being built to bring more crude to Cushing. For reference, a pipeline takes about four years to plan, permit, build, and test before it will be ready for service, so pipeline operators typically plan in advance or decide to convert existing pipelines to switch directions and carry crude when they previously carried natural gas or another product. Recently in service pipelines include:

- TransCanada Keystone. Largest by far (590 mbpd) from Hardisty, Alberta and the Williston Basin. Not Keystone XL.
- Plains All American Basin pipeline expansion. 50 mbpd. From the Permian Basin.
- Plains All American Medford-to-Cushing conversion. 25 mbpd. From the Mississippian Lime in Anadarko Basin. Converted to crude oil from LPG.

New pipelines to Cushing are currently being constructed. Some of the largest of these are:

- Plains All American Mississippian Lime. 175 mbpd. From Mississippian Lime in Anadarko Basin. Recently completed.
- SemGroup/Gavilon Glass Mountain. 140 mbpd. From Mississippian Lime and Granite Wash in Anadarko Basin.

Similar Problems in the Permian
The Permian Basin, in Texas and New Mexico, is a conventional oil play with production that peaked years ago, but has been given new life with the advancements in horizontal drilling and multi-stage fracking. The Permian faces similar difficulties as Cushing does with most pipelines currently in service running near capacity. Two of these pipelines are carrying crude to the already oversupplied Cushing hub. These include the Plains All American Basin pipeline with 450 mbpd capacity and the OXY Centurion pipeline with 300 mbpd capacity.

Due to this oversupply at Cushing, the new projects in the Permian aim to deliver crude directly to the Gulf Coast. Some of the major pipelines are:

- Magellan Longhorn reversal. 135 mbpd. Conversion and reversal of refined products line to Houston. Recently completed.

Keystone XL
This is the final stage in TransCanada’s Keystone pipeline system designed to take Canadian oil sands bitumen to the Gulf Coast. The project can be broken down into four phases. The first two phases are in service, and the third phase (from Cushing to the Gulf) is under construction. The final phase, Keystone XL, would directly connect Hardisty, Alberta to Steele City, Nebraska. It has been mired in political and environmental controversy. Due to crossing an international border, approval for the pipeline falls to the State Department. A final report by the Environmental Protection Agency (EPA) is due out in 2014. Much of the industry is waiting for clarity on Keystone XL. If approved, the system would move 850 mbpd from Northern Alberta to the Gulf Coast.
Storing Crude

When a hub bottlenecks, that crude has to be held somewhere, which is part of why storage tanks are a necessary part of North American energy infrastructure. Traders will often hold crude in storage when there is an upward sloping forward curve, to be able to profit from the difference in prices. Crude is stored at Cushing until there is room on pipelines to move it to the Gulf. As more takeaway pipeline capacity from Cushing comes online, there will be less need for storage there. But, should the amount of crude in the Gulf exceed refinery capacity, more crude storage will need to be built near the Gulf.

More recently, storage facilities have been used in a blending capacity. North Dakota and Texas produce light-sweet crudes, which are typically more expensive and of higher quality. However, the majority of the refineries on the Gulf were built to run the heavy sour crudes typical of Mexico and Venezuela. The light-sweet crude can be mixed with heavy Canadian bitumen or an import to make a custom barrel for each individual refinery, depending on its capabilities.

Hardisty, Alberta

Hardisty is the Canadian equivalent of Cushing. There is a need for storage as a lot of crude is waiting for pipeline capacity to head further south to the US. However, whereas Cushing has many interconnects, Hardisty is a one-way stop on the route from the oil sands to US refineries, at least until more rail terminals are built, or Keystone XL is built, or the 1.1 million bpd Energy East Pipeline comes online.

Crude-By-Rail

This crude oil trend owes its existence to the shale boom in the US. Production has grown so quickly in North Dakota (among other places) that takeaway pipeline capacity has not been able to keep up. Crude-by-rail has helped alleviate this bottleneck. While rail is considerably more expensive than pipeline transportation, the infrastructure is already in place, with track laid across much of North America and a large number of terminals and cars already built (although many more tank cars are needed, along with additional terminals). In addition to providing immediate takeaway capacity, rail provides significant flexibility. Producers can choose which market they would like to send it to, depending on whether the Gulf or the East Coast is more economic. Should a well suddenly dry up or production need to be shut in, the producer is not responsible for fulfilling a multi-year contract, as pipeline capacity often requires.

In 2013, rail has moved 75% of the Bakken oil production, up from 39% in April of 2012. According to the Association of American Railroads, crude and petroleum products transported by rail rose 48% in the past year. Rail allows people to take advantage of the spread between the prices of inland and coastal oil markets, although these have been narrowing recently. Still, rail continues to be used in both the Permian and the Eagle Ford.

On the West Coast, production has been declining in California and Alaska, but the refineries still need to run. There are no major pipelines running from the Mid-Continent to the West Coast. As marine transportation requires an expensive and time-consuming trip through the Panama Canal, rail is also providing the solution there. Rail is unlikely to be a long term substitute for Keystone XL. During the summer of 2013, a runaway crude train carrying Bakken oil exploded in Quebec, killing 47 people, so tighter regulations are expected going forward. Many of the tank cars transporting crude were built 10 years ago and need recertification this year, further shortening the supply of available cars.

Price Differentials – What Drives Infrastructure

Unlike most fungible goods, a barrel of crude is priced based on location, not simply on amount and quality. Crude trapped in Cushing, or further back in North Dakota is so plentiful that it is much less expensive than that sold on the coast. So, if a trader can get that North Dakota barrel down to the Gulf, a tidy profit can be made.

In 2012, West Texas Intermediate crude—a light sweet crude priced in Cushing, Oklahoma—traded at a $18 a barrel discount to Brent crude (a similar light sweet crude used as an international benchmark). It reached a short-term high of $19 a barrel in February, but has since fallen to $1.50 a barrel as of July 2013. The pipelines coming online at Cushing have helped narrow this spread, as have the floods in Alberta, which decreased supply. The EIA expects the spread to widen to $6 a barrel by the end of the year.

Other Fun Facts

- US crude oil production averaged 7.5 million barrels per day in July 2013, the highest level since 1991.
- In 2012, only 40% of petroleum consumed in the US was imported, the lowest level since 1991.
- One barrel of oil is 42 gallons.
- One barrel of oil will make 19 gallons of motor gasoline (the remainder is used to make jet fuel and heating oil).
- It costs about $30-$35 to produce a barrel of oil.
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