NGC GAS RUSH

Secondary Schools

NGC's Natural Gas Made Simple

THE NATIONAL GAS COMPANY OF TRINIDAD AND TOBAGO LIMITED

Category 1.
What is Natural Gas?

Introduction to Natural Gas

Natural gas is a combustible gaseous mixture made up of simple hydrocarbons found in the earth's crust. It may rise to the surface through natural openings in the earth's crust or be brought to the surface through man-made wells. In its purest form it is both colourless and odourless. In addition, it is combustible i.e. it gives off a great deal of energy when burned. Humans discovered thousands of years ago that this naturally occurring resource could be used for heat and light. It is one of the cleanest, safest and most useful energy sources.

Chemistry of Natural Gas

In order to fully understand natural gas, you first need to understand a bit about its chemistry.

Atoms

Atoms are the smallest building block of matter. The simplest and most convenient picture of the atom is called the *orbital system*. The hydrogen and carbon atoms are the building blocks of hydrocarbons. Atoms consist of a dense core called the *nucleus*, surrounded by one or more negatively charged particles called *electrons*.

Hydrogen Molecules

Two or more atoms can combine to form a molecule. When these atoms are combined or *bonded*, they share their electrons. In the case of a hydrogen molecule, two hydrogen atoms are joined together with each hydrogen atom sharing two electrons. A hydrogen molecule is thus represented as H_2.

Elements

Elements are the simplest chemical substances. They are made up of the same type of atom. For example, the substance called carbon consists of a number of chemically bonded carbon atoms.

Hydrocarbon Molecules

As the name suggests, **hydrocarbons** are substances made up of hydrogen and carbon elements only. Hydrocarbons can exist in three states of matter (gas, liquid and solid) depending on the number of carbon atoms and the prevailing conditions of temperature and pressure. The term **petroleum** refers to natural gas, crude oil and asphalt. It can be separated into products including natural gas, gasoline, naphtha, kerosene, fuel and lubricating oils, paraffin wax, and asphalt. Petroleum is used as raw material for a wide variety of derivative products.

Composition of Natural Gas

Natural gas consists of a mixture of several gases, mainly hydrocarbons. Some of the major components of natural gas are described below.

-Methane

In the simplest case, one carbon atom requires four hydrogen atoms to form a stable hydrocarbon molecule. This is the description of **methane,** the smallest hydrocarbon molecule and a major component of natural gas.

-Ethane

This is the next larger hydrocarbon molecule, which has two carbon atoms and six hydrogen atoms. **Ethane** is nearly as volatile as methane and so is included with the methane in residue gas (marketable gas remaining after extracting the heavier hydrocarbons, water and other impurities). The ethane enhances the heat content of the residue gas stream, increasing its value.

-Propane and Butane

These are two "straight chain" or "paraffinic" molecules in which all carbon atoms are bonded in a continuous straight chain. **Propane** has three carbon atoms whilst **butane** has four. These two compounds are gaseous at atmospheric conditions, but readily liquefy under moderate pressure.

-Condensate

Condensate refers to the light hydrocarbon liquid formed by condensation of compounds that were in the gaseous phase under initial reservoir conditions. It is highly volatile and ranges in appearance from colourless to light yellow, depending on the amount of heavier hydrocarbons present.

Category 2.
How was Natural Gas Formed?

It's easy to imagine the great dinosaurs being pulverized and rendered into petroleum. However, it has not been established that these animals existed in sufficient numbers to account for the incredible quantity of oil, gas and coal that has already been found and utilized.

Surprisingly, however, it appears that the only organisms existing in large enough numbers to possibly account for so much oil and gas are the many forms of microscopic plants and animals. Examples of these are crustaceans, plankton, worms, diatoms and algae that dwelled in oxygenated, near-surface waters of the oceans and lakes millions of years ago.

Essential Conditions for Oil & Gas Formation

Two conditions are necessary for these organisms to be the source of petroleum:

- Large numbers of dead organisms
- The organisms had to have been buried quickly to prevent bacteria from consuming them.

Over a period of millions of years dead animals, plants and microorganisms are protected from rapid decomposition by layers of sediment that are subjected to extreme earth movements and temperatures that push the rich, organic sediments deeper and deeper into the earth's crust. This causes physical and chemical changes in the organic compounds with the result being the formation of petroleum.

Reservoir Formation

The oil and gas migrate through tiny spaces, fissures and fractures in the rock. However, some layers of rock will not allow fluids to pass through and are therefore referred to as *"impermeable"*. These layers form a seal and trap the oil and gas leading to the formation of a so-called **petroleum reservoir.**

The earth's solid crust is broken up into a dozen semi-rigid tectonic plates. The boundaries of these plates are zones of tectonic activity, where earthquakes and volcano activities tend to occur. The geology of Trinidad is one of the most complex in the world as it is situated at the junction of the Caribbean, South American and North Atlantic Tectonic Plates. These plates interact with each other and the plates surrounding them, resulting in folds that are ideal geological traps for petroleum.

Did You Know?

Did you know that many people unfamiliar with the gas and oil industry may visualize petroleum existing in "underground lakes"? However, this notion is not accurate! If this were true, finding oil and gas would be extremely simple and inexpensive. The reality is however, that oil and gas reservoirs are made up of permeable rocks that can hold significant amounts of oil and gas within the pore spaces of these rocks.

Category 3.

How Natural Gas Is Measured

How is Natural Gas Analysed?

It must be noted that the value of natural gas lies not in its volume, but in its energy content. As a result, before it is measured, natural gas first has to be analysed to determine its energy or British Thermal Unit (BTU) content. Remember that BTU is one of the units by which the energy content of natural gas is measured. To give you an idea of the energy value of natural gas, 1 cubic foot has the equivalent energy value of three 100 watt light bulbs burning for one hour.

In order to determine its BTU content, an analysis of the composition of a natural gas sample is obtained mainly by a process called **gas chromatography**. Chromatography allows for the separation of the hydrocarbons, oxygen, nitrogen and carbon dioxide. NGC uses a computer-controlled gas chromatograph for this purpose. A printout of the results is then shown on a chart called a **chromatogram.** The chromatogram shows peaks of various heights and widths, each representing the concentration of each specific molecule present in natural gas.

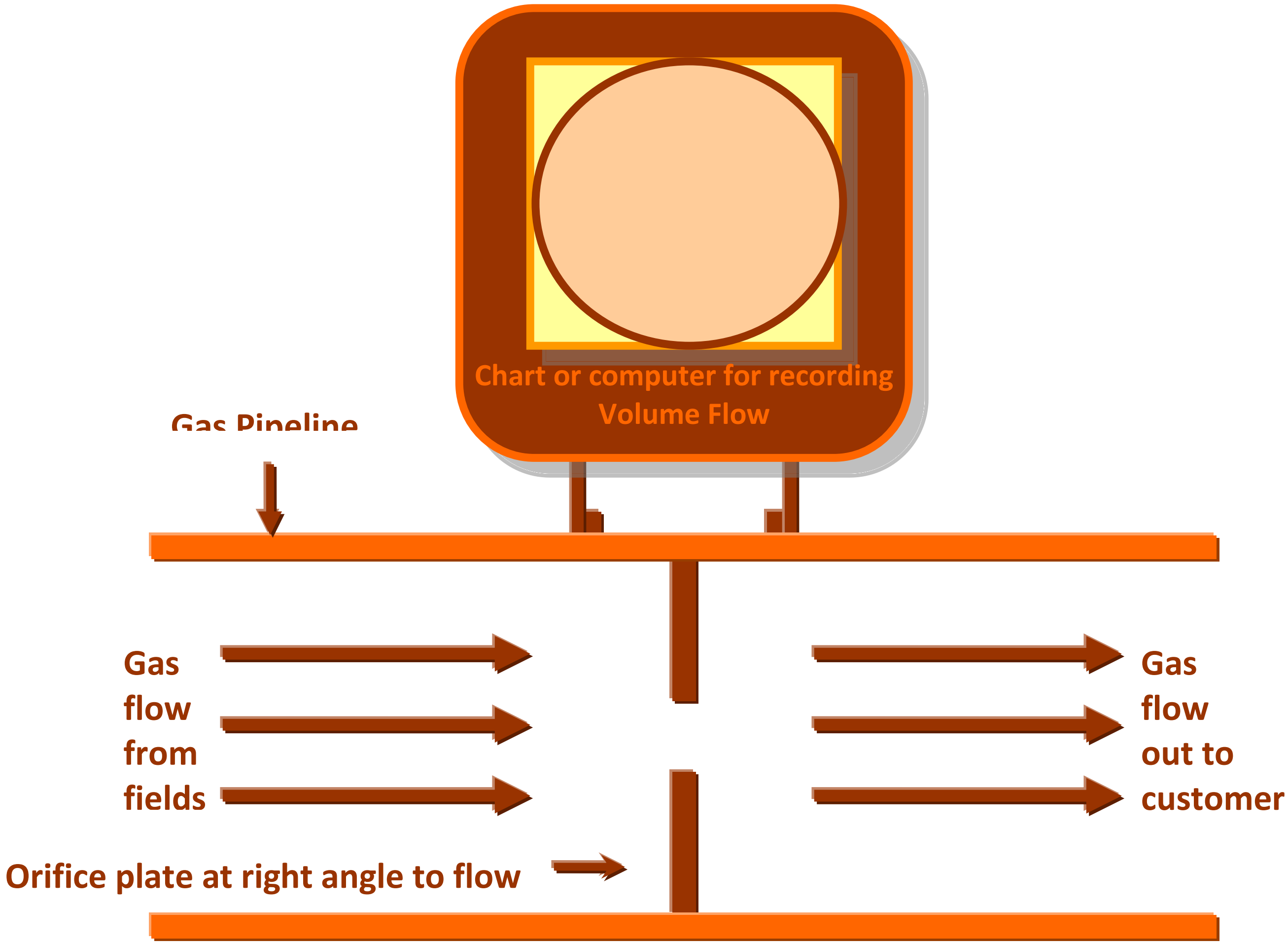
Measuring Volumes

Once analysed, natural gas can then be measured. Wherever a transfer of the ownership of natural gas occurs, meters are placed in order to ensure that it is properly measured. Measurement systems are an integral part of any natural gas pipeline system, as the gas is measured when it is purchased by NGC from the suppliers, and measured upon delivery to each consumer.

How Natural Gas is Measured at the Pipeline

The instrument most often used to measure natural gas volume flow is called the orifice meter. This comprises a thin metal plate positioned at right angles to the flowing gas in a pipeline. The metal plate has a small hole drilled through its surface. Gas flows through the bore and as it does so, a pressure difference occurs. This pressure difference is then translated into a volumetric flow using mathematical equations and displayed on a chart for computer interpretation as shown in Diagram 1 below.

Diagram 1 showing measurement of gas at pipeline



How Can You Tell How Much Natural Gas is in a Vessel?

The quantity of gas in a vessel is determined by the volume of the vessel as well as the pressure and temperature within it.

For example, if you are given two identical vessels "full" of gas, it is necessary to know the pressure within each vessel in order to know how much gas each vessel contains. One of these vessels might contain several times the amount of gas than the other simply because the pressure within it is higher.

Additionally, the higher the temperature within a vessel, the smaller the amount of gas that can be accommodated and vice versa, assuming that the pressure is kept constant. Conversely, at constant temperature, the higher the pressure, the smaller the volume occupied and vice versa.

Category 4.

Understanding Resources & Reserves

Natural Resources

Natural gas is a **non-renewable natural resource** *(See Gas Rush Booklet)***.** Natural gas resources are quite abundant and are more widely distributed than crude oil resources. As the cleanest of all hydrocarbon or fossil-based energy sources, natural gas holds tremendous promise for satisfying the world's energy needs for many years ahead.

Classification of Natural Gas Resources

Natural gas resources can be broken into four major categories based on their certainty of eventually coming out of the ground. These categories are defined as production, reserves, contingent resources and prospective resources and are described below.

Production

Production is the quantity of oil and natural gas that has been recovered already (by a specified date). This is primarily output from operations that has already been produced for use by consumers.

Reserves

As technology and economic conditions allow portions of the resources to be extracted, resources are reclassified into **reserves. Reserves** can be viewed as those quantities of resources that are discovered, are commercially recoverable and have been justified for commercial development. However, reserve estimates involve some degree of uncertainty, making it difficult to accurately estimate the amount of natural gas that can be recovered. This uncertainty depends mainly on the amount of reliable data (geological, engineering and economic) available at the time of the estimate and how these data are interpreted.

The relative degree of uncertainty is reflected by placing reserves into one of two main categories: **proved** or **unproved.** Proved reserves are those quantities which have been estimated with reasonable certainty to be commercially recoverable from known reservoirs under current economic conditions and operating methods. Unlike proved reserves, unproved reserves are less likely to be recovered and may be further classified into probable and possible reserves, according to the increasing uncertainty of their recoverability. Therefore probable reserves are less likely to be recoverable than proved reserves but more certain to be recovered than possible reserves.

The term 1P is frequently used to denote proved reserves, 2P is the sum of proved and probable reserves and 3P the sum of proved, probable and possible reserves. The best estimate of recovery is generally considered to be the 2P sum of proved and probable reserves.

Reserve estimates will generally be revised as additional data become available during exploration activities and/or as economic conditions change. These economic conditions include gas pricing, inflation, and the cost of recovering gas.

The **Reserves to Production ratio (RTP)** is often used as a gauge to indicate the size of the country's reserve base in relation to the rate of production. In other words, **RTP** is used to gauge the number of years that given reserves can support the current rate of gas production. The country's **RTP** ratio for proven reserves at the end of 2007 is 12.3 years.

Resources

Contingent resources are less certain than reserves. These are resources that are potentially recoverable but not yet considered mature enough for commercial development due to technological or business difficulties. For these contingent resources to move into the reserves category, the key contingencies (1.e. conditions) that prevented commercial development must be clarified and removed.

Prospective resources are estimated natural gas quantities which have not yet been discovered. They represent quantities of natural gas which are estimated, as of a given date, to be potentially recoverable from gas deposits identified based on indirect evidence but which have not yet been drilled. These are less certain than contingent resources since the risk of discovery is also added. For prospective resources to be classified as "contingent resources", hydrocarbons must be discovered and proven to be potentially recoverable.

In order for these quantities to move from one category to the next, the technical issues which cause them to be placed in less certain categories must be resolved. In the majority of cases, this requires that additional data must be obtained before any greater certainty can be recognized.

Did You Know?

Did you know that although Trinidad and Tobago's reserves are relatively small in comparison to larger gas-producing countries like Qatar, Venezuela and Nigeria, this country remains a leader in its model of gas monetization? Continued investor interest in exploration, development and industrial use as well as Government initiatives, keep this country a competitive force in the international gas business arena.

Category 5.

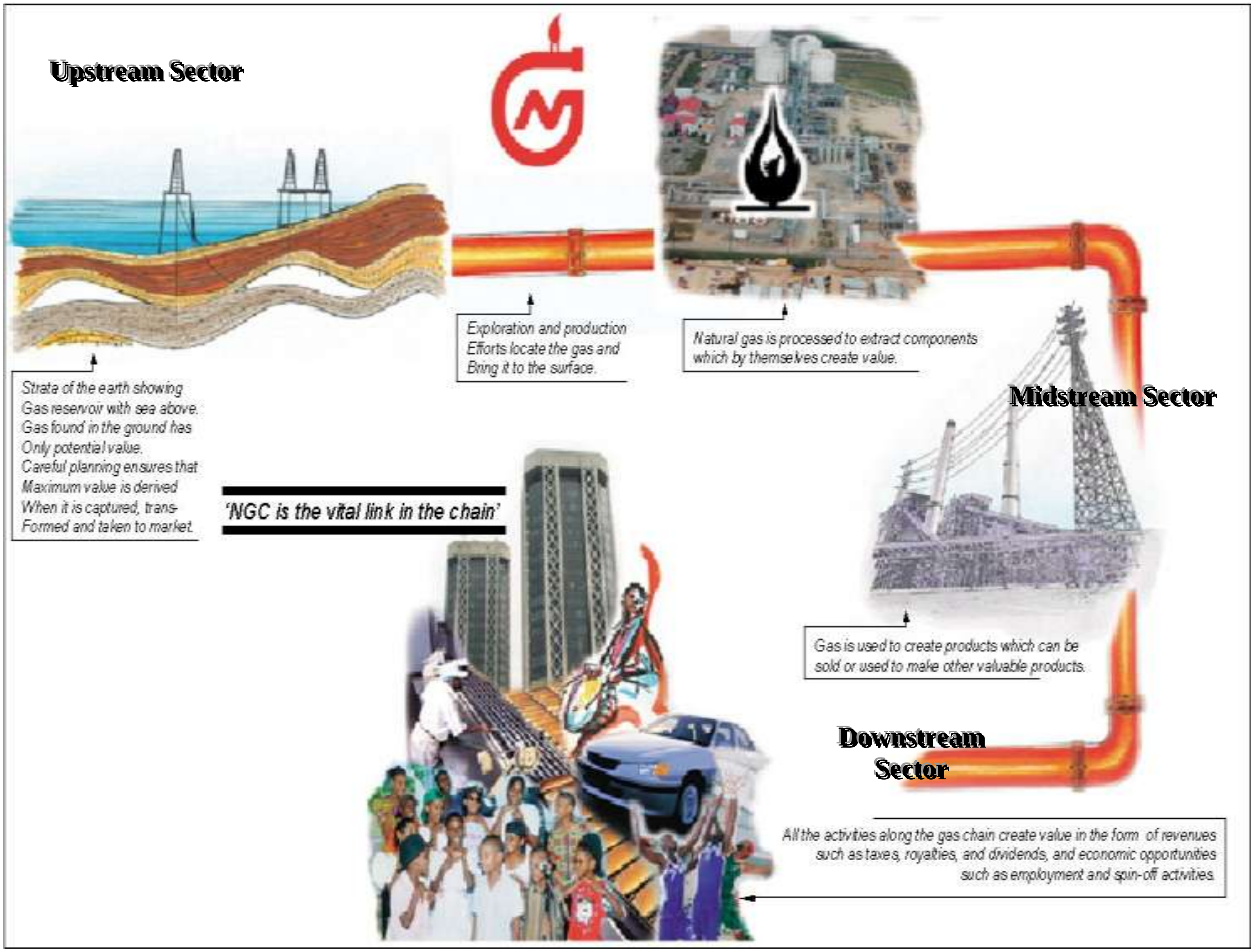
The Natural Gas Value Chain

Gas Monetization

The process of deriving value from gas resources is called gas **monetization**. This process is not a single stage one, but involves a chain of related activities that extract gas from the ground and carry it to its ultimate market destination. Natural gas needs a dedicated market and significant infrastructure even before it can be produced. As a result, the gas monetization process is more complex than that of oil which can be easily loaded unto a tanker and shipped to a number of existing market destinations.

Broadly speaking, the natural gas value chain is comprised of the **upstream, midstream and downstream** *(See Categories 7, 8, 9)*. Diagram 2 on the following page, depicts the natural gas value chain.

DIAGRAM 2: The Natural Gas Value Chain



Forms of Value

Economic Value

The primary form of value to all parties involved in the gas value chain is monetary in nature. To local and foreign investors, this value is in the form of a rate of return on investment. To Government, revenues are collected in various forms all along the gas value chain through Dividends and Corporation Taxes.

Social Value

On the social side of value to be accrued from the gas value chain lie:

- **Job creation and skill development**- Key skills that have been extensively developed over the years of industry growth include gas well services, project management, estate and marine infrastructure development and management, plant and pipeline construction, maintenance and operation, gas pricing and sales, market research and corporate law.

- **Positive impact on communities-** Energy sector companies have embarked on a wide range of social programmes, including development of community facilities, human capacity and skills development, enterprise development, health, safety and environmental awareness, as well as contributions to educational, social, cultural and sporting initiatives.

Factors Influencing the State's Share of Social & Economic Value

- **Tax Regime**- Tax and royalty rates, fiscal incentives, such as tax holidays, as well as capital and operating cost allowances that can be used to offset tax payments are all key variables in determining total Government revenue.

- **Downstream Portfolio Mix**- Natural gas pricing in Trinidad and Tobago is partly based on the prices of downstream products. These prices are cyclical and sometimes unpredictable in nature. As a result, gas prices on which Government upstream and midstream revenues are based can be significantly affected by this variability. The profitability of downstream companies is also affected and so too is Government's taxation in the downstream.

- **Greater Value Added** – The further development of the downstream industry which consists of derivatives of primary products has the potential for greater value added in terms of the total benefits per unit quantity of gas consumed.

- **Level of Participation by State Owned Companies**- One source of Government earnings is via dividends, which accrue to equity investment by

State-owned companies. Greater participation by the State has the potential to increase total Government revenue.

- **Extent of Involvement by Local Private Sector-** There is an additional benefit to the country when there is *local* private sector participation in the gas industry. This would help to ensure that any returns on investment are less likely to be expatriated but rather kept inshore and reinvested in the local economy.

- **Degree of Local Content-** Major stages of expenditure of financial and human resources in gas-based projects include the Pre-feasibility study, Detailed Feasibility study, and Engineering, Procurement and Construction Phases. These stages offer opportunities for the use of local services including engineering, environment, legal and financial consultancy, materials supply, foundation and structural works and plant fabrication. A greater degree of local content stimulates local business activity, generates jobs for nationals and increases skills development.

Category 6.
Impact of the Natural Gas Industry on the Economy

Trinidad and Tobago has traditionally been dependent on export-oriented production to stimulate economic development. While crude oil has traditionally been the main driver of the local energy sector, in 1997, natural gas production surpassed oil production on an energy equivalent basis for the first time. Policymakers have attempted to diversify the energy-based economy since 1975 by using natural gas as a catalyst for the development of a downstream petrochemical sector that comprised fertilizer, methanol and iron and steel plants. The successful completion of the first three LNG trains by mid-2003 represented a further step in monetizing the country's natural gas resources.

The main drivers behind initiatives to maximize value in the gas chain include:

- The availability of large proven natural gas reserves
- The desire for further diversification in the national economy
- A period of relatively predictable revenues from gas, due to long contract periods and certainty of gas output.

Key Economic Indicators

The impact of the natural gas sector on the economy can be determined by examining the following key economic indicators:

Gross Domestic Product (GDP) – Much of the improved performance in the economy from 1993 has been based on growth in the energy sector- notably natural gas. While much of this sector's growth is due (directly or indirectly) to initiatives taken in the gas sector, no detailed economic data exists to determine precisely the relative contribution of gas to the economy as distinct from oil. As a result, any net benefits from the natural gas subsector are inferred.

Government Revenue- It is difficult to ascertain the impact that natural gas-based industries have had in terms of increased tax revenues, as these are lumped with other companies, unlike the oil companies that fall under the Petroleum Taxes Act. However, the impact of increased gas sales will be reflected in the oil companies' accounts and in the overall oil sector revenue. The start of LNG exports from 1999 made revenue from natural gas sales a major contributor to oil income as a source of government revenue, with this trend continuing well into the 21st century.

Balance of Payments- By far, the greatest impact of the gas sector on the local economy is derived from trade with the rest of the world. This is because most gas-based products are exported. As a result, the sector has a significant effect on the Balance of Payments.

Investments- Trinidad and Tobago has traditionally invested heavily in its enclave sectors, whether agriculture or energy-based. Recent trends in the energy sector show that there is still significant investment in the oil and gas sector, with most of the investments over the last decade being either directly or indirectly in the gas sector.

Employment- Although the energy sector has brought tangible benefits to Trinidad and Tobago, it has not been a major direct contributor to long term employment, because of its capital intensive nature. As seen in Table 1, between 2000 and 2007, this sector accounted for between 3.1% and 3.78% of all persons employed. However, activity in the oil and gas sector creates employment in other sectors, such as construction and to a lesser extent, transport, storage and communications.

TABLE 1: Energy Sector Employment in Trinidad and Tobago

	2000	2001	2002	2003	2004	2005	2006	2007
Workers employed in petroleum and gas (000s)	15.93	15.48	17.23	16.07	18.57	19.26	19.7	22.04
Total employment	503.33	514.13	525.08	534.15	562.38	574.03	586.2	582.77
% employed in gas and oil	3.16	3.01	3.28	3.01	3.30	3.36	3.36	3.78
Unemployment rate (%)	12.17	10.83	10.4	10.47	8.37	7.97	6.22	5.54
Workers in construction (000s)	69.73	78.8	75.57	79.97	91.14	101.82	104.55	110.16
Workers in transport, storage and communications (000s)	39.19	38.88	41.79	41.56	41.62	41.8	42.72	41.53

Source: Central Statistical Office; Central Bank of Trinidad and Tobago

Category 7.

The Upstream Sector

Exploration – The Search for Oil and Gas

In the early years of petroleum exploration, the easiest way to find it was to look for evidence of oil seepage on the Earth's surface from fractures in underlying rocks. Examples of oil seeps in Trinidad can be found at the foot of the San Fernando Hill.

Today, however, the search for oil and gas is more complex. It begins with geologists and geophysicists using their knowledge to locate geographic areas that are likely to contain hydrocarbon bearing rock. The geologists' job is to observe, explore and scrupulously record any clue to the possible presence of hydrocarbons below ground. They examine rocks and sands and take samples to ascertain their nature and date the strata from which they were taken. Data gathered is used in mathematical models to determine where to drill for petroleum. They then seek to reconstitute a scenario that may have been written four billion years ago!

The work of the geologist is blended into that of the geophysicist who uses technology to locate and describe subsurface formations. The tool most commonly used by the geophysicist is **seismic technology (seismology),** which allows one to "see" beneath the surface of the Earth.

Seismology

Seismology is really very simple! In seismology, energy in the form of a sound wave is generated. The resulting waves spread out through the ground, encountering different strata and formations. The process is similar to a child bouncing a rubber ball. If the ball strikes a concrete sidewalk, it reacts quite differently than it would if it landed on a pile of sand.

As with the bouncing ball, each formation reflects the energy waves according to its own 'bounce" characteristics. The waves deflect upwards to the surface and are picked up by sensitive detection devices embedded in the ground. The geophysicist's seismic recordings are fed into powerful computers. The signals are then used to generate a picture of underground rocks and hydrocarbon zones. The picture is used to indicate where hydrocarbons might be found. Because drilling is very costly, as much information as possible is gathered before selecting the most promising site.

Drilling for Oil and Gas

Drilling begins after a **prospect,** or apparently suitable location, has been identified. Once the geoscientists have determined where they feel a prospective formation lies, an **exploration well** is drilled. If this is a new prospect in a remote or unknown area, it is called a **"wild-cat well".** Exploration/wildcat drilling is high risk, as the chances of finding a reservoir of commercial proportions are very low.

The other kind of drilling is called development drilling where less geological prospecting is required. With development drilling, overall costs are lower and the risk is considerably less than with exploration or wildcat drilling because more subsurface information exists in published reports and histories of previously drilled wells.

Field Development and Production

When hydrocarbons are located, the next very important step is to determine how to bring them to the surface. There are various methods available and the one selected should take into account the depth and type of strata, the gas-to-oil ratio, the viscosity of the crude oil and the economics of the entire project. If the well looks promising, the walls of the hole are cased, or lined with metal pipe to seal it from the rock. The lining is then cemented in place. Holes are also shot through the casing to allow the fluids to flow into the well. Finally, smaller diameter tubing is run down the hole to conduct the reservoir fluids to the surface. Efficient recovery takes proper engineering and planning along with the right equipment.

Field Processing

Most of the petroleum produced from a reservoir requires processing.
As the stream flows upwards, it undergoes continuous pressure and temperature reduction because it is leaving a high-pressure reservoir that is hotter than the Earth's surface and coming into contact with lower temperatures and pressures.

When the hydrocarbon mixture comes out of the well-head, it enters a flow line and is carried to the **header**, which consists of different types of valves and fittings. This is the junction connecting all the flow lines in a given area. It is at this point the oil and gas enter the **separators**, which remove natural gas from oil, condensate and water.

The separated gas is further treated to meet pipeline quality for sales or compressed and re-injected into the well for improved oil recovery. The treated gas is then compressed, a process which increases the gas pressure and therefore its energy, to facilitate its transport via pipelines to the customer or gas producing plant. The oil and water are further separated under gravity as the two liquids have different densities. Oil is sent to the refinery or exported and the water is treated and discharged or used for re-injection into the well to improve oil recovery.

Category 8.
The Midstream Sector

Natural gas is transferred through pipelines from the platforms to the shore. During its journey, the ownership and sometimes responsibility of natural gas changes hands at points referred to as **custody transfer points.**

The Journey of Natural Gas

At the beginning of the journey of natural gas through the pipeline, the pressure is about 900 psig (pounds per square inch) and the temperature is around 40^{o} C (105^{o} F). Further on in the journey, the natural gas will encounter an orifice meter where the gas flow is measured.

As the gas passes the orifice meter, it encounters a number of intrusions/interruptions.

- The first is normally a **thermo-well,** used to measure the temperature.
- A **probe** can also be found. This is used to extract gas samples from the middle of the pipe or stream. This device analyses the natural gas to determine the speed of the molecules, the type of molecules and how many types of molecules exist. Such analysis determines the composition of the gas as well as its quality and value.

As the natural gas prepares to leave the platform for the trip to land, it passes through a series of pipes with bends and loops. In Trinidad, this trip is up to 80 kilometers (50 miles) to shore.

Further along the journey to shore, just before the gas leaves the platform, it enters a pipe of the same or larger diameter at a right angle. This pipe is from the **pig launcher.** The **pig** is an important tool used to maintain the pipes by cleaning, scraping, wiping and drying the insides of the pipes.

The natural gas then travels 60 metres (200 feet) straight down a platform leg. The pipelines that gather the gas from the different platforms run along the sea bed to shore. They are normally weighted down by concrete because although they are made of steel, they become "lighter" and buoyant at the great depths and pressures of the ocean floor. This is known as the **Archimedes' Principle.**

These pipelines are protected from external corrosion from the salt water by a combination of pipeline coatings or wraps, paints and cathodic or sacrificial anodic protection. The coatings and a cover of sand in certain places prevent external corrosion as well. Water, hydrogen sulfide, carbon dioxide and other compounds are prevented from corroding the inside of the pipelines by corrosion inhibitors that creep along the walls and form a physical and chemical barrier on the internal walls of the pipes.

As the natural gas approaches the shore, the temperature drops and the pressure falls. The amount of liquid therefore increases. The more complex hydrocarbons or "heavy" ends drop out first at the nearest facility as they do not have sufficient energy to stay in the gaseous state.

There are two critical types of land stations that the natural gas will meet as it continues on its journey in the mid-stream. These are known as **pressure control** and **liquid control facilities.**

As the gas approaches the **pressure control facility,** it leaves the larger pipeline for a short while and travels into a smaller pipeline where it encounters the "pressure police", in the form of pressure monitors and regulator valves. These are set up so that the regulator valve will slow down the gas to ensure that it leaves the station at the correct pressure of around 750-800 psig. If for any reason the regulator valve fails, the monitor will take over to ensure that the pressure downstream of the station always stays below the setpoint of the monitor valve.

As the gas enters the **liquids control/removal facility,** the gas slows down quite a bit and the free liquid drops into a series of large-diameter holes at the bottom of the pipe. These lead to the barrels of what is known as a **slugcatcher,** designed to stop and remove large slugs or accumulations of free liquid. The liquid condensate is removed and piped away for storage and sale and can fetch a tidy sum on the market.

Liquids are not welcome in a gas line as they behave differently from gas molecules. It is more difficult for them to move along the system and unlike the gas molecules they cannot be compressed and so can cause a lot of damage if trapped in the wrong place. In addition, they cause a lot more chemical reactions resulting in a lot more corrosion, than that which is caused by gases. Finally, they also affect equipment like valve seats and seals which are specifically designed for gas service.

Next in the journey, is the separator which is like a big fat cigar about six feet across and twenty or more feet high. This works like a spin dryer, spinning so fast that the liquid molecules are pushed against the walls and drop to the bottom.

As the gas arrives at the liquid stripping plant called Phoenix Park Gas Processors Limited (PPGPL) at Point Lisas it goes through a process known as **cryogenics.** (See Interesting Definitions in the Journey of Natural Gas!).

During the cryogenics process, the temperature cools down to such low temperatures that the heavier gas molecules such as propane and butane and even some of the ethane become slow, convert to a liquid and fall out of the gas stream. There will therefore only be methane, a few ethane molecules and some carbon dioxide and nitrogen that make it through to the distribution system. These liquids will be sold, while the gas that is left (mainly methane and any remaining ethane) continues on its journey.

Before leaving PPGPL, the remaining gas is heated, dried and will then be distributed through pipes between 2" and 36" all over the country, from Penal in the South to Westmoorings in the West and to Arima in the East.

Gas leaves the mid-stream sector once it passes through another metering facility at the consumer's doorstep.

Interesting Definitions in the Journey of Natural Gas!

Archimedes' Principle- This is the law of buoyancy and states that any body partially or completely submerged in a fluid is buoyed up by a force equal to the weight of the fluid displaced by the body.

Cathodic Protection- This prevents corrosion of iron/steel by suspending magnesium or aluminum anodes in proximity to the pipeline and passing a continuous small current along the system.

Cryogenic Stripping Process- The cryogenic process consists of lowering the temperature of the gas stream to about -85^{o} C (-120^{o} F). **Amongst** others, one of the most effective ways of chilling the gas to these temperatures is known as the turbo expander process. In this process, external refrigerants are used to cool the natural gas stream and an expansion turbine is used to rapidly expand the chilled gas, causing the temperature to drop significantly. This rapid temperature drop condenses ethane and other hydrocarbons in the gas stream, while maintaining methane in gaseous forms.

Pig- This is an important plug like device that moves along the pipeline using the pressure of the gas itself. It is used to maintain the pipes by cleaning, scraping, wiping and drying the insides of the pipes. "Intelligent" pigs can take measurements of where the pipe is located, how it is oriented and laid, map the pipeline and measure and check its walls for defects and corrosion.

Sacrificial Anode-An anode attached to a pipeline to inhibit corrosion of the object. It is electrolytically decomposed while the object remains damage free.

Category 9.

The Downstream Sector

The downstream is the stage in which the metamorphosis of the methane molecule into final products is so great that there is little resemblance between the final product and the original form. Over the last fifty years, this industry has grown into a multi-billion-dollar industry comprising more than 25 world-scale plants producing mainly intermediate products, e.g. methanol, ammonia and urea. See Table 2 on the following page for a list of plants in the downstream gas sector.

The downstream sector has been concentrated in two main centres:

-**The Point Lisas Industrial Estate**, where ammonia, urea and Direct Reduced Iron (DRI) are currently produced

- **Point Fortin** where all the LNG is currently produced and exported.

These estates were all developed with large parcels of land, water, power, port facilities, and natural gas to service these types of plants.

Table 2: PLANTS IN THE DOWNSTREAM GAS SECTOR

Source: Energy Map of Trinidad and Tobago 2007 Edition

Plants in Point Lisas

Ammonia	**Capacity Tonne/Annum**
Trinidad Nitrogen I	500,000
Trinidad Nitrogen II	495,000
Yara Trinidad Limited	285,000
PCS Nitrogen	
1	445,000
2	495,000
3	250,000
4	610,000
Point Lisas Nitrogen Limited	610,000
Caribbean Nitrogen Co.	660,000
Nitrogen 2000	660,000
Ammonia Subtotal	***5,010,000***
Methanol	**Capacity Tonne/Annum**
TTMC 1	460,000
TTMC 2	550,000
CMC	550,000
MIV	550,000
Methanex	860,000
Methanex	1,650,000
Methanol 5000	1,890,000
Methanol Subtotal	***6,510,000***
Urea	**Capacity Tonne/Annum**
PCS Nitrogen	600,000
Total Petrochemicals	**12,120,000**
Iron Ore	
Nu-Iron Unlimited	1,500,000
Direct Reduced Iron	**Capacity Tonne/Day**
Arcelor Mittal	
DRI Unit I	190
DRI Unit II	90
DRI Unit III	90
Gas Processing	**Capacity Barrels/Day**
PPGPL	70,000

Plants in Point Fortin

LNG Processing	**Capacity Tonne/Annum**
ALNG Train 1	3,000,000
ALNG Train 2	3,300,000
ALNG Train 3	3,300,000
ALNG Train 4	5,200,000
Total LNG	**14,800,000**

As you now know *where* these products are made, let us look at *how* these products are made.

Liquefied Natural Gas (LNG)

LNG is a natural gas in its liquid state. Gas is liquefied as liquids take up less space than gases and are easier to handle and transport. To become liquefied, natural gas must be cooled to very low temperatures. LNG is then stored in specially insulated storage tanks before being shipped to consumers.

Methanol

This is produced by the reaction of carbon monoxide (CO) and hydrogen. Methanol is a toxic, colourless liquid at ambient conditions. It is transported in special containers due to its properties. The main uses of methanol are:

- Manufacture of formaldehyde, used to make urea formaldehyde for adhesives and thermosetting resins.
- Acetic acid, used in the manufacture of intermediate products that lead to end-user products such as emulsion paints, adhesives and polyester resins.
- MTBE, another intermediate product, used as an octane booster in gasoline.

Ammonia

This is produced by the **synthesis** of hydrogen and nitrogen. The pure streams of hydrogen and nitrogen are reacted to produce ammonia in a large vessel known as a **reactor.** Ammonia is a gas at ambient conditions and must be liquefied and either stored in special refrigerated storage tanks or used immediately in downstream plants such as urea plants. It is a commodity chemical, widely traded in global markets. The main uses for ammonia are as a fertilizer and in the manufacture of intermediate chemicals.

Urea

Urea is produced by the reaction of ammonia and carbon dioxide. The close proximity of a urea plant to an ammonia plant therefore results in great benefits in terms of lower transport costs as well as storage costs related to the storage of ammonia and carbon dioxide. Urea is widely used as a fertilizer and raw material in the manufacture of other fertilizers, UAN and chemicals such as melamine.

Metals

In general, metals are naturally available in an impure state mainly as oxides, e.g. iron ore and bauxite. In order to be useful as products, these metal oxides must be purified by various processing methods. It must be noted that in the case of bauxite, alumina must be first formed then further reduced to aluminium.

Direct Reduced Iron (DRI) is produced by the reduction of iron ore pellets or lumps. DRI is used in the manufacture of steel. Steel is produced in an **electric arc furnace (EAF),** which uses electricity for melting the DRI. The steel is melted into billets or ingots which are either exported or formed into rods. These are used further downstream to manufacture channels and wires.

Category 10.
T&T Natural Gas in a Global Context

Natural gas being the cleanest and most environmentally responsible and abundant fossil fuel, remains the fastest growing energy source. Worldwide gas consumption is projected to rise strongly in most regions of the world over the next three decades, driven chiefly by demand for power generation. In 2007 natural gas consumption increased by 3.6% to 3,808 mmcf/d in the utilization of natural gas compared to 2006 natural gas utilization.

Reserves Scenario

As of 2007, one half of the world's proven gas reserves are found in three countries: Russia (1,577 tcf), Iran (982 tcf) and Qatar (904 tcf). At the end of 2007, the world's RTP ratio was estimated to be about 60.3 years.

In 2007, natural gas production in Trinidad and Tobago averaged an estimated 4,041 mmcf/d. This represented a 4.2% increase above 2006. Trinidad and Tobago's world rank in terms of natural gas production is estimated to be 20th. However, Trinidad's proved reserves are expected to increase in response to growing long-term industrial demand, which is driving exploration activity.

Competitive Position

Trinidad and Tobago is one of the world's major natural gas development centres as it continues to attract international investors who are willing to establish both upstream and downstream industries.

Most of the natural gas produced (excluding that exported in the form of LNG) is utilized in the downstream sector where about a dozen industrial customers are engaged in the manufacturing of primary petrochemical products geared principally for export. Over the past two and a half decades, Trinidad and Tobago has experienced substantial growth in its petrochemical sector (ammonia and methanol), ensuring that this country remains as one of the leading exporters of both ammonia and methanol.

Having entered the world LNG market as recently as 1999, Trinidad and Tobago's position in world traded LNG in 2007 was 7^{th}. LNG would continue to impact upon the country's reserves, as it provides the stimulus for increased upstream activity.

Domestic Utilization

Given its small population and tropical climate, Trinidad and Tobago, unlike many developed countries, has limited domestic demand for natural gas. The principal domestic demand for natural gas in the country is for electricity generation.

Unique Industry Model

The characteristics and drivers of Trinidad and Tobago's natural gas industry differ in some significant respects from those of developed countries. This uniqueness emerges in part from the industry's very nature and geographic factors. These factors include:

- A small land mass and population
- Relatively limited reserves
- Few gas producers and industrial consumers
- Low domestic demand with most of the demand being exported

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