CHEMSYSTEMS
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Report Abstract

Gas to Ethylene

Technology, Cost of Production for Synfuels International ECLAIRS process comparison to steam cracking of ethane, reforming/methanol synthesis & MTO routes. Regional plant capacity and supply demand forecasts presented.

PERP 08/09S10

October 2009

Nexant

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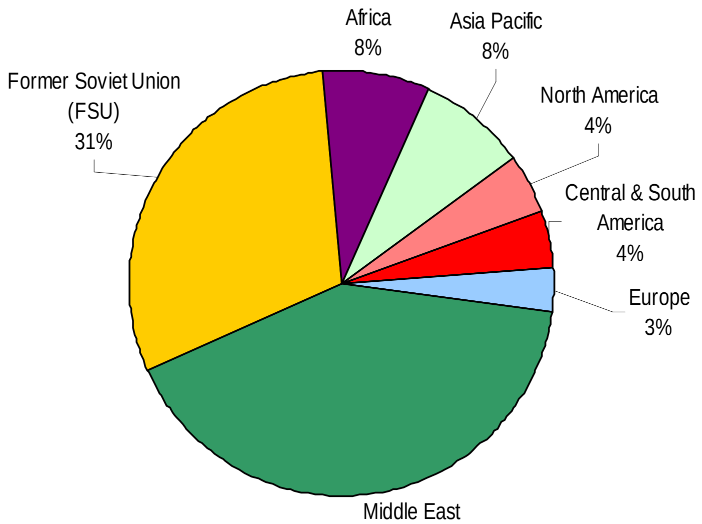
INTRODUCTION

Natural gas is the fastest growing energy resource in most regions of the world, driven by superior environmental performance as well as attractive economics for baseload use in power generation. Natural gas deposits are often located in areas far from their markets such as in the extreme south of Chile, in Qatar or in the North Atlantic Ocean. The Figure below provides a breakdown of global reserves, indicating the relatively low reserves in the major consuming centers of North America, Europe, and Asia. Even if natural gas is cheap at the source, transportation to the market is expensive. It is liquefied by cooling, for example in Qatar, or else is processed to methanol in order to ship this more expensive material, as is done in Punta Arenay in Southern Chile. Thus there is a drive to develop new technologies to allow efficient and cost-effective monetization of these stranded assets.

Distribution of Proven Natural Gas Reserves



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There are several options for the monetization of natural gas: pipelines, LNG (liquefied natural gas), chemicals (e.g., ammonia, methanol), and gas-to-liquids (GTL). Of these, the use of pipelines and the conversion to ammonia or methanol are the most mature and developed, followed by liquefaction and transport as LNG. Emerging technologies to convert remote gas to higher-value fuels and chemicals are approaching commercialization, one of which is the focus of this report. Higher-value products include synthetic fuels and chemicals produced directly from natural gas, fuels, and chemicals from natural gas via methanol, and electric power from methanol.

There are two broad technologies for gas-to-liquids to produce a synthetic petroleum product, (syncrude): a direct conversion from gas, and an indirect conversion via synthesis gas (syngas). The direct conversion of methane, (typically 85-95 percent of natural gas), eliminates the cost of producing synthesis gas but involves a high activation energy and is difficult to control. Several direct conversion processes have been developed but none have been commercialized being economically unattractive. Indirect conversion can be carried out via Fischer-Tropsch (FT) synthesis or via methanol. However, recently Synfuels International Inc., based in Dallas, Texas, has developed an alternative to the syngas/Fischer-Tropsch methodology of natural gas conversion with a patented process that has significant potential.

This report is focused on converting natural gas to ethylene. Although not easily transportable itself, ethylene can be used to produce a variety of other, easily transportable products (e.g., polyethylene).

NEW AND DEVELOPING TECHNOLOGY

The rapid development of the petrochemical industry in the Middle East has been based on the desire to add value to its substantial exports of crude oil. Associated gas, which was produced with crude oil and was re-injected or flared at the well-head, was transformed as the main feedstock for production of basic petrochemicals. Owing to a limited alternate value, the corresponding pricing structure for this feedstock was based entirely on the cost of extraction of natural gas liquids (NGL), especially ethane. This low feedstock cost base, aided by a number of fiscal incentives, acted as a primary impetus towards development of a robust petrochemical industry in the region.

However, further increases in ethane supply from associated gas are likely to be limited as OPEC (Organization of Petroleum Exporting Countries) limits crude oil supply to achieve its price stabilization targets. Thus, attention is focusing increasingly on sourcing ethane for petrochemical projects from non-associated gas, but this necessarily results in the need to find attractive uses for methane, which constitutes up to 98 percent of non-associated natural gas.

Gas is usually found in the same rocks as oil. This associated gas makes it easier to get the oil out of the ground because its pressure forces oil up the well. The oil can go into a storage tank, a truck, a ship, or a pipeline, but it's not as easy to deal with the gas. Where there's a gas-gathering network of pipelines leading to a market, gas is a valuable product worth collecting along with the oil. Without a pipeline network or a market, the gas is considered stranded and has little value.

The solution many oil producers choose is to burn the gas. The World Bank estimates 14 billion cubic feet a day (5.3 trillion cubic feet or 150 billion cubic meters annually) of oilfield gas is flared in countries such as Russia and Nigeria (equivalent to the combined gas consumption of France and Germany) by oil companies that have no economical way of getting the gas to market. (Nigeria has gone so far as to impose a fine of 9 cents per 1 thousand cubic feet of gas flared by operators, but this has not proved sufficient to compel them to end the practice.) That flared gas adds 400 million tons a year of greenhouse gases to the atmosphere.

Quadrillions of cubic feet of natural gas exist globally, but because of various barriers (geographical, transportability, undesirable product contents, or non-existing entry points to commercial markets) many of those deposits lay dormant in areas such as Peruvian jungles or Indonesian islands (i.e., stranded gas). Turning gas into a liquid would make it a valuable commodity. The usual way of doing this, however, is an expensive chilling process to take natural gas more than -260 °F (-162 °C) to produce LNG. Every step involved in transporting this liquefied natural gas product involves cryogenic chilling.

Natural gas can also be chemically transformed into a liquid that doesn't require cryogenic chilling. As mentioned above, one method, the Fischer-Tropsch (FT) process, was developed in Germany in the 1920s and can be used to turn either natural gas or coal into oil, but the process was so expensive that its only large-scale use was by countries that did not otherwise have access to oil – Germany and apartheid South Africa.

The Synfuels technology is a gas-to-liquids (GTL) or gas-to-ethylene (GTE) process. This new non Fischer-Tropsch method of conversion of natural gas to liquid has been deemed the Synfuels ÉCLAIRS Process (Ethylene from Concentrated Liquid-phase Acetylene - Integrated, Rapid and Safe).

One of the disadvantages of syngas-based GTL plants is that they are only economical at very large scales. In order to facilitate a broader and faster commercialization by making it possible for liquid fuels to be marketed from the great multitude of stranded and associated gas fields a different approach is needed. Smaller plants need smaller fields and require much less capital, allowing more companies and entities to participate. The Synfuels approach is much more amenable to smaller scale plants. There are thousands of gas fields capable of supporting a Synfuels' approach. Synfuels' technology, capital and operating costs relative to competing processes have been assessed in this report.

- ÉCLAIRS Process (Synfuels International)

  Historical background and detailed process description, including methane cracking/conversion to acetylene, absorption of the acetylene from the cracked gas using a solvent selective to acetylene and especially Synfuels' novel variation on acetylene hydrogenation. Pertinent process flow diagrams are also given.

- Methane To Olefins Via Methanol (MTO)

  Although the methanol synthesis process is a commercial technology and not considered a developing technology, it is relevant to the developing MTO processes and therefore included here for completeness.

  Process chemistry is outlined. There are several variants of methanol technology available or under development. The review here outlines some of the main process (reformer) options and (converter) types. Product quality, and technology offered by licensors is discussed (in particular Lurgi, UOP/Hydro and others). Process flow diagrams and descriptions are included.

COMMERCIAL TECHNOLOGY

A brief description of steam cracking of NGL feeds (the most common feeds employed in the Middle East) is outlined.

- The cracking of a single hydrocarbon or a complex mixture of hydrocarbons into vastly different compounds involves complex reaction kinetics, which are influenced by a number of different variables. These are briefly outlined.
- Natural gas liquids (NGLs) are composed essentially of ethane, propane, and butanes. The process described in this section is based on an ethane/propane feedstock, and illustrated by the process flow diagrams given. In particular, pyrolysis and recovery (a state-of-the-art flow scheme based on the fractionation sequence used in the great majority of ethylene plants throughout the world) are discussed.

ECONOMIC ANALYSIS

The following process economics have been evaluated:

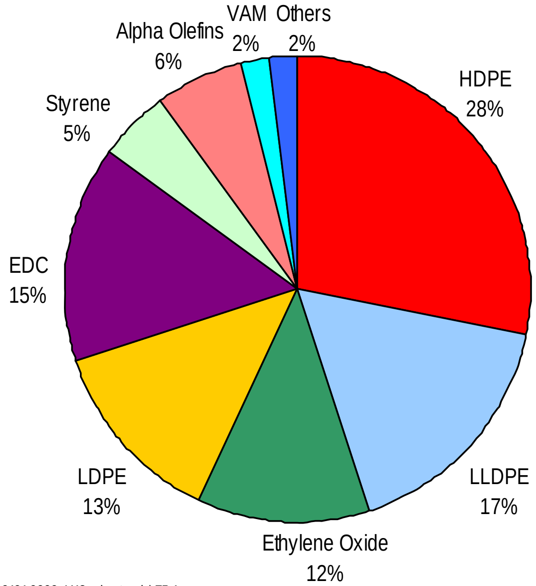
- Ethylene Cost of Production Estimate for Synfuels' GTE Process
- Methanol Cost of Production Estimate for Steam Reforming followed by Methanol Synthesis Process
- Ethylene Cost of Production Estimate for Methanol-to-Olefins Process
- Ethylene Cost of Production Estimate for Steam Cracking of Ethane Process

Also, the cost of production for ethylene has been analyzed for feedstock and by-product pricing sensitivity, economy of scale sensitivity, and capital investment sensitivity.

COMMERCIAL ANALYSIS

Some of the major chemicals and polymers that are produced from ethylene are illustrated in the figure below, showing U.S. ethylene consumption for the past year.

United States Ethylene Consumption



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Ethylene end use markets are diverse, owing to the wide spectrum of derivatives. These end use markets include: wire and cable insulation; consumer, industrial and agricultural packaging; woven fabrics and assorted coverings; pipes, conduits and assorted construction materials; drums, jars, containers, bottles and the racks in which to hold them; antifreeze; and solvents and coatings. Demand growth is therefore dependent on numerous final end markets.

- Supply, demand and trade data are given and discussed for the United States, Western Europe, and Asia Pacific. Included are tables listing capacity for each of these regions denoting plant location, company who owns the plant, specific plant capacity and process used to produce the ethylene.

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