COAL BASED METHANOL TO OLEFINS (MTO)

A Tale of Two Regions United States & China

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INTRODUCTION

Considering oil as the traditional feedstock, coal, natural gas, and bio feedstocks are considered the major alternatives for chemical production. Most of other alternate feedstocks like solar, wind, wave energy, batteries, etc. are most suitable for power and light generation – but not for chemical production.

Chemical production, originally based on coal was transformed to natural gas, after World War II by the United States. The natural gas is, generally considered cleaner and more environmentally friendlier than coal.
United States has abundant coal with the largest reserves in the world followed by Russia, China, India South Africa and Australia. The major global reserves include: (1) United States 273 billion tons, (2) Russia 173 billion tons, (3) China 126 billion tons, (4) India 93 billion tons and (5) Australia 90 billion tons.

Coal processing, unlike oil and natural gas, is far more complex and more disruptive to the land. Coal can only be monetized through mining – deep mining or strip mining. Coal, as mined, would require extensive cleaning, processing before it can be used. The mine reclamation, post coal utilization, is a major process. Oil and gas, on the other hand can be explored by drilling and processing.

Of the five regions, United States and China represent leadership in technology and implementation of coal to chemical projects.

The discussion is focused on the slow progress in United States of coal to chemicals projects versus China's fast paced progress of coal to chemicals projects.

The objective of this article is to provide a summary as well as logic of the technological and market developments related to coal to chemicals project possibilities in both regions.

OBJECTIVES

Traditionally the, coal to chemicals include ammonia/urea, acetic acid formaldehyde and acetylene derivatives. This article limits he discussion to olefin production only. The overall objective of this article is to present a summary of similarities and differences of MTO programs from USA and China in terms of:

1. Need for MTO Technology
2. Driving Factors
3. Commercialization Status
4. Current Programs
5. Future Prospects

For more detailed program, contact us at Chemical Market Resources, Inc.

BACKGROUND

In general, coal is monetized in three ways: (1) coal gasification – in-situ or otherwise, (2) coal liquefaction – in-situ or otherwise and (3) coal pulverization and external gasification.

Third choice, of coal pulverization is the dominant technology in China – which is simpler and more effective in faster monetization.

Converting coal to chemicals (olefins) involves four major steps:

1. Coal Mining, Cleaning and Preparation
2. Coal Gasification to Syngas production
3. Syngas to Methanol
4. Methanol/DME to Olefins

With the exception of step 4, the catalytic conversion of methanol/DME to olefins, most technologies are well established and in an advanced stage. The commercialization of these steps are more related to environmental issues and government policies and less to do with technology.

"Clean Coal Technology" the major driving factor for the first three steps, is an asymptotic goal with increasing costs with un-achievable goals at best. Hence the public opinion and governmental philosophies dictate the feasibility rather than tangible costs.

The Step 4, the conversion of methanol/DME to olefins is the major development that was the game changer, starting 1970s with Mobil's development of ZSM-5 catalyst system.

The technology was focused on two aspects: (1) gasoline fractions and (2) selective development of olefins – ethylene and propylene.

Methanol to Gasoline (MTG) was developed by Mobil in the early 70s and implemented in New Zealand and South Africa. After 40 years, the technology still is not fully commercial – because of: (1) fluctuating oil prices, (2) cost indifference of coal based technology, (3) the low aromatic content and (4) the need for blending.

Methanol to Olefins (MTO), Methanol to Propylene (MTP) and Methanol to Ethylene (MTE), have been the major links in commercialization of coal to chemicals, in spite of the fact that there are several chemicals that can be produced from coal.

The major interest for the coal based olefins is driven by the growth and preferences of polyolefins as the future plastic. Most polyolefin organizations have two major objectives:

1. Using MTO provides them an opportunity to develop "Green Resource" to produce traditionally oil based materials
2. If and when, successful the same MTO technology can also be used for all other renewable resources – corn, sugar cane, bio-mass etc. that advances their "Greening" of polyolefins.

The decision to push or not push the MTO technology is driven by the cost of feedstocks – much more than environmental issues.

Methanol As A Basic Petrochemical Building Block

Methanol CH_3OH or in short, CH_2 and H_2O represents one of the convenient routes for producing aliphatic petrochemicals using various sources including: (1) natural gas, (2) synthesis gas, (3) coal based methanol , (4) biomethanol and (5) Fisher-Tropsch product streams.

The CH_2 radical, is the basic building block of most organic petrochemicals. However, CH_2 radical does not exist in nature. Methanol essentially becomes the natural carrier for CH_2 radical for effective transportation and use. Hence using methanol to make olefins (methylene radical) is the most popular technology using various alternate feedstocks to the oil, the main source of energy.

Of all the alternative feed stocks, available to man, coal and natural gas/singes are the most attractive alternatives for chemical production. In both the cases methanol forms the preferred intermediate for the chemicals production.

Even though coal based chemicals include, ammonia/urea; Acetic acid and formaldehyde and others, the focus of this article is on methanol based olefins only.

The technology to produce methanol from coal and natural gas are well established and are driven by various issues specific to the source of methanol.

In the case of coal based methanol, the issues are more related to coal mining, transportation, cleaning and conversion to methanol. They are dominated by these issues.

Both in the case of coal based methanol and natural/syn gas basd methanol the effective transportation of methanol will be the key issue. Transportation of methanol is complicated by the fact that transporting a pound of methanol involves transportation of 0.57 pounds of water per every pound of energy in the form of CH_2. This makes logistics and plant sizes the major driving factor for methanol production.

ATTTRACTIVE REGIONS

Since, United States has abundant natural gas, oil, coal and above all, largest consumer base, it could afford to import oil to meet the national demand.

China, on the other hand, has abundant coal – but no oil/gas. without oil/gas and being one of the fastest growing regions, China requires coal to meet its growing needs.

People's Republic of China

People's Republic of China is the largest consumer of coal in the world, and is the largest user of coal-derived electricity, generating 1.95 trillion kilowatt-hours per year, or 68.7% of its electricity from coal compared to 1.99 trillion kilowatt-hours per year, or 49% for the US. With approximately 13 percent of the world's proven reserves, China has enough coal to sustain its economic growth.

Most Chinese reserves are located in the north and north-west of the country, which poses a large logistical problem for supplying electricity to the more heavily populated Eastern coast areas. To obviate the logistics of coal

transportation and with an aim to develop the technology, China is currently focusing on the Western interior for developments – essentially meeting two objectives: (1) increase the coal utilization and (2) develop the under developed regions.

Shanxi Province contains most of China's easily accessible coal. China's largest open-pit coal mine in Haerwusu in Inner Mongolia Autonomous Region started production on the 20th of October 2008, operated by Shenhua Group. It is rich in low-sulfur steam coal.

Coal to chemicals projects, especially for olefin are considered a high priority in China because China wants to mitigate the dependence on imports.

The most common technology currently available is the coal-to-olefins (CTO) project in China between the US-based Dow Chemical and China's largest coal mining company, state-run Shenhua Group.

The Dow/Shenhua CTO facility, called the Yulin Integrated Chemicals project, and is scheduled to start in 2016. Shenhua and Dow would likely form a 50:50 joint venture around the massive complex, expected to be the world's largest CTC project.

In the last two years, China has built nearly 20 plants that convert coal into a gas that can be used to make such things as plastic and pharmaceuticals. Chinese government put severe restrictions in May 2009 to discourage uneconomical and environmentally unfriendly projects. The government wishes to improve the environmental and economic performance of these facilities.

The new plants draw on technology developed by companies such as General Electric Co. and Royal Dutch Shell PLC.

China considers coal to olefins a key part of the national strategy.

THE UNITED STATES

United States' estimated recoverable reserves of coal stand at 275 billion tons, an amount that is greater than any other nation in the world, enough to meet the domestic demand for more than 250 years at the current rates of consumption,

USA's coal is used primarily for the production of electricity and represents nearly 50% of the power generated. These facilities plants are normally operated as "baseload" generators (the generating equipment normally operates on an around-the-clock basis).

Coal gasification for chemical production was proven viable by Eastman Chemical Company. Eastman has over 20 years of commercial operation. Texas lignite provides flexibility for chemicals, power and fuel CO2 removal can be built in to gasification CO2 sequestration ready. Eastman has been gasifying coal into methanol since 1983, and since 1991 has been producing acetyls and other chemicals entirely from coal feedstocks.

In July 2007, the company began construction of a $1.6bn (1.2bn) gasification project in Beaumont, Texas, US, scheduled to be operational by 2011. The facility was projected to be about five times larger than the gasification facility at the company's

headquarters in Kingsport, Tennessee, US.

However Eastman backed out of this plan in the year 2009 – due to commercial viability of low cost oil.

Most other coal to chemicals projects suffered the same fate. There has not been a successful commercial venture that addressed MTO in the United States. The pioneering technology developed by Mobil and Lurgi are still in the pilot stages.

Most people suggest MTO technology's feasibility in the U.S or North America is low because of environmental issues and the cost economics. The United States will still be the leader in technology development.

THE MAJOR ISSUES – COMPARISON – U.S vs. CHINA

This section will compare U.S and China on the current and future viability of U.S vs China.

Conversion of coal based methanol to olefins was driven by Mobil's technology developed in the early 1970s. The technology, developed by Mobil at a pilot level, still remains at pilot level at ExxonMobil Corporation.

The only semi-commercial, /commercial units were developed outside the United States, following the logic of need versus the environmentally feasible choice for commercialization.

Looking at the five major coal rich nations in the world:

United States has the coal reserves, technology - but the desire to produce coal based chemicals is tempered by the demand for environmental friendliness.

Russia – has the coal reserves, but lacks technology and infrastructure for commercialization. Due to the nature of the Nation, the probability is low that the feasibility will be there.

China – has the desire, need and developing technology to develop coal to chemicals. Their recent willingness to cooperate with Western organizations would make it the most probable region of success

India – has the need and desire... but lacks technology, infrastructure and investment for successful implementation of coal to chemicals. India will continue to have an academic interest in this subject with continuous programs.

Australia – has the desire to develop alternative feedstocks, but will have low interest due to lack of major chemical industry.

Thus, the major regions of interest for the foreseeable future will be U.S and China.

1. The Need for MTO Technology

CHINA essentially has two choices: (1) commercialize the Western technology through licenses and/or jvs or (2) develop indigenous technologies.

At the first glance, since the usefulness of MTO technology is immediate, developing jvs with the Western technology developers for commercial operations would be the safest bet in the short term basis.

However, coal based technology will be driving factor in China for future, much more so than the other regions. Hence China is better off developing in-house technology as soon as possible with the Government support.

UNITED STATES currently has the leading technology in MTO and extensive experience in implementation. However, the factors of environmental friendliness and the use of coal as a hedge factor against fluctuating oil prices will continue.

The probability of full commercialization of MTO technology in the United States is low. Any new technology developments can/will be used for jvs in other regions and/or licensing.

2. MTO Driving FACTORS

CHINA is driven by growth and need for development. China's projected growth and need for providing improved living standards will outweigh the needs for Global sustainability issues. Requiring the same level of sustainability standards for China as the advanced countries of the world is both unreasonable and growth stunting. Sustainability is a Global issue, while growth in China and India are the local issues.

UNITED STATES as a one of the most advanced regions of the world has to face a different set of problems of potentially slowing down the growth in order to achieve sustainability.
United States attempted to commercialize the MTO technology since 1970s with little success due to energy economics and environmental issues. This will continue for the foreseeable future.

3. Commercialization Status

CHINA is planning on commercializing the technology. Most programs are in planning stage and about to be implemented. Most of the current technologies are improvements on the Western technologies and/or licenses/jv

There are parallel efforts to develop indigenous technologies by the major Chinese organizations.

UNITED STATES currently has no major commercialization plans for MTO in the continent. The last program that was close to commercialization by Eastman has been benched due to cost economics.

Most U.S organizations will continue to attempt these technologies in feedstock advantaged regions. The major determining factor will the cost feasibility without vertical integration – the main factor in Dow backing off from sugarcane based ethylene.

4. FUTURE PROSPECTS

CHINA will have the best prospects and commercialization opportunities for MTO technologies for some time to come. The technologies developed by China will present a major competition to the global technology suppliers.

UNITED STATES will have fewer opportunities for MTO program implementation in the U.S soil due to feedstock disadvantages and oil situation.

The rest of the world, with the potential for jvs and plant setups will provide excellent opportunities to fine-tune the technology. Most commercialization will come through technology licensing and/or jvs.

CONCLUSIONS

The coal based methanol to olefins will provide a sustainable future alternative to the current Oil/Natural Gas based olefin derivative industry.

With coal based methanol, the MTO will provide a feedstock cost advantaged position for coal rich regions. MTO will provide additional incentives for bio based alternatives.

MTO technology a carrier of CH_2 radical – the DNA of olefin based petrochemical industry will have a bright future.

For more in-depth details and cost economics or regional attractiveness, contact info@cmrhoutex.com