

Multiclient Prospectus

Coal to Chemicals

Is It Coal's Time Again?

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Contents

Section	Page
1 Introduction	1
1.1 OVERVIEW	1
1.2 BACKGROUND	1
1.3 ABSTRACT.....	3
2 Scope of Work	8
2.1 OVERVIEW	8
2.2 COAL GASIFICATION.....	9
2.3 COAL TO CHEMICAL PRODUCTS.....	9
2.4 REGIONAL ECONOMICS.....	11
2.5 COMMERCIAL EVALUATION	13
2.6 STRATEGIC CONSIDERATIONS	13
3 Approach	14
4 Contact Information	15
5 Authorization Form	16
6 Qualifications	18
6.1 GENERAL.....	18
6.2 SUMMARY OF PROJECTS RELATED TO COAL	20

1.1 OVERVIEW

Nexant has developed a new multiclient study to analyze the technologies and economics of utilizing coal to produce major petrochemicals via gasification and other known “on-purpose” processes.

Overall Value Premise

Coal, which can be viewed as the critical factor in the growth of the industrial age in the 1700s and the organic chemicals industry in the mid-1800s, may be ready to once again attain a key role in the global chemical industry. Certainly coal lost its key role to low-priced oil and gas in the middle of the 20th century, but it may be poised for a comeback now that conventional oil and gas production is being strained by the rate of global economic growth and the rate of depletion for many larger reserves. For many regions around the world, coal now appears to offer a realistic and available chemicals starting point when compared to the alternatives of importing LNG, LPG, naphtha or crude oil. This prospectus describes the background of why this is an important and timely issue, the scope of our analysis, and the approach we used in the study. We also detail our experience and qualifications to perform the study, and how you may subscribe.

1.2 BACKGROUND

Coal gasification is a well-proven technology that has had many applications ranging from the earliest uses of coal gas for heating and lighting in urban areas (“town gas”), progressing to the production of synthetic fuels, such as liquid hydrocarbons and synthetic natural gas (SNG) chemicals, and most recently to large-scale IGCC (integrated gasification combined cycle) power generation.

By definition, the petrochemical industry is based on feedstocks derived from natural gas or petroleum. However, before 1940, many of these same organic chemicals were frequently referred to as “coal chemicals”. In the United States, oil and gas have, for the last sixty years or more, been abundant, leading to a situation where the preponderance of organic chemicals has been manufactured from these feedstocks. In other countries, (e.g., South Africa, India, and possibly most importantly, China) coal has been an important feedstock during recent years.

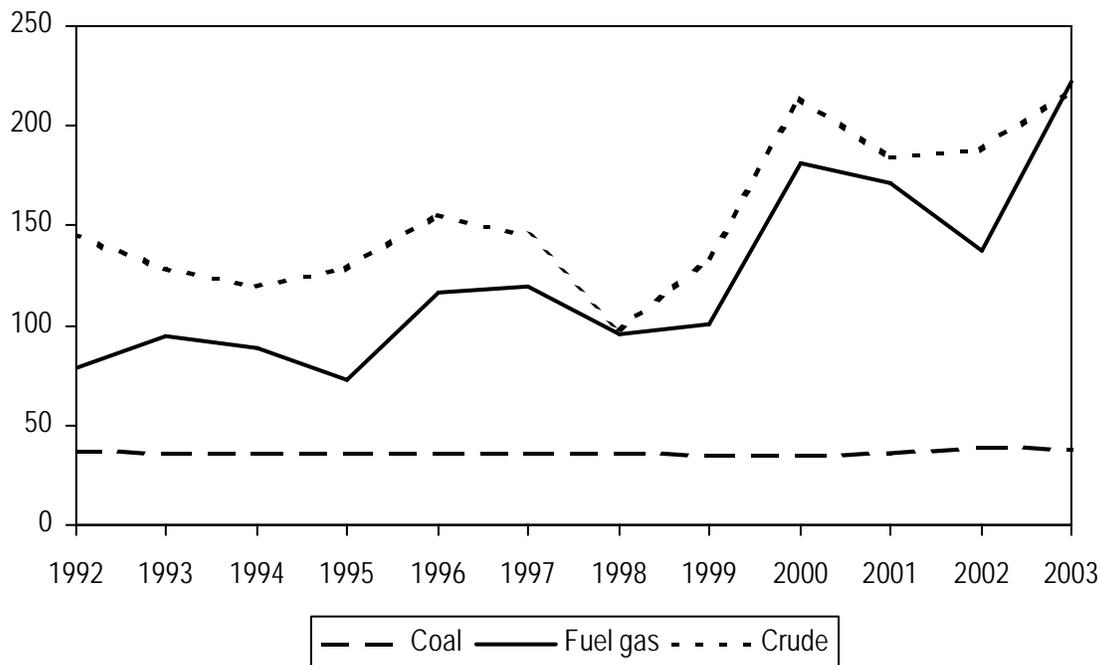
Essentially all of the important first-stage organic petrochemicals were made from coal during the period of about 1900 to 1930. The coke oven industry provided by-product ammonia, ammonium sulfate, benzene, toluene and phenols. In the fuels and fuels-chemicals sector, success was achieved in producing straight chain hydrocarbons, alcohols, and other organic chemicals from synthesis gas, as exemplified by the work of Bergius, Fischer and Tropsch, and others.

Inexpensive oil and natural gas liquids motivated the chemical industry to switch almost completely to natural gas and petroleum liquids over the 1940-1965 period. As an example, in the United States, DuPont started to make methanol from coal in relatively large amounts at

Belle, WV, but soon shut this unit down when inexpensive natural gas became available during the early 1950s. The use of coal for the production of organic chemicals diminished greatly over time as a consequence of both cost and environmental concerns, the latter having issues both in by-products produced and the effects of coal mining/extraction.

With the current tightness in North American natural gas supplies and high cost incremental supplies placing a floor under the price of natural gas, the prospects for coal and/or coal gasification as a source of petrochemicals and power are becoming a much more realistic alternative. As petroleum and natural gas supplies decrease relative to demand, prices are expected to continue rising, making coal a more economic and competitive feedstock. But, as crude and natural gas prices have continued to rise, coal prices have remained relatively flat, as shown for the U.S. in the 1992 - 2003 period (Figure 1.1).

Figure 1.1 U.S. Historical Crude/Gas/Coal Prices
(U.S. dollars per ton)



Q205_71440.002.03_Charts.xls\Figure 1.1

As crude and natural gas continue to rise in price, alternate production of petrochemicals from coal becomes more of a cost reality.

Regions with large coal reserves, such as China, are now re-examining the potential for coal to chemicals. For example, the Shenhua Group and Dow Chemical recently announced that they have agreed to evaluate the feasibility of coal-to-olefins projects in China. The Dow study will examine the economics, market, logistics and technology for large-scale coal-to-olefins plants around Yulin City, Shanxi province. China has the third largest coal reserve in the world, after

the United States and the former Soviet Union (FSU). It can be expected that similar initiatives will follow elsewhere.

In the United States, the Energy Secretary has recently called for speedy passage of an energy bill and said the administration will push hard for greater use of coal to help relieve U.S. energy demand. Though the focus of his proposal is for power generation, he also drew attention to developing technology for use of coal as a feedstock for synthetic crude oil. As the technology for coal gasification for power and fuels advances, the competitiveness of coal to chemicals in the United States will logically follow.

Though coal tar, a product of coke ovens, will continue to be a source of certain chemicals (e.g. anthracene to carbon black, naphthalene to phthalic anhydride, among others), the gasification of coal is considered to be a major potential “on-purpose” source of commodity petrochemicals. Another “on-purpose” route for coal to chemicals is via the production of acetylene, which can be used to produce a variety of chemicals, including vinyl chloride monomer and polyvinyl chloride. The economics for this production becomes attractive as the crude/coal price spread increases, and this route may prove important in areas with large coal reserves.

1.3 ABSTRACT

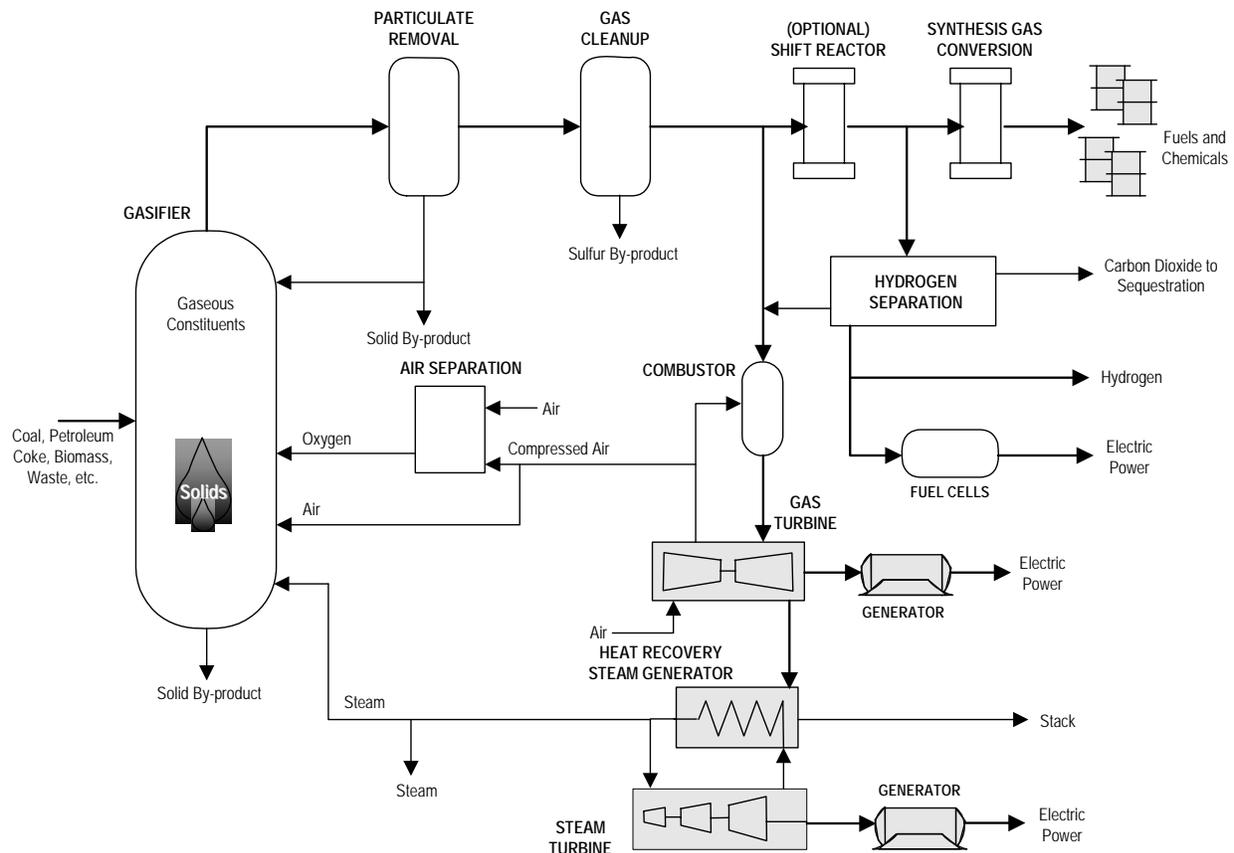
The attractiveness of the use of coal for chemicals production is primarily dependent upon three key factors:

- The price and availability of alternate feedstocks, i.e., gas and crude
- Advances in environmental protection technology
- Advances in gasification technology

The fundamentals of these three factors have changed dramatically in the favor of coal since the mid-1900s when coal lost its role as the basic feedstock for organic chemicals.

Chemicals can be produced from the three principal products of coal gasification; synthesis gas and hydrogen, as well as carbon monoxide. Figure 1.2 depicts a simplified flow chart illustrating the utilization options for coal-derived syngas. Various gasification and environmental cleanup technologies convert coal (or other carbon-based feedstocks), oxidant, and water to syngas for further conversion into marketable products: electricity, fuels, chemicals, steam, hydrogen, and others.

Figure 1.2 Gasification-Based Energy Conversion System Components



Source: "Major Environmental Aspects of Gasification-Based Power Generation Technologies", SAIC Report for DOE, December 2002

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Coal can also serve as a direct feedstock for the production of acetylene via calcium carbide hydration; and from there, to a wide variety of acetylene-based chemicals.

There are a number of important reasons for heightened interest in coal as a source of energy and feedstocks:

1. Energy and Feedstock Security -- The United States has recoverable reserves of about 275 billion tons, equivalent to 225-250 years of supply at current usage rates, a greater amount than any other country.

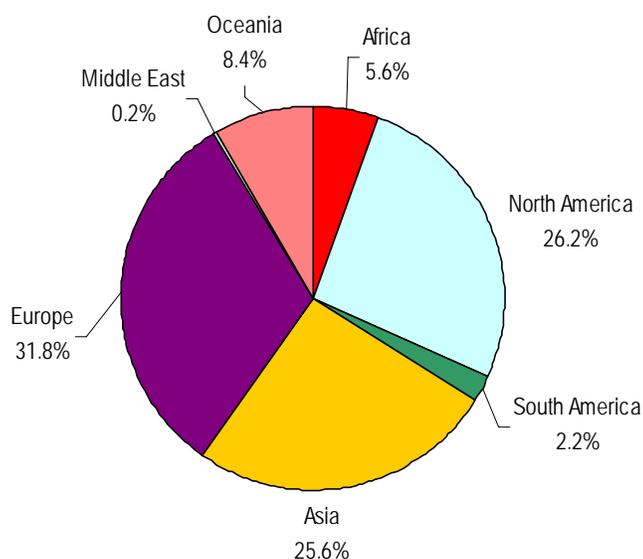
Other regions, such as Asia (especially China) and Western Europe, also have considerable coal reserves that could be used as a hedge against crude supply threats, as shown in Table 1.1 and Figure 1.3.

Table 1.1 Major Proven Coal Reserves, by Country ⁽¹⁾
(Billion tons)

United States	275
Russia	173
China	126
India	93
Australia	90

⁽¹⁾ Source: Clean-Energy U.S.

Figure 1.3 Regional Coal Reserve Share



Q205_71440.002.03_Charts.XLS\Figure 1.2

In 2004, China announced the discovery of new coal reserves estimated at 1.4 billion tons in Wenshui County in the Shanxi Province of Northern China.

China has exhibited continued activity in coal to chemicals, largely as coal to ammonia/urea, coal to calcium carbide-PVC, and others. More recently, coal-to-methanol and other chemicals (BDO and derivatives, etc.) have become important in China. A number of small coal-to-ammonia/urea plants have been shut down in the past decade due to poor economics and competition from imports. On the other hand, Sinopec and PetroChina have quite a few naphtha-based ammonia/urea plants (large scale) that have been retrofit to use coal as the feedstock via the coal gasification route from Shell, among others. At least one domestic company has also developed a coal gasification process.

Also in China, the Shenhua Group is building a major coal-to-liquids project utilizing the U.S.-based Hydrocarbon Technologies, Inc. (HTI) process. Two other projects are under study utilizing the Sasol process, one by Shenhua, and the other by the Ningxia Coal Industry Co.

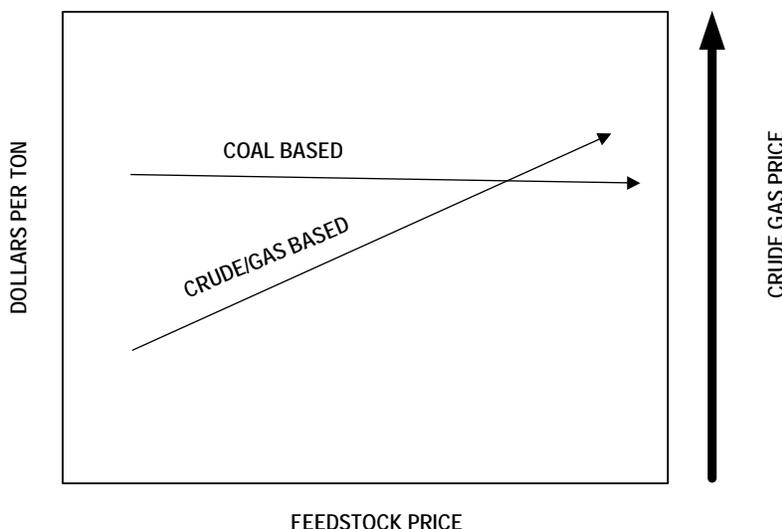
Developing coal-based liquid fuel and chemicals is more a strategic issue for the Chinese government due to their reluctance to become more reliant upon imported oil. With crude oil imports exceeding 100 million tons per year, the Chinese government is trying to find ways to lower imports.

For China, coal-to-chemicals is a hot topic and almost every local coalmine group has a coal chemical strategy as part of their long-term planning. Numerous projects have been proposed, but how many of them will go ahead is unknown at this point.

- Infrastructure Availability – Existing means are in place for distribution of coal by rail and barge, as well as via mine-mouth utilization
- Cost Advantage/Stability – Coal costs less than other hydrocarbon fuels/feedstocks and is less volatile in price today. For example, steaming coal at \$0.75 - \$1.75 per million Btu compares favorably with natural gas at \$4.00 - \$6.00 per million Btu, based on recent price ranges.

With the continuing improvement in gasification technology and increasing conventional crude/gas based feedstock, the opportunity for coal-based chemicals will increase, and may result in a favorable cost position, as seen in Figure 1.4.

Figure 1.4 Cost of Production Comparison



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- Diversity – Utilization of coal insulates against the price and availability shock potential of oil and natural gas

Likewise, there are multiple reasons for the choice of gasification as the means to utilize coal, compared to direct use as a combustion fuel, including environmental, current and improving cost competitiveness, and feedstock flexibility (gasifiers can operate on a wide variety of feedstocks).

There have been significant developments in the last few years based on increased interest in gasification. GE Energy acquired ChevronTexaco's gasification technology, which had been licensed for use in the chemicals, electric power and hydrogen producing industries for more than 50 years. In acquiring ChevronTexaco's coal gasification technology business, GE Energy broadens its gasification plant offerings and expands its ability to provide coal-fired generation that produces fewer air pollutants than conventional coal combustion.

In May, 2004, ConocoPhillips announced the signing of a worldwide alliance agreement with Fluor to facilitate the development, design and construction of new projects utilizing its E-Gas technology. Through the alliance, ConocoPhillips and Fluor will partner to provide project development and turnkey support for engineering, procurement, construction, operation and maintenance for solid fuel gasification facilities in both the chemical and energy segments.

The list of potential chemicals that can be derived from coal is almost boundless, given that coal provides both the hydrogen and carbon atoms needed for petrochemical production.

2.1 OVERVIEW

Given the economies of scale envisioned for a coal-to-chemicals facility, it is likely that the technology will typically best suit large volume commodity chemicals. However, smaller scale chemicals and specialty chemicals can also certainly be produced under the correct economic situations.

Nexant examined the technologies for coal gasification to chemicals by reviewing and evaluating the processes and economics for the production of major petrochemicals, including:

- Methanol
- Ammonia/Urea
- Olefins/Polyolefins
- Acetyls (acetic acid, vinyl acetate)
- Formaldehyde

An especially intriguing coal-to-chemical application is acetylene and acetylene-based chemicals. Though not a product of coal gasification, this is another example of “on-purpose” use of coal for the production of major petrochemicals. Though not as dependent upon advances in technology, such as for gasification, the use of coal to produce acetylene and downstream derivatives gains attractiveness as the price difference between coal and crude widens. In China, almost 60 percent of VCM capacity is based on acetylene. China has large reserves of easily accessible coal and the ability to produce low cost power from coal also contributes to the competitiveness of the gas-based acetylene process. The acetylene-based chemicals that are investigated include:

- Acetylene
- VCM
- Vinyl acetate
- Acrylic acid

2.2 COAL GASIFICATION

Nexant describes and reviews the available technologies for coal gasification and investigates developments that may prove important from both cost and environmental standpoints.

With regard to commercially available technologies, we reviewed the three major types:

- Fixed-bed reactors
- Fluidized-bed reactors
- Entrained-flow reactors

We also reviewed the technologies as presented by the major licensors:

- KBR Transport Gasifier
- Advantica BGL (British Gas/Lurgi)
- GE Energy (Chevron Texaco/GE) Entrained-Flow Gasifier
- E-GAS (ConocoPhillips) Entrained-Flow Gasifier
- Shell Entrained-Flow Gasifier
- Lurgi Dry-Ash Gasifier
- Prenflo Entrained-Bed Gasifier
- Noell Entrained-Flow Gasifier
- High-Temperature Winkler Gasifier
- KRW Fluidized-Bed Gasifier
- Lurgi Multi-Purpose Gasification (MPG)

2.3 COAL TO CHEMICAL PRODUCTS

Nexant developed cost of production economics for the major petrochemical products that are produced from coal and that may be produced from coal as the coal/natural gas-petroleum price relationship moves toward favoring production from coal.

The chemical and fuel products included in the economic evaluation of coal gasification to chemicals are:

- Methanol
- Ammonia/Urea
- Olefins/Polyolefins
- Acetyls (acetic acid, vinyl acetate)
- Formaldehyde

Nexant compared the cost of production for the chemical or chemical family via coal gasification with the cost to produce via the conventional process and feedstock. As well, cost comparisons with major alternate or emerging routes, such as methanol to olefins for ethylene and ethane oxidation for acetic acid, are assessed, as shown in Table 2.1.

Table 2.1 Coal Gasification to Chemicals and Fuel

	Coal-Based Process	Conventional Feedstock	Conventional Process	Alternate Route	Emerging Route
Petrochemicals					
Methanol	Synthesis from syngas	Natural gas			
Ammonia/Urea	Synthesis from syngas	Natural gas			
Ethylene/LLDPE	Syngas to methanol to olefins (MTO)	Hydrocarbon Feedstocks	Steam cracking	MTO via natural gas	
Acetic acid (acetyls)	Syngas to methanol carbonylation	Natural gas		Ethylene oxidation	Ethane oxidation
Formaldehyde	Syngas to methanol oxidation	Natural gas			

With regard to direct chemical production from coal, Nexant compares production costs for acetylene and acetylene-based chemicals, such as those shown in Table 2.2.

Table 2.2 Coal to Chemicals

Petrochemicals	Coal-Based Process	Conventional Feedstock	Conventional Process	Alternate Route	Emerging Route
Acetylene	Calcium carbide	Natural gas	Natural gas oxidation (POX)		
VCM	Acetylene	Ethylene	EDC cracking		Ethane oxidation
Vinyl Acetate	Acetylene	Ethylene	Ethylene acetoxylation		
Acrylic Acid	Reppe (acetylene)	Propylene	Propylene oxidation		

2.4 REGIONAL ECONOMICS

Nexant developed cost of production economics for the various chemicals and fuels via the process routes listed on a regional basis, taking into account typical regional conditions, including:

- Cost of production estimates for typical expected 2004 Q4, 2008 and 2015 oil and gas conditions are developed for each of the processes and feedstocks for comparison to the coal based routes.
- Costs of production from coal are developed for the U.S., China and Central Europe. Competitive and export economics are developed for the U.S., China and the Middle East.

The economic comparisons are used to help develop regional production and competitive dynamics, which are illustrated by comparing the delivered cost of the product to a typical import location. Thus, LLDPE competitiveness is shown by developing costs for an ethylene/LLDPE complex as exported to China from the Middle East (natural gas-based MTO) as compared to LLDPE produced in China from coal and from conventional routes. A typical cost of production worksheet for a coal-based gasifier (power production) is shown in Table 2.3.

Nexant developed price forecasts for the future years for the countries and regions involved in the production cost estimates. These estimates include all major raw materials, by-products and utility and wage unit costs. ISBL (inside battery limits) and OSBL (outside battery limits) capital costs are estimated for each process on a USGC basis and are adjusted for the particular countries and locations using our technology database of construction cost location factors. Location factors for labor force size and costs (social charges) and general plant overhead are also applied.

Sensitivities are performed for important process variables, including capital cost and coal price.

For each chemical, Nexant estimated an “indifference” price, i.e., the price at which production from coal feedstock (either directly or via gasification) makes economic sense. This results from the sensitivity analyses.

2.5 COMMERCIAL EVALUATION

Nexant developed forecasts of the major product groups included in the technoeconomic evaluations. The forecasts included demand, production and trade, globally and by region. The forecasts include:

- Methanol
- Ammonia
- Polyethylenes/polypropylene
- VCM/PVC

2.6 STRATEGIC CONSIDERATIONS

The use of coal as a source of carbon for organic chemicals appears to have a good future, although in the very long run, alternative energy sources and environmental issues, such as the greenhouse effect, may limit the use of coal for energy production. Nexant estimates, based on the comparative economics and pending and potential legislation, what portion of the petrochemical industry could be transferred to coal-based processes and the effect this would have on the overall business dynamics.

Nexant also explores such strategic considerations as:

- The likely rate of adoption of coal as the precursor to chemicals in key geographic regions and key hurdles to broad-scale adoption
- Partnering and licensing considerations for companies wishing to consider entry into coal-based chemicals
- Environmental risks, both real and perceived, and likely mitigation actions to ensure the future of coal-to-chemicals
- Technology development opportunities and available support from both public- and private-sector sources

The evaluations of conventional technology are based on Nexant's in-house and published information regarding process technology, augmented by contacts with licensors, engineering contractors and other experts in the industry. The evaluations of developing technology are "built up" from a review of patents, public domain information, and discussions with the technology developing companies and engineering contractors.

Nexant used proprietary and commercial state-of-the-art software tools to develop the technology and economic estimates. These are well established, state-of-the-art engineering tools in the chemical process industry and are used by major engineering contractors.

The economic evaluations are premised as typical regional costs of production based on capital costs that will be appropriate for "factored estimates". They would not reflect specific site issues, but should represent the countries or regions as a whole.

Commercial information and forecasts were developed from Nexant's extensive in-house databases, augmented with selected regional fieldwork.

Market projections were developed with the aid of Nexant's Supply/Demand computer modeling systems.

Please visit www.nexant.com to authorize engagement of the study, or return the following authorization form to one of the Nexant offices listed below.

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1. The undersigned (hereafter "Client") hereby subscribes to purchase from Nexant, Inc. ("Nexant"), Nexant's study, *Coal to Chemicals: Is it Coal's Time Again?*, in accordance with the following terms and conditions.

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7. Additional copies of the report are available at US\$500 each. The complete report will also be available electronically on CD-ROM at a cost of US\$1,000.
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9. Unless specified otherwise, there are no warranties of any kind for reports and consulting services provided under this Agreement. Nexant's total liability under this Agreement is limited to the total amount paid to Nexant for the reports.
10. This Agreement will be governed by the laws of the State of New York.

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6.1 GENERAL

Nexant uses multidisciplinary project teams drawn from the ranks of our international staff of engineers, chemists, economists and financial professionals, and from other Nexant groups to respond to the requirements of each assignment. Most of the staff of consultants possess credentials in both scientific and commercial disciplines plus substantial industrial experience. The collective talents of our staff, strategically located and closely linked throughout the world, result in valuable insights gained through a variety of perspectives.

ChemSystems is an international consultancy that is now part of Nexant, Inc., and is dedicated to assisting businesses within the global energy, chemical, plastics and process industries by providing incisive, objective, results-oriented management consulting. Over three decades of significant activity translate into an effective base of knowledge and resources for addressing the complex dynamics of specialized marketplaces. By assisting companies in developing and reviewing their business strategies, in planning and implementing new projects and products, diversification and divestiture endeavors and other management initiatives, Nexant helps clients increase the value of their businesses. Additionally we advise financial firms, vendors, utilities, government agencies and others interested in issues and trends affecting industry segments and individual companies. Whether identifying opportunities, managing change or confronting competitive challenges, we adhere to the highest ethical and professional standards.

ChemSystems, founded in 1965, was originally an independent, management-owned consultancy. IBM acquired it in 1998, and from early 1998 until August, 2001 ChemSystems was a part of IBM Global Services and IBM's Chemical and Petroleum group. Effective September 1, 2001, the ChemSystems unit of IBM was acquired by Nexant, Inc. Nexant, Inc. is an independent industry-expert consulting firm, that was spun off from Bechtel over three years ago, that provides technology solutions and experienced-based technical and management consulting services to electric utilities, energy producers, chemical companies, oil and gas companies, governments, and energy end-users worldwide. All of the staff and intellectual capital of ChemSystems was acquired by Nexant, Inc. Thus, Nexant, Inc., with ChemSystems as part of its Chemicals and Petroleum Division, continues to maintain fully-integrated operations in White Plains, New York; London, England; San Francisco, California; and Washington, D.C. Other business unit offices are located in Boulder, CO and Phoenix, AZ, and satellite business or project offices are located in Tokyo, Bangkok, Beijing, Seoul, and Houston. We also work with representatives throughout the world.

From major multinationals to locally-based firms and governmental entities, our clients look to us for expert judgment in solving compelling business and technical problems and in making critical decisions. The acquisition of ChemSystems by Nexant, Inc., has enhanced ChemSystems' ability to successfully serve its clients. This merger's success arises from complementary methodologies and technologies, which are used to provide services to clients and allow us to provide more complete and effective consulting.

Nexant's clients include most of the world's leading oil and chemical companies, financial institutions, and many national and regional governments. Nexant, Inc. is active in most of the industrialized countries of the world, as well as in most of the developing areas including the Middle East, Africa, and East and Southeast Asia.

Major annual programs are:

- Process Evaluation/Research Planning (PERP)
- Petroleum and Petrochemical Economics (PPE)/ChemSystems Online (CSOL) – United States, Western Europe and Asia

The PERP service covers technology, commercial trends, and economics applicable to the chemical industry. The program has more than 50 subscribers, including most of the major international chemical companies. Many of the processes to be analyzed in this multiclient have been assessed in the PERP program.

PPE/CSOL covers the market and manufacturing economics for major petrochemicals.

Over the past three years, the program has been completely overhauled and upgraded. The models and databases that run the analysis have been replaced with a start-of-the-art industry simulation program that has taken the 30 years of industry knowledge and experience of our consultants and enhanced it to a proved new level of forecasting expertise.

The new simulation model is used to generate the PPE reports and also an internet serviced brand ChemSystems Online, that provides global data, analysis and forecasts of:

- Plant capacity
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- Supply/demand and trade
- Profitability analysis
- Forecast
- Price forecast
- Techno-economic analysis

A subscription to ChemSystems Online includes both written reports (the PPE program) on the petroleum and petrochemical industry and internet access to all data analysis and forecasts. Your subscription may be tailored to meet your specific company requirements and the fees reflect the value brought to your business. Insightful analysis and a reliable forecasting methodology provide the means to significantly improve your business performance through better investment decisions and improved competitive position.

6.2 SUMMARY OF PROJECTS RELATED TO COAL

- **SYNTHETIC FUEL CAPITAL AND PRODUCTION COSTS** -- Nexant performed this study for the U.S. Department of Energy (DOE) as input to their assessment of the costs and benefits of flexible and alternative fuel use in the U.S. transportation sector. Nexant reviewed state-of-the-art coal liquefaction technology and developed production cost estimates for producing synthetic crude and then upgrading the syncrude to a gasoline product.
- **CHEMICALS FROM COAL AND SHALE FEEDSTOCKS** -- Recognizing the eventual importance of coal and shale resources in replacing gas and petroleum, this study examined the various technologies that could be used to produce feedstocks and chemicals. Three separate potential implementation cases were treated in detail: Economic, By-product, and "National Need." The production of synthetic fuels, olefins and aromatics and their derivatives from coal and shale were projected through the year 2000. A large number of patent references and flowsheets are included in the study, which also reviewed the chemical implications of synthetic fuels programs in the United States and elsewhere. There is also a section on utilization of U.S. tar sands resources.
- **SYNTHESIS GAS (FUTURE SOURCES)** -- This report reviewed the technology for production of synthesis gas (H₂, CO mixtures) from a number of sources. Most emphasis was devoted to coal and biomass (municipal solid waste and wood) gasification and new gasification technology. The report discussed downstream processing requirements and examined coal and biomass properties and their impact upon gasifier design. The economics of producing industrial fuel gas (gasifier effluent after acid gas removal) via different routes were compared to the direct use of natural gas and low sulfur fuel oil.
- **HYDROGEN-SYNTHESIS GAS STUDY** -- Nexant completed a multiclient study on the production of hydrogen and synthesis gas from heavy oils and coal. The objective of this study was to analyze the effects on the U.S. natural gas shortage on that portion of the petrochemical industry dependent upon natural gas as a feedstock, with particular emphasis on ammonia, methanol, and hydrogen-based chemicals. The study included a section on comparative costs for all hydrocarbon feedstocks from natural gas to coal.
- **WEST GERMAN COAL RESEARCH AND DEVELOPMENT/COAL GASIFICATION** -- West German companies have undertaken a massive effort to update their technologies to meet motor fuels and chemical requirements from indigenous and imported coals. An unusually productive marriage of government and private money, deployed in pilot plants located in chemical and energy complexes, is steadily advancing the state of the art in West Germany. Promising United States technologies are also being considered and improved. This study reviewed and analyzed the individual programs for their merit and impact on synthetic fuels and coal-based chemicals projects in the industrialized countries.
- **EVALUATION OF COAL BASED AMMONIA/METHANOL PROJECT** -- Nexant developed the overall facilities concept and developed capital cost estimates for this project. Lurgi and Koppers-Totzek gasifiers were studied in detail. Internal steam and

power balances were developed and the optimal synthesis gas processing sequence was developed.

- **EVALUATION OF COAL/NATURAL GAS BASED METHANOL/POWER** -- Nexant developed the overall facilities concept and capital cost estimates for an integrated complex employing "second generation" coal gasification, steam/methane reforming and combined cycle power generation technologies for the co-production of methanol and power. Relative coal and natural gas consumption was based on producing a stoichiometrically balanced methanol synthesis gas from coal-based hydrogen deficient and natural gas based carbon deficient synthesis gases.
- **COAL TAR CHEMICALS** -- In response to a Japanese company's request for an analysis of coal tar chemicals, Nexant conducted a study of U.S. and West European markets/applications and evaluated the technology for four basic coal tar chemicals and specific hydrogenated derivatives. The compounds studied included tetralin, biphenyl, acenaphthene, phenanthrene and hydrogenated derivatives of acenaphthene and phenanthrene. The technology review covered all aspects of the chemistry of these materials as well as all applications and developments worldwide.
- **IMPACT OF COAL CONVERSION PLANTS ON AROMATICS** -- For a U.S. chemical company, Nexant assessed the economic feasibility of aromatics recovery from by-products streams of coal gasification and coal liquefaction plants. Production technology and economics are provided for benzene, toluene, phenol, cresol, xylene, and coal derived naphtha.
- **SMOKELESS FUELS FROM COAL** -- For a specialty fuel producer, Nexant identified and characterized methods for producing smokeless briquettes that met international standards and identified potential binders that could be used with existing equipment to produce smokeless briquettes that could be used for export. Binders studied included: coal tar pitch, petroleum resin, coal and starch.
- **MARKETING ASSESSMENTS OF COAL PRODUCTS/BY-PRODUCTS** -- Nexant, under contract to Tri-State Synfuels Company (a partnership between Texas Eastern Synfuels Inc. and Texas Gas Synfuel Corporation) examined in detail the marketability of products from a Lurgi/Fischer-Tropsch coal-based facility being considered for Henderson, Kentucky. The coal conversion facility was being evaluated by Tri-State under a cooperative funding agreement with the U.S. Department of Energy. The products from the plant included high Btu substitute natural gas (SNG) liquid transportation and heating fuels, and a wide range of chemical products and by-products. Nexant analyzed the general eight-state region surrounding the proposed plant. Recommendations and observations were made relating to possible changes in the originally envisioned slate of products that might improve the project's revenue generation capability. Future product prices and values were forecast, based on Nexant's prevailing long-term prognosis of energy, petroleum and petrochemical demands. Nexant performed two similar market analysis studies for New York Power Authority (NYPA). One involved a proposed 600 MW coal gasification combined cycle power plant considered for the Buffalo area. Nexant analyzed current and future markets for the

fuels and chemicals (including synthesis gas derivatives) that could be manufactured in the complex. The second study was for a coal gasification plant being evaluated by NYPA for the South Bronx. Products considered for this plant included medium-Btu gas (and potential products) steam, sulfur, carbon dioxide and industrial gases (oxygen, nitrogen and argon).

- **VALUE OF COED PROCESS COAL-DERIVED LIQUIDS IN A PETROLEUM REFINERY** -- This study analyzed the value of liquids produced in a plant designed to make synthetic crude oil from coal.
- **VALUE OF LIQUIDS PRODUCED FROM COAL IN A COG (COAL, OIL GAS) REFINERY** -- This study, for the Pittsburgh & Midway Coal Mining Company, determined the value of coal-derived liquids in petroleum refineries.
- **COAL-METHANOL SLURRY PREFEASIBILITY STUDY** -- This study analyzed the economic viability of using coal-methanol slurry fuels in Malaysia.
- **COAL-LIQUID MIXTURE** -- Assistance was provided to the U.S. Synthetic Fuels Corp., on oil, water and methanol coal mixture technologies, economics and markets in regard to defining the scope for a planned solicitation.
- **COAL MINE ASSETS APPRAISAL** -- Certain coal mining equipment (mobile and fixed) and systems were evaluated and appraised in support of a lease financing.
- **EVALUATION OF COAL TO SYNTHETIC GASOLINE PROJECT** -- This project compared the attractiveness of gasoline production from coal derived methanol via the Mobil MTG (methanol-to-gasoline) process, to the economics of direct coal liquefaction as well as coal based methyl fuel production.
- **CHEMICALS FROM COAL AND SHALE** -- This study was performed under an RANN grant by the Office of Energy R&D Policy, NSF. The objectives of this study were: estimate feedstock demands for major organic chemicals through the year 2000; gauge the probable timing as to when chemical feedstock demands will constitute an unreasonably large fraction of conventional hydrocarbon sources; identify the potential technologies for (a) transformation of coal and shale building blocks to primary organic chemical building blocks or feedstocks, and (b) synthesis of current "petrochemicals" from such coal and shale-derived building blocks; define research and development strategies and a related program to assure that any conversion of the organic chemical industry to coal and shale would be based upon available and the most economically possible technology.
- **SYNTHESIS GAS FOR CHEMICALS** -- This multiclient report dealt with the applicability of emerging synthesis gas based routes to chemicals compared to traditional production methods. The synthesis gas based routes were analyzed based on the economics of large-scale production of synthesis gas from coal.

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The logo for Nexant ChemSystems features a stylized white icon of a curved arrow or 'N' shape to the left of the company name. 'Nexant' is written in a large, bold, white sans-serif font, and 'ChemSystems' is written below it in a smaller, white sans-serif font.