Prospectus

Stranded Gas Utilization: Methane Refineries of the Future
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Almost 60 percent of roughly 141 trillion cubic meters (5,000 trillion cubic feet) of proven natural gas reserves in the world can be categorized as remote or stranded gas. This massive global resource is largely untapped, and conventional means of development face major logistical and economic barriers.

LNG technology provides one method for transporting the stranded gas to market, but the capital-intensive infrastructure requirement can be cost prohibitive. Emerging technologies in gas-to-liquids (fuels and chemicals) may play a significant role in monetizing these resources, particularly when competing with products made from crude oil at the relatively high current prices. Gas derived liquids are free from sulfur, aromatics and metals and could assist refineries in meeting the new guidelines for cleaner fuels.

Recent process improvements in methane reforming technologies, fuel grade methanol production (mega-scale plants), developments in improved Fischer-Tropsch processes for conversion of gas to liquids, and the production of olefins from methanol are some of the more important areas of research and development that are expected to increasingly spur future use of stranded gas, as shown in Figure 1.1.
A new Nexant, Inc./ChemSystems’ study on remote gas reserves “Stranded Gas Utilization: Methane Refineries of the Future”, will provide an in-depth quantitative and qualitative analysis of the various end uses, manufacturing processes, and economics for converting large, remote natural gas reserves to viable products.

The study will analyze the current and emerging state-of-the-art technologies for converting stranded natural gas to the following products:

### FUEL OR SUBSTITUTES
- LNG
- Gasoline from Methanol (MTG)
- Diesel: Dimethyl ether (DME) as a substitute
- Middle distillates: via Fischer-Tropsch processes

### CHEMICAL PRODUCTS
- Light olefins (MTO) and derivatives

### FERTILIZERS
- Ammonia

### POWER
For each process (described in more detail in Section II, Scope) Nexant, Inc./ChemSystems will provide a detailed technical and commercial evaluation. A key part of the study will be to estimate the relationship between plant size and remote gas price, which will be needed to make the processes viable at different crude oil price levels.

The cost of the study is US$10,000 (ten thousand U.S. dollars).
Section 2  Introduction

Current global proven natural gas reserves equal about 141 trillion cubic meters (5,000 trillion cubic feet) or about 880 billion barrels of oil equivalent. Table 2.1 shows the natural gas resources in different regions of the world. Eastern Europe and the Middle East together account for more than 70 percent of the reserve base. Almost 60 percent of global proven reserves can be categorized as remote or stranded gas.

Table 2.1  Proven Reserves of Natural Gas

<table>
<thead>
<tr>
<th>Region</th>
<th>Trillion Cubic Meters</th>
<th>Trillion Cubic Feet</th>
<th>Billion Barrels of Oil Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>6.9</td>
<td>242</td>
<td>43</td>
</tr>
<tr>
<td>South America</td>
<td>7.3</td>
<td>259</td>
<td>46</td>
</tr>
<tr>
<td>Western Europe</td>
<td>5.4</td>
<td>192</td>
<td>34</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>56.7</td>
<td>2,001</td>
<td>355</td>
</tr>
<tr>
<td>Africa</td>
<td>9.7</td>
<td>342</td>
<td>61</td>
</tr>
<tr>
<td>Middle East</td>
<td>45.1</td>
<td>1,594</td>
<td>283</td>
</tr>
<tr>
<td>Asia-Pacific</td>
<td>9.9</td>
<td>351</td>
<td>62</td>
</tr>
<tr>
<td><strong>World Total</strong></td>
<td><strong>141.0</strong></td>
<td><strong>4,981</strong></td>
<td><strong>884</strong></td>
</tr>
</tbody>
</table>

This study will provide analyses of the various end uses and manufacturing processes for converting large, remote reserves of natural gas to viable products. While extensive R&D on gas conversion has been performed for decades, interest in this area has intensified due to recent high levels of crude oil prices.
This study provides an assessment of the following current and emerging stat-of-the-art technologies for converting stranded gas to the following usable products:

**FUEL OR SUBSTITUTES**

- LNG
- Gasoline from Methanol (MTG)
- Diesel: Dimethyl ether (DME) as a substitute
- Middle distillates: via Fischer-Tropsch processes

**CHEMICAL PRODUCTS**

- Light olefins (MTO) and derivatives

**FERTILIZERS**

- Ammonia

**POWER**

A brief description of the issues that will be addressed for each of these emerging technologies is discussed below:

**Fuel or Substitutes**

- LNG: The liquefaction and transport of remote gas is a well-established global industry. This study will provide an overview of the current state of the art for LNG production and transport, as well as a review of expected developments that will make the process more cost competitive.

- Gasoline from Methanol: The methanol to gasoline (MTG) process developed by Mobil (now ExxonMobil) was commercialized at the New Zealand Synthetic Fuels Corporation in 1985. The plant has since been sold to Methanex. In an effort to improve MTG economics, Haldor Topsoe developed TIGAS, an integrated gasoline synthesis process by modifying the three process steps (syngas production, methanol synthesis and conversion to gasoline). Nexant, Inc./ChemSystems will evaluate these and other potential processes and developments as alternates to crude oil derived gasoline.

- Diesel substitute: Diesel fuel is a large potential application for remote natural gas-derived products. Dimethyl ether (DME) has shown interesting promise as a substitute for crude oil-derived diesel fuel. Its properties exceed the most stringent and proposed engine emission regulations, while affording excellent diesel properties and high cetane number. Current technology, using methanol as the raw material, has been noncompetitive with conventional diesel fuel, hindering the growth of DME as a diesel...
substitute. Nexant, Inc./ChemSystems will evaluate the economics for both the conventional methanol route and developing one-step processes from natural gas, as proposed by Haldor Topsoe and Air Products, among others.

- Fischer-Tropsch Middle Distillates: Nexant, Inc./ChemSystems will analyze technology advances in Fischer-Tropsch synthesis of natural gas to middle distillate liquid transportation fuels. This route can be an attractive alternative to direct liquefaction of natural gas or, in the case of remote gas, the high cost of transporting natural gas via pipeline. Nexant, Inc./ChemSystems will evaluate the most advanced and technically viable and competitive of the Fischer-Tropsch processes, such as those developed by Syntroleum, Rentech, Sasol (SSPD) and Shell (SMDS). New developments, such as advanced reactor design (i.e., ExxonMobil AGC-21), will be incorporated into the economic cases to ascertain the competitiveness of the process versus crude oil-based technologies and products.

Chemical Products

- Light Olefins: The conversion of natural gas into short chain light olefins, e.g. ethylene and propylene via methanol, is a potentially viable means to add value to methane. The complication is the methanol intermediate, in itself a valuable commodity. In recent years, there have been several developments in methanol to olefins (MTO) technology based on alternate catalysts to ZSM-5 that exhibit a higher selectivity to light olefins. Commercially viable processes, most notably that developed by UOP and Norsk Hydro (the UOP Hydro MTO process) and Exxon Mobil (Exxon Mobil MTO process) will be evaluated and compared economically to conventional olefin production technology.

Fertilizers

- Ammonia: Total nitrogen consumption (fertilizer and industrial) is forecast to grow to more than 130 million metric tons N by 2010. Fertilizer use accounts for approximately 87 percent of worldwide ammonia consumption. The study will examine and evaluate advances in natural gas to ammonia technology with emphasis on the major licensors such as KBR, Haldor Topsoe, ICI Katalco, Linde, and Uhde.

Power

- Recently, Foster Wheeler announced an exclusive licensing agreement with Starchem, Inc. to commercialize a large-scale production technology of methanol from remote natural gas for use as fuel in some combined cycle power plants. Fuel grade methanol can be transported safely at low cost to distant markets for use as gas turbine fuel for electric power generation. This is especially beneficial for plants located in regions where pipeline natural gas is not available and where power demand is too small for LNG to be practical. Nexant, Inc./ChemSystems will examine the economics of the so-called “Well Head to Wire” technology and compare this process with alternative technologies.

Each of these technologies will be evaluated from technical, economic and commercial perspectives, as follows:
Technology Evaluation – A detailed review and status of the various process routes including: patent review and analysis, identification of technology holders and offerers, licensor package evaluation and cost of production development, and identification of the stage of process package commercial development with a listing of actual and announced projects.

Regional cost of production estimates will be developed for each of the technologies. Costs will be developed on an “ex-plant” and delivered basis, depending on the likely market destination for each product. Sensitivities will be performed for gas cost, plant scale, and other important variables, and competing technologies will be compared to conventional technology (e.g., MTO vs. steam cracking).

Economic Evaluation – The study will assess the remote gas price necessary for these processes to be viable at different crude oil price levels. Nexant, Inc./ChemSystems will perform this assessment for a range of crude oil prices including Nexant, Inc./ChemSystems’ baseline outlook for Mideast marker crude (Dubai, FOB) as well as high and low boundary cases for crude that bracket the expected volatility range. Economic assessments will be made to determine wellhead gas prices necessary to make the natural gas-based processes economically viable versus the range of crude prices.

Commercial Evaluation – Nexant, Inc./ChemSystems will perform an analysis of the growth potential of the end products included in the technical evaluation. This analysis will provide an indication of the future demand for the various products and the need for and likelihood of new plants. The analysis will be performed on a global and regional basis, with attention to regional demand and logistical shipping issues.
Section 4  

Approach

The evaluations of conventional technology have been based on in-house and published information regarding process technology, augmented by contacts with licensors engineering contractors and other experts in the industry. Stranded gas implementation technology elevations have been “built up” from a review of patents, publish domain information, and discussions with the technology developing companies and engineering contractors.

Nexant, Inc./ChemSystems has used proprietary and commercial stat-of-the-art software tools to develop the technology evaluations and economic estimates. These are well established, state-of-the-art engineering tools in the process chemical industry and are used by major engineering contractors. To the degree allowed under copyright and licensed user restrictions, the detailed software generated output will be included in the report.

Commercial information and forecasts have been developed from Nexant, Inc./ChemSystems’ extensive in-house databases, augmented with selected regional fieldwork.

Market projections have been developed with the aid of Nexant, Inc./ChemSystem’s Supply/Demand computer modeling systems.
Section 5  Subscription Form

Please visit www.nexant.com to authorize engagement of the study or return the following authorization form to one of the Nexant, Inc./ChemSystems’ offices.

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1. The undersigned (hereafter “Client”) hereby subscribes to purchase from Nexant, Inc./ChemSystems (“Nexant”), Nexant’s study, Stranded Gas Utilization: Methane Refineries of the Future, in accordance with the following terms and conditions.

Nexant will provide to Client the following information and services:

(a) Three (3) bound copies of the report

(b) Access to electronic downloads of the report via a password-protected area from www.nexant.com

(c) If desired, a presentation of the final study results. Travel and living expenses, if applicable, will be reimbursed by the client at cost.

2. While the information supplied by Nexant to Client will represent and original effort by Nexant, based on its own research, it is understood that portions of the report will involve the collection of information available from third parties, both published and unpublished. Nexant does not believe that suchem information will contain any confidential technical information of third parties, but cannot provide any assurance that any third party may, from time to time, claim a confidential obligation to such information.

3. The information disclosed in this report will be retained by Client for the sole and confidential use of Client and its 51 percent or greater owned affiliates in their own research and commercial activities, including loaning the reports on a confidential basis to third parties for temporary and specific use for sole benefit of Client.

4. Client further agrees that it will use reasonable efforts to keep the information in the reports for its sole use; however, this restriction shall not apply to information which is or becomes generally available to the public in a printed publication, which is already in the possession of Client, or which is received by Client in good faith from a third party without an obligation of confidentiality.

5. Client shall not republish any of the report except within its own organization or that of its 51 percent or greater owned affiliates. Client further agrees to refrain from any general publication of the reports, either directly or through its affiliates, so as to constitute passage of title into the public domain or otherwise jeopardize common law or statutory copyright in said report.

6. Clients will be invoiced by and shall pay to Nexant a total of US$10,000 for the printed version of the report. The above fixed price is net of local taxes, duties, etc. Amounts are due upon receipt of invoice and payable within thirty (30) days. Late payments shall accrue interest at the rate of 1.5% per month. Fees quoted do not include any applicable sales tax, or use or value added tax, all of which are for the account of Client.

7. Additional copies of the report are available at $200 each. The complete report will also be available electronically on CD-ROM at a cost of $1,000.

8. The obligations of paragraphs 3 and 4 shall terminate five (5) years from receipt of reports.

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.
AUTHORIZATION FORM

AGREED TO AND ACCEPTED: AGREED TO AND ACCEPTED: NEXANT, INC.

CLIENT: _______________________________ Name: _______________________________

Name: _______________________________ Signature: _______________________________

Signature: ______________________________ Title: _______________________________

Title: _______________________________ Date: _______________________________

Reports to be sent to:

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

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Phone: _______________________________ Fax: _______________________________

E-mail address: _______________________________

Number of Copies Desired: _____ Total Cost: _____

If purchase order is required, please provide the purchase order below:

Purchase Order #: _______________________________

NEXANT, INC./CHEMSYSTEMS
44 SOUTH BROADWAY, 5TH FLOOR
WHITE PLAINS, NY 10601-4425, U.S.A.
FAX: 1-1914-609-0399
Section 7  Qualifications

7.1 GENERAL

Chem Systems 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, Inc./ChemSystems helps clients increase the value of their businesses. Additionally, we advise financial firms, vendors, utilities, government agencies and other interested on 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.

Nexant, Inc./ChemSystems 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 located and closely linked throughout the world, result in valuable insights gained through a variety of perspectives.

Chem Systems, founded in 1965, was originally an independent, management-owned consultancy. IBM acquired it in 1998, and from early 1998 until August, 2001, Chem Systems was part of the IBM Global Services and IBM’s Chemical and Petroleum groups. Effect September 1, 2001, the Chem Systems’ unit of IBM was acquired by Nexant, Inc. Nexant, Inc. is an independent industry-expert consulting firm, spun off from Bechtel two years ago, that provides technology solutions and experienced-based technical and management consulting services to electric utilities, energy producers, oil and gas companies, governments, and energy end-users worldwide. All of the staff and intellectual capital of Chem Systems was acquired by Nexant, Inc. Thus, Nexant, Inc. with Chem Systems as part of its Chemical 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 Tokyo, Bangkok, Cairo, New Delhi, Moscow, 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 export judgment in solving compelling business and technical problems and in making critical decisions. The acquisition of Chem Systems by Nexant, Inc., although it has just recently taken place, is expected to enhance Chem Systems’ ability to successfully serve its clients. We expect this merger to be a success since both firms’ methodologies and technologies, which are used to provide services to clients, are complementary and will allow us to provide more complete and effective consulting.
Nexant, Inc./ChemSystems’ clients include most of the world’s leading oil and chemical companies, financial institutions, and many national and regional governments. Nexant, Inc./ChemSystems 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) – United States, Western Europe and Asia
- Polyolefins Planning Services (POPS)

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 covers the market and manufacturing economics for major petrochemicals. The program has approximately 100 clients.

7.2 SPECIFIC EXPERIENCE RELEVANT TO STRANDED GAS UTILIZATION

Nexant, Inc./ChemSystems is uniquely qualified to perform this comprehensive analysis based on our multidisciplinary business approach and has been carrying out studies of this type throughout our more than 35 year history.

Nexant, Inc./ChemSystems has extensive experience in the areas of natural gas technology and commercial utilization. Projects based on natural gas feedstocks have involved the full range of services including strategic assessments of energy options, market analysis and forecasts, process selection, cost estimating, financial analysis, preparation of bid documents, contractor selection and project management through to plant operation.

A partial list of projects includes:

- **TECHNOECONOMIC EVALUATION** -- For a major U.S. chemical company seeking to identify and evaluate viable chemical outlets that could consume significant quantities of remote gas resources in world-scale facilities, Nexant, Inc./ChemSystems screened a broad group of major chemicals that were first or second derivatives of methane. For the selected chemicals, market related information and production economics and technology evaluation were provided.

- **TECHNOECONOMIC EVALUATION** – Nexant, Inc./Chem Systems was retained by a Japanese energy-related agency to evaluate the status and trends of natural gas conversion to liquid fuels technologies. Processes already commercial (Sasol, Mobil, Shell), ready for commercialization (Exxon, Haldor Topsoe), as well as under development (Syntroleum, Statoil), were assessed and comparisons made with
competitive processes. For each of the processes, detailed descriptions of the investment required, the feedstocks and chemistry of the processes, and the costs of production were provided.

- **PRODUCTION ECONOMICS** – Nexant, Inc./Chem Systems developed the cost of producing dimethyl ether (DME) via a recently announced process in large scale natural gas plants and delivering it as a substitute for conventional diesel fuel. The client was also interested in comparing DME production costs with other alternative processes for converting remote natural gas to a fuel product.

- **MARKET POTENTIAL** -- The natural gas division of an international petroleum company authorized Nexant, Inc./Chem Systems to determine the market potential for natural gas based chemicals including: ammonia, urea, methanol, acetic acid and for novel conversion technologies. Nexant, Inc./ChemSystems provided the global market size, growth factors, cost of production (ammonia, methanol, acetic acid) and an overview of primary technology licensors or contractors who are candidates as partners.

- **OPPORTUNITY ANALYSIS** -- A major U.S. chemical producer interested in developing and producing hydrocarbons in Asia engaged Nexant, Inc./ChemSystems to ascertain the market opportunities for available methane in selected regions in China for petrochemical or related products. We provided a general overview of the Chinese energy market and the role of natural gas in energy, industrial and chemical applications; infrastructure overview in the target regions/locations; focused assessment of natural gas opportunities for chemicals and for energy/industrial applications in the selected regions.

- **NATURAL GAS UTILIZATION** -- An Australian client interested in developing natural gas fields that contained undesirable amounts of inert gases for industrial gas customers engaged Nexant, Inc./ChemSystems to assess the suitability of these resources as chemical feedstocks or as fuel in a variety of applications: direct reduction of iron; steel making; methanol; ammonia/urea; chloralkali and ethane based petrochemicals. In each case, gas consumption, specifications, cost of gas treatment, if any, problems or benefits from impurities and the cost benefit of several levels of treatment were determined.

### 7.3 OTHER EXPERIENCE INVOLVING NATURAL GAS

- **PETROCHEMICALS FROM REFINERIES** -- This in-depth business assessment evaluates opportunities to produce high value petrochemicals from lower value refinery streams. The analysis examined the operational and capital costs benefits of integrated operations versus stand-alone petrochemical facility construction. The study also evaluated the global market outlook for over twenty petrochemical products. The profitability of producing these products from pro forma refineries located in the world’s three major refining centers (USGC, Singapore, Rotterdam) was evaluated.

- **THE LATIN AMERICAN ENERGY, REFINING AND PETROCHEMICAL INDUSTRIES IN TRANSITION** -- A geographically-focused business assessment that evaluates the key issues facing the energy and refining industries in all major Latin
American countries. Industry competitiveness is assessed and energy and major petroleum product supply/demand trends analyzed for each country and the region.

- **PROCESS EVALUATION/RESEARCH PLANNING (PERP)** -- Nexant, Inc./ChemSystems’ premier technology evaluation service prepared several reports in the last few years on gas to liquids: Developments in Natural Gas to Liquid Fuels Conversion; Advances in Fischer-Tropsch Technology; Methane Conversion to Olefins and Liquids, Methanol to Olefins.

- **GAS-BASED CHEMICALS AND FUELS: GLOBAL PROSPECTS TO THE YEAR 2000** -- An industry analysis that quantified the likely scale of gas/gas liquids-based investments in the 1990s and assessed the potential impacts upon industry structure and pricing. The major focus was on the economics of gas and gas liquids conversion and the implications for current project planning. The study addressed the following: the potential for gas and gas liquids conversion projects based on an overall market/economic assessment of the possible products; the likely capacity of new gas and gas liquids projects and their competitiveness; and the likely impact of gas and gas liquids based developments on the supply and pricing of the relevant products. Key issues covered included: resource base (gas and gas liquids), market potential (potential products), technology (new versus improved), production and shipping economics (competitiveness and profitability), investment Intention (countries and capacity development) and strategic assessment (impact, opportunities and threats).

- **LPG AVAILABILITY AND PRICING** -- A global analysis of LPG availability from a variety of sources, LPG pricing and the demand for LPG in all significant end-use markets. Forecast supply/demand balances provided the basis for projecting prices, after having also considered various political/economic factors including how LPG was priced by overseas producers and how U.S. governmental policies and programs affect global LPG market.

- **AMMONIA BUSINESS** -- Nexant, Inc./ChemSystems evaluated the impact of changing economics and markets on the global ammonia business, especially the effect on U.S., West European and Japanese industry of trends towards fertilizer self-sufficiency in the developing world. The study also covered export-oriented production of ammonia, urea and other fertilizers by the gas-rich countries. Detailed production economics were produced for all types of feedstocks, as applicable for various parts of the world.